The suffixing preference: a processing explanation*

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Abstract

Cross-linguistic studies of morphology have demonstrated that there is an asymmetry in the type of affixation preferred: languages which would he predicted on independent structural grounds to prefer suffixes to prefixes do so, hut languages which would he predicted to prefer prefixes to suffixes also show a tendency toward suffixation. In other words, independently of other structural considerations there is an overall preference for suffix morphology. It is argued here that this preference results from the way language is processed by its users. Two lines of psycholinguistic evidence are drawn upon: (1) word onsets are more psychologically salient than other parts of the word; (2) stems and affixes are processed separately. In the light of these considerations it is argued that language users prefer to process stems before affixes, and for this reason languages prefer to order stems before affixes. Thus the linguistic and psycholinguistic evidence combine to suggest an explanation which has implications both for language typology and for the structure of psychological models of language processing.

1.0. Introduction

Recent research on language universals has uncovered several cases of what we will call *left-right asymmetries.*[2] In some cases, linguistic categories that are predicted by independently well motivated principles to be leftward-occurring within their respective phrases actually show up on the right, whereas the converse fails, i.e. when these same independent principles predict a rightward occurrence in languages of the relevant type, there is no leftward skewing and the categories in question do occur to the right. In others, a leftward skewing may be favored. Most of the cases documented so far involve asymmetries within syntax. For a number of these, explanations of an extragrammatical nature have been

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proposed, which make use of certain findings from Psycholinguistics, particularly from theories of language comprehension. The importance of such findings for the field of linguistics is that they provide suggestive explanatory hypotheses for left-right asymmetries across languages which may otherwise be unexplained. For Psycholinguistics such work is important for theories of language processing, since what is being claimed is that principles of processing are reflected not just in the use of language but also in its structure. The need to readily comprehend and produce language joins other demands upon successful communication systems (the need for rich expressive power, learnability, etc.) in constraining the variation space within which the set of possible human languages can be constructed. Asymmetries in linguistic structure may also provide evidence for one processing model rather than another.

The present paper will concentrate on some left-right asymmetries in morphology rather than in syntax, involving the cross-linguistic preference for suffixing over prefixing. Our goal is twofold: to set out some of the cross-linguistic facts in this area; and to consider some explanatory hypotheses for the grammatically unpredicted asymmetries in these data that are strongly suggested by current psycholinguistic research on lexical access.

We shall mention two important provisos at the outset. The processing hypotheses to be pursued appear reasonable given the experimental findings and processing principles currently at hand. For the argument to be fully convincing, however, it will need to be shown that the relevant principles do indeed generalize to the processing of genetically diverse languages. So far the languages on which processing experiments have been conducted come from an embarrassingly limited genetic stock. In particular, it will need to be shown that the kinds of morphological structures whose cross-linguistic patterns of occurrence we will seek to motivate in processing terms actually have the processing advantages and disadvantages that we will be claiming for them across languages. In addition, there is at least one nonprocessing proposal for these morphological asymmetries in the linguistic literature, involving principles of historical change. It will be argued here that the historical account is seriously flawed in many respects and is not sufficient to explain the known data. The major contribution of the present paper is therefore an attempt to integrate two hitherto quite separate lines of enquiry into natural language. It is our hope that our hypotheses will provoke further experiments on the processing of diverse languages which may enrich both theories of processing and the kinds of explanations to which linguists appeal when attempting to explain cross-linguistic regularities.

The order of presentation is as follows. The next section briefly

summarizes the kinds of processing explanations advanced for some left-right asymmetries in syntax. Section 3 presents some morphological universals and documents the suffixing preference. Sections 4 and 5 review the relevant processing literature on lexical access. Finally section 6 presents our processing hypotheses for the suffixing preference.

2.0. Some left-right asymmetries in syntax

There are numerous syntactic left-right asymmetries across languages for which processing explanations have ultimately been offered (see Hawkins 1983: 98-112 for a summary). The processing insights that are appealed to in this context are essentially of the type summarized in Fodor et al. (1974) and derive from experiments on the use of English. We shall give just one illustrative example here involving relative clauses.

Across languages there is an asymmetry in the distribution of relative clause orders: the languages that are independently predicted to have the relative clause after the head noun (as in English), do so; the languages that are independently predicted to have the relative clause before the head noun may or may not do so, and in a significant number of cases have postnominal relatives just as in English. The result is a rightward skewing in favor of postnominal relatives overall.

More precise quantitative data are set out in Table 1. The ratios of prepositional to postpositional languages, of VO to OV languages, and of NGen to GenN languages is in each case roughly 50-50 in the expanded sample of Hawkins (1983). But there is a roughly 70%-30% skewing in favor of postnominal as opposed to prenominal relatives. More significantly, the head-before-modifier languages (cf. section 3.2 below for discussion of these terms) are almost exclusively postnominal, whereas some 40% of otherwise modifer-before-head languages also have the postnominal relative clause order.

What could explain this preference? Antinucci et al. (1979) address this question. They argue that prenominal relatives cause perceptual problems that are avoided in their postnominal counterparts. For example, they provide too many opportunities for misanalyzing subordinate as main clauses in structures such as (1) (in which N_s = Subject NP, N_0 = Object NP, and square brackets surround the relative clause):

(1) a. $[N_S V]N_S N_0 V$
b. $N_S[N_0 V]N_0 V$

Examples of (la) and (lb) from Japanese:

(2) a. Inu-ga kande-iru kodoma-ganeko-onadete-iru
dog-nom biting-is child-nom cat-acc patting-is
The child whom the dog is biting is patting the cat.'
b. Inu-ga ringo-o tabete-iru kodomo-o kande-iru
dog-nom apple-acc eating-is child-acc biting-is
The dog is biting the child who is eating the apple.'

Antinucci et al. argue that although verb marking or nominal case marking in such languages will prevent actual ambiguity in most instances, the on-line processing of clauses such as (a) and (b) will involve adopting first one recognition hypothesis in favor of main clause status for the NPs preceding the first verb, [N_SV] in (a) and N_S[N_0V] in (b), and then rejecting it, in favor of subordinate clause status. But no such structural misanalysis arises in the corresponding English examples, in which the head precedes the relative clause. More generally, Hawkins (1983: 98-106) points to additional processing problems posed by these relative clause structures, involving head recognition within the NP (drawing on the experimental findings of Moore 1972), and presents

Table 1. *Relative clause ordering quantities across language types (cf. Hawkins 1983).*

Head + Modifier	Modifier + Head
Pr + NP	NP + Po
VO (SVO v VSO)	OV
NGen	GenN
NRel	RelN v NRel
99% of Pr + NP lgs have NRel; 1% have RelN	61% of NP + Po lgs have RelN; 39% have NRel
94% of SVO lgs have NRel; 6% have RelN	56% of OV lgs have RelN; 44% have NRel
100% of VSO lgs have NRel; 0% have RelN	

(NB! The only SVO lgs with RelN in the data [total = 4] also have NP + Po.)

The proportions of Pr + NP to NP + Po, VO to OV, and NGen to GenN = roughly 50-50, and the correlations between Pr + NP, VO, and NGen on the one hand, and between NP+Po, OV, and GenN on the other, are very strong indeed.

Abbreviations:

NP + Po noun phrase precedes postposition (e.g. *the room in)*
Pr + NP preposition precedes noun phrase (e.g. *in the room)*

VO verb precedes direct object (e.g. *threw the rock)*
OV direct object precedes verb (e.g. *the rock threw)*

NRel head noun precedes relative clause (e.g. *the dog that was killed by me)*
RelN relative clause precedes head noun (e.g. *the by me killed dog)*

NGen noun precedes genitive (e.g. *book of Harry)*
GenN genitive precedes noun (e.g. *Harry's book)*

evidence for a ranking of numerous noun-modifiers according to degree of structural complexity or *heaviness*, with consequences for pre- and postposing within the noun phrase. Similar processing hypotheses for left-right asymmetries in sentence complement positioning across languages are found in Grosu and Thompson (1977) and Dryer (1980), and for a left-right asymmetry in the directionality of unbounded movements in Fodor (1979).[3]

3.0. Left-right asymmetries in morphology

The original insight upon which the research reported in this section is based comes from Greenberg (1966): across languages suffixal morphology within the word is more frequent than prefixing, and both are considerably more frequent than infixing (whereby an affix is inserted into a lexical stem; for a detailed discussion of types of affixation processes see Matthews 1974: ch. 7). The goal of Hawkins and Gilligan (i.p.) is to discover the cross-linguistic regularities in this area in detail. The purpose of the present paper is to summarize these findings to date, to consider the grammatical principles and regularities that can be argued to underlie them, and to explore a possible psycholinguistic explanation for the suffixing preference which, like the asymmetries of the previous section, appears not to be predictable by independent grammatical principles alone.

The major pattern of interest that emerges from Hawkins and Gilligan's work can be summarized in the following chart:

	Prefixes	*Suffixes*
VO Pr + NP	**X**	**X**
OV NP + Po	**O**	**X**

Languages with VO and/or Pr + NP word orders in their syntax regularly have prefixes and/or suffixes in their morphology. But in a suggestively large number of cases, languages with OV and/or NP + Po have suffixes only. This distribution strongly implies the need for two major principles at the explanatory level: one which explains why prefixes occur productively only in VO and Pr + NP languages, while similar functions in OV and NP + Po languages are performed by suffixes; and another that favors suffixing in both language types and that is partially opposed to the independent predictions of the first principle for VO and Pr + NP

languages. It will be argued here that the first principle makes crucial reference to the notion 'head of phrase' in both syntax and morphology, and that heads are identically ordered relative to their modifiers at both levels (the head ordering principle). The second principle, responsible for the postposing asymmetry, will be argued to be a psycholinguistic one. Its effects corroborate the head ordering principle's prediction for suffixing in OV and NP + Po languages and account for why suffixes occur at all in VO and Pr + NP languages.

Section 3.1 below summarizes the morphological universals work; section 3.2 motivates the head ordering principle; section 3.3 sets out the need for a set of counterprinciples to the head ordering principle and documents the suffixine asymmetry in morphological universals.

3.1. *Some prefixing and suffixing universals*

The correlations observed by Greenberg (1966) between basic word order and morpheme order in his 30-language sample are summarized in Table 2. These data establish clearly the greater frequency of suffixing over prefixing. Greenberg also points out that both are considerably more frequent than infixing. The data of Table 2 show that suffixing is massively preferred in NP + Po and OV languages, and that if a language is prefixing only, the basic word order will be Pr + NP and VO. What is missing in Greenberg's discussion, however, is any indication of what the precise morphemes were (in terms of meaning and syntactic function) that he studied. Hawkins and Gilligan (i.p.) have accordingly set up a categorization of morphemes and attempt to formulate implicational universals which link morpheme order to verb and adposition order within phrasal categories. The languages consulted number over 200 and are drawn from three samples: a computerized typological sample of 125

Table 2. *Morpheme order correlations with verb and adposition order in Greenberg's sample*

	Prefix only	Both	Sullix only
Overall morpheme order and verb position			
VO (i.e. VSO and SVO)	1	16	2
OV (i.e. SOV)	0	1	10
Overall morpheme order and adposilion order			
Pr + NP	1	15	0
NP + Po	0	2	12

languages collected by Leon Stassen, with entries for many hundreds of linguistic properties including some morpheme orders; a computerized sample of morphological properties employed by Joan Bybee; and a sample of 39 languages collected by Gilligan.[4] Only a handful of languages belong to more than one of these sets.

Below we list 13 implicational universals. Of these, five are exceptionless (numbers 3, 4, 6, 8, and 10), and the remainder are statistical in Greenberg's sense, i.e. they hold with more than chance frequency. The number of exceptions is quantified in each case. The first six universals refer to nominal morphology (i.e. affixes of the noun), the next six to verbal morphology, and the last universal refers to both.

(3) If a language has CASE affixes on N, they are always suffixed.

(4) If a language has NP + Po or SOV, GENDER affixes on N (if any) are suffixed.

(4a) If a language has prefixed GENDER affixes, it will have Pr + NP and VO (i.e. neither NP + Po nor SOV).

(5) If a language has NP + Po or SOV, PLU RAL affixes on N (if any) are suffixed with considerably greater than chance frequency (Gilligan's sample: 93% of NP + Po and 96% of SOV languages conform).

(6) If a language has NP + Po or SOV, NOMINALIZING affixes on N (if any) are suffixed.

(7) If a language has NP+Po or SOV, DEFINITENESS affixes on N (if any) are suffixed with greater than chance frequency (Stassen's sample: 85% of NP + Po and 92% of SOV languages conform).

(8) If a language has NP + Po or SOV, INDEFINITENESS affixes on N (if any) are suffixed.

(9) If a language has NP + Po or SOV, TENSE affixes on V (if any) are suffixed with considerably greater than chance frequency (Bybee's sample: 100% of SOV languages conform; Gilligan's sample: 100% of NP+ Po and SOV languages conform; Stassen's sample: 95% of NP + Po and 92% of SOV languages conform).

(10) If a language has NP + Po, MOOD affixes on V (if any) are suffixed.

(11) If a language has SOV, MOOD affixes on V (if any) are suffixed with more than chance frequency (Bybee's sample: 88% of languages conform; Gilligan's sample: 89% of languages conform).

(12) If a language has VALENCE (INTRANS/TRANS/DITRANS) affixes on V, they are suffixed with more than chance frequency (Bybee's sample: 93% of languages conform).

(13) If a language has SOV, CAUSATIVE affixes on V (if any) are suffixed with more than chance frequency (Bybee's sample: 86% of languages conform).

(14) If a language has PERSON-MARKING affixes on V (DIRECT OBJECT), they are prefixed with more than chance frequency (Bybee's sample: 75% of languages conform).

(15) There is more prefixing on V than on N. If a language has any prefixes on N, it will also have prefixes on V with considerably more than chance frequency (Gilligan's sample: 100% of languages conform; Stassen's sample: 97% of languages conform).

Notice that most of these universals are formulated with NP + Po or SOV as the antecedent of an implication whose consequent is suffixing order, as in (4): if a language has NP+Po or SOV, GENDER affixes on N (if any) are suffixed. It follows that if gender affixes are NOT suffixed in some language, that language cannot be either NP + Po or SOV but must be Pr + NP and VO. Thus (4) is logically equivalent to (4a) in which prefixes constitute the antecedent property and Pr + NP and VO the consequent. By similar reasoning, all of the implicational universals with NP + Po or SOV as antecedent and suffixing as consequent can be converted to corresponding universals with prefixing as antecedent and Pr + NP and VO as consequent.

3.2. *The head ordering principle*

The universal data point to the reality of a generalization linking morphology and syntax with respect to the notion 'head' as is assumed in fact in current generative work on morphology (e.g. Aronoff 1976; Williams 1981). Within syntax, the categories N, V, P, and Adj are the heads of their respective phrasal categories (NP, VP, PP, AdjP) and they preserve category constancy. That is, the categorial status of the respective dominating categories is determined by the head of phrase, and not necessarily by any modifiers. The verb is the head of the verb phrase, the adposition (preposition or postposition) the head of the adposition phrase, the noun the head of the noun phrase, etc. Similarly, within morphology it is possible to argue that the component morphemes of whole words are divided into heads and modifiers, and that the morpheme which determines the categorial status of the word in question (more precisely, of the immediately dominating lexical category) is the head. Thus a derivational affix always determines the category status of its immediately dominating lexical category, and may or may not change the category of the item to which it attaches. The suffix *-ess* when added to *lion* does not change the category of the latter: both *lion* and *lioness* are nouns. But the suffix *-ness* attached to *sad* converts an adjective to a noun, and here it is crucially the affix rather than the stem that determines

the category of the resulting word *sadness*. Inflectional affixes, like *-s* in English (cf. *girl/girls)*, pattern like *lion/lioness* and maintain the categorial status *of* the item to which they attach. But the net result is that the categorial status of a word containing affixes can always be computed from the affix, but not necessarily from nonaffixes or stems. And it is therefore feasible to assume (for the sake of morphological simplicity and generality) that derivational and inflectional affixes are always the heads of their respective lexical categories. Evidence for this in turn comes from the very head *of* the phrase/head of word generalization that emerges from our universals linking word order within the phrase to morpheme order within the word.[5]

The head ordering principle is formulated in Hawkins and Gilligan (i.p.) as follows:

(16) *The head ordering principle (HOP)*
The affixal head of a word is ordered on the same side of its subcategorized modifier(s) as P is ordered relative to NP within PP, and as V is ordered relative to a direct object NP.

The HOP therefore predicts prefixes in Pr + NP and VO languages and suffixes in NP + Po and OV languages. Clearly, these predictions are not completely correct on their own. But there is a need for the HOP as part of the explanatory package. Let us review this evidence.

First, whenever we can set up implicational universals defined on basic < word orders on the one hand and suffixing or prefixing for individual morpheme categories on the other (cf. section 3.1), the correlation is always in accordance with the HOP: NP + Po and/or SOV always implies suffixing, never prefixing; and prefixing implies Pr + NP and VO, never NP + Po and/or SOV.

Second, when we examine languages with exclusive suffixing or exclusive prefixing across the categories examined here, the same pattern emerges. NP + Po and SOV languages may exhibit suffixing only, but they do not exhibit prefixing only. And the prefixing-only languages (which are very few in number) are Pr + NP and VO, and not NP + Po and SOV. In fact, the observed correlation between prefixing only, suffixing only, and word order within the syntax is exactly that of the summary chart in section 3.0. Exclusive suffixing is found in both language types; exclusive prefixing only in VO and Pr + NP languages.

3.3. *The suffixing preference*

Clearly, the HOP is not the only principle determining the order of affixal morphemes across the world's languages. If it were we would expect a

perfect lineup between head categories within the syntax and within the word. Instead, there is a skewing toward suffixing. Before addressing the explanatory problem that this raises, we must describe and quantify the available facts. In order to do this we first set up several purely descriptive counterprinciples to the HOP. By examining precisely where the counter-principles are or are not opposed to the independent predictions of the HOP we will have a body of facts that we can begin to explain.

Consider first gender affixes. There is evidence for the descriptive counlerprinciple formulated in (17):

(17) GENDER affixes (on N) are suffixed.

In the languages of Gilligan's sample, the average ratio of prefixing to suffixing in Pr + NP and VO languages is 59% to 41% and that for NP + Po and OV languages is 0% to 100%, as shown in Table 3. In other words, three of the four cooccurrence cells arc productively filled, and one (prefixing with OV and NP + Po) is not. The HOP in conjunction with counterprinciplc (17) leads us to expect such a distribution. Both principles predict the cooccurrence of suffixing with OV and NP + Po; neither predicts prefixes with these word orders. But for VO and Pr + NP languages, the HOP predicts prefixing while counterprinciple (17) predicts suffixing, and it is significant that both affix orders are productively attested. That is, both principles succeed in asserting themselves in VO and Pr + NP languages and we see a reflection of their relative strength in the different proportions of languages involved. Counterprinciple (17) overrides the HOP in 59% of the relevant languages, while the HOP wins out 41% of the time.

The relative strength of these principles in such cases of conflict is something that we will ultimately want to account for. In the meantime, notice only that there is no residue of languages whose affix orderings are not explained. When the two principles are not in conflict, they merely

Table 3. *Ratio of prefixing to suffixing for gender affixes in Gilligan's sample.*

Ratio	%/%
Prefixing to suffixing ratio in Pr + NP languages:	62/38
Prefixing to suffixing ratio in NP + Po languages:	0/100
Prefixing to suffixing ratio in VO languages:	56/44
Prefixing to suffixing ratio in OV languages:	0/100
Average prefixing to suffixing ratio in Pr+NP and VO languages:	59/41
Average prefixing to suffixing ratio in NP + Po and OV languages:	0/100

Tabic 4. *Overall proportions for gender affix correlations with basic word order.*

	Prefixes (%)	Suffixes (%)
VO Pr + NP	**30**	**20**
OV NP + Po	**0**	**50**

reinforce one another's predictions for suffixing in OV and NP+Po languages. Of course even if there had been a handful of languages in the unattested fourth cooccurrence cell, the skewing in the distribution would still have been statistically significant. A random distribution would place 25% of the relevant languages in each cell; if any one cell has significantly less than 25% in it, the distribution is no longer random. In the present instance, the overall proportions are given in Table 4.

Counterprinciple (17) turns out to be just one of many such counterprinciples that we are led to formulate. Below we summarize some of the others, indicating alongside each the relative strength of the counterprinciple and of the HOP when they are in conflict. We also state whether there is any residue of languages unaccounted for.

(18) CASE affixes (on N) are suffixed.
Relative strength of counterprinciple (18) to the HOP: 100% to 0%.
Residue of languages unaccounted for: 0%.

(19) PLURAL affixes (on N) are suffixed.
Relative strength of counterprinciple (19) to the HOP: 75% to 25%.
Residue of languages unaccounted for: 4%.

(20) NOMINALIZING affixes (on N) are suffixed.
Relative strength of counterprinciple (20) to the HOP: 84% to 16%.
Residue of languages unaccounted for: 0%.

(21) DEFINITENESS affixes (on N) are suffixed.
Relative strength of counterprinciple (21) to the HOP: 58% to 42%.
Residue of languages unaccounted for: 9%.

(22) INDEFINITENESS affixes (on N) are suffixed.
Relative strength of counterprinciple (22) to the HOP: 58% to 42%.
Residue of languages unaccounted for: 0%.

(23) TENSE affixes (on V) are suffixed.
Relative strength of counterprinciple (23) to the HOP: 50% to 50%.
Residue of languages unaccounted for: 1%.

(24) MOOD affixes (on V) are suffixed.
Relative strength of counterprinciple (24) to the HOP: 50% to 50%.
Residue of languages unaccounted for: 5%.

(25) VALENCE (INTRANS/TRANS/DITRANS) affixes (on V) are suffixed.
Relative strength of counterprinciple (25) to the HOP: 100% to 0%.
Residue of languages unaccounted for: 7%.

(36) CAUSITIVE affixes (on V) are suffixed.
Relative strength of counterprinciple (26) to the HOP: 30% to 70%.
Residue of languages unaccounted for: 0%.

(27) PERSON-MARKING affixes (DIRECT OBJECT) (on V) are suffixed.
Relative strength of counterprinciple (27) to the HOP: 75% to 25%.
Residue of languages unaccounted for: 10%.

The relationship between these counterprinciples operating in conjunction with the HOP. and the universals of section 3.1 can now be accounted for. Most of the universals are implicational statements formulated with NP+Po and OV as the antecedent properties and suffixing as the consequent (or alternatively with prefixing as the antecedent and Pr+ NP and VO as consequent properties). The reason why they are formulated in this way should be clear. Pr + NP and VO cannot be antecedent properties in such statements, because these word orders regularly cooccur with both prefixing and suffixing. Suffixing, likewise, occurs productively with both word order types. Only OV and NP + Po guarantee a unique set of affix orders (suffixing), and only prefixing guarantees a unique set of word orders (VO and Pr+NP), and for this reason these properties can be the antecedents of implicational universals. In other words, these universals are formulated the way they are on account of the three-way distribution of affix orders and word orders set out in Table 4 and in the chart in section 3.0. And this distribution is a consequence of the fact that the above counterprinciples typically reinforce the HOP's independent predictions for suffixing and oppose its predictions for prefixing. It will always be possible to formulate implica-

tional universals when counterprinciples and the HOP cooperate in the manner shown and when there is no residue of languages unaccounted for. If there is such a residue, the universal will be statistical, as long as the size of the residue is not too great.

The nature of the suffixing preference across languages can now be summarized as follows. We began with Greenberg's observation that suffixing is more frequent than prefixing (and infixing). Upon pursuing the cross-linguistic correlations between affix order within the word and word order within the phrase we have established that adherence to, and departures from, the HOP favor suffixing. The number of suffixing counterprinciples given above exceeds the number of prefixing counterprinciples (cf. example 27) by a factor of 10 to 1. As a result, there are numerous affixes that are predominantly suffixed (e.g. PLURAL [on N], TENSE [on V], MOOD [on V], etc.), whereas only PERSON-MARKING (DIRECT OBJECT) has a preference for prefixing. There is also one set of affixes that is exclusively suffixed (CASE [on N]), whereas there are no affixes that are exclusively prefixed.

The suffixing preference also emerges from the frequency of occurrence of languages with overall suffixing or prefixing (i.e. exclusive suffixing or prefixing for all the morphological categories of the respective samples, listed in note 4). These numbers are summarized in Table 5, with correlations given for VO and OV word order. This table shows that the proportion of OV languages with exclusive suffixing greatly exceeds the proportion of VO languages with exclusive prefixing. If we average the figures from all four samples, then 58% of OV languages have overall suffixing, whereas only 12% *of* VO languages have overall prefixing. In

Table 5. *Exclusive prefixing and suffixing in the language samples (relative to sample properties)*

	Exclusive prefixing (%)	Exclusive suffixing (%)
% of VO languages		
Greenberg's sample	5	11
Stassen's sample	7	36
Bybee's sample	18	0
Gilligan's sample	17	4
% of OV languages		
Greenberg's sample	0	91
Stassen's sample	0	59
Bybee's sample	0	39
Gilligan's sample	0	44

addition, there are no OV languages in any of the samples with exclusive prefixing, whereas there are VO languages with exclusive suffixing. These facts confirm the suffixing preference, and they also support the reality of the HOP. for the reasons given in section 3.2.

We must now mention an important proviso to the results of this section. The pattern of interaction that we have been describing between the HOP and the counterprinciples, with the resulting universals of section 3.1, does not work in all cases. For the following five affix orders of Hawkins and Gilligan (i.p.) all four logically possible correlations with word order appear to be possible (i.e. anything goes): POSSESSIVE affixes (on N), NEGATION affixes (on V), ASPECT affixes (on V), VOICE affixes (on V), and PERSON-MARKING affixes (SUBJECT) (on V).

Notice finally that the affixes that we have been concentrating on are primarily inflectional rather than derivational. There is a reason for this concentration. Inflectional categories are more constant across languages, and hence more amenable to cross-linguistic comparison, whereas derivational categories are more language-particular and idiosyncratic.

In the following section we shall consider a possible explanation for why suffixing should be so preferred cross-linguistically. We shall argue that this preference reflects characteristics of the process of lexical access in speech understanding, i.e. it is the result *of* a putatively general property of linguistic performance. In brief, the process of word recognition involves using the sound of a word to access the lexical entry, as listed in a mental dictionary. Psycholinguistic evidence indicates both that the beginning of a word is its most salient part for this access process, and that lexical access separates the processing of lexical semantics from the processing of the kinds *of* phrasal syntactic and semantic information typically carried by the affixes whose cross-linguistic distribution we have been documenting. We will argue that for these reasons, and because the use of lexical information must at least largely precede the use of syntactic information in comprehension, it makes sense for affixes which do not aid lexical recognition and which are primarily relevant for the processing of larger syntactic and semantic units to be postposed rather than preposed in a word. Sections 4 and 5 summarize the psycholinguistic evidence bearing on these issues.

4.0. Psycholinguistic evidence: word onsets

Studies of word recognition strongly suggest that the psychologically most salient part of any word is its beginning portion. The evidence is of

two general kinds: beginning portions are the most effective cues for successful recall or recognition of a word (see section 4.1 below); and the effects of distorting the beginning of a word are much more severe than the effects of distorting later portions (section 4.2). Some further effects in word production argue for a cooperative principle in production and perception processes (section 4.3). The combined evidence suggests a view of the mental lexicon as a structure determined primarily by the exigencies of the temporal constraints operative in spoken-word understanding (sections 4.4 and 4.5).

4.1. *Onsets as retrieval cues*

A number of recent studies have investigated listeners' recognition of spoken words when only fragments of the words are presented. Grosjean (1980, 1983) has explored the effects of context on the recognition of words presented in successively larger fragments from the onset on. However, only Nooteboom (1981) has compared the effectiveness of initial and final portions of spoken words as retrieval cues. Nooteboom chose Dutch words with unique initial and final portions; for instance, the word *kannibaal* has seven phonemes, and no other Dutch word has the same four initial phonemes, or the same four final phonemes. Listeners were presented with either the unique beginning portion or the unique final portion and were asked to guess the word. The initial fragments provoked correct responses in 95% of presentations, but the correct response rate for final fragments (which determined the word no less unequivocally than the initial fragments) was significantly lower at 60%. Moreover, correct response latency was significantly faster for responses to initial fragments than for responses to final fragments.

An analogous result was found with visual presentation by Broerse and Zwaan (1966). These authors also chose words in which the informativeness *of* initial and final portions was precisely matched; again, presentation of initial fragments elicited faster and more accurate word recognition than presentation of final fragments.

Similarly, recall of a word from a previously presented list is prompted more effectively by giving the initial portion as a cue, while the middle portion is the least useful cue; again response latency is also faster with initial prompts (Horowitz etc. 1968, 1969).

In a 'tip-of-the-tongue' (TOT) state, the speaker quite often knows something about the word being sought; and the most common correctly known aspect of the word is its onset (Brown and McNeill 1966; Browman 1978). The most effective cue for bringing a person OUT of a

TOT state, i.e. prompting correct recall of the partially remembered word, is also to provide or confirm the knowledge of the word's onset (Freedman and Landauer 1966).

4.2. *The effects of onset distortion*

The effects of distortion of parts of a word on recognition performance are greatest if the distortion occurs at the word onset. This was established for spoken words as early as 1900 by Bagley, who found that mispronouncing an initial consonant disrupted recognition far more than mispronouncing a final consonant. Similar effects occur with visual presentation; blurring the first few letters *of* a word interferes with recognition more than blurring the end (Oleron and Danset 1963), and the same is true for reversing the position of two adjacent letters (Bruner and O'Dowd 1958).

By contrast, distortions at the ends of words are so little disruptive that they can go unnoticed. Studies of shadowing (Marslen-Wilson 1975; Marslen-Wilson and Welsh 1978), in which listeners are required to repeat back an auditorily presented text, have established that mispronunciations in the text are particularly likely to be replaced by the correct phoneme, without noticeable disruption of the speaker's fluency, if they occur toward the end of a word.

Cole (1973; Cole and Jakimik 1978, 1980) studied the detection of such deliberate mispronunciations. Explicit comparison of word-initial with word-final consonant mispronunciations in monosyllabic words showed that, as would be predicted, word-initial mispronunciations were more detectable (Cole and Jakimik 1978). Reaction time to respond to the mispronunciation was, on the other hand, consistently slower if the distorted segment was at the beginning of the word (Cole 1973; Cole and Jakimik 1980); thus the disruption of word identification acts simultaneously to increase the likelihood of the mispronunciation being noticed but to delay the response to it, since the response in mispronunciation detection depends on successful reconstruction of what the word ought to have been, a process which is more difficult the more recognition has been disrupted.

In correctly pronounced words the greater attention paid to word onsets has as a consequence a reduced likelihood of slips of the ear occurring on initial segments; the most likely part of the word for a hearing slip to occur is the middle (Browman 1978).

Evidence of the kind summarized in this section has led Marslen-Wilson (for example 1978, 1980; Marslen-Wilson and Welsh 1978) to

propose a theory of auditory word recognition specifically based on left-to-right processes. According to this model the first segment of a spoken word activates the lexical elements corresponding to all words beginning with that segment; this set of words constitutes the 'initial cohort'. As subsequent segments are heard, they cause all words which do NOT contain them to drop out of the cohort. Eventually the cohort will contain only one word; this state constitutes word recognition. Obviously this state can be reached well before the end of the word, if the word in question has few lexical colleagues beginning in the same way. The point in the word at which all other members of the initial cohort have dropped out is called the word's *uniqueness point.* Where it is in a word depends entirely on the properties of the rest of the lexicon; thus the uniqueness point of *dwindle* is on the third segment, since no other word beginning with *dw-* has that vowel; but the uniqueness point of *intestine* does not occur until the final segment, where it parts company with *intestate.*

This model, it can be seen, amounts to a definition of what constitutes an onset with respect to the preceding discussion. It claims that those portions of the word preceding the uniqueness point will be unpredictable and hence of great importance for successful word recognition; segments which follow the uniqueness point will be redundant and tolerant of distortion. Thus the effective 'onset' of *intestine* is the entire word, of *dwindle* only the first three segments.

Although there is experimental evidence which indicates that the 'cohort model' may be too restrictive to cope with all aspects of word recognition (Nooteboom 1981; see also section 4.5 below), its concept of the word as divided into two parts, one informative and the other uninformative, is potentially helpful in accounting for many of the effects discussed in this paper. The next section describes some word production processes, for example, in which the relative informativeness of word parts appears to be crucial.

4.3. *Word onsets in production*

Although relatively few phonological elision and assimilation processes apply specifically to word onsets, some such processes apply across word boundaries and hence have the effect of distorting the initial segment of the word following the boundary. Cooper (see for example Cooper and Paccia-Cooper 1980) has studied in considerable detail the factors which determine whether or not this kind of (optional) phonological process is applied in speech production. For one such rule, palatalization (which

produces an affricate from an alveolar stop followed by a palatal glide), Cooper explicitly investigated the effects of manipulating the information load of the word preceding the word boundary (which would be distorted at its end by the palatalization) and of the word following it (which would have its onset distorted). For instance, the high-frequency *rode* in 'rode your horse' was replaced by the low-frequency *goad;* "had utensils' by 'had euglena'. Similarly, either the word before or the word after the critical boundary was assigned contrastive stress. The results were very clear. Manipulation of the word preceding the boundary had no effect on the likelihood of palatalization occurring across the boundary. When the word following the boundary was of low frequency, however, or when it was contrastively stressed, the frequency of palatalization fell from over 50% to almost zero.

This result indicates that speakers are aware of the importance for listeners of word onsets and try not to distort them, especially if they are more than usually informative. The same principle appears to govern speakers' choice of neologistic word formations. Speakers frequently make up words, usually by adding endings to existing words; (28)-(30) are three examples from the first author's collection of spontaneous neologisms:

(28) idioticness, it's as good a word as any
(29) I can't morphologize that
(30) a pretty zombific lot

Analysis of this collection reveals that neologisms characteristically preserve the base form transparently within them; the word *idiotic* is pronounced identically in *idioticness* as it would be on its own, whereas *idiotic* would not have been perfectly preserved if the speaker had chosen instead to say *idioticity* (which by analogy to similar English words ought actually to have been the preferred form). Slips of the tongue show a similar effect — in general, errors of affixation (e.g. saying 'professoral' instead of 'professorial') exhibit the base form more transparently than the real word would have (Cutler 1980a). This pattern reflects a real speaker preference for transparent derivations over opaque ones; when speakers are given a choice of alternative derived forms of the same base, they consistently prefer the transparent options (Cutler 1980a). Some apparent exceptions to this general rule prove not to be exceptions when Marslen-Wilson's distinction between informative and uninformative parts of the word is applied; derived words which do not preserve all of the base word, for instance, or which bear primary stress on a syllable different from the stressed syllable of the base word, prove to be quite acceptable AS LONG AS THEY PRESERVE THE BASE WORD AS EAR AS ITS UNIQUENESS POINT (Cutler 1981).

In word formation as in the application of phonological rules, therefore, speakers behave in accord with listeners' priorities in word recognition. Onsets — defined as the first segment and as many subsequent segments as are necessary for identifying the word — receive special treatment in word production.

4.4. *Left-to-right lexical access*

Speech takes place in time; the onset of a spoken word arrives first at the listener's ear. The temporal constraints of understanding speech provide a compelling explanation for why word onsets should appear so overwhelmingly important. In fact, it would surely be very surprising if the lexicon used in speech comprehension were NOT organized in such a way as to accommodate optimally to the constraints on auditory word recognition.

Our view is that the evidence surveyed in this section argues persuasively for a lexicon in which the temporal structure of the listed words is of paramount importance. Moreover, we suggest that the pervasiveness of onset salience, expressing itself not only in auditory comprehension but in reading as well, and in parallel effects in speech production, argues that the importance of the temporal structure of words in their mental representation extends beyond the auditory access code. There are certainly further speech production effects which suggest that the lexicon used in production gives weight to left-to-right phonological structure. As mentioned above, speakers with a word on the tip of their tongue frequently are fairly sure of its onset; and their erroneous guesses most often coincide with the target word in the initial segments. Slips of the tongue in which the intended word is replaced by another word with no semantic relation to it of any kind (e.g. *winter* for *window)* show a similar pattern; such slips tend to resemble the target word phonetically, with by far the greatest resemblance occurring in the initial segments (Fay and Cutler 1977).

In fact, Fay and Cutler used the evidence of these 'malapropisms' to argue that there is only one mental lexicon used in both production and perception, and that its primary organizational principle is left-to-right phonological structure (that is, it is arranged first and foremost for the convenience of the comprehension process). The semantic ordering demanded by the production process would be in some sense subsidiary. A word's nearest neighbor in the phonological ordering would be the word which sounded most like it left-to-right *(intestine* would be right next to *intestate),* and malapropisms would occur when an intended word's near neighbor was selected by mistake.

Giving greater consideration to the demands of the comprehension

process rather than the production process makes perfect sense, Fay and Cutler argued, since the temporal limitations on speech understanding, and the often very imperfect signal which is presented to the listener, make the process of lexical access in comprehension vastly more difficult than the analogous process in production. Fay and Cutler's model of a single, phonologically ordered lexicon is admittedly controversial; many current models of lexical structure and access postulate separate listings for production and comprehension purposes, or an unordered central lexicon with separate access codes for listening, speaking, reading, and writing (left-to-right phonological structure being of major importance only to the first). For the purposes of the present paper, it is unimportant how these current controversies are eventually resolved; it is only important that temporal phonological structure be represented in some significant part of the lexical system.

Our present argument concerns not the structure of the lexicon, but the structure of the language as a function of the processing regularities we have observed. Given that the human language processing system appears to have accommodated itself to the temporal constraints of speech understanding by assigning particular salience to word onsets, how might this adaptation in turn lead to further adaptation of the structure of words in the language, to ensure that words are optimally processed by such a system?

Nooteboom (1981) has suggested two ways in which one might expect phonological structure to accommodate to the characteristics of an onset-weighted processor: (a) word onsets should tend to be more phonologically variable than word endings, and (b) phonological assimilation and coarticulation rules should tend to apply less to word onsets than to word endings. Here, however, we are concerned with MORPHOLOGICAL structure, which, we suggest, is no less affected by the properties of the processing system than is the phonology. In section 6 we will spell out how we think morphological effects have been brought about. First, however, we will conclude this section with a look at some apparent counterevidence to the primacy of word onsets.

4.5. *The comparative salience of endings*

It is not the case that ONLY word onsets are important in word recognition. The strictest form of, say, the cohort model, or any other model of lexical access which allowed only left-to-right word search, would hold that latter parts of the word — segments following the uniqueness point — are entirely redundant. Yet the evidence shows

clearly that although onsets are unquestionably the most salient word parts, ENDINGS ARE MORE SALIENT THAN MIDDLES.

For example, endings are better recall prompts than middles in Horowitz et al.'s (1968,1969) experiments described above; and reversal of letters at the end of a word disrupts recognition more than word-medial reversal (Bruner and O'Dowd 1958). Both of these are visual word recognition effects, and one might argue that in reading, where the entire word is presented simultaneously in space, the recognizer can afford to attend to other parts of the word. Recall, however, that slips of the ear happen less often on endings than on middles of words (Browman 1978). Consider, further, the fact that TOT guesses are more often correct about the final parts of the intended word than about medial parts; and that malapropism errors coincide with their intended targets more often in final segment than in medial segments (Hurford 1981; Cutler and Fay 1982). Both these latter effects in word production strongly suggest that a lexical explanation is called for: ends are more salient than middles of lexical representations.

Finally, consider also the fact that one can retrieve words successfully given only an ending (think of a word ending with *-vark).* This is true even in the auditory modality; Nooteboom's (1981) subjects still achieved 60% successful word recognition given only the latter parts of the words. This simply could not be done if words could only be accessed from the lexicon in left-to-right order. Thus it appears that although word onsets are most important for word recognition, word terminations can be quite important too. Section 6 will suggest why this should be so.

5.0. Psycholinguistic evidence: affixes

There is abundant evidence from studies of lexical access and structure that, at the very least, morphological structure is lexically represented. Some psycholinguists have even argued that the evidence indicates that only bases appear in the lexicon, with complex forms being produced and comprehended via the application of morphological rules. Others have suggested that, while affixed forms may be lexically available, it is the stem which is the head of the lexical entry, and hence the basis for lexical access. The relevant psycholinguistic evidence is summarized below, separately for inflections, derivational suffixes, and prefixes.

5.1. *Inflections*

The evidence for separate processing of stem and affix is strongest in the case of inflections, such as tense or number marking. There is abundant

evidence that inflected words do not have lexical representation independent of their base form, and that base word and inflection are separated in language processing. In tachistoscopic presentation inflected words seem to be perceived as two units (Gibson and Guinet 1971). Recall of adverbs ending in -*ly* is affected by the frequency of the base adjective rather than the frequency of the inflected adverb form (Rosenberg et al. 1966). Regular inflected forms (e.g. *pours)* show a repetition priming effect on their base words (e.g. *pour)* as strong as that of the base word itself (Stanners et al. 1979). Priming with irregular inflected forms (e.g. *hung)* is less effective than priming with the base word itself (e.g. *hang)*, though still significantly better than no prime at all (Stanners et al. 1979). Pretraining with an inflectional variant (e.g. *sees)* significantly facilitates later learning of a word (e.g. *seen)* in comparison with no pretraining, or with pretraining on a word having as much visual similarity to the target word as the morphological relative (e.g. *seed;* Murrell and Morton 1974). Only REGULAR inflections provide effective priming, however, when the dependent variable is accuracy of report of a degraded auditory signal (Kempley and Morton 1982). Plural morphemes tend to get detached in memory representations (van der Molen and Morton 1979). Lexical decision reaction times are sensitive both to the frequency of occurrence of the surface form and to the combined frequency of base plus inflectional variants (Taft 1979).

This body *o^* evidence has led psycholinguists to suggest that inflectional affixes may be generated by rule in speech production and stripped prior to lexical access in speech perception. Speech errors in which misplaced inflections accommodate to their erroneous rather than their intended environments, as in (31),

(31) I'd hear one if I knew it.

have also been used to support such a model (Fromkin 1973; Garrett 1976; MacKay 1979; Butterworth 1980). Jarvella and Meijers (1983) proposed a stem-based lexicon on the basis of an experiment in which they primed target verbs with differently inflected forms of the same stem, or with similarly inflected forms of different stems; subjects performed same-different stem judgements significantly faster than same-different inflection judgements. Similarly, MacKay (1976) based the same claim on the finding that translating a present into a past tense form takes longer and is more subject to error the more complex the relation between base and inflected form.

Other authors have been more cautious, proposing models in which inflected forms are represented but only as subsidiary entries to base or stem forms (Stanners et al. 1979; Cutler 1983; Henderson 1985). An

experiment by Lukatela et al. (1980) investigated noun inflections in Serbo-Croatian; from the fact that lexical decision responses to nominative forms were consistently faster than responses to genitive or instrumental forms, the authors argued for a model of lexical representation of inflected forms in which the nominative comprises the nucleus of a cluster of separate entries, one for each form. Even the most radical recent proposal for a model in which complex forms have their own separate lexical listings (Butterworth 1983) allows for the internal representation of morphological structure within the listing, and the grouping together of morphologically related forms in the lexicon.

5.2. *Derivational suffixes*

There is no indication that words with derivational suffixes are in any way more difficult to understand than monomorphemic words; the very few experimental studies which claim to have shown a processing cost for morphological complexity of this kind are seriously flawed (see Cutler 1983: 61). However, there is evidence that the morphological structure of derived words is computed as they are understood. For instance, Manelis and Tharp (1977) found that subjects took longer to decide whether two letter strings were both words if one was suffixed and the other not *(printer/slander)* than if both were suffixed *(printer/drifter)* or both simple *(slander/blister).* Similarly, understanding a derived word produces facilitation for understanding its morphological relatives (Kintsch 1974; Stanners et al. 1979). This suggests that lexical storage of words with derivational suffixes embodies close connections with other members of the same morphological family, as argued by Cutler (1983) and Henderson (1985). Production evidence showing slips of the tongue which confuse morphological relatives, such as (32),

(32) if you have a hierARCHy of frames ...

in which *hierarchy* has been pronounced with the stress pattern of its relative *hierarchic,* suggest the same conclusion (Cutler 1980b). Similarly, the evidence from neologism formation (section 4.3 above) demonstrates that speakers have control over the morphological structure of their vocabulary.

5.3. *Prefixes*

The psycholinguistic evidence on the processing of prefixes is in some ways similar to the evidence on suffixed words. Simply recognizing

prefixed words is no more difficult than recognizing monomorphemic words (Taft and Forster 1975; Fay 1980; Cutler 1983). But recognizing a prefixed word produces facilitation for its stem (Stanners, Neiser, and Painton 1979). However, prefixes have aroused much livelier debate than suffixes; this debate was begun by Taft and Forster (1975), who claimed that the process of recognizing a prefixed word necessarily required stripping the prefix from the stem, since lexical access could only proceed via a stem representation. This claim was based on experiments which measured the time to reject nonwords in a lexical decision task as a function of whether or not the nonwords were stems of existent prefixed words: for example, *juvenate* from *rejuvenate* versus *pertoire* from *repertoire*, which is not prefixed. The *juvenate* type of nonword took significantly longer to reject than the *pertoire* type. This response time difference also held when the items were presented bearing pseudoprefixes *(dejuvenate* versus *depertoire).* Taft and Forster argued that *rejuvenate* is actually stored in the lexicon as *juvenate* + *re.* Taft and Forster's experiments have been criticized on methodological grounds (Cutler 1983; Henderson 1985) and have stimulated many subsequent studies (Rubin et al. 1979; Stanners, Neiser, and Painton 1979; Fay 1980; Taft 1981; Henderson et al. 1984). The current situation is unclear; a conservative reading of the literature suggests that the strong version of the prefix-stripping model (access via stem only) may not be warranted, but that morphological decomposition of prefixed words appears to be a routinely available strategy in word recognition.

5.4. *Stem-affix separability*

The psycholinguistic literature on morphological complexity is in agreement that morphological structure is available to the language-processing devices. There is considerable diversity as to how this might be achieved, from strict affix-stripping models at the strongest end of the continuum to, at the other, attempts to account for the experimental results via simple contiguity of morphological relatives in the lexicon. But even those who wish to argue that complex forms have separate lexical representations (e.g. Butterworth 1983; Segui and Zubizarreta, this volume) admit that morphological boundaries are marked in these representations. For present purposes it is not necessary to subscribe to one or other model of the role of affixes in lexical access; the point that we wish to make is sufficiently general to be applicable, we feel, to any current model.

One line of psycholinguistic evidence, bearing on all affix types, has not yet been mentioned. If a nonword is presented in a lexical decision task, it

takes longer to reject if it bears a real affix, be this inflectional or derivational, prefix or suffix (Fay 1980; Lima and Pollatsek 1983; Henderson et al. 1984). This strongly suggests that some separate processing of the affix is undertaken despite the nonexistence of the stem. Indeed, we will argue that this is the most basic conclusion to be drawn from psycholinguistic studies of affixation: at some level it is necessary to process stems and affixes separately. All the evidence is compatible with this very general claim; most processing models embody far stronger claims. Furthermore, the information carried by affixes is of a different nature from that carried by stems. Affixes constitute a closed class, with predictable syntactic effects; they are in this respect entirely equivalent to other closed-class linguistic items, 'function words[1] such as articles and conjunctions. Stems on the other hand are open-class items; a new stem, embodying an entirely new meaning, can in principle be created at any time (although in practice new stems — for example, *byte* — are rarer than new meanings for old stems — for example, *chip* — or new derivations — *debug).* Thus as long as lexical and syntactic processing are considered distinct operations in production and comprehension, stems and affixes must at some level be processed separately.

Interestingly, certain patients with language disorders show systematic affixation errors — additions, deletions, or substitutions — which parallel their errors with function words (Patterson 1980). Most of these errors happen to involve suffixes, but this may reflect the fact that the reports deal mainly with English-speaking patients, and English contains more suffixes than prefixes.

Note that our main conclusion does not distinguish between prefixes and suffixes; and we have also not separated inflectional from derivational affixes. It is impossible to compare their separate effects in the current experimental evidence, because the evidence is confounded: nearly all the research in this area has been carried out on English, and in English all inflectional affixes are suffixed. It is to be hoped that psycholinguists will soon turn their attention to those few languages with inflectional prefixes (e.g. Welsh). Meanwhile, for our present purposes it is, again, unnecessary to distinguish between inflections and derivations; a detailed discussion of the psycholinguistic considerations involved in making this distinction may be found in Henderson (1985). The one consideration which may be relevant to our argument is the degree to which a particular affix has entirely syntactic function or exercises also some SEMANTIC effect; the more its function is entirely syntactic, the more its processing will be distinct from the way its stem is processed.

Psycholinguistic studies of affixes, then, suggest that there is a processing distinction between stem and affix; both types of information are

necessary but they must be separable. The implications of this in the light of the evidence reviewed earlier will be discussed in the next section.

6.0. Explaining the suffixing preference

In this section we bring together the linguistic evidence of distributional asymmetries in affix attachment and the psychohnguistic evidence from studies of lexical access, summarized in the preceding sections, and argue that the two lines of evidence combine to provide an explanatory model with relevance to both linguistics and Psycholinguistics.

For ease of exposition, we will base our reasoning on the simplest examples, i.e. words consisting of just one stem and one affix. English examples are *sad+ ness*, *walk + ed* or *girl+s*. Our argument is of relevance only to stem-affix ordering; it is neutral with respect to ordering of affixes in multiply affixed items, which may be determined by principles qualitatively different from the processing explanation proposed here.

In section 6.1. below, we will spell out our argument about computational order of stems and affixes. Section 6.2 contains some additional arguments based on relative redundancy of stems versus affixes. Before concluding, we will also show how the infrequency of infixing can be explained on processing grounds independently of the preference for suffixes over prefixes (section 6.3), and we will also consider and reject an alternative explanation of the suffixing preference based on principles of language change (section 6.4).

6.1. *Order of computation for stems and affixes*

The distributional evidence shows that languages prefer stems to precede affixes. The psychohnguistic evidence on word onsets indicates that speakers and listeners pay most attention to the beginnings of words, rather less attention to the ends, and least attention of all to the middles. The psychohnguistic evidence on affixes suggests that stems and affixes must at some level be processed separately.

We maintain that the simplest explanation encompassing these three effects is, speakers and listeners process stems before affixes. That is, the stem favors the most salient beginning position of a word, and the affix the less salient end position, because in the compositional process of determining the entire meaning of a word from its parts, the stem has computational priority over the affix. Thus the fact that languages exhibit a suffixing preference, i.e. stem + affix order on numerous occasions when

their remaining structural characteristics would predict the reverse, reflects the order of computation of stem and affix in processing.

In a model of comprehension, this argument in a sense follows inevitably from the fact that affixes convey primarily syntactic information, stems primarily lexical-semantic information. Case affixes, for example, function to integrate a noun or noun phrase into the overall interpretation of a clause. Even within the word itself and with affixes whose syntactic and semantic functions are not primarily clausal in nature, stems typically have computational priority over affixes. Consider, for example, *sad+ness.* We can paraphrase the meaning of *sad* as 'having an unhappy state of mind', and that *of -ness* as 'the abstract quality of X', where X is the thing that *-ness* combines with, much as a function category applies to an argument category within a categorial grammar to make a derived expression. The effect of the suffix cannot be determined without knowing what stem it has combined with.

All current psychological models of comprehension are based on a tacitly accepted general ordering of lexical before syntactic before higher-level semantic processing. However, current models differ fundamentally in the way they describe the relationship between these levels of processing. Briefly, there is a major controversy concerning the autonomy versus interdependence of levels; at one end of a continuum in this regard stand models which view the various levels of processing as strictly serially ordered and autonomous, at the other end models which allow interaction between any and all levels. (Of course, there are many intermediate models, which allow feedback only between adjacent levels, or only under certain conditions, i.e. which mix features of the serial autonomous and interactive positions.) With respect to the two levels we are considering, the lexical and syntactic levels, a serial model would require all lexical processing to be complete before syntactic processing was begun on the same items; irresoluble ambiguities would have to be passed on to higher levels for resolution. Lexical processing would be wholly independent of prior syntactic context. An interactive model, on the other hand, would allow for prior syntactic processing to be fed back to constrain decisions — for example, the choice between noun and verb form of a syntactically ambiguous word — at the lexical level.

While the present argument makes no general claim about the structure of a model of comprehension, it does suggest that in respect of lexical processing, and syntactic processing of the particular kind in which affixes are involved, a serial autonomous model might provide the best description. That is, if the preferred order of computation is, as we have argued, stems first, affixes second, it does not appear that feedback from the kind of syntactic information provided by affixes is of value in constraining

lexical access. This limited conclusion of course says nothing about other kinds of syntactic information, such as word-order information. Our argument does, however, amount to a claim for noninteractive serial ordering of lexical and affixal processing in comprehension.

We would also argue that stem-affix computational order should apply in production. We see no principled reason why affix distribution across languages should be determined by processing considerations from comprehension alone. The ordering of lexical processing and syntactic processing in psycholinguistic models of production is a matter of dispute; although it has been claimed that speech error evidence suggests that much syntactic processing precedes lexical processing in production (e.g. Fromkin 1971, 1980), the justification for this claim has been questioned (Cutler and Isard 1980; Butterworth 1982), and other models have either ordered lexical selection strictly before syntactic specification (e.g. Garrett 1976) or postulated two separate but parallel processes (e.g. Butterworth 1980). Again, our argument is most consistent with a model such as Garrett's: lexical selection strictly preceding affixal processing.[6]

6.2. *Redundancy of stems versus affixes*

There are two further processing considerations which argue in favor of a stem-affix sequencing in languages, although neither seems to us either as simple or as compelling as the computational order argument. Both rely on the assumption of greater redundancy for affixes in comparison with stems; phonological redundancy in the first case, syntactic/semantic in the second.

As pointed out in section 5, affixes comprise a closed class, a very much smaller set than the set of stems. They are also all short. Thus, of necessity, they exhibit vastly less phonological diversity than do stems. In any left-to-right comprehension model, therefore, prefixed words will be less informative in the most salient initial portions than will equivalent words carrying the same information in a suffix. In the cohort model, for example (see section 4.2 above), the initial cohort for any prefixed word will contain all other words with the same prefix; the uniqueness point will occur later in an affix-stem ordering than in a stem-affix ordering. This will effectively delay lexical access for prefixed words in comparison with suffixed words.

This consideration seems to us less satisfactory than the computational order argument for two reasons. First, it refers exclusively to comprehension, whereas the computational order claim applies equally to comprehension and production. Second, if pushed to its logical conclusion, it is forced to assume the computational order argument. What is delayed by

prefix redundancy is access to the lexical semantics. Access to the affix information itself, on the other hand, is speeded in prefixed as opposed to suffixed words. Given our assumption, based on the psycholinguistic evidence, that BOTH stems and affixes need to be processed, and processed SEPARATELY, early processing of either one should be equally useful UNLESS THERE IS A PREFERRED PROCESSING ORDER. That is, delay in accessing the stem should only matter if stems are preferably dealt with before affixes. Early access to the affix should be helpful unless affixes are preferably dealt with after stems.

The second kind of redundancy concerns the considerable predictability, in context, of the syntactic and/or semantic properties of some affixes (particularly the more inflectional ones). It might be argued that presence of the affix is not at all necessary for comprehension. Consider the English sentence *yesterday I walked to the store.* The past tense meaning of the *-ed* suffix is already implied by the adverb and the suffix can be masked or deleted without serious consequences. Similarly, many verb agreement affixes, or nominal and adjectival inflections, may be redundant in many environments. Lexical stems, by contrast, are predictable to a much lesser degree. There are many more lexical stems than grammatical affixes that the speaker could use on any one occasion, and context does not guarantee the same degree of predictability (or at least does not reduce the range of options so severely) as it does for affixes. It therefore makes sense that lexical stems should be given greater prominence by being regularly assigned a more salient position in the word, namely initial position.

Unfortunately, the force of this argument is also weak. Most affixes are not predictable most of the time. The most suffixed morphemes of all are case affixes, and the information they convey is typically vital for sentence understanding and is unpredictable on account of word order freedom. (Recall that affixes regularly receive the second position on the saliency hierarchy, final position, rather than the least salient medial position.)

Although both of these considerations may have a partial role to play in explaining the suffixing preference, we feel that the computational order argument is the most convincing, as well as being, in its application to both production and comprehension, and its implications for psycho-linguistic models as well as linguistic explanations, the most powerful.

6.3. *The infrequency of infixing*

Infixing — the insertion of an affix into the middle of a word — is the rarest form of affixation. (An example is *fikas* in Bontoc, a Philippine

language, which means 'strong', while *fumikas*, into which *um* has been infixed after the initial consonant, means 'he is becoming strong'.) We believe that the infrequcncy of infixing is also motivated by a general processing consideration, namely that languages are reluctant to break up structural units. This applies not only to morphemes but also to phrasal units; witness the relative infrequcncy of discontinuous constituents in syntax both within and across languages. It appears highly likely that the adjacency of immediate constituents, both in morphology and syntax, facilitates processing, whereas discontinuities and crossed branching complicate it. By this explanation either prefixing or suffixing should be vastly preferable to infixing, as indeed the distributional facts attest that they are.

Of course, if a stem has been effectively recognized by the time its uniqueness point has been processed, one might argue that infixing a morpheme between the uniqueness point and the end would provide all the continuity necessary (since the end should be irrelevant), AND get the important affixed information in at the earliest possible useful point, i.e. just when the word has been recognized. There is yet another processing reason for avoiding this, however: the relative insaliencc of middle positions in a word. The evidence summarized in section 4.5 suggests that the middle of a word is its least salient part. It may be that affixes are simply too informative and important to be inserted into the LEAST salient position in a word. i.e. into the kind of position that can be distorted with minimal consequences for word recognition and recall. For example, languages with rich case suffixing regularly permit considerable word-order freedom and scrambling of major constituents in the clause. As a result, the case affix becomes crucial in identifying the grammatical function of each NP within the clause, and there could be real communicative disadvantages to relegating such affixes to the least salient position in a word. Communicative disadvantage would result from infixing, then. wherever a morpheme was informative, i.e. not predictable; and as pointed out above, although some affixes are predictable some of the time, the majority of them are usually not. (Of course, many languages have multiple suffixes on a single word. In such cases we would want to predict that the most syntactically crucial affix would be assigned final position.)

Thus there are two reasons, both based on processing considerations, why infixing should be less favored than suffixing or prefixing: stem discontuity and the insalience of medial positions. These reasons do not involve the principle of stem-affix computational order. The computational order argument explains why of the two relatively SALIENT positions, the stem takes the most salient and the affix the second most salient; thus computational order explains why, of the two kinds of affix which leave the stem intact, suffixes are preferred to prefixes.

6.4. *The suffixing preference and language change*

Notice finally that there is a competing explanation for the suffixing preference in the linguistic literature, involving principles of language history and change. This alternative is summarized in Givon (1979). Here we shall merely summarize our arguments against it very briefly; see Hawkins and Gilligan (i.p.) for more detail. Givon observes that affixes are regularly derived historically from independent and productive words whose behavior was formerly governed by the rules of syntax. For example, verbal affixes are frequently derived from independent auxiliaries and modals. Such elements occur regularly to the right of the (non-finite) verb in SOV languages, giving SOVAux. The attrition of the auxiliary to an affix produces a suffix on the verb, i.e. SOV_{af}, if we assume that morpheme orders are frozen relics of earlier syntactic orders. Givon does make this assumption. He also makes a further assumption: that all current language families were originally SOV in their syntax. Given this latter assumption, and given the rightward positioning of auxiliaries and modals relative to the verb in SOV languages, coupled with the diachronic drift from independent word to affix, the suffixing preference is explained.

Unfortunately, this SOV assumption is highly questionable. The distribution of OV to VO languages at present is roughly 50-50, as is that of NP + Po to Pr + NP. This distribution provides no foundation for the assumption of a 100% skewing in favor of OV in the past. Nor are Givon's arguments using syntactic reconstruction convincing. Even for the Indo-European family, whose western branches provide the best attested evidence for the progression from SOV to VO, it has been argued (Hawkins 1982, 1983) that the ultimate syntactic reconstruction for Proto-Indo-European that is most consistent with language universals is VO and Pr + NP rather than the reverse. There are also numerous counterexamples to Givon's claim that today's morphological order reflects yesterday's syntactic order. And in addition his account provides no adequate explanation for the even greater suffixing preference in nominal rather than verbal morphology.

6.5. *Conclusion*

This paper has attempted to bring together linguistic and psychohnguistic evidence in such a way that the resulting explanatory synthesis is of value to both disciplines. We have shown how cross-linguistic studies of morphology have provided strong indications of a general tendency for languages to prefer suffixes to prefixes. Two separate lines of psycholin-

guistic research have been drawn upon to provide relevant evidence: studies of word recognition and production indicate that word onsets are accorded more attention than other parts of the word, and studies of morphological processing indicate that stems and affixes are processed separately. We have argued that the linguistic and psychological evidence together suggest that language structure reflects the preference of language users to process stems before affixes, in that the component preferred for prior processing receives the most salient position in the word, the component to be processed second a less salient position. That is, the suffixing preference results in stems generally being ordered before affixes because language users prefer to process stems before affixes. This conclusion is of importance for both linguistics and Psycholinguistics. For the former, it suggests an explanation for this particular left-right asymmetry in morphology which does not rely on unsupported diachronic assumptions. For the latter, it provides potential constraints on one component of a processing model, in that it suggests that lexical and affixal processing are serially ordered.

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Notes

1. This paper arose from discussion following a presentation by the second and third authors to a European Psycholinguistics Association workshop on 'Cross-linguistic studies of morphophonological processing' held at the Maison des Sciences de l'Homme, Paris, in June, 1984. We thank the members of the workshop for their comments on our proposal. Correspondence address: MRC Applied Psychology Unit, 15 Chaucer Road, Cambridge CB2 2EF, England.
2. Throughout this paper we will use *left* and *right* in their standard metaphorical sense of a temporal ordering. Thus in discussing how some elements tend to precede others in syntax and morphology, we will refer to left-right asymmetries' (sections 2 and 3); in discussing lexical access beginning with word onsets, we will refer to 'left-to-right word recognition processes' (section 4). However, we recognize that the *left-right* metaphor is based on a left-to-right orthography; in a right-to-left orthography, prefixes still precede suffixes and words are still read beginning to end! The terms *left* and *right* should therefore be taken as having temporal reference only; our conclusions apply to language, not to its various spatial representations.
3. Notice the following methodological points in connection with these proposed processing explanations for syntactic universals. First, they are generally given in terms of comprehension rather than production strategies. But ultimately it is likely that the

explanation for these cross-linguistic facts will involve a complex interplay of both comprehension and production strategies. Since so little is known about production at the moment, the relevant findings from comprehension experiments are being used as an index of processing ease or difficulty in general.

Second, these explanations assume that processing considerations constrain the type of rule that a grammar will employ and the types of rule variation that show up across languages. The need to process (produce and comprehend) language rapidly in real time is thereby seen as one of the demands that are made upon successful human communication systems and as contributing to defining the notion 'possible human language'.

Third, underlying many of these explanations is the assumption that processing difficulty is a gradient notion which may have empirical consequences for language frequencies. At the extreme end of some gradient, the processing difficulty may be so great that the relevant structures will be nonoccurring across all languages, such as mirror-image structures as discussed in Chomsky (1972), unbounded rightward movements, etc. But otherwise the degree of processing difficulty will be reflected in the RELATIVE numbers of languages with the structures in question, and in the frequency with which a processing consideration can either assert itself in the absence of contrary predictions, or override an independently motivated grammatical principle. Thus, the proportion of languages whose relative clauses depart from the predicted prenominal order gives an indication of the degree of processing difficulty involved.

4. The 125-language sample by Stassen gives information on the ordering of the following categories of morphological affixes, where the relevant languages have such affixes: (affixes on nouns) case, definiteness, indefiniteness: (affixes on verbs) tense, aspect, person-marking (subject), negation. The 40-language sample from Bybee provides information on morphological affixes on the verb only: tense, aspect, mood, person-marking (subject and object), negation, voice, valence (intransitive/transitive/ditransitive affixes), causative. The 39-language sample by Gilligan contains information on the following: (affixes on nouns) case, gender, plural, possession, definiteness, nominalization; (affixes on verbs) tense, aspect, mood, person-marking (subject), negation, voice.
5. In those cases where an affix does not change the category of the item to which it attaches, i.e. inflectional and some derivational affixes, one could in principle argue that the non-affix is the head. This is the position taken by Williams (1981) in arguing that certain prefixes in English are not heads (e.g. *un* in *unable),* and in arguing more generally for a righthand head rule. But there are important exceptions to his approach involving prefixes which do change category status, for example *a-* in *akin* (= adj, *kin* = N). We shall therefore pursue the morphologically more general assumption here that affixes are always heads.
6. There are other orderings in the morphosyntactic domain which exhibit distributional asymmetries similar to that of stems and affixes. Adjective-Noun order, Determiner-Noun order, and order of elements in compounds are the three most important. Ultimately we would hope to be able to give a processing account of why, for instance, English, as a VO and Pr + NP language, orders adjectives and determiners before the noun and prefers head-final compounds, although basic head-modifier order would prefer the reverse in all cases. Such an account would, however, enormously extend the scope of the present paper and would require, in particular, a review of many more bodies of psycholinguistic evidence similar to the evidence on affixes described in section 5.

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