Heads[1]

ARNOLD M. ZWICKY

Department of Linguistics, The Ohio State University

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1. THE PROBLEM

Recent work on morphology – Lieber, 1981; Williams, 1981; Kiparsky, 1982; and Selkirk, 1982, in particular – has extended the notion of HEAD from syntax into new areas in morphology. In particular, these writers propose that in forms with derivational affixes, like English *happiness*, the affix is the head of the combination; for instance, Kiparsky assumes (following Lieber) 'that all word formation is endocentric', meaning by this 'that the category of a derived word is always non-distinct from the category of its head, in English usually the rightmost constituent (cf. Williams, 1981)' (133).

What makes this proposal attractive is that it allows us to take advantage of a general principle, called Percolation by most of these writers, which requires that the category of a construct and the category of its head be identical, so that assigning *-ness* the category N has the effect of 'projecting' that category (rather than the category of the other constituent, the A *happy*) onto the construct *happiness*. Percolation also requires that other morphosyntactic features, such as gender and number, be identical for the construct and its head; Percolation then plays exactly the same role in morphology that the Head Feature Convention of Gazdar & Pullum (1982) plays in syntax. On this analysis, *happiness* belongs to the category N for the same reason that *those penguins* belongs to the category NP, that is, N-with-two-bars: because the head of each construct (*-ness* and *penguins*, respectively) is itself an N.

Now it would be sophomoric to criticize this analysis merely because its principal move, assigning *-ness* to the category N, is utterly untraditional and therefore astonishing. On the other hand, anyone who puts this analysis forward surely has some burden to show that there is a reason for believing in it beyond the one fact that it appears to get things to work.

The Percolation proposal depends, first, on some unexamined assumptions about heads in syntax, and, second, on a claimed parallelism between syntax and morphology. I will show (in Section 2) that there are a number of distinct

syntactic notions that might be candidates for the title 'head', and (in Section 3) that a similar profusion of candidates appears in morphology. Five of the syntactic notions clearly require representation in a grammar, independently of the need to state a syntactic percolation principle. The 'head' for the purposes of syntactic percolation can be identified with one of these, the morphosyntactic locus. The 'head' in morphological Percolation must play a double role; it is the morphosyntactic locus, the morphological constituent that bears inflectional marks, AND it is the morphological constituent that determines the category of the construct. This second role, as category determinant, corresponds (Section 4) to no useful syntactic notion, and in syntax the category determinant (insofar as there is one) and the morphosyntactic locus do not in general coincide. Indeed (Section 5) they do not generally coincide in morphology either, where, I argue, the location of inflectional marks is not to be managed via percolation, and where category determination resides not in constituents but in rules performing morphological operations. There is a place for a morphological counterpart to the Head Feature Convention, but it does not apply generally in word formation, being restricted to certain types of compounding.

2. HEADS IN SYNTAX

The intuition to be captured with the notion HEAD is that in certain syntactic constructs one constituent in some sense 'characterizes' or 'dominates' the whole. From these basic ideas, however, it is possible to move in many directions. Moreover, the syntactic theory in which the concept functions might be more or less formalized, the name *head* might or might not be used for the concept, and the head-like concept might play any of several different roles in the theory (it might be a primitive concept, it might be defined in terms of other concepts, it might serve as a pretheoretical notion with an operational definition, and so on). Here, for instance, is Jespersen presenting what I take to be a semantic-argument (Section 2.1.1) treatment of heads; the theory is informal, the word *head* is not used – instead Jespersen speaks of words with 'primary rank' – and the notion of rank is defined in terms of a primitive (semantic) notion of definition, qualification, or modification:

> In any composite denomination of a thing or person..., we always find that there is one word of supreme importance to which the others are joined as subordinates. This chief word is defined (qualified, modified) by another word, which in turn may be defined (qualified, modified) by a third word, etc. We are thus led to establish different 'ranks' of words according to their mutual relations as defined or defining. In the combination *extremely hot weather* the last word *weather*, which is evidently the chief idea, may be called primary; *hot*, which defines *weather*, secondary, and *extremely*, which defines *hot*, tertiary (1924: 96).

I will not attempt to survey the history of head-like concepts in different syntactic theories. The task would be gargantuan,[2] and in any case it is not necessary. My concern is not with the history of the matter, but with its logic. What is important is the set of notions that syntactic theory should make available, not the set that happens to have been developed extensively.

The initial question is then what head-like notions the theory of grammar must supply. Three such notions are needed if syntax is to interface with other components of grammar, in particular semantics, the lexicon, and (inflectional) morphology. The first of these picks out the constituent acting as the SEMANTIC ARGUMENT, as opposed to the semantic functor, in a syntactic combination (Section 2.1.1). The second picks out the SUBCATEGORISAND, the constituent that is lexically subcategorized with respect to the sister constituents it can occur with (Section 2.1.2). The third picks out the MORPHO-SYNTACTIC LOCUS, the constituent on which inflectional marks will be located (Section 2.1.3).

In addition, we expect any syntactic theory to give some account of government and of concord. In both some constituent is 'dominant' – the constituent determining government (Section 2.2.1) or the constituent deter-mining concord (Section 2.2.2).

These five notions (semantic argument, subcategorisand, morphosyntactic locus, governor, determinant of concord), it seems to me, must be incorporated in any theory of grammar. It is natural then to expect that an independent primitive notion of HEAD will be unnecessary in syntax and that one of these five will serve in its place. In Section 2.3 I argue that the head for the purposes of syntactic percolation (in a principle like the Head Feature Convention) is the morphosyntactic locus. The remaining four notions are intimately related; subcategorisands are semantic functors, and paraphrasing Bach's (1983:70) succinct formulation, functors agree with their (semantic) arguments and govern them. If this position can be maintained, then the five notions reduce to two independent primitives: the semantic argument and the morphosyntactic locus.

The remaining portions of my syntactic discussion take up several side issues. Section 2.4 examines evidence about headship from rules of particular grammars which refer directly to heads. Section 2.5 considers two operational criteria for heads in syntax. And Section 2.6 briefly examines a head-like notion that figures prominently in dependency grammar.

To clarify the differences between the various notions I will be examining,

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[2] Some measure of the size of this task can be gained from Section 1 of Muysken, 1982, which summarizes the proposals of 19 works of X-bar theory with respect to which categories are the heads of which others. Despite the fact that the 19 works share a great many assumptions, including the 'conviction that natural language is in large part characterized by endocentric n-tuple articulation' (Muysken, 1982: 58), no two of them agree on the details of the category sets and bar assignments.

I will discuss how they apply to the following combinations of constituents in English:

1 – Det + N, as in *those penguins*;
2 – V + NP, as in *control those penguins*;
3 – Aux + VP, as in *must control those penguins*;
4 – P + NP, as in *toward those penguins*;
5 – NP + VP, as in *we control those penguins*;
6 – Comp + S, as in *that we control those penguins*.

Not all aspects of this list are unproblematic, but a certain degree of specificity is necessary if actual examples are to be made relevant to the issues at hand. I have been conservative in my assignment of categories (not assuming ahead of time that V and VP are subcategories of the same category, for instance, and not lumping Aux and V together, or P and Adv), and the single constituent division that might be viewed as controversial, Aux + VP in 3, is one for which there is good evidence, from the familiar phenomena of so-called Verb Phrase Deletion (*I intend to control those penguins, and you must*) and Verb Phrase Fronting (*Control those penguins you must*).

2.1 *Relating syntax to other components*
In the next three subsections I consider semantic arguments, subcategorisands, and morphosyntactic loci.

2.1.1. *The semantic argument.* Like Jespersen in the quotation above, we could take the head/modifier distinction to be at root semantic: in a combination X + Y, X is the 'semantic head' if, speaking very crudely, X + Y describes a kind of the thing described by X. On this basis, N is the semantic head in Det + N (*those penguins* describes a kind of penguin), and VP is the semantic head in Aux + VP (*will leave* describes a kind of leaving).

A sharpening (and extension) of this proposal builds on the fact that in the semantic interpretation of Det + N, Det represents a functor on an argument represented by N, and in the semantic interpretation of Aux + VP, Aux represents a functor on an argument represented by VP. We might then propose that in X + Y, X is the 'semantic head' if in the semantic interpretation of X + Y, Y represents a functor on an ARGUMENT represented by X.[3]

If so, then in V + NP, P + NP, and NP + VP, NP is the semantic head, since the semantic interpretation of all three constructs involves a functor

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[3] A serious note of caution is in order here. The mechanisms of a system of logic rich enough to provide the basis for a description of natural language semantics will not themselves force a decision as to what is functor and what is argument. With a certain amount of formal ingenuity, a Montague-style semantics that treats Det as a functor on the argument N can be redone as a system treating N as a functor on the argument Det. The intuitively correct assignment of certain items as arguments and others as functors can be guaranteed only if substantive assumptions about the relationship of semantics and syntax are made, as in Klein and Sag (to appear).

(represented by V, P, or VP) on an argument represented by NP. And S is the semantic head in Comp + S, since the semantic interpretation of the construct involves a functor on propositions as arguments.

2.1.2. *The subcategorisand.* In some constructions, one slot has a special status in that the items that can fill that slot must be listed in the lexicon, while its sister constituents are not so constrained. These are instances in which one constituent is SUBCATEGORIZED with respect to its ability to occur with a particular set of sister constituents. The verb *give* is subcategorized to occur with either NP NP or NP *to* + NP as its sisters (*give Kim money, give money to Kim*); *donate* is subcategorized to occur only in the second of these two constructions (**donate Kim money, donate money to Kim*).

Subcategorization is associated with certain rules of constituent combination, namely those introducing lexical categories. I will assume that rules of constituent combination are paired with principles of semantic interpretation, so that there will necessarily be a close relationship between subcategorization and semantic interpretation.

Turning now to my list of sample constructions, I note first that since neither category in NP + VP is lexical, there is no subcategorisand there. In each of V + NP, Aux + VP, P + NP, and Comp + S, there is one lexical and one phrasal category, so that if there is to be a subcategorisand, it must be the lexical category. This is certainly correct for V in V + NP; the subcategorization of verbs according to the sister constituents they combine with was illustrated above. It also seems correct for Comp + S, since complementisers are subcategorized according to whether they combine with full finite clauses (*that the penguins are flying*), with finite clauses lacking a constituent (*what the butler saw*), with marked-infinitive constructions (*for the penguins to be flying*), and so on, and different principles of semantic interpretation are called for in each situation.

I cannot discuss the remaining constructions without supplying considerable, and rather theory-specific, analytic detail, which would take us unprofitably far from the issues at hand. I will comment briefly on Det + N only. Here I would want to maintain that a construction like *those penguins* results not from a single rule combining Det with N, but rather from (at least) two rules, one combining Det with a phrasal category Nom, and the other permitting an N unmodified by adjectives to be one of the realizations of Nom. Such internal structure within NPs is not particularly controversial (indeed, Jackendoff (1977) goes well beyond the minimal structure I am suggesting here), but assuming only the intermediate phrasal category Nom entails that if there is a subcategorisand in Det + N, it is Det, because Det is the only lexical category in the rule combining Det and Nom. This is a welcome consequence, given the familiar fact that determiners are lexically subcategorized according to whether they can combine with singular count nouns (*each*

*penguin/*penguins/*sand*), plural count nouns (*many *penguin/penguins/ *sand*), or mass nouns (*much *penguin/*penguins/sand*).

2.1.3. *The morphosyntactic locus*. One way in which a constituent can 'characterize' a construct is that it can be the bearer of the morphosyntactic marks of syntactic relations between the construct and other syntactic units.

There are two significantly different understandings of the phrase 'the bearer of the morphosyntactic marks of syntactic relations'. In the first, the marks are actual bits of inflectional material, and we have an operational criterion for headship: the (actual) inflectional locus within a construct is a candidate for the head of the construct.

In the second understanding, the marks are abstract properties, morpho-syntactic features associated with constituents at various levels, and we have a theoretically primitive notion, picking out the constituent (if there is one) that must share morphosyntactic features with the construct as a whole. This is a general notion of *morphosyntactic locus* which is to be considered as an explication of headship in syntactic theory. The actual inflectional locus will serve as a guide to the morphosyntactic locus in specific cases, at least in languages with sufficiently rich inflectional morphology. Speaking very loosely, the morphosyntactic locus is the 'potential inflectional locus', the constituent on which inflectional features will be marked if the language has the appropriate morphology.[4]

Note that the morphosyntactic locus is not merely a PLACE, but a particular CONSTITUENT, and the process of locating inflectional marks may involve several stages, at different levels of constituent structure. In the SOV language Hidatsa, for instance, features of mood associated with an S are associated with the morphosyntactic locus in NP + VP, VP; and these features are associated with the morphosyntactic locus in NP + V, V, where they are realized as suffixes (see Zwicky, to appear).

Now consider the English sample constructions. The actual inflectional loci in cases 1–3 are quite clear. N is the inflectional locus in Det + N; the distinction between singular *the child* and plural *the children* is linked to number distinctions in VP. Aux is the inflectional locus in Aux + VP; the number and person distinctions in *be/am/is/are/was/were controlling those penguins* are linked to these distinctions in the subject NP. And V is the inflectional locus in V + NP, because of the person and number distinctions expressed in *control/controls those penguins*.

The distribution of marks of tense gives information about the inflectional loci in NP + VP (VP) and in Comp + S (S). In the first case, person and number

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[4] I am assuming that general syntactic theory can be explicit enough about morphosyntactic loci to permit them to be referred to even in the grammars of language with little or no inflectional morphology. This must certainly be the case if MORPHOSYNTACTIC LOCUS is to be a theoretically primitive notion (like NOUN or CONSTITUENT), as I propose (in Section 2.3) that it should be.

are marked on both the NP and VP, but only the VP bears the marks of tense. In the second, only S bears the marks of tense.

English P + NP has no actual inflectional locus: the NP does bear the marks of person and number, but person and number play no role in the distribution of P + NP constructs; and P in English is uninflected. However, there is a phenomenon long recognized as analogous to case inflection here, namely the choice of one preposition over another in constructions like *inform Sandy of the news* and *tell the news to Sandy*, where the prepositions *of* and *to* mark particular syntactic arguments of the verbs. The analogy suggests that P is the morphosyntactic locus in P + NP.

2.2. *Syntactic domination*

Both government and concord constitute arenas in which one constituent in a construct can intuitively be said to 'dominate' another. These I examine in the following two subsections.

2.2.1. *The governor.* Syntactic government, speaking rather loosely, is the selection of the morphosyntactic shape of one constituent (the GOVERNED, or SUBORDINATE, constituent) by virtue of its combining with another (the GOVERNOR).

Governors are thus easily confused with subcategorisands. Intuitively, the difference is that subcategorization concerns the very possibility of one constituent's combining with some other co-constituent(s), while government concerns the form that a co-constituent has in such a combination. The distinction is analogous to that between word formation rules (which say when morphemes can combine with one another) and allomorphy rules (which say what shapes morphemes take when they combine). I am assuming that rules of combination, syntactic or morphological, have principles of semantic interpretation associated with them, from which it follows that an instance of subcategorization is paired with a semantic principle, but that an instance of government lacks this semantic correlate.

Government is also easily confused with concord. Again speaking intuitively, in both phenomena morphosyntactic features of one constituent can determine the morphosyntactic features of a sister constituent, but in concord the same features are involved in the determining and the determined constituents, while in government different features are involved.

There are, in fact, two rather different sorts of government. In government of the first type, the governed constituent bears features simply by virtue of its occurring in a construction. In government of the second type, a lexical cleavage within the governor is projected as inflectional marks on the governed constituent.

Of my six example constructions in English, V + NP, P + NP, and NP + VP illustrate government of the first type. V and P are the governors in V + NP and P + NP, respectively, and VP is the governor in NP + VP, since accusative

forms of personal pronouns are required in the first two combinations, while nominative forms occur for NP in the third: *control them*, *to them*, but *they fly*.[5]

A typical instance of the second type of government occurs in languages (like Latin and German) in which some verbs require that their direct object NPs be marked with one case (the dative, say), while other verbs require that their direct object NPs be marked with a different case (like the accusative). A lexical division within the set of verbs is projected as a case difference on the objects, the verbs themselves bearing no marks of the distinctions. And a single principle of semantic interpretation covers both situations, so that this is not an instance of subcategorization.

On similar evidence, Aux is the governor in Aux + VP.[6] The English category of auxiliary verbs divides into several subtypes according to the inflectional form of the VP that follows, and the auxiliaries are themselves unmarked with respect to these lexical distinctions. For instance, the modals require unmarked-infinitive, or 'base', VPs (*should control the penguins*), progressive *be* requires present participial VPs (*are controlling the penguins*), and passive *be* and perfective *have* require past participial VPs (*are controlled by penguins*, *have controlled the penguins*). I see no reason to claim that different principles of semantic interpretation are at work for the different subtypes – Gazdar, Pullum & Sag (1982: 598) introduce the auxiliaries with a rule schema that includes a single interpretive principle for the whole set – so that we have here a fairly clear case of the second type of government, rather than subcategorization.

2.2.2. *The determinant of concord.*

Yet another sense in which one constituent can 'dominate' another is for the first to determine concord features, realized inflectionally, on the second.

The clearest examples of concord – subject–verb agreement in English is one such – are those in which the relevant feature is realized inflectionally on both constituents. What is not necessarily so clear even in these examples is

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[5] The assignment of V and P as the governors in V + NP and P + NP is intuitively correct and has not been disputed to my knowledge. However, many have had reservations about saying that VP governs NP; it is somewhat counterintuitive to say that the VP 'causes' nominative marking on its NP subject. These reservations are manifested in analyses that treat NP + VP as exocentric, or as endocentric with a head other than NP or VP. In an exocentric treatment of NP + VP, NP receives the nominative as the unmarked, or default, case. In a *tertium quid* endocentric treatment, the governor could be an element bearing (abstract) features of intonation contour, sentence type, tense and modality, negation, and/or the like; Robinson (1970: 274f.) develops an analysis along these lines, citing precedents in Harris and early transformational grammar. In the variant of this approach adopted in Chomsky, 1981, the third constituent is a phonologically empty element INFL, which assigns case to a subject NP in the same way that V does to an object NP.

[6] Pullum and Wilson (1977) seem to have been the first to develop an analysis of the English auxiliaries based on the explicit recognition that the relation between an auxiliary and the verb form following it is one of government in the traditional sense.

which constituent determines concord; such English data as *The penguin swims* versus *The penguins swim* do not tell us whether the NP or the VP is the determining constituent for the purposes of concord. The existence of inherently plural, but morphologically unmarked, nouns like *people*, together with the nonexistence of inherently singular, but morphologically unmarked, verbs, suggests that the NP is the concord determinant in English. And the NP + VP case is clearer in some other languages. In Swahili, for instance, nouns divide lexically into a number of gender classes, each marked overtly by a prefix on the noun; verbs occur with corresponding (often identical) prefixes, but each verb can occur with all of the prefixes. These facts indicate very clearly that the subject NP is the determinant of concord on the VP, and insofar as we are willing to propose that the direction of determination is universal, they suggest that NP is the concord determinant in English as well.

N is the concord determinant in Det + N, given English facts like *this penguin* versus *these penguins* and the clear directionality of determination in languages with arbitrary gender, like French and German. English gives no evidence about the concord determinant in V + NP, but languages like Hungarian, in which the verb carries marks agreeing with features of the object, suggest that NP is the concord determinant.

2.3. *The head in syntactic percolation*

It is now time to observe that among the five head-like notions I have discussed there are only three distinct candidates for the title of head in syntax. One is the semantic argument, The second is, rather embarrassingly, its exact opposite, the semantic functor. The third is the morphosyntactic locus.

The semantic arguments in my six sample constructions are, in order, *N* in Det + N, *NP* in V + NP, *VP* in Aux + VP, *NP* in P + NP, *NP* in NP + VP, *S* in Comp + S. The list of determinants of concord is not distinct from this list. The subcategorisands and governors are simply the other choices in each pair, that is, the semantic functors: *Det* in Det + N, *V* in V + NP, *Aux* in Aux + VP, *P* in P + NP, *VP* in NP + VP, *Comp* in Comp + S.

The proposal that the determinants of concord are universally semantic arguments dates at least to Keenan (1974); see also Bach & Partee (1980) and the formulation of the idea as the Control Agreement Principle of Gazdar & Pullum (1982: 30 f.). The further connection to government and subcategorization, again on a universal basis, is explicit in Bach (1983) (who uses the term *selection* for what I have called subcategorization). Even if concord, government, and subcategorization can be reduced to a single argument–functor relation in universal grammar, it might (as I believe is the case) still be necessary to distinguish them in grammars and in syntactic theory, on the grounds that the phenomena falling under these three headings are to be described by rules which are of different types and which are subject to different sorts of conditions. Nevertheless, when it comes to finding a suitable

candidate for head in syntax, there is really only one nominee here, with two mirror–image variants.

The morphosyntactic loci in the sample constructions are *N*, *V*, *Aux*, *P*, *VP*, *S* – matching the semantic arguments only for the first and last constructions, *N* in Det + N and *S* in Comp + S, and matching the semantic functors in the remaining examples, *V* in V + NP, *Aux* in Aux + VP, *P* in P + NP, and *VP* in NP + VP.

The most parsimonious solution to the problem of selecting heads in syntax is to employ, if possible, a notion that already figures in the grammar – the semantic argument, the semantic functor, or the morphosyntactic locus.

It is easy to see that neither the semantic argument nor the semantic functor could be the distinguished constituent for the purposes of the Head Feature Convention, that is, for the purposes of percolation in syntax. I take it as a rock-bottom, uncontestable requirement on the selection of heads for the purposes of this principle that Det + N should belong to an N-type category (that N should be its head) and that V + NP should belong to a V-type category (that V should be its head). But N is the semantic argument in the first case, V the semantic functor in the second. I would also want to maintain (though these claims have been contested) that for the purposes of the Head Feature Convention NP + VP should belong to a VP-type category, and that Comp + S should belong to an S-type category. But VP is the semantic functor in the first case, S the semantic argument in the second.

In contrast, the morphosyntactic locus fits all these requirements perfectly. I conclude that unless there is very good reason for doing otherwise, the morphosyntactic locus should be identified as the head in syntactic percolation. In certain constructions, then, one constituent – as for which one, that must be stipulated (see Gazdar & Pullum, 1982: sec. 8) – serves both as the bearer of morphosyntactic features and as the constituent belonging to the category of the construct as a whole.

2.4 *Grammar–internal evidence*

If a universal principle (governing percolation in this instance) can refer to heads, there is no reason why rules of particular languages could not do so as well. It would be especially nice to have some generalizations about the linear ordering of constituents which made crucial reference to heads, for then their application to unclear cases might provide evidence about which constituents are the heads in these cases.

Hudson (1980: 182–185) calls attention to this possibility, alludes to several sets of data that might illustrate such generalizations, and makes the important connection to studies of word order from the point of view of language universals and typology (such as Greenberg, 1963, and Vennemann, 1975). This same connection is emphasized throughout Anderson (1976), which uses the 'principle of natural serialization' of Bartsch and Vennemann

(1972: 131) as a tool for selecting heads for various constructions in English.[7]

A simple example of the sort of rule we are looking for is suggested by Greenberg's Universal 16: 'In languages with dominant order VSO, an inflected auxiliary verb always precedes the main verb. In languages with dominant order SOV, an inflected auxiliary always follows the main verb'. Consider an SOV language; it puts VP after NP in S, V after NP in VP, and Aux after VP in VP. The generalization would appear to be that the heads of V-type constructs are last in those constructs. But this generalization can be stated only if S is a V-type construct (V with three bars, say). What remains to be shown is whether the generalization does in fact hold for some SOV languages; the appearance of the phrase 'dominant word order' in Universal 16 means that much more must be said about particular languages.

2.5. Operational criteria

I now mention two operational tests that have often been suggested as ways of picking out heads: look for the constituent that is distributionally equivalent to the whole construct, and look for the obligatory constituent. I can think of no *a priori* reason for supposing that these criteria should be elevated to theoretical notions, and in fact they appear to be imperfect guides to the head in syntactic percolation.

2.5.1. *The distributional equivalent.* An operational criterion says that the head characterizes a construct in the sense that it is the one constituent that belongs to a category with roughly the same distribution as the construct as a whole.

In Bloomfield's (1933: 194) loose formulation, the head is the constituent that belongs to 'the same form-class' as the construct. In Hockett's (1958: 184) clearly distributional formulation: 'The constituent whose privileges of occurrence are matched by those of the constitute is the *head* or *center*'. Historically, the most careful presentation of this structuralist notion is in Harris (1951: ch. 16), where the word *head* is not used, though the substitutability criterion of Wells (1947) is extensively employed and a superscript notation (of which the current bar notation is a simple variant) is developed for indicating the constituent that is distributionally equivalent to the construct.

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[7] Neither of these works is particularly satisfying. Hudson merely sketches some linearization rules out of the context of other relevant rules, so that it is hard to judge the adequacy of the generalizations. Anderson's discussion is much more extensive, but his hewing to natural serialization results in some very odd assignments of heads – not only Aux in Aux + VP, which is nonstandard but for which there is good evidence, but also Adj in Adj + N and Adv in VP + Adv. These assignments contradict those needed for percolation in syntax. Indeed, the notion of head that Anderson and Hudson are using is that of dependency grammar, which is probably not the same notion as the head in syntactic percolation (see Section 2.6).

For there to be a distributional equivalent, the construct must have SOME constituent belonging to a category with roughly the same distribution as the construct – that is, the construction must be endocentric, in the traditional sense of this word. On this understanding, only the first three of my example constructions clearly have distributional equivalents, and the last perhaps has one: N is the distributional equivalent of Det + N, since the distribution of Det + N is roughly the same as the distribution of Ns like *penguins* and *Kim*;[8] V is the distributional equivalent of V + NP, since the distribution of V + NP is roughly the same as the distribution of Vs like *write* and *vanish*; VP is the distributional equivalent of Aux + VP, since the distribution of Aux + VP is roughly the same as the distribution of VPs like *control those penguins* and *go to Fresno*; and S is perhaps the distributional equivalent of Comp + S, since the distribution of Comp + S is roughly the same as the distribution of S's like *we control those penguins* – but only very roughly, for although S and Comp + S share a context in *realise (that) we control those penguins*, only S occurs as an independent unit (**That we control those penguins*), and only Comp + S occurs in the context of *That we control those penguins astonishes everyone*.[9]

In contrast, the P + NP construct has the distribution of neither P nor NP. Instead, since it combines with V alone or with V and NP to make a construct of category VP (*move towards those penguins, put the suntan lotion on those penguins*), it has roughly the distribution of Adv. The NP + VP construct has the distribution of neither NP nor VP. Instead, it has a unique distribution and is assigned to a new category S.

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[8] The discussion by Lyons (1977: 392) indicates that the application of the criterion is no simple matter. Lyons asserts that it is 'obviously incorrect' to say that Det + N is endocentric; the construct has the distribution of a proper name or personal pronoun, not a common count noun. In later discussion (Section 11.4), he broaches the possibility that 'determiners, despite their conventional treatment as modifiers of the nouns with which they occur, may often be regarded, from a syntactic point of view, as heads rather than modifiers'. Thus, the criterion can be used to argue that N is the head, that neither constituent is, or that Det is, depending on which set of facts you look at.

[9] Though P + NP and NP + VP are certainly exocentric from a distributional point of view, and Comp + S might be, some or all of them are treated as endocentric in certain current syntactic theories. In Gazdar and Pullum (1982), for instance, all three are analyzed as endocentric: P and P + NP are both subcategories of P; VP and NP + VP are both subcategories of VP, hence also of V; and S and Comp + S are both subcategories of S, hence also of V. These category assignments play a crucial role in the placement of inflectional marks (Section 2.1.3 above). The assignment of P + NP to PP – that is, P with one or more bars – is very nearly universal amongst X-bar syntactic theories (e.g., generalized phrase structure grammar, lexical-functional grammar, government and binding, Jackendoff's 1977 X-bar syntax). The assignment of S and Comp + S as subcategories of one category is equally widespread. On the other hand, some analysts treat NP + VP exocentrically, as belonging to a category S distinct from V, while others treat it endocentrically, as a subcategory of V; see the chart summarizing eight different proposals in Gazdar *et al.* (1983: 3).

Notice that these distributional equivalents differ from the morphosyntactic loci (VP is the distributional equivalent, but Aux the morphosyntactic locus, in Aux + VP), the semantic arguments (V is the distributional equivalent, but NP the semantic argument, in V + NP), and the semantic functors (N is the distributional equivalent, but Det the semantic functor, in Det + N). The distributional equivalent represents a genuinely new head-like notion.

2.5.2. *The obligatory constituent.* If the head of a construct truly CHARACTERIZES it, then we should expect the head to be the part that is present in all its occurrences – that is, we should expect the head to be obligatory (and non-heads to be optional). In the reconstruction of dependency grammar in constituent–grammar terms by Robinson (1970), this criterion is paramount: 'the category of the distinctive constituent is the sine qua non, whose obligatory occurrence characterizes the construction' (271).

Notice that this criterion is closely related to the preceding one, and might be considered to be an extension of it to (some) syntactically exocentric constructions.

However, if it is to be usable in all but a tiny handful of cases, we must make a distinction between constituents that are OPTIONALLY PRESENT and those that are ELLIPTICAL. The NP of V + NP is optionally present; there are both transitive and intransitive verbs. Similarly, the Aux of Aux + VP is optionally present; there are verb phrases with and without auxiliaries. The V of V + NP can, however, be an elliptic zero (as in *I ate sushi, and Kiyoko a hamburger*), and so can the VP of Aux + VP (as in *I can swallow goldfish, but you can't*). Speaking very crudely, elliptical constituents must be interpreted from context (linguistic or otherwise), but optionally present constituents do not require such contextual interpretation (see Matthews, 1981: 43 f.).

With this background, we can review the six sample cases from English, to determine which constituent (if any) is the obligatory one.

For the four cases in which the criterion of the previous section picks out a distributional equivalent, the criterion of obligatoriness agrees. In Det + N, the N is the obligatory constituent; *problems* and *rice* are simply determiner-less NPs, but most noun-less NPs, like *Timmy's* and *the pink*, are elliptical. In V + NP, the V is the obligatory constituent, and in Aux + VP the VP is the obligatory constituent, as I pointed out above. For Comp + S, S is the obligatory constituent, given that Comp does not occur without S, though S occurs without Comp in examples like *I think the penguins are ready to eat.*

For NP + VP, the existence of subjectless imperative sentences like *Hand me that dwarf!*, in combination with the fact that a sentence consisting entirely of an NP (like *Your desk chair*) is understood as elliptical, means that VP is the obligatory constituent in NP + VP. As for P + NP, the evidence is theory-bound, though in favour of P as the obligatory constituent: if prepositions and particles belong to the same category, in the fashion of

Emonds (1972), then NP-less Ps are exemplified by VPs like *put the penguin on.*[10]

This criterion clearly tests for the same notion as the previous one, and that notion is distinct from those summarized in Section 2.3. What is not all clear is whether the notion of distributional equivalent/obligatory constituent plays any systematic role in syntactic theory.

2.6. *Rulers in dependency grammar*

In approaches to syntax that take some generalized notion of 'dependency', rather than constituency, as the main theoretical primitive (see Matthews, 1981: 78–84 for summary discussion, 94 f. for references), some head-like notion plays a central role. Terminology is a vexed matter here; writers in English on dependency grammar (including Robinson, Anderson, and Hudson already cited) sometimes translate the French *régissant* (versus *subordonné*) and the German *Regens* (versus *Dependens*) as 'head' (versus 'modifier'), but it would only confuse my discussion of head-like notions to adopt this usage. Unfortunately the term GOVERNOR is already taken as well, and I will fall back on the rather colourless term RULER.

Dependency grammar deals in relations among words, not among constituents; dependency diagrams indicate dependency as a directional relation between a ruled word and its ruler word. However, it has been known for some time (see especially Robinson, 1970) that dependency diagrams can be mechanically converted to constituent diagrams, with indications of dependency relations between words replaced by indications of which constituent in a construct (if any) is the ruler. Constituent diagrams can also be mechanically converted to dependency diagrams if rulers are indicated for the endocentric constructions in them.[11] The question now is what the notion of ruler has to do with the other head-like notions I have been surveying.

A careful reading of Sections 2 and 3 of Hudson (1980a) particularly in the light of my survey up to this point, suggests quite strongly that no coherent single notion of ruler can be established; the great diversity of views about the assignment of rulers (see Korhonen (1977) in particular) would presumably follow from this fact. Hudson intends that the ruler should be both the governor and the determinant of concord, that it should be the semantic argument, and that it should be the subcategorisand. This is to insist that the ruler should be the semantic argument on two counts and the semantic functor on two others, and that is simply contradictory.

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[10] On the other hand, there are a small number of P-less NPs with adverbial function, among them *home* and *there*. The question about them is whether they are to be analyzed as PPs without Ps (as assumed in Jackendoff, 1977) or simply as NPs; the fact that these adverbial NPs occur overtly as objects of prepositions, as in *near home* and *in there* suggests very strongly that the straightforward analysis as NPs is correct.

[11] Hudson (1980a), Dahl's (1980) brief reply, and Hudson's (1980b) response to Dahl are directed at an issue I am not addressing here, namely the question of whether constituency information is ever necessary in rules of grammar.

There is, however, a fair consensus among dependency grammarians on many specific instances. The consensus assignments can be summarized in the terminology of the preceding sections: for endocentric constructions, the ruler is the distributional equivalent/obligatory constituent; for exocentric constructions, it is the governor. If rulers are picked out in this fashion, then RULER is a notion distinct from all the others we have considered: V is the ruler in V + NP, but NP the semantic argument; N is the ruler in Det + N, but Det the semantic functor; VP is the ruler in Aux + VP, but Aux the morphosyntactic locus; and Comp is the ruler in Comp + S, but S the distributional equivalent and obligatory constituent.

Recall now that the notions discussed in Sections 2.1 through 2.3 have a privileged status, in that they are assured of having roles to play in the grammars of individual languages, and so must in some way be made available in syntactic theory. As in Section 2.5.2, the question is whether there is any real place for an additional distinct notion RULER in the theory; what would be required is a demonstration that there are generalizations like those alluded to in Section 2.4. AND that these can be stated in terms of rulers but not in terms of semantic arguments (equivalently, determinants of concord), semantic functors (equivalently, governors or subcategorisands), or morphosyntactic loci (equivalently, heads in syntactic percolation). In the absence of this demonstration, there is no place for rulers in syntactic theory.

3. HEADS IN MORPHOLOGY

Of the five head-like notions that must be represented in syntax, the first three – the semantic argument (Section 3.1.1), the subcategorisand (Section 3.1.2), and the morphosyntactic locus (Section 3.3) – must also be represented in morphology. The fourth – the governor (Section 3.2) – plays a very limited role in morphology. The fifth – the determinant of concord – plays no role at all, because parts of words do not exhibit concord with one another.

Section 3.4 examines a new notion, the morphological determinant, which plays a crucial role in the morphological Percolation principle.

Then, as in Section 2, I consider some side issues briefly: distributional equivalents and obligatory constituents in Section 3.5, and morphological prominence based on syntactic criteria in Section 3.6.

3.1. *Relating morphology to other components*
As in syntax, morphological combinations have an associated semantics, where the functor–argument distinction must be made. Also as in syntax, morphemes are lexically subcategorized according to the types of (morphological) constituents they can combine with.

3.1.1. *The semantic argument.* The semantic argument in English endocentric compounds is the second constituent – *cookie* in *Christmas cookie*, since

Christmas cookies are kinds of cookies (characterizable by their connection with Christmas), but *Christmas* in *cookie Christmas*, since a cookie Christmas is a kind of Christmas (one somehow characterizable by cookies). Neither constituent is the semantic argument in exocentric compounds like *redcap* and *instep*.

The semantic argument in derivation is always the base rather than the affix, since the affix represents a functor applying to the argument represented by the base. This is as true of derivation that doesn't change the category of the base (as in *blue-ish*) as of derivation that does (as in *blue-ness*).

3.1.2. *The subcategorisand.* English compounding does not seem to involve subcategorization. Derivation does, however, and the base is the subcategorisand. It is a lexical peculiarity of English, for instance, that the adjectives *soft*, *hard*, and *quick* combine with the causative/inchoative suffix *-en*, while *easy*, *difficult*, and *slow* do not.

3.2. *The governor*
In a small class of cases, one of the items combining in word formation bears a mark analogous to the inflectional marks of government in syntax. The other, unmarked, item is then the GOVERNOR.

In English (and German and Dutch) noun–noun compounding, one noun sometimes occurs with a suffix that is formally identical to the plural or genitive suffix, both when this mark would be semantically appropriate (as in *publications list*, with a plural, and *cat's paw*, with a genitive) and when it would not (as in the examples *bondsman, kinsman, landsman, marksman* cited by Bloomfield (1933: 230)). The marked noun is always the first of the pair, indicating that the second is the governor.

3.3 *The morphosyntactic locus*
An account of morphology must indicate how the marks of inflectional morphology are distributed within a word, just as an account of syntax must indicate which word in a phrase the marks of inflectional morphology are located on. Assuming that words have some internal constituent structure analogous to that of syntax, we can ask which morphological constituent in a word formation rule will bear the phonological marks of inflection. That is, we can ask about the morphosyntactic locus within the word.

Proponents of Percolation in morphology claim that the morphosyntactic locus in English and German is the suffix in derivational suffixing and the rightmost element in compounding. Taking morphology to be directly analogous to syntax, this claim would mean that a word like *happinesses* would have the internal structure [*happy* + [*ness* + *es*]] rather than the internal structure [[*happy* + *ness*] + *es*] that would seem to be called for on morphological and semantic grounds. Indeed, for phonological purposes (such as stress assignment) the former structure seems to be appropriate, as Aronoff &

Sridhar (1983) have pointed out. It is then possible to propose that both structures are made available by the grammar, via readjustment rules altering morphological constituent structures so as to derive 'prosodic structures' suitable for the purposes of phonology.[12] I will not develop this proposal further here, but will focus instead on the claim that derivational suffixes and rightmost elements of compounds are morphosyntactic loci.

Note that the claim is not merely that inflectional suffixes are located next to derivational suffixes and rightmost elements of compounds – that is true, but would be sufficiently accounted for by saying that morphosyntactic features are realized as inflectional suffixes – but also that there is a close bond between a word–final morpheme and a following inflectional suffix. Evidence for this bond in English can be found in the fact that nouns exhibit the same irregular allomorphy when they are second elements of compounds as they do when they are alone: *maple leaves, baby teeth.*

The evidence for this bond is more striking in languages with grammatical gender; thus Bauer (1983: 30) identifies the 'grammatical head' in endocentric compounds as 'the element marked for number, and also, in languages which have grammatical gender, the element that determines the gender of the compound'. Two sets of facts are presented together here. Let us consider compounding in German. A compound like *Landsmann* 'compatriot, countryman' has its plural marked on the last element, *Mann.* Consequently, the declension class of the compound (it is a plural in *-er*, which is accompanied by umlaut) is that of the last element (*Mann* takes a plural in *-er*); this indicates the close bond between the rightmost element and a following inflectional affix. In addition the gender, too, of the compound is that of the last element; *Landsmann* is masculine because *Mann* is masculine. This last fact, however, is not a manifestation of a bond between element and inflectional affix. For the purposes of adjective agreement (*neues Christentum* 'new Christendom', but *neuer Landsmann* 'new compatriot'), the whole compound word *Landsmann* must be specified as belonging to the masculine gender, and this is not achieved by saying where the inflectional affixes are located. Instead, the gender relationship is an illustration of MORPHOLOGICAL DETERMINATION, which I consider in the next section.

Matters are similar in German derivation. A final derivational suffix like *-tum* in *Christentum* 'Christendom' bears the mark of the plural. The declension class of the derived word (again a plural in *-er*) is that associated with- *tum*: *Christentuemer.* It is also true that the (arbitrary) gender of the

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[12] The general point here is that the grouping of morphemes into formal units might not be identical to the grouping of material into phonological units. This position has been generally accepted as it applies to phrasal syntax and phrase phonology, and it has long been recognized that an analysis of this sort is required for clitics (like the English possessive *'s*) which are distributed with reference to syntactic phrases (in the English case, at the end of a NP) but attach phonologically to whatever word they happen to be adjacent to. But it is only recently that this view has been taken (most forcefully by Selkirk (e.g. 1980)) in morphology.

derived word (in this case neuter) is determined by the suffix, but that is again a matter of morphological determination rather than the location of inflection.

3.4. *The morphological determinant*

The use of Percolation to determine the category of the construct in word formation requires that the head for the purposes of morphological Percolation be the MORPHOLOGICAL DETERMINANT, the morphological constituent that intuitively 'dominates' its co-constituents and so 'determines' the category of the construct.

Now there are several ways of making the sense of 'determination' more precise. Here the idea seems to be that in some construct of category Z one of the constituents, of category X, is largely restricted to occurring within constructs of category Z, while its co-constituent, of category Y, occurs in constructs belonging to a number of categories in addition to Z. As a result, Z can be predicted on the basis of X, but not on the basis of Y.

In English (and German) the morphological determinant in a derivational formation involving a suffix is the suffix, because a suffix occurs only in constructs of one category (and with bases from one word class), while a base of some word class can occur in constructs of several categories (combining with a number of different suffixes). The English suffix *-ness* occurs only in noun constructs (where it combines only with adjectives), but an adjective occurs in adjective and verb constructs as well as noun constructs (and it combines with a variety of suffixes): adjective *bluish*, verbs *widen* and *traditionalize*, nouns *happiness*, *width*, and *practicality*.

In English (and German) the morphological determinant in noun–noun compounding is the element on the right, because a right-hand element that is count, mass, common, or proper occurs only in a construct that is respectively count, mass, common, or proper, whereas left-hand elements are not so constrained; *Christmas cookie*, a proper noun in combination with a common noun, is itself a common noun, and *sugar cookie*, a mass noun in combination with a count noun, is itself a count noun. German gender determination also indicates that the morphological determinant in noun–noun compounding is the element on the right, because a right-hand element of gender G occurs only in compounds of gender G, whereas left-hand elements of gender G can occur in compounds of all three genders.

In some cases the appearance of morphological determination is simply a result of the fact that rightmost elements in words are inflectional loci. We would not want to say that the 'plurality' of the suffix *-ness* in *sadnesses* or the second word *cookie* in *Christmas cookies* determines the plurality of the whole word. Rather, we want to say something that is very nearly the converse: the plurality of the whole word is expressed by inflectional marks located on the rightmost element.

3.5. *Distributional equivalents and obligatory constituents*

Distributional equivalents within words can be determined in the same way as distributional equivalents within phrases; as in Section 2.5, this head-like notion is necessarily rather limited in its applicability.

Most English derivational formations do not have a distributional equivalent, because they are category-changing; *blueness* lacks a distributional equivalent, since neither the adjective *blue* nor the suffix *-ness* has roughly the distribution of the noun *blueness*. Some English compounds also lack distributional equivalents; in *step-in*, neither the verb *step* nor the particle *in* has roughly the distribution of the noun *step-in*.

Category-preserving derivational formations do have distributional equivalents, and these are of course the bases; *bluish* and *blue* have roughly the same distribution. (In some cases it is not at all clear whether the formation is category-preserving or category-changing: Does the abstract noun *kingdom* belong to the same category as the animate noun *king*?) Most English compounds also have distributional equivalents, so long as 'distribution' and 'same category' are understood narrowly. *Sugar cookie* has the distributional equivalent *cookie*, and *Christmas cookie* the distributional equivalent *cookie*, on this interpretation; recall the discussion of these examples in the preceding section. In general, the second noun is the distributional equivalent in a noun–noun compound in English.

In Section 2.5, the criterion of distributional equivalence could be extended to new cases by adding a criterion of obligatoriness to it. This will not do in morphology, where the criterion of obligatoriness merely picks out free morphemes as opposed to bound morphemes. For English, the criterion usually picks out the bases in derivational formations and normally does not apply to compounds. Rather than supplementing the distributional criterion it conflicts with it.

3.6. *Morphological prominence based on syntactic criteria*

Bloomfield's (1933: 233 ff.) classification of compounds uses still another head-like morphological notion, one based on syntactic criteria (for Bloomfield, the relevant head-like notion of syntax is the distributional equivalent). A variant of this idea appears in Lees' (1960) treatment of compounds, in which they are derived by transformation from syntactic combinations.

On this proposal, the central element of *pickpocket* is *pick*, because the verb is the distributional equivalent in a syntactic combination like *pick pockets*; the central element of *step-in* is *step*, because the verb is the distributional equivalent in a syntactic combination like *step in*; and the central element of *blackbird* is *bird*, because the noun is the distributional equivalent in a syntactic combination like *black bird*. The proposal extends to cases where morphological formations do not preserve syntactic word order: *keep* is the central element of *upkeep* because it is the distributional equivalent in *keep*

up; *knob* is the central element of *door knob* because it is the distributional equivalent in *knob of a door*; and *bake* is the central element of *cookie baker* because it is the distributional equivalent in *bake cookies*.

Copulative compounds like *producer–director* either have two coordinate centres[13] or none (if we insist that the distributional equivalent is the ONE constituent belonging to a category with the distribution of the category of the whole construct).

The proposal has no obvious extension to derivation rather than compounding. On the one hand, we might say that derivational formations simply lack centres in this sense. On the other hand, we might use Bloomfield's implicit assumption that derivational affixes are not syntactic elements, in which case the base is always the central element in a derivational formation, because it is the ONLY syntactic element in the combination.

4. THE MORPHOLOGY–SYNTAX PARALLEL

The Percolation proposal in morphology uses a notion of 'head' that combines the morphosyntactic locus and the morphological determinant. The appeal of the proposal is the claim that Percolation is not a new principle, specific to morphology, but is simply the percolation principle already required in syntax. I argued in Section 2.3 that the head for the purposes of syntactic percolation is the morphosyntactic locus. If the Percolation idea in morphology is to retain its appeal, this notion of head in syntax must also combine the morphosyntactic locus with the SYNTACTIC DETERMINANT, the syntactic analogue of the morphological determinant. I now examine the rather odd notion of syntactic determination, which I believe has never been entertained as an explication of headship in syntax, and observe that syntactic determinants and morphosyntactic loci do not coincide. The claimed parallelism between morphological Percolation and syntactic percolation fails.

I begin by repeating the characterization of determination given in Section 3.4, which is now to be applied in syntax: In some construct of category Z one of the constituents, of category X, is largely restricted to occurring within constructs of category Z, while its co-constituent, of category Y, occurs in constructs belonging to a number of categories in addition to Z; as a result, Z can be predicted on the basis of X, but not on the basis of Y.

Consider again the six sample constructions of Section 2. In $V + NP = VP$, $P + NP = PP$, and $NP + VP = S$ the constituent NP occurs in three different constructs, and it occurs as well in the possessive construction of *those penguins' bills*; V, P, and VP are all more restricted, and consequently are the

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[13] Bloomfield's proposal, which assumes that phrases like *producer and director* have multiple centres; similarly Lyons (1977: 391) on syntactic coordination. And see the Hudson–Dahl exchange on this point. Sag *et al.* (1984) formulate the multiple-head proposal in a generalized phrase structure grammar framework.

syntactic determinants in these constructions. Aux combines only with VP, whereas VP combines with (at least) Aux and NP, so that Aux is the syntactic determinant in Aux + VP = VP'. Finally, Comp combines only with S, whereas S combines with Comp, subordinating conjunctions, and co-ordinating conjunctions, to make three different constructs, so that Comp is the syntactic determinant in Comp + S = S'.

The assignment of Det, Aux, and Comp as syntactic determinants corresponds to the intuition that these constituents serve as 'marks of' the constructs NP, VP', and S', respectively.

These assignments are, in fact, identical to those for subcategorisands (Section 2.1.2) and governors (Section 2.2.1). Syntactic determinants are semantic functors.

As in Section 2.3, it follows that syntactic determinants and morphosyntactic loci do not coincide. They differ in two of the six sample constructions (Det + N and Comp + S) and can be expected to differ elsewhere as well. Syntactic percolation uses the morphosyntactic locus alone, not the morphosyntactic locus in concert with the syntactic determinant.

5. PROBLEMS WITH PERCOLATION

The Percolation idea in morphology is subject to criticism on several fronts. Stipulating the morphosyntactic locus as 'head' for the purposes of Percolation does not achieve a conceptual economy as intended (Section 5.1), and stipulating the morphological determinant as 'head' for these purposes actually enlarges the stock of concepts (Section 5.2). Indeed, the two notions do not necessarily coincide (Section 5.3). It will suffice to specify instead that inflectional suffixation is an operation on the rightmost morpheme in a word, and that determination is a property of rules, not of constituents combined by those rules. Finally, the existence of 'process morphology' (Section 5.4) undermines the Percolation proposal in any case.

5.1. *The morphosyntactic locus*
I now reconsider the English and German data in Section 3.3, which illustrated the close bond between (on the one hand) a derivational suffix or a right-hand element of a compound and (on the other) an inflectional suffix. The description that I wish to counterpose to the Percolation treatment of these facts is that in these two languages inflectional suffixation is an operation on the rightmost morpheme in a word.

The Percolation proposal achieves conceptual economy by identifying the rightmost morpheme as the morphosyntactic locus, thus avoiding any need to distinguish two different types of ordering principles in morphology – one type referring to heads, another type referring to the margins of the word. I maintain that principles of both types are needed in syntax, though reference

to heads rather than margins is the customary state of affairs, and I also maintain that ONLY reference to margins is needed in morphology. The conceptual economy is thus a false one.

Syntactic principles locating inflectional morphemes typically refer to heads rather than to margins. The customary state of affairs is that syntactic heads are only coincidentally located at one margin of their phrases. On the other hand, there IS a class of morphemes some of which are located on heads, some at margins; these are the (special) CLITICS; see the summary discussion in Zwicky (1977). There might also be, as suggested in Zwicky (1984), some instances in which inflectional marks are syntactically located at a phrase margin. But certainly location at a margin is an exceptional arrangement in syntax.

In contrast, morphological principles locating inflectional morphemes seem always to refer to margins, never to morphological constituents that would constitute heads on any criterion other than this one. Saying this is only rephrasing the familiar dictum that inflectional affixation takes place outside word formation, at the margins of the word.

Inflection is consequently indifferent to the internal organization of words. Notice that in English compounding there are many different relationships among the constituent words (compare *Christmas cookie, pickpocket, black-bird, step-in, producer–director*), but all types of compounds have plurality marked on the last word: *Christmas cookies, pickpockets, blackbirds, step-ins, producer–directors.*[14] Notice in particular that the location of the plural marker is the same for endocentric compounds (*Christmas cookie*) and for exocentric compounds (*pickpocket, blackhead*), including those like *step-in*, in which the right-hand element is not even a noun.

I conclude that it would be (in general) ill-advised to attempt to exploit the head of the Head Feature Convention as the morphosyntactic locus in morphology, and that any saving in conceptual apparatus that would follow from such a move is a false economy.

5.2. *Morphological determination*

Morphological determination in suffixal derivation, like syntactic determination generally, resides in the material representing the semantic functor. The morphological determinant in compounding, however, is usually the semantic

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[14] There are well-known apparent exceptions to the 'inflections last' principle for English compounds: *governors general, battles royal, passers-by, ladies-in-waiting, bills of lading*, and the like. These are certainly LEXICAL ITEMS, but there is no reason to think that they are compounds. They are stressed like phrases, never like compounds, and they are inflected like phrases, not like clear instances of compounds. Their properties are adequately accounted for if they are treated as idioms belonging to the syntactic category Nom. Indeed, since in general there can be idioms belonging to any of the categories of syntax, and since idioms belonging to the lower-level categories are especially frequent, it would be astonishing if English had no Nom idioms with the properties of *passers-by* and the like.

argument. It follows that the morphological determinant cannot be identified consistently with any semantic notion. If, as I argued in the preceding section, the location of inflectional marks in morphology is not to be achieved by indicating, for each rule of combination, the constituent that is the morpho-syntactic locus, then MORPHOLOGICAL DETERMINANT is a genuinely new theoretical notion. Attempting to treat the morphological determinant as the head in Percolation means that the stock of concepts is increased, not reduced.

The connection between semantic functor and morphological determinant in derivation is a natural one, alluded to in Section 3.1.1. Both concern the outputs of a rule combining base and suffix: (a) morphological determination is the specification of the morphosyntactic properties of the word resulting from the rule (for German *Christentum*, for instance, the rule affixing *-tum* must specify that the resulting word is neuter); and (b) the semantic functor operates on the semantic argument to provide the interpretation of the word resulting from the rule.

Things are different in compounding. In the German compound *Landsmann*, *Mann* is the 'semantic head', that is, the argument; a *Landsmann* is a kind of *Mann*. Similarly in the English examples *Christmas cookie* and *cookie Christmas* from Section 3.1.1.

5.3. *The coincidence of morphosyntactic locus and morphological determinant.*

Even if we disregard the problems of the two preceding sections, there are still instances in which the morphosyntactic locus and morphological determi-nant do not coincide. These are exocentric compounds like *red-head*, which lack morphological determinants but nevertheless have inflection marked on the right-hand element.

Indeed, when exocentric compounds are examined along with endocentric compounds, it becomes clear that *no* compound has a morphological determinant in the sense of Section 3.4. However head-like the rightmost member of a compound might be for the purposes of locating inflectional morphology, it does not actually determine the category of the compound; noun–final compounds can be nouns (*red-head*), adverbs (*bareback* in *She rode bareback and without any reins*, and *uphill* in *They travelled uphill for six hours*), or measure adjectives (*three-dollar* in *a revolting three-dollar dinner*), at least.

It should now be clear that it is a mistake to try to pick out a CONSTITUENT in a rule of combination as the source of morphological determination. It is possible to do this in many instances, but not in general; determination is a property of rules, not necessarily something localizable in one of the constituents. This is such an obvious fact about syntactic determination that my discussion of syntactic determinants in Section 4 had a distinct air of

unreality about it. But it is also true of compounding, and I shall suggest that it extends to derivation as well.

The association of determination with rules rather than constituents is rather more obvious in languages with richer inflectional morphology than English. In German examples like the neuter *Vergissmeinnicht* 'forget-me-not' (ending with the negator *nicht*) and the masculine *Schlagetot* 'hulking brute' (ending with the adjective *tot* 'dead'), the gender of the whole is in no sense determined by the final member – or by any other member, for that matter.

Such cases are admittedly rare in the world of German compound nouns, and might easily be treated as isolated lexicalizations. A more regular, and more telling, case is provided by the 'copulative', or *dvandva*, compounds of Sanskrit. In these compounds two or more noun stems are concatenated, and the whole is understood as if the constituent words were conjoined. With respect to morphological determination, there are two schemes: according to Whitney (1889: sec. 1253), either 'the compound has the gender and declension of its final member, and is in number a dual or a plural, according to its logical value' (*devāsurās* 'the gods and demons'), or 'the compound, without regard to the number denoted, or to the gender of its constituents, becomes a neuter singular collective' (*ahorātram* 'a day and night'). In the first scheme, we have the same system as German for gender, though number is determined semantically. In the second scheme, gender and number and declension class are all determined, not by some constituent word, but by the rule that combines words.

What I am proposing about compounding is, rather conservatively, that there are a number of compounding RULES. Each rule involves (a) the operation of concatenating two words, (b) these words belonging to specified categories, (c) with the result of the operation being a word of a specified category; moreover, with each rule is associated a principle of semantic interpretation for the compounds it provides.

The facts about endocentric compounds must still be described. The generalization for German and Sanskrit appears to be that in any rule of the form $X + N = N$, the construct inherits the morphosyntactic features of the N on the right. I am thus proposing that the rightmost element is indeed the head in the formation of certain German and Sanskrit, and for that matter English, compound nouns, but not in the second type of *dvandva* compound in Sanskrit (or in German compound nouns not ending in a noun, if there are any productive types of these), or in suffixal derivation in general. A principle analogous to the Head Feature Convention (if not the Head Feature Convention itself) applies in these constructions; but this principle is much more restricted in its application and effects than Percolation.

Now consider derivation. Here there is a close association between rule and affix, so that the Percolation proposal will get the right result – but only if the language happens not to introduce the same affix in two different rules. English, with its rather modest derivational morphology, might be such a

language. What is at issue is the analysis of facts like the following: English *-al* combines with verbs to form nouns (*arrival*) and with nouns to form adjectives (*herbal*); *-ful* combines with nouns to form adjectives (*careful*) and with nouns to form nouns (*handful*); stressless *-ate* combines with nouns to form nouns (*protectorate*) and with nouns to form adjectives (*passionate*); and zero derivation creates a whole series of types of deverbal nouns and another of denominal verbs.

Now it is certainly possible that each of the 'affixes' I have listed is really a pair of homophonous affixes. And several writers (including Lieber, 1981: ch. 3) have denied that English has any rule of zero derivation for noun–verb pairs, though on their account it does have homophonous noun–verb pairs in its lexicon. If, however, English has ANY two distinct cases of zero derivation, the Percolation proposal can be maintained for the language only if it is claimed that there are distinct zero affixes as well as distinct rules of derivation (and if such a claim can be entertained, the question of whether Percolation operates in a language is no longer an empirical one). I submit the following cases: first, the zero derivation of adjectives from present and past participial forms of verbs (*the sleeping child, a plucked chicken*); and second, the zero derivation of nouns of nationality from adjectives of nationality (*a tall Canadian/Swiss/Somali/Zairois*).

I conclude that morphological determination resides not in a formative, but in a rule performing an operation; for compounding, the operation is the concatenation of two operands, and for affixal derivation, the operation is the concatenation of material at one end or the other of an operand.[15] The apparently determinant formative in compounding is only one of the operands, and the apparently determinant formative in affixal derivation is merely a concomitant of the operation. This approach permits a single formative to be an operand in distinct operations, or to be a concomitant of distinct operations.

5.4. *Process morphology*

A special problem arises with the morphosyntactic-locus and morphological-determinant conception of head in languages with derivational 'process' morphology. What are we to say about a language (like several of those cited by Marantz, 1982) in which reduplication serves as the sole mark of derivation? Or a language (like German) in which ablaut patterns can so serve? Similar questions arise for umlaut, tone shifts, and consonant shifts, and related questions attend infixation, discontinuous affixation (like the German past participle *ge-...-t/-en*), and subtractive formations.

On the Percolation proposal, a piece of derivational process morphology must be the inflectional locus, and it must be the morphological determinant –

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[15] A similar position on syntactic determination has been developed in some detail in Carlson, 1983.

but it isn't a formative that attaches to a base. For Percolation to function equally for process morphology as for affixation, we apparently have to abstract 'process morphemes' that combine with bases (as Joseph & Wallace (1984: sec. 1) have observed in their critique of Williams, 1981). The Percolation treatment of inflectional loci and morphological determination apparently obliges us to hew to an agglutinative approach to derivational morphology, and so gives rise to such pseudo-questions as whether an instance of ablaut derivation in German involves a prefix or a suffix. Unadorned, the Percolation treatment calls up the full range of problems that process morphology posed for structuralist morphologists.

The recent literature contains several alternatives to an agglutinative treatment of process morphology. In a couple of these Percolation has a natural place, but in others the effect of Percolation is achieved by two independent mechanisms.

There is the nonagglutinative proposal of Williams (1981), who calls for 'headless' word formation in cases like the English noun–verb pairs exemplified by *breath–breathe, life–live,* and *bath–bathe.* Here the effect of Percolation is split, with Percolation itself doing the job for affixal derivation, and some other mechanism (not explored by Williams) doing the job for process derivation.

Another view, suggested by Lieber (1981), is that the allomorphs related by process morphology should simply be listed in the lexicon, and should be associated with one another by (nondirectional but context-sensitive) 'morpholexical rules'. Again, the effect of Percolation is split, with Percolation itself working in affixal derivation, and a feature–assignment mechanism working in process derivation (base forms are assigned the value $[-F]$ and derived forms the value $[+F]$, and the two are related by a morpholexical rule).

Another, proposed especially by McCarthy (1981, 1982), merges the 'long component' treatment of discontinuous morphology advanced by Harris (1951) with the 'autosegmental' approach to phonology proposed by Goldsmith (1976). In this 'prosodic' view of process morphology, process morphemes are represented separately from their bases, but the operation combining them is not agglutination, but rather superimposition; the base and the process morpheme lie on separate 'morphemic tiers', in a dimension orthogonal to the left-to-right linear ordering of segments and of affixal morphology. McCarthy has not, so far as I know, explored how Percolation would be managed in this framework, but it is easy to find a natural place for it, since derivative word formation in this framework is simply the combination of base and affix, in either of the two dimensions the framework provides. It follows that word structures are three-dimensional objects, rather than the two-dimensional tree structures of orthodox morphological analysis.

Marantz (1982) advocates a mixed approach, in which a prosodic analysis is appropriate for some phenomena, a morpholexical-rule analysis for others.

Still another idea, which was prepared for in the discussion of Section 5.3, involves distinguishing a (grammatical) RULE from the OPERATION that the rule performs.[16] Concatenation of material to (one end or the other of) a base is one operation that a rule could perform, but there are others: the rule could 'wrap' the base around some material (infixation); it could duplicate some of the substance of the base (reduplication); it could alter phonological features of the base in a systematic way (or simply mark the base as being subject to a particular phonological rule); or it could perform several of these operations in concert.

One attractive feature of this approach is that it embodies the observation (much stressed by Lieber, 1981) that a single operation typically plays a number of diverse roles in the morphology of a language, often functioning in both derivational and inflectional morphology; a single reduplication operation, for instance, might be an exponent of a rule deriving causative verbs from adjectives, an exponent of a rule deriving intensive verbs from simple verbs, and an exponent of plural inflection on nouns. A less attractive feature is that, unless more is said, this framework permits powerful morphological 'transformations', of the sort that the approaches of Lieber, McCarthy, and Marantz were designed to avoid. In any case, the effect of Percolation would be achieved in this framework by treating the 'head features' as specified by the rule, and there would be no affixes to serve as the 'heads' of anything, since affixes would merely be concomitants of the operation performed by the rule.

Only McCarthy's prosodic proposal and the rule/operation proposal treat the morphological-determination aspect of Percolation in process morphology as a unitary phenomenon. The first requires a novel three-dimensional view of word structure but is otherwise consistent with a single principle of Percolation. The second allows the more traditional two-dimensional view of word structure but dispenses with Percolation entirely.

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[16] This idea arises in two rather different traditions. In one it represents an extension to morphology of Richard Montague's approach to syntactic rules, as in Schmerling, 1983. In the other it is the result of replacing an unsatisfactory morphemes-as-formatives view with a more general morphemes-as-operations view, in the development of a modern process morphology by, among others, Matthews (1967, 1972, 1974), Anderson (1977), and Janda (1983).

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