CHAPTER 11

Psycholinguistic Factors in Morphological Asymmetry

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1 Introduction

Recent research on language universals has uncovered several cases of what we will call *left-right asymmetries.*[1] In these univerals, linguistic categories that are predicted by independently well-motivated principles to be, for example, leftward-occurring within their respective phrases will often show up on the right, whereas the converse fails: 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 other examples, a leftward skewing may be favored. Most of the cases documented so far involve asymmetries within syntax, for which explanations of an extragrammatical nature have been proposed that make use of certain findings from Psycholinguistics, particularly 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 claime 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 in constraining the variation space within which the set of possible human languages can be constructed (cf. Hawkins this volume). Asymmetries in linguistic structure may also provide evidence for one processing mode over 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. Some explanatory hypotheses for the grammatically unpredicted asymmetries will be given that are strongly suggested by current psycholinguistic research on lexical access.

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 morphologic

univerals 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   Some Left-Right Asymmetries in Syntax

There are a number of syntactic left-right asymmetries across languages for which processing explanations have been offered. Hawkins (1988a) discusses several. Hawkins (1988b) argues, even more ambitiously, for a processing explanation both for such asymmetries *and* for basic grammatical regularities such as cross-categorial head ordering from which asymmetrically ordered categories depart (cf. also Frazier 1979, 1984).

Consider, for example, the positioning of relative clause and head noun. There is an asymmetry in their distribution across languages. The languages that are independently predicted to have the relative clause after the head noun (that is, head-initial languages such as English) do so; the languages that are independently predicted to have the relative clause before the head noun (that is, head-final languages) may (Japanese) or may not (Sumerian) do so, and in a significant number of cases have postnominal relatives as in English. The result is a rightward skewing in favor of postnominal relatives overall.

This skewing becomes significant when we consider that the ratios of head-initial to head-final languages are roughly equal across languages. In all current samples of which we are aware, the proportions of pre-positional (Pr + NP) to postpositional (NP + Po), and of verb-object (VO) to object-verb (OV) languages hover around the 50-50 mark, as shown in table 11.1. By contrast, between one-eighth (Lehmann 1984) and one-quarter (Hawkins 1983) of the world's languages have pre-nominal relatives in different samples, with the great majority of the remainder having postnominal (that is, head first) constructions in these noun phrases. And whereas head-initial languages have almost exclusively postnominal relative clauses, a significant proportion of otherwise head-final languages also have the postnominal relative clause order.

What could explain this preference? Antinucci et al. (1979) were the first to address this question. They argued that prenominal relatives cause perceptual problems that are avoided in their postnominal counterparts. They provide too many opportunities for misanalyzing subordinate clause constituents as matrix constituents in structures such as (1). Because the relative clause precedes its head, subordinate clause constituents such as NP, and V will often be integrated on-line into the matrix clause, producing a garden path effect, and forcing the parser to reconstruct the tree retrospectively by introducing the circled dominating nodes over the misrecognized constituents.

Table 11.1 Proportions of head-initial and head-final languages in current samples[a]

Sample	in lgs	Word order	% of sample
Hawkins (1983)	336	Pr + NP	44%
		NP + Po	56%
Greenberg(1966)	142	Pr + NP	44%
		NP + Po	56%
Stassen (cf. Hawkins and Gilligan1988)	113	Pr + NP	50%
		NP + Po	50%
Ruhlen(1975)	427	VO(SVO,VSO,VOS)	48%
		OV(SOV)	52%
Tomlin (1986)	402	VO(SVO,VSO,VOS)	54%
		OV(SOV,OVS)	46%
Hawkins (1983)	336	VO(SVO,VSO,VOS)	48%
		OV(SOV)	52%
Greenberg(1966)	142	VO(SVO,VSO)	55%
		OV(SOV)	45%
Stassen (cf. Hawkins and Gilligan 1988)	113	VO(SVO,VSO)	54%
		OV(SOV)	46%
Mallinson and Blake (1981)	89	VO (SVO, VSO, VOS)	52%
		OV(SOV,OVS,OSV)	48%
Ultan(1978)	75	VO(SVO,VSO,VOS)	56%
		OV(SOV)	44%
Perkins (cf. Bybee 1985)	40	VO(SVO,VSO)	47%
		OV(SOV)	53%

This table gives the proportions of Pr + NP to NP + Po and of VO to OV languages in current samples. The samples are listed in descending order of sample size, first for adposition order, then for verb position. VO stands for SVO, VSO and also VOS, as shown. SVO typically outnumbers VSO in these samples by at least 2-to-l, with VOS being much rarer than VSO, cf. Pulium (1981), Tomlin (1986) and Hawkins (this volume). OV stands for SOV, but occasionally also for OVS and OSV, again as shown. We indicate in parentheses which particular subtypes of VO and OV are represented.

"The proportions hover around 50-50 in these different samples. The precise aggregates are: 46% Pr + NP to 54% NP + Po (three samples); and 52% VO to 48% OV (eight samples); which averages out at 49% head-initial to 51% head-final.

(1)
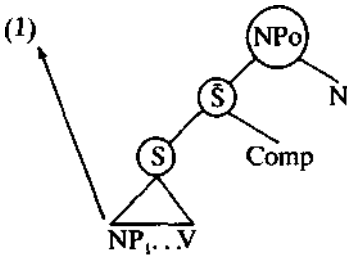
An illustrative example from Japanese is (2) (cf. Clancy et al. 1986):

(2) (Japanese)
Zoo-ga $_{NPo}(_s(_s(_{NP1}$(kirin-o)   taoshi-ta))   shika-o) nade-ta.
'elephant-SU   giraffe-OBJ knocked-down deer-OBJ patted',
i.e.
The elephant patted the deer that knocked down the giraffe.

kirin-o and *taoshi-ta* can be parsed on-line as a matrix clause direct
object and verb for the subject *zoo-ga* (by Frazier's 1978 principle of
Minimal Attachment), and it is not until the head noun *shika-o* is
encountered that the misanalysis will be recognized and the appropriate
reanalysis can take place. The attendant processing difficulty associated
with such structures in Japanese has been demonstrated experimentally,
both for adults (cf. Frazier & Rayner this volume) and for children (in
Japanese and Korean, cf. Clancy et al. 1986). But no comparable
structural misanalysis arises in the corresponding postnominal relatives,
in which the head noun serves to immediately indicate the leftmost
boundary of the dominating NPo, whereupon the relative clause and its
daughters will be attached under the domination of this NPo (cf. further
Hawkins 1988b).[2]
   Underlying this and other processing explanations for syntactic uni-
versal is the assumption that processing difficulty is a (quantifiably)
gradient notion, with empirical consequences for language frequencies
and implicationally defined co-occurrences of properties (cf. Hawkins,
this volume, 1988b; Cutler and Hawkins 1987). The relevant implica-
tional universal for relative clauses is set out in (3), together with
exemplifying languages and quantitative data. With the exception of one
or two languages like Chinese (which combine prepositions - but also
postpositions - with prenominal relatives) a prenominal relative clause
occurs only in fairly rigid head-final languages (those with both NP + Po
and OV).

(3) If a language is head-initial (Pr + NP v VO), then it is NRel within NP;
(i.e. if RelN, then -(Pr + NP v VO), i.e. NP + Po & OV).

Co-occurrences:

1   Pr & VO | English; Arabic; Swahili; Malagasy
2   Pr & OV | Persian; German
3   Po & VO | ^{NRel} Finnish; Koyo
4a   Po & OV | Galla; Sumerian; Lushei
4b   Po & OV } RelN Korean; Lahu; Basque

Quantitative data (from Hawkins 1983):

1% of Pr lgs = RelN; 99% of Pr lgs = NRel;
61% of Po lgs = RelN; 39% of Po lgs = NRel
2% of V0 lgs = RelN; 98% of VO lgs = NRel;
56% of OV lgs = RelN; 44% of OV lgs = NRel

The proportion of languages whose relative clauses depart from the predicted prenominal order, coupled with the almost complete absence of the reverse skewing (head-initial languages with prenominal relatives), gives an indication of the degree of processing difficulty associated with the prenominal structure. The difficulty is clearly within the level of tolerance (in contrast to mirror-image transformations, cf. Hawkins this volume), but it is dispreferred nonetheless, and this dispreference is in opposition to the demands of consistent head ordering across categories (which is also argued to have a processing motivation in Hawkins (1988b, albeit of a different kind).[3] The resolution of such conflicts is played out in language variation and in the implicational universals that define it. The relative strengths of the competing principles are seen in the frequencies with which languages opt for one or the other solution.[4]

3   Left-Right Asymmetries in Morphology

Greenberg (1957, 1966) was the first to point out that suffixal morphology within a word is more frequent across languages than prefixing, and that 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, cf. Matthews 1974: ch. 7). The goal of Hawkins and Gilligan (1988) is to discover the cross-linguistic regularities in this area in greater detail. In the present paper we shall summarize these regularities, consider the grammatical principles that can be argued to underlie them and explore a possible psycholinguistic explanation for the suffixing preference.

The major pattern of interest that emerges from Hawkins and Gilligan's work can be summarized in (4):

(4)
$$\left\{ \begin{array}{l} \text{VO} \\ \text{Pr} + \text{NP} \end{array} \right\} \qquad \begin{array}{cc} \textit{Prefixes} & \textit{Suffixes} \\ \text{X} & \text{X} \end{array}$$

$$\left\{ \begin{array}{l} \text{OV} \\ \text{NP} + \text{Po} \end{array} \right\} \qquad \begin{array}{cc} \text{O} & \text{X} \end{array}$$

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 univerals; 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 suffixing 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 thirty-language sample are summarized in table 11.2. 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 11.2 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 (1988) have accordingly set up a categorization of morphemes, and formulate implicational universals linking morpheme order within each category to verb and adposition order in the syntax. The languages consulted number around 200 and are drawn from three samples: a computerized typological sample of 113 languages collected by Leon Stassen, containing entries for many hundreds of

Table 11.2 Morpheme order correlations with verb and adposition order in
Greenberg's sample

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

linguistic properties including some morpheme orders; a forty-language computerized sample of morphological properties provided to us by Joan Bybee and originally collected by Revere Perkins; and a sample of fifty languages compiled by Gary Gilligan. Only a handful of languages belong to more than one of these samples.

The morpheme categories that have been documented within these three samples are summarized in table 11.3. In addition, Stassen and Gilligan provide syntactic information on adposition order (Pr + NP and NP + Po) and verb position (VSO, VOS, SVO, SOV). Perkins-Bybee give syntactic information on verb position only.

Below we list the eighteen implicational universals of Hawkins and Gilligan (1988). Of these, six are exceptionless (numbers (5)-(9) and (15)), and the remainder are statistical in Greenberg's sense, that is, they hold with more than chance frequency.

(5)   If a language has CASE affixes on N, they are always suffixed.
(6)   If a language has NP + Po, GENDER affixes on N (if any) are suffixed.
(6) a. That is, if a language has prefixed GENDER affixes, it will have Pr + NP.
(7)   If a language has SOV, GENDER affixes on N (if any) are suffixed.
(7) a. That is, if a language has prefixed GENDER affixes, it will have VO (that is, not SOV).
(8)   If a language has NP + Po, INDEFINITENESS affixes on N (if any) are suffixed.
(9)   If a language has SOV, INDEFINITENESS affixes on N (if any) are suffixed.

Table 11.3 Morphological categories of this study*

Affixes on N	Affixes on V
CASE (Stassen, Gilligan)	MOOD (Perkins–Bybee, Gilligan)
GENDER (Gilligan)	TENSE (Stassen, Perkins–Bybee, Gilligan)
PLURAL (Gilligan)	ASPECT (Stassen, Perkins–Bybee, Gilligan)
NOMINALIZATION (Gilligan)	VALENCE (Perkins–Bybee)
INDEFINITENESS (Stassen)	CAUSATIVE (Perkins–Bybee)
DEFINITENESS (Stassen, Gilligan)	
	PERSON-MARKING (SUBJECT) (Stassen, Perkins–Bybee, Gilligan)
	PERSON-MARKING (OBJECT) (Perkins–Bybee)
POSSESSIVE (Gilligan)	NEGATION (Stassen, Perkins–Bybee, Gilligan)
	VOICE (Perkins–Bybee)

*The six nominal and five verbal affixes occurring *above* the line figure in universals (5)–(21). For the five affixes below the line, no *implicational* universals linking affix order and syntactic order are possible.

10)   If a language has NP + Po, NOMINALLZING affixes on N (if
        any) are suffixed with considerably greater than chance
        frequency.
11)   If a language has SOV, NOMINALIZING affixes on N (if any)
        are suffixed with considerably greater than chance frequency.
12)   If a language has SOV, DEFINITENESS affixes on N (if any)
        are suffixed with greater than chance frequency.
13)   If a language has NP + Po, PLURAL affixes on N (if any) are
        suffixed with considerably greater than chance frequency.
14)   If a language has SOV, PLURAL affixes on N (if any) are
        suffixed with overwhelmingly greater than chance frequency.
15)   If a language has NP + Po, MOOD affixes on V (if any) are
        suffixed.
16)   If a language has SOV, MOOD affixes on V (if any) are suffixed
        with greater than chance frequency.
17)   If a language has NP + Po, TENSE affixes on V (if any) are
        suffixed with overwhelmingly greater than chance frequency.
18)   If a language has SOV, TENSE affixes on V (if any) are suffixed
        with greater than chance frequency.
19)   If a language has NP + Po, ASPECT affixes on V (if any) are
        suffixed with greater than chance frequency.
20)   If a language has VALENCE affixes on V (that is,
        INTRANSITIVE/TRANSITIVE/DITRANSITIVE affixes),
        they are suffixed with more than chance frequency.
21)   If a language has SOV, CAUSATIVE affixes on V (if any) are
        suffixed with more than chance frequency.
22)   There is more prefixing on V than on N. If a language has any
        prefixes on N, then any affixes on V will include prefixes with
        more than chance frequency.

   Most of these univerals are formulated with NP + Po or SOV as the
antecedent of an implication whose consequent is suffixing within the
morphology, as in (6): if a language has NP + Po, GENDER affixes on N
(if any) are suffixed. It follows that if gender affixes are *not* suffixed in
some language, that language cannot be NP + Po but must be Pr + NP.
Thus (6) is logically equivalent to (6a) in which prefixes constitute the
antecedent property and Pr + NP is the consequent, and similarly for (7)
and all of the other implicational universals with NP + Po or SOV as
antecedent and suffixing as consequent.
   These universals result in the three-way distribution between affix order
and syntactic order depicted in (4). NP + Po and OV imply the co-
occurrence of suffixing, and prefixing implies Pr + NP and VO. Pr + NP
and VO, on the other hand, imply nothing, since they co-occur with both
prefixing and suffixing, and suffixing likewise co-occurs with both
Pr + NP/VO and NP + Po/OV.

3.2   *The Head Ordering Principle*

These implicational universals point to the reality of a generalization linking morphology and syntax with respect to the notion 'head', as is assumed in fact in recent 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 most immediately dominating category 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 and 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 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. Across languages inflectional affixes are generally unique to some particular category, cf., for example, the case inflections of the various noun paradigms in Latin, or the person and tense inflections of Latin verbs. And hence the nature of the dominating lexical category can be just as readily determined from the affix as from the stem in these cases. As a result of the categorial status of a word containing affixes can regularly be computed from the affix, whereas non-affixes or stems will very often have their categorial status changed through the addition of a (derivational) affix. 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.

On the other hand, in those cases where an affix does not actually change the category of the item to which it attaches, that is, inflectional and some derivational affixes, one could in principle argue that the non-affix is the head. For example, Williams (1981) argues that certain prefixes in English are not heads (for example, *un-* in *unable* and *undo),* and argues more generally for a right-hand 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).* And the number of affixes like *un-* which appear not to determine higher categorial status is relatively small in number. In these cases we shall simply have to state that

un- is homophonous between [+Adj] and [+Verb] values, etc. In this way we can preserve the morphological generalization that lexical category status can always be computed from affixes (both derivational and inflectional), whereas the same generalization cannot be made for stems. And we also gain a consistent generalization linking morphology and syntax with respect to the notion 'head': heads at both levels determine the status of their immediately dominating categories.

Further evidence for this head of phrase/head of word generalization comes from the very universals linking word order within the phrase to morpheme order within the word which we summarized in the last section. Head-final order in the syntax (NP + Po and SOV) guarantees head-final order in the word (suffixing); and head-initial ordering in the word (prefixing) guarantees head-initial ordering in the syntax (Pr + NP and VO). That is, these universals define a common ordering for a common (albeit abstract) entity at both levels, and in the simplest, unmarked case this is what we should expect. We can accordingly define a common Head Ordering Principle, as in (23):

(23)   *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 sufficient on their own. If they were, we would expect a perfect line-up between head categories in the syntax and in the word, and our implicational universals would be reversible: NP + Po would imply suffixing *and* suffixing would imply NP + Po; prefixing would imply Pr + NP *and* Pr + NP would imply prefixing. But there *is* still a need for the HOP as part of the descriptive and explanatory package. Let us review the evidence.

First, whenever we can set up implicational universals defined on basic word orders on the one hand and on suffixing or prefixing for individual morpheme categories on the other, 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/or VO, never NP + Po and/or SOV.

Second, consider the languages that have exclusive prefixing or suffixing for all morpheme categories within each of our samples, as shown in table 11.4. The same implicational pattern emerges: if a language has exclusive prefixing, then it has Pr + NP and VO word orders, not NP + Po and SOV; if it has NP + Po or SOV, it can have exclusive suffixing, but not exclusive prefixing.

Third, the aggregated proportions of prefixing to suffixing in all the languages of our samples provide additional evidence for the HOP (cf.

Table 11.4 Exclusive prefixing and suffixing in the language samples (relative to sample properties)

	Exclusive prefixing %	Exclusive suffixing %
% of VO languages		
Greenberg sample	5	11
Stassen sample	8	44
Perkins-Bybee sample	18	0
Gilligan sample	10	**13**
	Avge 10	Avge 17
% of Pr + NP languages		
Greenberg sample	6	0
Stassen sample	8	46
Gilligan sample	_1_	**12**
	Avge 7	Avge 21
% of OV languages		
Greenberg sample	0	91
Stassen sample	0	61
Perkins-Bybee sample	0	39
Gilligan sample	_0	58
	Avge 0	Avge 62
% of NP + Po languages		
Greenberg sample	0	86
Stassen sample	2	60
Gilligan sample	_0	50
	Avge 0.7	Avge 65

Hawkins and Gilligan 1988): the average ratio of prefixing to suffixing in head-initial (Pr + NP/VO) languages is split roughly evenly, that is, there are significant numbers of prefixes; the average ratio for head-final (NP + Po/OV) languages shows a 4-to-1 to 7-to-1 skewing in favor of suffixes for different categories, that is, suffixes predominate.

3.3 *The suffixing preference*

The HOP cannot be the only principle determining affix order across the world's languages, on account of the suffixing preference. Before addressing the explanatory problem that this raises, let us describe and quantify the facts.

Hawkins and Gilligan (1988) set up the following counterprinciples to the HOP:

(24) GENDER affixes (on N) are suffixed.
(25) CASE affixes (on N) are suffixed.
(26) INDEFINITENESS affixes (on N) are suffixed.
(27) NOMINALIZING affixes (on N) are suffixed.
(28) DEFINITENESS affixes (on N) are suffixed.
(29) PLURAL affixes (on N) are suffixed.
(30) MOOD affixes (on V) are suffixed.
(31) TENSE affixes (on V) are suffixed.
(32) ASPECT affixes (on V) are suffixed.
(33) VALENCE affixes (on V) are suffixed.
(34) CAUSATIVE affixes (on V) are suffixed.

The HOP predicts prefixing in head-initial languages and suffixing in head-final languages. The above counterprinciples predict suffixing in both language types. That is, both sets of principles cooperate to predict the co-occurrence of suffixing with OV and NP + Po, and neither predicts prefixes with these word orders. But for VO and Pr + NP languages, the HOP predicts prefixing while the counterprinciples predict 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.

The proportions of languages with prefixing versus suffixing for these categories across the globe (that is, proportions relative to the numbers of languages that do actually have morphological affixes) are shown in table 11.5. The relative strength of the HOP and the counterprinciples within head-initial languages can be read off the first line in each chart, and the residue of languages accounted for (if any), that is, head-final languages with prefixes, can be seen in the bottom left-hand corner of each. A random distribution in these correlations would assign 25 percent to each of the four cells. The lower the residue's percentage relative to 25 percent, the more insignificant it becomes.

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 or SOV as the antecedent properties, and suffixing as the consequent (or alternatively with prefixing as the antecedent, and Pr + NP and VO as consequent properties). These statements result in the three-way distribution of affix orders set out in (4) that is documented in table 11.5. This distribution is a consequence of the fact that the above counterprinciples always reinforce the HOP's independent predictions for suffixing, and oppose its predictions for prefixing. It will always be possible to formulate implicational universals when counterprinciples and the HOP cooperate in this manner and when there is no residue of languages unaccounted for. If there is such a residue, a statistical universal can be formulated, as long as the size of the residue is not too large.

Table 11.5   Order correlations with head-initial and head-final word order

	GENDER		CASE		INDEFINITENESS	
	Prefixes	Suffixes	Prefixes	Suffixes	Prefixes	Suffixes
VO Pr + NP	20%	30%	0%	50%	25%	25%
OV NP + Po	0%	50%	0%	50%	0%	50%

	NOMINALIZING		DEFINITENESS		PLURAL	
	Prefixes	Suffixes	Prefixes	Suffixes	Prefixes	Suffixes
VO Pr + NP	7%	43%	22%	28%	14%	36%
OV NP + Po	3%	47%	8%	42%	2%	48%

	MOOD		TENSE		ASPECT	
	Prefixes	Suffixes	Prefixes	Suffixes	Prefixes	Suffixes
VO Pr + NP	24%	26%	26%	24%	27%	23%
OV NP + Po	2%	48%	1%	49%	9%	41%

	VALENCE		CAUSATIVE	
	Prefixes	Suffixes	Prefixes	Suffixes
VO Pr + NP	0%	50%	29%	21%
OV NP + Po	6%	44%	7%	43

The nature of the cross-linguistic morphological asymmetry in favor of suffixing can now be summarized. First, all the above counterprinciples to the HOP's predictions favor suffixing over prefixing, and never the other way round. As a result, suffixes are predicted either by both principles (in NP + Po and OV languages) or by the counterprinciples alone (in

Pr + NP and VO languages) and so end up being more frequent than prefixes overall, as Greenberg observed. There is even one set of affixes in our data that is exclusively suffixed (CASE (on N)), whereas there are no affixes that are exclusively prefixed.

Second, the suffixing preference emerges from the correlations between word order and exclusive prefixing and suffixing given in table 11.4. Exclusive suffixing occurs in both word order types (Pr + NP/VO and NP 4- Po/OV), whereas exclusive prefixing occurs only in the Pr + NP/ VO type. In addition, the average number of languages with exclusive suffixing and NP + Po and OV (a co-occurrence predicted by the HOP) far exceeds the average number of languages with exclusive prefixing and Pr + NP and VO (which is equally predicted by the HOP): 65 and 62 percent of NP + Po and OV languages (respectively) are exclusively suffixing; 7 and 10 percent of Pr + NP and VO languages (respectively) are exclusively prefixing. There is therefore a skewing towards suffixing even in those co-occurrences that are predicted by the HOP.

Third, the aggregated proportions of prefixing to suffixing documented in Hawkins and Gilligan (1988) also reveal a suffixing skewing. There are roughly equal proportions of prefixes to suffixes in head-initial languages, and a 4-to-l to 7-to-l skewing to suffixes in head-final languages, making more suffixing overall.

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, that is, 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 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 co-operative 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 percent 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 percent. 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 et al. 1968; Horowitz et al. 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, that is, 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 1983), 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; Marlsen-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 towards 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 (e.g. 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 more informative than the other, 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 (e.g. 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 percent 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; (35)-(37) are three examples from the second author's collection of spontaneous neologisms:

(35) idioticness, it's as good a word as any

(36) I can't morphologize that

(37) 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 (for example, 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 far 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 (for example, *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 for these "malapropisms' to argue that there is only one mental lexicon used in both speech production and speech 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 neighbour 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 neighbour 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, phonoiogically 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 purpose 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: (i) word onsets should tend to be more phonologically variable than word endings, and (ii) 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 later 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 the experiments of Horowitz et al. (1968, 1969) 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 segments 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

percent 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. Moreover, in a more recent
experiment van der Vlugt and Nooteboom (1986) presented listeners
with the same word fragments as used in Nooteboom's earlier study, with
the sole difference that the previously missing portion of the word was
now present but masked by white noise. Under these conditions word
recognition was not significantly different for initial versus final fragments.
This suggests that some information about overall word length can
usefully constrain lexical access even if word-initial portions are missing.
Of course, measures of correct identification such as Nooteboom used
show what the lexical access system is capable of when information is
poor; but measures of relative *speed* of identification, as summarized
above, still suggest that word onsets are disproportionately important in
auditory word recognition.

5 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 inde-
pendent 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). If a
word is homographic between an uninflected and an inflected form (e.g.
German *SAGE),* the uninflected form appears to be processed first, even
when, as in this instance, the inflected form is of far higher frequency
(Guenther 1988). 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. 1979a; Fowler et al. 1985).
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. 1979a). 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), and inflectional suffixes of all kinds tend to be overlooked in script scanning tasks (Drewnowski and Healy 1980; Smith and Sterling 1982). 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 of 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 (38):

(3 8) 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 judgments significantly faster than same-different inflection judgments. 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. 1979a; Cutler 1983; Henderson 1985). A series of experiments by Lukatela and colleagues have investigated the processing of inflected words in Serbo-Croation, using both visual (Gurjanov et al. 1985; Gurjanov et al. 1987; Lukatela et al. 1980; Lukatela et al. 1982; Lukatela et al. 1983) and auditory (Katz et al. 1987) presentation. In brief, these studies find that lexical decision responses to nominative forms are consistently faster than responses to genitive or instrumental forms. Lukatela and his colleagues argue 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. Fowler, Napps and Feldman (1985) argue even more conservatively that

inflected words are represented as a concatenation of their component morphemes. 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. 1979a). 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 (39):

(39)   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 derivationally 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 et al. 1979b). However, the matching effect, reported above, which Manelis and Tharp found for suffixes does not hold for prefixes (Segui and Zubizarreta 1985). In general, 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 pseudo-prefixes *(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 et al. 1979b; Fay 1980; Taft 1981; Henderson et al. 1984). More recently, there have been results from eye-movement studies supporting the notion of prefix-stripping in reading (Lima 1987), and evidence for the same effect in auditory word recognition (Taft et al. 1986). However, Taft's most recent evidence (Taft 1988) suggests that the strong version of the prefix-stripping model (access via stem only) may not be warranted; instead, Taft now proposes (separate) representation of both prefix and stem in the input to the lexicon. Decomposition of prefixed words nonetheless appears to be a routinely available strategy in word recognition, with the main question still at issue being the content of lexical entries for prefixed words.

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 1985) 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 present 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; Laudanna and Burani 1985). 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' 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 - e.g. *byte* - are rarer than new meanings for old stems - e.g. *chip* - or new derivations - *debug)*. Thus as long as lexical or syntactic processing are considered distinct operations in production and comprehension, stems and affixes must in some sense 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; Job and Sartori 1984). Most of these errors happen to involve suffixes, but this may reflect the fact that the reports deal mainly with Italian- and English-speaking patients, and both Italian and English contain 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 languages in which all inflectional affixes are suffixed. It is to be hoped that psycholinguists will soon turn their attention to those few languages with inflectional prefixes (for example, 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. (See Segui and Zubizarreta 1985 for further elaboration of this argument.)

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 Explaining the Suffixing Preference

In this section we bring together the linguistic evidence of cross-linguistic asymmetries in affix attachment, and the psycholinguistic 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, that is, words consisting of just one stem and one affix. English examples are *walk + ing, 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 consider some facts about language change that are of relevance for the suffixing preference (section 6.4).

6.1 *Order of computation for stems and affixes*

The cross-linguistic evidence of implicational and distributional universals shows that languages prefer stems to precede affixes (section 3). The psycholinguistic 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 (section 4). The psycholinguistic evidence on affixes suggests that stems and affixes must at some level be processed separately (section 5).

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 initial 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, that is 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, mis argument follows inevitably from the fact that affixes convey primarily syntactic information, stems primarily lexical-semantic information, if one assumes that lexical processing precedes syntactic and higher-level semantic processing (cf. below). Case affixes, for example, function to integrate a noun or noun phrase into the overall interpretation of a clause, and they are invariably suffixed. But 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.

In fact, all current psychological models of comprehension are based on the tacitly accepted general ordering of lexical before syntactic before higher-level semantic processing. But 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 or feedback between any and all levels. (Of course, there are many intermediate models, which allow feedback only between adjacent levels, or only between certain levels, or only under certain conditions, that is, 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 to 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. If it were, we would expect more prefixing. This limited conclusion, of course, says nothing about other kinds of syntactic information, for example, word order information. Our argument does, however, amount to a claim for non-interactive 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.

6.2 *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 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 pre-

dictable 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 in its implications for psycholinguistic 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 *urn* has been infixed after the initial consonant, means 'he is becoming strong.') We believe that the infrequency of infixing is also motivated by a general processing consideration, namely: languages are reluctant to break up structural units. This applies not only to morphemes but also to phrasal units: witness the relative infrequency 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, that is, just when the word has been recognized. There is yet another processing reason for avoiding this, however: the relative insalience of middle positions in a word. The evidence summarized in section 4.5 suggested that the middle of a word is its least salient part. It may be that affixes are simply too informative to be inserted into the *least* salient position in a word, that is, 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, that is, not predictable.

6.4 *The suffixing preference and language change*

Notice finally that there are some relevant considerations of a historical nature that need to be taken into account in connection with the suffixing preference (cf. Hall this volume for detailed discussion).

Givon (1979) makes three interesting observations: (i) affixes typically derive historically from independent words, for example, verbal affixes from independent auxiliaries and modals; (ii) affix orders are frozen relics of earlier syntactic orders, for example, auxiliaries regularly occur to the right of the (non-finite) verb in SOV languages, SOVAux, resulting in a suffix when the auxiliary becomes morphologically bound, that is, SOV_{af}; and (iii) all current language families were originally SOV in their syntax. It is tempting to infer from these observations that the true explanation for the suffixing preference is a historical one. Given assumption (iii), coupled with rightward positioning of auxiliaries and modals relative to the verb in SOV languages and the diachronic drifts of (i) and (ii), the suffixing preference would appear to be explained.

Unfortunately, the crucial SOV assumption (iii) is quite unsupported. The proportion of OV to VO languages and of NP + Po to Pr + NP languages is currently 50-50, as was shown in table 11.1 above, and this random distribution provides no foundation for the assumption of a 100 percent skewing in favor of OV in the past. 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 syntactic reconstruction for Proto-Indo-European most consistent with language universals is VO and Pr + NP, rather than the reverse.

Assumptions (i) and (ii), however, are both reasonable and well supported (though there are some counterexamples to both, cf. Comrie 1981:209-11). And Hall (this volume) develops an interesting account of the suffixing preference which integrates the processing considerations that we have developed here with these diachronic facts. Specifically, he argues that our order of computation consideration facilitated the drift from adjacent words to stem and affix when a suffix would result, and opposed it when a prefix would have resulted, and this produced the synchronic suffixing preference as well as a retention of independent words corresponding to the bound morphemes of suffixing languages (for example, prepositions in head-initial languages are generally independent

words; postpositions in head-final languages are suffixed as often as they are independent words).

We welcome this integration of Psycholinguistics and diachrony, and this view of processing as a facilitator of certain changes and a check on others. The diachronic dimension, however, does not provide any explanation for the Head Ordering Principle linking syntax and morphology, since affixes (the heads of words) do not always derive historically from head categories in the syntax (cf., for example, definiteness, indefiniteness, gender and plural affixes on nouns, which generally derive from various modifiers on the nominal head, cf. Greenberg 1978). And if one prefers some other account of the prefixing/head-initial and suffixing/head-final correlation that the HOP defines, there will be no ready historical explanation for it either (contrary to what Hall this volume suggests), since die relevant syntactic heads and modifiers from which prefixes and suffixes derive are not positioned with sufficient consistency in relation to the future stem to guarantee the prefixing/head-initial and sufrixing/head-final correlation (for example, the kinds of syntactic determiners and deictic elements from which definiteness, indefiniteness and gender affixes derive may regularly precede or follow the head noun in both head-initial and head-final languages, cf. Hawkins 1983).

6.5   *Conclusions*

This paper has attempted to bring together linguistic and psycholinguistic 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 revealed an asymmetry in favor of suffixing over prefixing. Two separate lines of psycholinguistic research have been drawn upon in providing an explanation: 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 psycholinguistic 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 (initial) 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.

Notes

This paper is a much revised and updated version of a paper that was originally published in *Linguistics,* 23 (1985), 723-58, under the title 'The suffixing preference: a processing explanation'. The original paper was co-authored with

Gary Gilligan. The most recent version of our prefixing and suffixing universals in relation to basic word order across languages can be found in Hawkins and Gilligan (1988).

1 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.

2 Japanese is rare among prenominal relative clause languages in not having any subordination (S) indicators within the relative clause. Generally, these languages employ either a clause-final complementizer (Basque, Lahu, Chinese) or a distinctive participial verb form, again in clause-final position (Dravidian languages, Turkish). These devices will, of course, enable the parser to construct S prior to encountering the head noun of NPo and will (in the case of participial verbs) avoid a misanalysis of the subordinate verb as a matrix verb. For an explanation of why S indicators cannot be clause-initial in prenominal relatives (even though they can be both clause-initial and clause-final in postnominal relatives), cf. Hawkins (1988b).

3 Notice that most processing explanations for syntactic universals are given in terms of comprehension rather than production strategies. Ultimately it is likely that the explanation for these cross-linguistic facts will involve a complex interplay of both comprehension and production strategies. But since relatively little is known about production at the moment, the findings from comprehension experiments are being used as an index of processing ease or difficulty in general (cf. further Hawkins 1988b).

4 The evidence we have presented in this section suggests (contra Frazier and Rayner this volume) that left-branching relative clauses *are* more difficult for processing, though not for the 'depth' reasons advanced in Yngve (1960). Our primary evidence is the striking asymmetry in their distribution across languages compared with the word orders of table 11.1, coupled with the kinds of Minimal Attachment that they so regularly invite (cf. further Hawkins 1988a, b).

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