Journal of Psycholinguistic Research, Vol. 8, No. 5, 1979

Lexical Insertion, Inflection, and Derivation: Creative Processes in Word Production

Donald G. MacKay[1]

Received September 14, 1977

This study examines the distinction between creative and noncreative behavior as applied to the production of words and sentences. Under one hypothesis words such as "governor" and "government" are stored as independent units and produced by rote, but under another these nouns are not produced as fully integrated units but are generated by rules for combining stems ("govern") and affixes ("-ment" and "-or"). Analyses of German and English speech errors supported the generation-by-rule thesis and indicated that word stems, prefixes, and suffixes must be separately stored in the internal lexicon and marked as to syntactic function in combining with other word components. The data also suggested a three-stage model of lexical processes in the production of speech: a lexical insertion stage whereby abstract lexical formatives are called on or introduced into sentences by means of abstract syntactic and semantic features; a rule application stage whereby feature agreement rules are applied to the formative and then inflectional, derivational, and phonological rules are applied to derive the phonetic string; finally a serial output stage whereby the phonetic string is translated into serially ordered motor commands.

INTRODUCTION

Naturally occurring speech errors such as "Rosa always date shranks" (from Fromkin, 1973) raise important questions as to how we store and produce words. The intended output was "Rosa always dated shrinks" and the basic questions are why the past tense suffix was

This research was supported by NIMH Grant RO 19964 to Donald Mackay.
[1]Psychology Department, University of California, Los Angeles, California 90024.

0090-6905/79/0900-0477$03.00/0

dropped in "dated" and why the vowel was changed in "shrinks." One possible answer to such questions is that words such as "dated" and "shrinks are not stored as phonological units in the internal lexicon (the hypothetical system for storing lexical information) but are generated by rule from lexical representations such as ("date" verb) + [PAST] and [("shrink" verb) noun] + [PLURAL], where + [PAST] and + [PLURAL] are abstract markers for triggering the appropriate plural and past tense rules. In this view the error "date shranks" reflects an instance of marker misapplication: the marker for triggering the past tense rules for the verb "date" was inadvertently misapplied to another verb occurring later in the intended utterance. The misapplied marker triggered rules which formed the underlying representation [("shrank") noun] + [PLURAL], which becomes manifest as "shranks" with application of the appropriate plural rule.

There are several problems with this interpretation. One is that individual examples are always open to alternative interpretations (see Fromkin, 1973 for two other explanations of this particular error). In fact, a forceful case can be made that unique or irreplicable events can never be conclusively explained, but only patterns appearing within large numbers of instances. Thus, since no other errors of this sort have been reported or analyzed to date, attempts at explanation may be premature.

A second problem is that the marker misapplication interpretation rests on a number of unsubstantiated and perhaps implausible assumptions, e.g., the assumption that a noun such as "shrinks" is not stored as a unit in the internal lexicon but as a stem "shrink" plus rules for pluralization. A second assumption is that the stem "shrink" is marked in the lexicon as a verb since past tense rules only apply (or misapply) to verbs. This assumption seems implausible since the stem marker VERB in the derivative "shrinks" plays no role in the syntax or semantics of the sentence being produced.

The present study examined the plausibility of such assumptions by analyzing a corpus of German errors where examples resembling "Rosa always date shranks" are fairly common. Our goal was to develop a model of lexical processes in speech production (and misproduction), and the basic issue was how speakers store and produce complex words, i.e., words containing derivational affixes e.g., the "-ment" in "government," inflectional affixes e.g., the "-s" in "goes," derivational alternations e.g., the stress alternation rule for deriving "cónvict" (noun) from "convíct"

(verb), or inflectional alternations e.g., the vowel alternation relating "dug" and "dig."[2]

There are two widely held and diametrically opposed positions on the storage and production of complex words: the *generation-by-rule* and the *generation-by-rote* hypothesis. Under the generation-by-rote hypothesis production of complex words constitutes noncreative behavior reflecting readout from a rote storage system. Words such as "decision" are represented as a single unit in lexical memory, e.g., as a string of phonological or phonetic segments ready to be inserted into an articulatory program. Associated with each lexical component is a unitary meaning which serves to retrieve the word. One example of the generation-by-rote hypothesis appears in Wickelgren (1969, 1976). In Wickelgren's model, words are stored as fully integrated units in a rote memory system and generated by means of a simple readout mechanism. The word "decision," for example, is stored as an integrated set of allophones which are translated directly into motor commands. There are no syntactic mechanisms for combining stem ("decide") and affix ("-ion;;) or for altering vowels and consonants.

Wickelgren's (1969) arguments in favor of generation-by-rote were as follows: we rarely create new words unlike novel sentences; word production is repetitive (we produce the same words over and over again in essentially equivalent manner) whereas sentence production is not (we almost never repeat sentences); and a creative or rule-governed account for word and sentence production would seem to provide parrots with the mental apparatus for producing syntactically structured speech, a clearly undesirable situation.

All three arguments are open to question. The repetitive aspect of word production is not inconsistent with the hypothesis that producing words requires rules for combining stems and affixes. And the fact that we rarely create novel words is equally irrelevant since similar rules may

[2]More generally, inflections are morphemes (usually suffixes in German and English) that do not change the class (noun, verb) of the word they are added to and can often be added to every word within a class, e.g., English possessive inflection ("-s") can be added to any noun. Other major types of inflection are plurality (for nouns), number agreement (for verbs), past tense (for verbs), progressive tense (for verbs), and comparative and superlative case (for adjectives). By way of contrast, derivations change the class of words, generally by adding affixes or altering segments in German and English. For example, the adjective "rocky" is derived from the noun "rock" the noun "decision" from the verb "decide."

be used for reproducing old words such as "knighthood" as for creating new ones such as "suffixhood". Moreover, a rule-governed account for sentence and word production in humans wouldn't necessarily provide parrots with the mental apparatus for producing syntactically structured speech since humans and parrots could produce words (and sentences) in radically different ways regardless of similarity in acoustic output.

The present study examines evidence from errors in speech which contradicts the generation-by-rote hypothesis and supports the generation-by-rule hypothesis. Under generation-by-rule, production of at least some words requires syntactic rules for combining stems and affixes. In this view, the internal lexicon contains base forms similar to "decide" plus rules for producing derivatives such as "decision" and inflectives such as "decides."[3] The derivational rules can be quite complex, as in this example where "decision" is derived from "decide" by means of a combinational rule for adding the "-ion" suffix plus alternation rules for changing vowels and consonants.

CORPUS

The errors examined were obtained from a corpus of over 4000 errors published in German by Meringer (1906) and Meringer and Mayer (1895). The present study dealt with a subset of a subset of this corpus. Specifically we examined only errors involving inflectional or derivational affixes or alternations. And we limited our analyses mainly to syntagmatic errors or errors involving sequential misplacement of these components. A syntagmatic rather than paradigmatic corpus was selected because paradigmatic errors are often ambiguous with regard to morphological processes. By way of illustration, the paradigmatic substitution of "mootion" for "motion" (observed by the author) may reflect a failure to apply the vowel alternation rules for deriving "motion" from "move" (MOOVE), but another perhaps more plausible interpretation is that the error reflects a blend of two simultaneously activated forms ("movement" and "motion") rather than misapplication of derivational rules. To avoid such ambiguities, we restricted our analysis mainly to syntagmatic errors.

Meringer's corpus contained over 400 syntagmatic errors involving morphological rules or components, i.e., word stems, prefixes, and

[3]See footnote 2.

suffixes. Of these, 12 were made by children (aged 3.5–6.0 approximately) and the remainder by educated adults, mainly professors at the University of Vienna and their wives. Also included in Meringer's corpus were the intended utterances, determined whenever possible by speaker interrogation so as to ensure correct tabulation and to exclude instances of intentional humor (i.e., nonerrors).

RESULTS

The results are organized under two main categories: derivational phenomena for errors involving derived words and inflectional phenomena for errors involving inflected words. Whenever possible, the principles underlying the German errors are illustrated by means of English examples—either actual English examples observed by, say, the author or hypothetical English examples (marked with the suffix (I) for invented) or word-for-word translations of German examples (marked with the suffix (T) for translation). The data revealed no interesting effects associated with the traditional subcategories of anticipations, perseverations, and transpositions, and these subcategories receive no further discussion.

Derivational Phenomena

Three classes of derivational phenomena were noted: a stem class phenomenon, a suffix class phenomenon, and a derivational alternation phenomenon.

The Stem Class Phenomenon

It has frequently been noted that misplaced words usually substitute for words of the same syntactic category (noun, verb, adjective). This word class phenomenon also held true in Meringer's corpus of word substitutions: speakers almost invariably substituted words of the same syntactic category. But the present analyses also uncovered a stem class phenomenon for substituted word stems ($N = 220$). Excluding ambiguous cases ($N = 8$), the data showed that misplaced stems almost always substituted for stems of the same syntactic class: noun stems were substituted for noun stems, verb stems for verb stems, and adjective stems for other adjective stems. Example 1a illustrates this phenomenon: the noun stem "boat" is interchanged with the noun stem "noise," which happens to be a component of the adjective "noisy."

1.a. The noisy boats ——→ the boaty noises[4]

b. Collective emotion ——→ emotive collection (hypothetical nonoccurring example)

c. Noisy adjournment ——→ adjourny noisement (hypothetical nonoccurring example)

There were no errors involving substitution of a stem and a nonstem as in 1b or of a noun stem and a verb stem as in 1c. Moreover, the stem class phenomenon was not a statistical artifact: there were ample opportunities for stem substitutions of differing syntactic class since in German, as in English, words can be formed from stems of virtually any syntactic category (*cf.* Table I).

The Suffix Class Phenomenon

The suffix class phenomenon was discovered in an analysis of 32 affix substitutions. It has previously been noted that in Dutch prefixes are substituted for prefixes and suffixes for suffixes (Nooteboom, 1969). This was also true for Meringer's corpus of German affix substitutions: never

[4]The arrows in these formulas stand for "was produced as." A dash — indicates that an irrelevant part of the context has been omitted while dots . . . indicate that the speaker paused after the error and began again.

Table I. Examples Showing Various Relationships Between Stem and Word Class in English[a]

	Example word	Word class	Stem class
Identical stem and word class	trees	Noun	Noun
	repayed	Verb	Verb
	yellowish	Adjective	Adjective
Differing stem and word class	motivate*	Verb	Noun
	quicken*	Verb	Adjective
	noisy*	Adjective	Noun
	inventive*	Adjective	Verb
	inventor*	Noun	Verb
	sadness*	Noun	Adjective

[a]Cases where the stem and word class differ are indicated with an asterisk.

did a prefix of one word substitute for a suffix or stem of another word. But there was in addition a suffix class phenomenon in the German data: suffixes were always substituted for suffixes of the same general type. Thus derivational suffixes such as "-ment" were always substituted for other derivational suffixes such as "-ence" (as in 2) and never for inflectional suffixes such as "-ed" (past tense marker) or "-es" (inflectional agreement marker).

2. His dependence on the government———→his dependment (I)

Moreover, derivational suffixes for forming nouns (e.g., "-ment" or "-ence") were always interchanged with other nominalization suffixes and never with suffixes for forming other word classes such as the adjective marker "-ive" in "inventive." A similar phenomenon is almost certain to hold for speakers of English: Fromkin's (1973) corpus contains several examples where suffixes from the same class are substituted e.g., "perceptic" for "perceptual", "specialating" for "specializing," and "peculiaracy" for "peculiarity," but contains no unambiguous substitutions of suffixes from different classes e.g., "stupidence" for "stupidly" or "governly" for "government" (hypothetical examples).

Derivational Alternation Phenomenon

Derivational alternations (N = 24) were scored whenever derivational markers of an intended form became altered in an error. These changes occurred only when a stem in a word of one syntactic class (say a verb) was substituted for a stem in a word of differing syntactic class (say a noun). A typical example is shown in 3a where the stem for the past participle "gehängt" was anticipated as part of a noun, thereby losing its derivational markers (vowel umlaut, prefix and suffix).

3.a. — Vortrag gehängt———→—Vorhang . . . (German example)
b. The workers have lost their battle———→The losers . . . (I)

An analogous but hypothetical English example is shown in 3b to illustrate the remarkable nature of these derivational alterations.

Inflectional Phenomenon

Four classes of inflectional phenomenon noted in the corpus are discussed below: inflectional alternations, misagreements errors, misinflection errors, and regularization errors.

Inflectional Alternations

Inflectional alternations ($N = 68$) were scored whenever inflectional markers of intended words were changed as a result of syntagmatic misplacement of a word or stem. In 57 of the examples, a misplaced stem itself underwent inflectional changes appropriate to its new syntactic position. For instance, misplaced verbs changed inflectional markers to agree in person and number with their new surface subject. A typical example appears in 4a, where the present participle "becoming" replaced the verb "is," thereby changing its suffix from "-ing" to "-s." Related examples where verb stems simply lost an inflectional marker rather than gained a new one are shown in 4b,c.

4.a. What he is, I am becoming → What he becomes, I am becoming (T)

b. It suffices to let ——→ It suffices to suffice (T)

c. He wants to know ——→ He wants to want (T)

In the remaining 11 inflectional alternations, a misplaced word caused inflectional changes in a form already in correct position in the intended utterance. Specifically, misplaced nouns caused inflectional alternations in correctly positioned articles and adjectives, which in German must agree in case, number, and gender with the nouns they modify. A typical example is shown in 5, where the intended article "dem' (singular) becomes "den" (plural) to agree in number with the misplaced noun "Handlungen."[5]

5. Unter dem Eindruck ——→ Unter den Handlungen . . .
gewisser Handlungen

[5]Instances of allomorphic alternation reported in Fromkin (1973) provide an interesting parallel to the inflectional alternations described here. Examples of allomorphic alternation are shown in 6a where the article "a" became "an" before a misplaced vowel-initial word, and in 6b, where the plural allomorph "-z" became "-ez" following a misplaced stem ending in a homorganic affricate.

6.a. A fall in pitch occurs at the end of the sentence →
An end of the sentence occurs at the fall in pitch

b. ministers of the church ——→ churches of the minister

Whereas inflectional alternations are triggered by context-dependent syntactic agreement rules for case, gender, and number, allomorphic alternations are triggered by context-dependent phonological agreement rules of a somewhat parallel sort.

Misagreement Errors

Misagreement errors ($N = 39$) were tabulated whenever the speaker produced an inappropriate inflectional form which violated agreement rules for person ($N = 17$), gender ($N = 18$), number ($N = 2$), or case ($N = 2$). In every instance the misagreement errors could be explained as due to misapplication of inflectional agreement rules for words occurring earlier or later in the intended output. A typical example involving inflectional agreement rules for person appears in 6a, where the unintended output "am" agrees in person with the subject from the preceding clause rather than with the actual subject "he."

7.a. I always think back, he is saying → I always think back he am saying (T)

b. schliessen sich an die Form des Fusses → schliessen sich an den Form des Fusses

c. There were other places like Freiburg is → there were other places like Freiberg are (T, nonliteral)

A typical example involving inflectional agreement rules for gender appears in 7b, where the article "den" agrees in number with "Fuss" (masculine) rather than "Form" (feminine). Note that the surface article for "Fuss" was not itself anticipated since this would have given "des" rather than "den" in the surface output. Examples reflecting misapplication of number and case agreement rules were less frequent but followed similar principles. In 7c, for example, the unintended verb "are" agrees in number with the wrong noun, "places" (plural) rather than "Freiburg" (singular).

Misinflection Errors

Misinflection errors ($N = 4$) were scored whenever a word underwent an unintended inflectional modification which did not violate agreement rules. In each case the misinflection could be explained as due to misplacement of an abstract marker for triggering inflectional rules in words appearing earlier or later in the intended output. A typical example is shown in 8a with an approximate translation in 8b. In the intended utterance "könnte" appears in conditional mode and "haben" in simple declarative mode. But in the error "haben" also appears in conditional

mode as if the abstract marker for triggering conditional inflection had been perseveratively overapplied to "haben" as well as "können."

8.a. Es ist so shade, dass wir kein Bett dort haben, dass ich könnte . . .——→
Es ist so shade, das wir kein Bett dort hätten, dass ich könnte . . .

b. It is so unfortunate that we don't have a bed there, that I could . . .——→
It it so unfortunate that we wouldn't have had a bed there, that I could . . . (T)

c. So schon wie meine Freundin vom letzten Jahr, wird sie sein . . .——→
So schön wie meine Freundin vom letzten Jahr wurde sie sein . . .

d. As pretty as my friend from last year will she be . . .——→
As pretty as my friend from last year will she have been . . . (T)

A misinflection suggesting misapplication of a past tense marker appears in 8c with an approximate translation in 8d. Here the intended verb "wird" has been misproduced in past tense form, "wurde," most likely because of misplacement of the past tense marker for the underlyng verb "war" (was), which is not even manifest in the surface form of the equative construction "as pretty as my friend (was)." An alternative interpretation is that the past tense aspect of the noun phrase "last year" somehow triggered application of the past tense rules associated with the subsequent verb.

Regularization Errors

There were 58 regularizations errors in Meringer's corpus, i.e., cases where regular past tense inflections were added to irregular verbs, e.g., "goed." Regularization errors are paradigmatic rather than syntagmatic phenomenon but were included in the present analyses as being immune to the ambiguities associated with other paradigmatic errors.

Since regularizations of preterites (e.g., "goed") have been examined extensively elsewhere (MacKay, 1976), the present analyses focused on regularizations of past participles. German past participles are normally formed by adding a prefix (usually "ge-") and a suffix ("-t" or "-en") to the stem, and fall into three major classes, depending on the nature of the suffix and on the occurrence or nonoccurrence of vowel

alternation. *Weak* (i.e., *regular*) past participles, e.g., "gemacht," take the suffix "-t" with no vowel alternation, as in "machen"–"gemacht." *Mixed* past participles, e.g., "gedacht," take the regular suffix "-t," but also undergo vowel alternation, as in "denken"–"gedacht." *Strong* past particles, e.g., "getrunken," take the irregular suffix "-en" and undergo vowel alternation as well, as in "trinken"–"getrunken."

Meringer's corpus contained 26 regularizations of strong past participles: 12 by children (aged 3.5–6.0 approximately) and 14 by adults. These 26 regularizations fell into two classes: complete vs. partial regularizations. Complete regularizations introduced regular suffix "-t" *and* regular stem (e.g., "getrunkt" for "getrunken") while partial regularizations introduced regular suffix (e.g., "getrunkt" for "getrunken") *or* regular stem (e.g., "getrinken" for "getrunken") but not both. Partial regularizations ($N = 10$) were almost as common as complete regularizations ($N = 16$) in the corpus as a whole but were much less common for children than adults: partial regularizations composed 17% of child regularizations as compared to 65% of adult regularizations.

This difference suggests an incomplete knowledge hypothesis for children as opposed to a rule misapplication hypothesis for adults. Under the incomplete knowledge hypothesis, children (unlike adults) usually produced complete regularizations because they did not know the past participle rules for strong verbs such as "trinken." This interpretation receives further support from the fact that the children (unlike adults) usually failed to correct their regularization errors on their own accord (Meringer, 1906). But adults producing partial regularizations such as "getrunkt" clearly knew that verbs such as "trinken" were irregular (so as to produce the vowel alternation) but must have applied the wrong rules (i.e., mixed rather than strong past participle rules).

Other differences between regularization errors of children and adults are consistent with this explanation. One is the phenomenon of overregularization: the addition of further past tense markers to regular preterites, e.g., "walkted," "smashted." Overregularizations are common among children (Ervin-Tripp, 1964) but extremely rare among adults: no adult overregulations were found in Meringer's or Fromkin's (1973) corpus or in an experiment on the production of past tense inflections (MacKay, 1976). This difference is readily explained under an incomplete knowledge hypothesis: out of ignorance children sometimes mistake verbs such as "smasht" for present tense stems (resembling "hate" or "wade") and so add further past tense markers to give "smashted." A similar explanation holds in reverse for the backformations of children, who unlike adults sometimes mistake verb stems

ending in "t" or "d" (e.g., "feed," "wade") for preterites and produce "fee" or "wa" as the present tense form.

Another interesting difference between regularization errors of children and adults lies in the type of suffix used for regularization (which can be directly inferred from the nature of the stem-final segment). The frequency of regularization using the "-t," "-d," or "-ed" suffix was determined from data reported in Slobin (1971, p. 221) for 24 children aged 1.5–4.0. Frequencies of regularization were then translated into probabilities: the ratio of regularization frequency to total (correct and regularized) frequency of use per child per verb. These probabilities appear in Table II along with similar data from MacKay (1976) for regularization errors of adults. Like the adults, the children produced "-t" suffix regularizations (e.g., "taket") more often than "-d" suffix regularizations (e.g., "digd"), but, unlike adults, they produced virtually no "-ed" regularizations (e.g., "hited"). This difference is readily explained under an incomplete knowledge hypothesis: since rules for "-ed" suffixes are mastered late (rarely before age 4.0, Ervin-Tripp, 1964), the children in Slobin's study had not yet learned the rules for producing "-ed" sufffix regularizations.

DISCUSSION

As pointed out in the introduction, a straightforward explanation of the error "Rosa always date shranks" required several assumptions needing further support. The *generation-by-rule assumption* held that complex words such as "shrank" are constructed by applying vowel alternation rules to the stem ("shrink"). The *rule marker assumption* held

Table II. Probability of Regularization (per Verb per Subject) for Adults (from MacKay, 1976) and Children (from Slobin, 1971, p. 221) for Three Suffix Types

	Probability of regularization suffix types		
	-d	-t	-ed
Adults	0.011	0.047	0.039
Children	0.003	0.006	0.000

that abstract markers such as + [PAST] and + [PLURAL] trigger the lexically stored rules for forming words such as "shrank" and "things" from their stems, "shrink" and "thing." A third assumption was that abstract rules or rule markers for forming one complex word can be misapplied to a word stem earlier or later in the intended utterance (to be designated the *rule misapplication* assumption). A fourth assumption held that complex words such as "government" and "shrinks" are formed from stems ("govern" and "shrink") which are marked in the internal lexicon as to original syntactic function (VERB). This will be designated the syntactic marking assumption.

The present data strongly supported all four assumptions. Consider the generation-by-rule assumption. Regularization errors such as "diged" reflect misapplications of the regular rules for preteritization, although, as discussed above, young children often misapply these rules out of ignorance rather than error. Inflectional alternations also required generation-by-rule to explain the fact that misplaced verb stems acquired new inflectional markings as a result of inflectional agreement rules applying in their new syntactic environment. This phenomenon cannot be explained under the assumption that inflected verbs such as "suffices" or "wants" are stored and produced as fully integrated units. Rather, these words must be stored as stems ("want," "suffice") which acquire inflectional agreement suffixes by application of context-dependent rules, i.e., rules contingent on features of the surface subject in the syntactic structure being produced. Thus, when a verb stem was mistakenly called on or misinserted into a sentential context with novel subject agreement constraints, the stem acquired a new inflectional suffix as a result of normal application of these context-dependent rules.

Derivational alternations are also consistent with generation-by-rule. In derviational alternations, the stem in a word of one syntactic class was substituted for the stem in a word of differing syntactic class and thereby acquired new derivational markings. These changes suggest that derivational rules for a particular stem are triggered by abstract markers such as +[NOUN] which are part of the phrase marker or syntactic structure into which the stem is inserted (or misinserted).

Abstract Rule Markers

Misagreement, misinflection, and inflectional alternation errors supported the rule marker assumption, which holds that abstract markers such as + [PAST] trigger phonological rules, the exact nature of which

depend on the lexical item to which the marker is attached. In misagreement and misinflection errors, a general class of rules was misapplied rather than any particular rule within a class, as occurred with regularizatrion errors. These "rule class" errors suggest that rule markers such as +[PAST], +[CONDITIONAL], +[PLURAL], and +[THIRD PERSON] call on whatever parricular rule appears in the lexicon. In this way, the same marker applied to a different lexical item can call up different inflectional rules. For example, if the marker +[PAST] is misapplied to the stem "shrink" rather than "date" in assembling a sentence, the irregular past tense rule associated with "shrink" would be called up rather than the regular past tense rule associated with "date."

The rule marker assumption receives further support from inflectional alternations, even though these result from lexical misinsertion (i.e., misplacement of stems or whole words) rather than misapplication of rules or rule markers. Consider the inflectional alternations where misplaced verb stems acquired new inflectional markers as a result of agreement rules applying in their new sentential environment. These newly acquired inflectional markings reflected operation of generalized rule classes rather than particular phonological rules. For example, the stem "become" ("werden") was substituted for "is" in 4a and underwent its own approporiate third person inflection (giving "wird") rather than the inflection for "is," the verb it substituted. The phonological rule appropriate for "werden" was triggered by an abstract rule marker such as +[THIRD PERSON SINGULAR] which was part of the phrase marker into which "werden" was misinserted.

The Internal Structure of Words

The stem class and suffix class phenomenon supported the syntactic marking assumption: that stems and affixes must be marked in the internal lexicon as to morphological function or underlying syntactic class. This is rather surprising since the morphological class of stems and affixes plays no role in the meaning or syntax of an utterance. For example, an adjective derived from a noun (e.g., "noisy") has the same sentential function as any other adjective (e.g., "loud").

The stem class phenomenon must relate to how lexical components are retrieved from permanent memory and can be explained by a minor revision of the model of word production (and misproduction) outlined in MacKay (1974). In this model, words such as "ungentlemanliness" have

the component structure shown in Fig. 1, but in addition the components must be labeled as to basic syntactic function, such that nominal components, e.g., "man" are called on by different rules from adjective components, e.g., "gentle," and adverbial suffixes, e.g., "-ly," by different rules from nominal suffixes, e.g., "-ness."

The stem class phenomenon thus reflects the nature of the stem insertion rules in this model: underlying verb stems as in "lost" were substituted for other verb stems as in "workers" rather than, say, adjective stems as in "sadness" because the verb stems are called on by different rules from adjective stems. Suffix substitutions also reflect the misapplication of lexical insertion rules in this model, and the suffix class phenomenon reflects the fact that inflectional suffixes are called on by different rules from derivational suffixes, so that inflectional suffixes cannot be misexpanded as derivational suffixes or *vice versa*.

Assembly of the Articulatory Program

Inflectional alternations allow a preliminary characterization of the operations underlying the assembly of articulatory programs. For example, inflectional alternations indicated that number agreement rules for

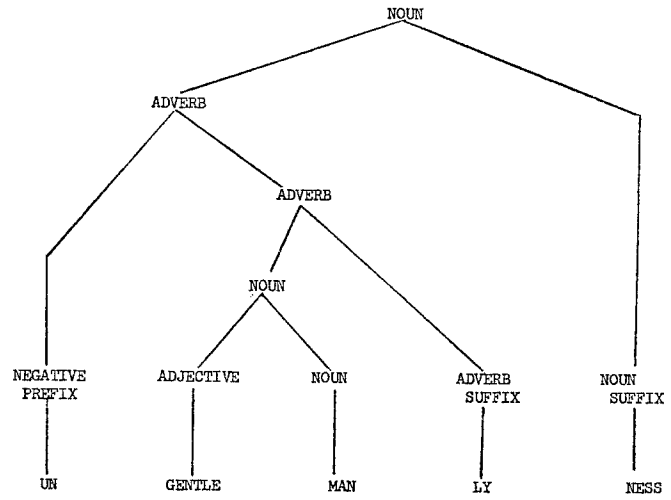

Fig. 1. Functional components and structure of the word "ungentlemanliness."

articles and adjectives follow the insertion or misinsertion of the formative for the nouns they modify. Moreover, misinsertion of noun formatives must have preceded the sequential specification of the surface output, since articles and adjectives precede nouns in the surface output. These phenomena suggest a three-stage model of lexical processes in the production of speech: Stage 1 involves the insertion of abstract lexical formatives for both content and function words (discussed below) into a syntactic frame. Stage 2 involves the application of derivational and inflectional rules to give a preprogrammed assembly of the intended sequence, stored temporarily in an output buffer (*cf.* MacKay, 1970). Stage 3 involves the scanning of this preprogrammed assembly and results in the serially ordered articulation of the surface output.

This proposal runs counter to the usual model (e.g., Fry, 1973), where assembly of the output sequence (i.e., stages 1 and 2) and serial generation of this sequence (stage 3) constitute one and the same process. This standard model simply cannot explain the phenomenon under consideration. If the assembly phase proceeds in a simply left-to-right fashion, then assembly of later items could not possibly influence assembly of earlier items as occurred with inflectional alternations of articles and adjectives. Rather, these phenomenon suggset that the assembly phase must be somewhat independent of the serial output phase.

The present proposal also runs counter to the model that Clark and Clark (1977) derived from studies of Fromkin (1973) and Garrett (1975). Clark and Clark (1977) proposed that in forming an articulatory program content words (nouns, adjectives, verbs, and adverbs) are specified before function words, i.e., pronouns (I, he . . . they), determiners (a, the, this . . . some), quantifiers (much, a few, more . . . four hundred), prepositions (in, on, beside . . . to), intensifiers (very, too . . . quite), coordinate conjunctions (and, but . . . so, yet), adverbial conjunctions (although, if, because . . . before), conjunctive adverbs (nevertheless, besides . . . hence), relative pronouns (who, which, whose . . . that), auxiliary verbs (can, may . . . have, must), or the linking verb (be) (see Clark and Clark, 1977).

Although there are many important differences betweeen content and function words, it seems unlikely that content words are specified before function words. For example, hesitation pauses often follow function words, as in "the . . . principal investigation," as if speakers have fully specified the function word "the" before specifying the upcoming content words (see Maclay and Osgood, 1959). This would be impossible if

content words are specified before content words as Clark and Clark propose.

Nature of Lexical Features

The present data call for a distinction among three types of lexical features for triggering lexical insertion, derivation, and inflection: inherent, noninherent, and variable features (after Chomsky, 1965). Inherent features are stored in the lexicon as part of a particular lexical item. Examples discussed above are [+Strong], [+Weak], [+Mixed] for determining the past participle inflections of German verbs. Noninherent features are not associated with any particular lexical item but are selected as part of the meaning and syntactic structure of an intended utterance or sentence plan. Examples are +[GENETIVE], +[PAST], +[PLURAL], +[CONDITIONAL]. As indicated by the + outside the brackets, noninherent features are added to syntactic entities such as verbs or nouns. Noninherent features specify rule classes rather than particular inflectional or derivational rules. Variable features are features of articles, adjectives, and verbs, which acquire their particular values by means of agreement rules discussed below. Variable features are neither stored in the lexicon nor generated directly during syntactic or semantic planning of an utterance.

Nature of the Rules

The exact nature of the rules underlying lexical insertion, derivation, and inflection remains to be determined, but proposals similar to Chomsky's (1965) lexicalist hypothesis seem quite plausible in view of the present findings. The data argue for at least four different types of rules, applied in the following order: feature matching rules, agreement rules, interpretive rules, and morphophonemic rules.

Figure 2 illustrates the operation of these rules by means of an example: the noun phrase "der Brüder" (after Chomsky, 1965). Feature matching rules are applied after the speaker has planned the syntactic and semantic features of the constituent. The speaker has already chosen to express the concept (of the brothers) by means of a genitive noun phrase (rather than a prepositional phrase) and has represented the article as one set of features, including [+Definite] and the noun as another set of features, along with the noninherent features +[PLURAL] and +[GENITIVE]. The feature matching rules match these features against

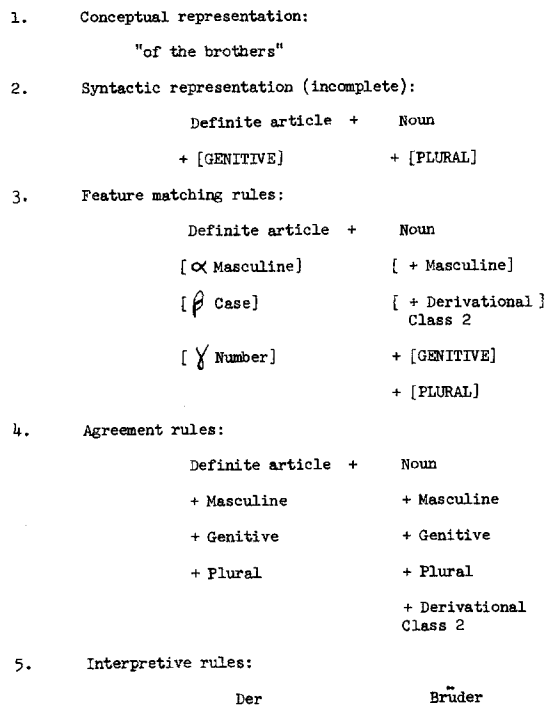

Fig. 2. Stages in the formation of the articulatory program for "der Brüder."

features stored in permanent memory, determine the lexical stem with the most features in common, and insert its formative into working memory. For example, the definite article formative in the German lexicon consists of a set of inherent features, including [+Definite] and a set of variable features, including [α Number], [β Case], and [γ Gender], and the feature matching rules insert this entire formative into its corresponding syntactic slot. The agreement rules then determine the values of the variable features (α, β, and γ) from the corresponding features of "Bruder," once its formative is inserted into the noun phrase marker. The formative for "Bruder" consists of a set of inherent features including among others, [+ Masculine] and, say, [+ Derivational Class 2], and acquires the noninherent features +[PLURAL] and +[GENITIVE], which are already represented in the phrase marker for the noun phrase being produced.

Interpretive rules come into operation now that the lexical feature matrices are complete. These rules specify the article as "der" and change the stem "Bruder" to "Brüder" by a rule specifing that stressed vowels are fronted for formatives with the features +[PLURAL] and [+ Derivational Class 2].

These forms are inserted into an output buffer, where morphophonemic and phonological rules are applied (see Fromkin, 1973) before the surface form is read out.

Such rules allow a detailed interpretation of inflectional and derivational alternations as well as the allomorphic alternations reported in Fromkin (1973). In inflectional alternations, articles and adverbs changed their inflectional endings to agree with misinserted noun formatives, the reason being that their noninherent features α[Number], β[Case], and γ[Gender] acquire + or − values only after a noun formative is inserted into the phrase marker. Although the wrong noun formative was inserted, feature agreement rules were applied as usual and the resulting feature values were interpreted in automatic fashion by the interpretive rules.

Derivational alternations can be explained in somewhat similar fashion. For example, if the formative for "lose" is inserted in a verb phrase structure containing the noninherent feature +[PAST], it becomes interpreted as "lost" as in "the workers lost." But if this same formative, "lose," is inserted into a noun phrase, it will acquire other noninherent features, +[NOUN] and +[AGENITIVE], which serve to trigger the nominalization LOSER. Derivational markings of a stem depend on the syntactic slot or phrase marker into which the stem formative is inserted, and stem formatives inserted into a novel phrase marker acquire novel noninherent features which trigger novel derivational markings.

The present data are clearly consistent with Chomsky's (1970) lexicalist hypothesis whereby stems are altered and combined with affixes by means of interpretive rules stored in the lexicon. But the present data do not rule out the somewhat more complex transformationalist hypothesis (*cf.* Chomsky, 1970) whereby affixes for words such as "refusal' or "worker" are introduced by means of transformational rules applying to base forms such as (NP "refuse") and (NP "work"). Further research on the structure of the base and on the precise nature of the underlying rules for calling on stems and affixes is needed to determine which hypothesis best describes the detailed nature of the rules underlying the production and misproduction of words.

CONCLUSIONS

The present data indicate that concepts are not mapped directly onto words in speech production. Models such as Wickelgren's (1969), where a unitary conceptual representation directly activates the phonetic form of a word, simply cannot account for phenomena such as derivational and inflectional alternations.

Rather, the conceptual representation for inserting a phonetic form into working memory must be translated into abstract formatives consisting of at least three distinct types of features: inherent, noninherent, and variable features. Two types of rules (feature matching and agreement rules) operate on these feature formatives before the phonological component of the lexicon is consulted. And even then lexical retrieval requires more than a simple readout from a rote memory: there must be rules for altering stems and for combining stems and affixes. The present findings indicate that words have a complex syntax of their own, which plays a role in lexical retrieval. Moreover, the syntax of a word must be to some extent independent of its semantics in speech production: derivational alternations indicated that the semantic component can call up a lexical item such as "lose," but its syntax (noun or verb) and final phonological form depend on the independently determined syntactic frame into which it is inserted. Finally, the present results indicate that models of lexical retrieval and production must distinguish between *underlying* words (abstract lexical items prior to insertion into syntactic frames) and *surface* words (forms resulting from application of derivational and inflectional rules). Any model which fails to make this distinction is clearly either incomplete or inadequate.

If rule-guided behavior is creative behavior, then speech production at the word level clearly represents creative behavior. Of course, this is not to say that learning and storing a new word in the lexicon do not involve *some* rote components or that the rules for forming new words are identical to the rules for generating old ones. Indeed, it seems likely that not all rules for producing existing words are available for creating new ones. One interesting possibility is that noninherent features such as +[PAST] trigger some rules directly, e.g., in English and German, the regular or weak past tense rules, and that these rules can be used freely in forming new words. On the other hand, irregular or strong rules as in "run"–"ran" may be viable speech production rules triggered by inherent features stored with particular lexical items but may be unavailable for creating new words.

Other issues for further research hinge on the limitations of the speech error data. The present data indicate that complex mechanisms underlie errors such as "Rosa always date shranks" and support the assumptions required for one possible explanation of this error, but, because of the problems associated with unique or irreplicable events, we will never know whether this explanation is true of this particular error. Even when patterns can be established for large numbers of errors, speech error data pose interpretive problems. One is the *generalizability problem.* By way of illustration, the present data show that in natural speech production for some speakers on some occasions some words are retrieved in the manner outlined above. We cannot make the generalization that all speakers on all occasions retrieve all conceivable words in this way. Indeed, it seems likely that in generating rhymes, for example, we may retrieve words as units rather than morphological components (see MacKay, 1976).

Another problem is known as the *adductive solution limitation.* Explanations of speech errors constitute a type of problem-solving discipline involving proof by adduction. We adduce answers to problems such as "Why do syntactic errors usually involve word stems of the same syntactic class?" The answers necessarily provide a satisfactory explanatory fit to the problem at hand. But any particular adductive solution may be nonunique since most problems can be solved in many different ways. Theories based on adduction must be supplemented with more powerful verification procedures, i.e., experiments based on induction and deduction. The present findings are in complete accord with experimental tests to date (*cf.* MacKay, 1974, 1976), but many aspects of the storage and production of complex words suggested here warrant further research. It also remains to test Lashley's (1951, p. 121–22) hypothesis that mechanisms for storing and producing words are characteristic of other cerebral activities and that "not only speech, but all skilled acts seem to involve the same problems of serial ordering and assembly, even down to the temporal coordination of muscular contraction, in such a movement as reaching and grasping."

ACKNOWLEDGMENT

The author thanks J. Loranger for her help in analyzing the data.

REFERENCES

Chomsky, N. (1965). *Aspects of the Theory of Syntax*. MIT Press, Cambridge, Mass.

Chomsky, N. (1970). Remarks on nominalization. In Jacobs, R., and Rosenbaum, P. (eds.), *Readings in Transformational Grammar*. Ginn and Co., Toronto.

Clark, H. H., and Clark, E. V. (1977). *Psychology and Language: An Introduction to Psycholinguistics*. Harcourt Brace Jovanovich, New York, pp. 278–280.

Ervin-Tripp, S. M. (1964). Imitation and structural change in children's language. In Lenneberg, E. H. (ed.), *New Directions in the Study of Language*. MIT Press, Cambridge, Mass. pp. 163–189.

Fromkin V. A. (ed.) (1973). *Speech Errors as Linguistic Evidence*. Mouton, The Hague.

Fry, D. B. (1973). Linguistic evidence of speech errors. In Fromkin, V. A. (ed), *Speech Errors as Linguistic Evidence*. Mouton, The Hague, pp. 157–163.

Garrett, M. F. (1975). The analysis of sentence production. In Bower, G. H. (ed.), *The Psychology of Learning and Motivation*. Vol. 9, Academic Press, New York, pp. 133–177.

Lashley, K. S. (1951). The problem of serial order in behavior. In Jeffres, L. A. (ed.), *Cerebral Mechanisms in Behavior: The Hixon Symposium*. Wiley, New York, pp. 121–122.

MacKay, D. G. (1970). Spoonerisms: The structure of errors in the serial order of speech. *Neuropsychologia* **8**:323–350.

MacKay, D. G. (1974). Derivational rules: Dead souls or living people in the perception, production and storage of words? Paper presented to the Psycholinguistic Circle of New York, April.

MacKay, D. G. (1976). On the retrieval and lexical structure of verbs. *J. Verb. Learn. Verb. Behav.* **15**:169–182.

Maclay, H. and Osgood, C. E. (1959). Hesitation phenomena in spontaneous English speech. *Word* **15**:19–44.

Meringer, R. (1906). *Aus dem Leben der Sprache*. Behrs Verlag, Berlin.

Meringer, R., and Mayer, K. (1895). *Versprechen und Verlesen*. Göschensche Verlagsbuchhandlung, Stuttgart.

Nooteboom, S. G. (1969). The tongue slips into patterns. In Nomen, *Leyden Studies in Linguistics and Phonetics*. Mouton, The Hague.

Slobin, D. I. (1971). On the learning of morphological rules. In Slobin, D. I. (ed.), *The Ontogenesis of Grammar*. Academic Press, New York, pp. 215–224.

Wickelgren, W. A. (1969). Context-sensitive coding, associative memory and serial order in (speech) behavior. *Psychol. Rev.* **76**:1–15.

Wickelgren, W. A. (1976). Phonetic coding and serial order. In Carterette, E. C., and Friedman, M. P. (eds.), *Handbook of Perception: Language and Speech*. Vol. 7, Appleton-Century, New York.