Cognitive Phonology

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1. Introduction

Phonology is usually thought of as the study of the 'sound systems' of languages. In this article I will make an attempt to explain what that means for me and why I refer to the approach that I favor as 'cognitive'. Frankly, I have no idea how phonology could ever be anything but cognitive. However, there is a certain view that explanation in this domain must be crucially built upon our understanding of how sounds are produced and perceived. I do not dispute that insight into linguistic sound systems can be derived from such understanding. My point is that some fundamental properties of sound systems cannot be understood in this way, but rather must come from theories about the cognitive representations that underlie sound systems. Hence 'cognitive phonology'. As we will see, phonology, being cognitive, is not fully encapsulated in the mind, as there must also be a system for externalizing the phonological representations.

In section 2 I first discuss what it means to say someone knows linguistic sound events. Section 3 argues for a strong parallelism between grammatical components (phonology, syntax and semantics) and contains a brief excursion on the evolution of language. Sections 4 and 5 home in on the phonological component, discussing static (i.e. phonotactic) and dynamic (i.e. allomorphy) phenomena, respectively. In section 6, I argue that even though the phonological system is non-derivational and constraint-based, two levels (in different planes) are necessary. Section 7 offers some conclusions.

This article can be read as an attempt on my part to explain to interested parties (linguists who are not, or not primarily, phonologists, scholars in other fields, colleagues, friends, relatives) what it is that I'm studying and why I hold certain beliefs or guiding ideas about this subject. Hence I do not presuppose much prior knowledge of phonology, although the exposition becomes increasingly more involved and complex, all of which, I hope is not offending Hans den Besten, to whom I offer this article as a token of both my esteem for him as a linguist as well as my friendship as a colleague.

2. Knowledge of linguistic sounds

Humans do not appear to be very good at communicating telepathically, i.e. by reading the thoughts in each other's minds. To travel from one mind to the other, thoughts need *carriers* that are perceptible. Most human languages make use of carriers that are *audible*, although communication (taken as a broader concept) also uses a great deal of visual information, notably in the gestures and 'body languages' that humans display when they express their thoughts. In addition, sign languages, as used in Deaf communities, are human languages that are totally based on visual forms. Other sensory channels (smell, taste and touch) play a much smaller role in human communication (while being quite significant among other animal species), although tactile communication can reach quite sophisticated levels, even as an alternative to spoken or signed language. (See Finnegan 2002 for a comprehensive overview of the different channels of communication.)

I will confine the discussion here to that part of communicative acts that is taken care of by spoken language. Human languages, then, contain an inventory of 'sound events' that are *conventionally* (and largely arbitrarily) linked to 'meanings' or 'concepts' that constitute the building blocks out of which we construct our thoughts. By stringing these sound events together we construct complex words and sentences that represent our hidden thoughts. If the listener *knows* the conventional linkage between sound events and their meanings, as well as the grammatical rules for decomposing complex expressions that encode the complex thoughts of the speaker, communication can proceed successfully.

What does it mean to say that the language user knows the sound events that are linked to meanings? Clearly, sound events as such (i.e. as physical acoustic events) do not form part of cognition. There is no part of the brain that literally contains an inventory of acoustic events that somehow can be released upon command. Rather, human *produce* sounds every time they speak. Sounds are produced by specific actions or movements of certain body parts. How this works in detail is studied under the heading of 'articulatory phonetics'. Speakers apparently know these specific movements (as appropriate for achieving certain acoustic targets) and it might therefore be assumed that it is this (largely unconscious) knowledge (rather than the sounds themselves) that forms part of human cognition. But this cannot be enough. Language users do not recognize sounds by visually identifying the movements that produce them (although such visual information is used in speech recognition when available). If 'speech' recognition was totally based on the visual perception of articulatory movements, spoken languages would be sign languages! Rather they identify the sounds as such (which is why can talk over the telephone or listen to the radio). In other words, language users have a mental, perceptual (i.e. a psycho-acoustic) image of the sounds that allows them to parse the acoustic speech signal into units that can be matched with words or meaningful parts of complex words. It would seem, then, that knowledge of sound events has two aspects, an *articulatory plan* and a *perceptual or psycho-acoustic image*.

It is a widely accepted view that the knowledge of sound events that correspond to morphemes and words is quite specific, in that it takes the form of a mental representation that is *compositional* (rather than holistic). This means that the cognitive representation is built out of smaller parts or 'atoms' that are in themselves meaningless. At one time it was believed that the atoms corresponded roughly to complete slices of the

acoustic signal and the atoms were thus called **phonemes** (since X-emes are fundamental units in the component that deals with X). Subsequent research revealed, however, that phonemes themselves consist of smaller parts, and these were called *features*.

There has been a long debate on the question as to whether the articulatory aspects or the perceptual aspects of features are more fundamental. For a revealing discussion, I refer to Fowler and Galantucci (2002). In their view, the articulatory plan is fundamental. The articulatory basis of features is also clearly present in most work on feature theory since Chomsky and Halle (1968), especially in its 'feature geometric' descendants (cf. Halle 1983, 2003). A consequence of taking articulation as basic is that in speech perception, listeners must be assumed to crucially draw on their articulatory knowledge. The idea is that perceived stimuli are internally linked to the corresponding articulatory plan which then can be matched with the articulatory-based phonological form of lexical items. This proposal is known as the 'motor theory of speech perception' advocated by Liberman and Mattingly (1985). (In a way, it is claimed then that hearers mentally 'see' the articulatory movements that underlie the acoustic events.) This theory forms the basis of the "articulatory phonology' model (cf. Browman & Goldstein 1986). Others (among them, Roman Jakobson) believe that the perceptual image is fundamental, mainly because of its presumed close relationship to the acoustic aspect of sounds, which is shared by speaker (through feedback) and listener. See Harris (1994) as well as Anderson and Ewen (1987) for a defense of this position. I will not enter into this debate here, and keep a neutral stand on the issue, in that I will assume that the cognitive representation of sounds simply has two layers, an articulatory plan and a perceptual image. In fact, my own views on the true atoms of phonology involves the postulation of just two units which can hardly be said to have any phonetic definition, articulatory or perceptual. (See van der Hulst 2000, in press d, in prep a.)

In any event, it seems safe to conclude that knowledge of sound events involves *compositional mental representations* of these events, and that makes the 'sound side' of linguistic signs as abstract and cognitive as the meaning side. Just like (word) meaning can be thought of in terms of *concepts* that stand in some relationship to real world objects, phonology must also be understood as a *conceptual system* that stands in some sort of relationship to real world objects (namely certain types of noises, or certain types of behavior, i.e. articulatory behavior); see van der Hulst (in press b) for a more detailed discussion.

But wait, says the philosopher. We know that not all word meanings or concepts that constitute them correspond to something in the real world. And I was hoping that he would say that because if he is right (and I think we all agree that he is, although the case can more easily be made for compositional conceptual structures than for the 'atomic' concepts), then there is no reason to assume that all phonological concepts stand in a direct referential relationship to some real world noise or behavior. I will return to this point below when we will see that a phonology that is limited to concepts that correlate with phonetic events fails to provide insight into many phonological phenomena.

According to some, the phonological primes (i.e. features) are hard-wired as part of an innate human language capacity, rather than being 'constructed' from scratch in the course of cognitive development and language acquisition. This view must rely on some sort of evolutionary development whereby skills to make certain kinds of sounds become hard-wired, presumably because of adaptive advantages of some sort (more on that

below). However, if this is so, and if spoken language 'phonetics' has determined the nature of the primes in the evolutionary past, how can this same endowment be helpful to a deaf person? Clearly, it cannot, and I am assuming here without discussion that sign languages are true human languages that, as far as we know now, share all essential structural properties with spoken languages. As a consequence, deaf people either must construct their phonology in some other way (perhaps using some non-specialized general cognitive ability that allows them to construct a phonology-like conceptual system) or they have no compositional conceptual system comparable to phonology at all, which implies that conceptual representations of articulatory movements and perceptible forms of signs are stored in the lexicon holistically.

The first option is logically consistent, although it predicts differences between the course of acquisition of the phonologies of spoken and signed languages. There appears to be little support for any significant differences. If anything, the contrary is true. Striking similarities between the acquisition course of languages in both modalities have been put forward as 'evidence' for the claim that sign languages and spoken languages are both natural human languages, stemming from the same innate capacity (Klima and Bellugi 1979, Emmorey 2002, Meier, Cormier and Quinto-Pozos 2002). The second option (sign languages have no phonology) flies in the face of the results that installed the idea that sign languages are natural languages in the first place. Stokoe's seminal work (Stokoe 1960) lead to the recognition of the fact that sign languages, in fact, have a phonology. This finding lead to an explosion of work on sign languages, especially American Sign Language (Klima and Bellugi 1979, Emmorey 2002, Fischer and van der Hulst 2003; see van der Hulst (1993, 1995, 1996, 2000), van der Kooij (2002) for detailed discussion of phonological compositionality in signs and many references to current work).

The conclusion must be that phonological categories are constructed in the course of language acquisition. Elsewhere I propose that the innate language faculty (or some more general faculty) provides a universal mechanism for constructing the set of primitives and I specify the properties of that mechanism in some detail (van der Hulst 1993, 2000, to appear d, in prep a).

3. Parallelisms between grammatical systems

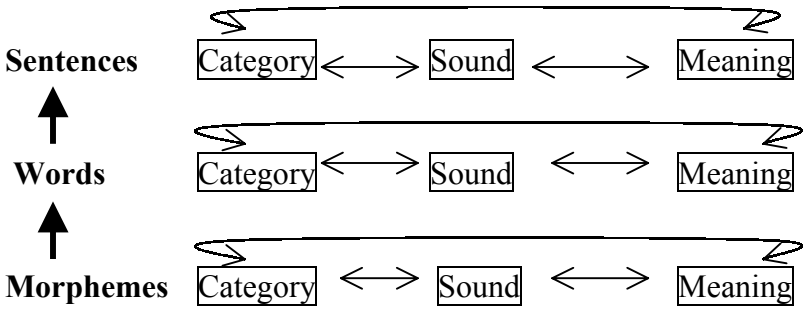
We have established that linguistic signs comprise two sides, meaning and phonology, both mental-conceptual, and thus cognitive entities. There is, of course, a third side to signs, which is their syntactic properties or behavior. Given that linguistic signs can be combined to form complex expressions, a system is in place that regulates the structure of these complex expressions. This system is apparently autonomous. It is independent from the sound properties of signs, and it does not seem to be determined by their meanings. The system is called *syntax* (here taken to include morphology), which means something like 'orderly arrangement'.

In the Chomskyan view of language and grammar, the syntax (understood as the 'orderly arrangement' of morphemes and words) is the central part of the grammar. Syntactic rules or constraints characterize (morpho-)syntactic structures which then are matched with semantic and phonological (often called 'phonetic') interpretations.

Jackendoff (2002) replaces this syntacto-centric view with another conception of grammar in which there are three parallel systems and correspondence rules between the structures that each of these systems characterize as well-formed. Jackendoff presents this conception in some detail, and in doing so, he tries to establish a view of grammar and linguistics that other researchers in the broad area of cognitive science can perhaps more easily relate to than the current views of Chomsky and his close followers. In fact, Jackendoff argues that generative grammar, after having stimulated enormous interest in an interdisciplinary endeavor called 'cognitive science', has largely isolated itself from this field by producing increasingly inaccessible results.

Whether Jackendoff's attempt will be successful remains to be seen; see Ritter (to appear). In any event, I for one agree with the idea of viewing the grammar as a set of three parallel systems, each of which is responsible for characterizing a set of well-formed expressions. In fact, I favor, in addition, a separation of a word grammar (or set of parallel systems) and a sentence grammar (ditto):

(1)



The arrows going from morphemes to words, and from words to sentences represent, what one might call, a generator, i.e. a 'device' that delivers random combinations of units at the next lower level. The task of the grammar is to characterize those well-formed combinations that are well-formed on all three counts. In this view, well-formed words and utterances are well-formed combinations of a well-formed phonological, semantic and syntactic expression. (See van der Hulst, in press b for further discussion.)

The general form of the syntactic system is very simple. Given a finite set of category labels (such as sentence, noun, verb, and so on) and a finite set of combination (or syntactic) rules (or constraints), a set of complex structures can be admitted. This set is infinite given a quite simple trick, *recursivity*, which boils down to the possibility of allowing some categories to occur (directly or indirectly) inside categories of the same type. This allows a 'loop' that causes infinity. Abler (1989) refers to systems of this sort as 'particulate systems'. In a particulate system, each building block of complex expressions remains identifiable (i.e. no blending takes place), while contributing its properties to the whole construction. The sum total of properties of the whole construction is dependent on the properties of its parts, as well as on their specific orderly arrangement. Philosophers and semanticists recognize here Frege's principle of compositionality, according to which the meaning of a complex sign is derivable from the meaning of its parts, and their specific arrangement. Frege's principle may be seen as the semantic instantiation of the particulate principle. Abler's intention is to point out that nature is full of 'particulate systems', referring specifically to chemistry and physics, where the periodic table provides the building blocks (or perhaps the ingredients that

make up the elements), and genetics, where 4 nuclear bases form the building blocks. Abler also includes language in his discussion.

When we consider the syntactic system of language, as just discussed, we notice the properties of a particulate system, but, and this brings us back to phonology, language has particulate properties that are independent from the syntactic system. With reference to the diagram in (1), we can say that all three subsystems of language (or grammar) are particulate systems. The need for a phonological particulate system is most evident when we consider words, especially simplex (i.e. monomorphemic) words. Perhaps languages could have been organized in such a way that each morpheme would have had, on the sound side, one indivisible, atomic sound concept. This is not, of course, how we think of the sound side of signs today, as already argued above. Take the sign *cat*. The phonological concept for this sign is not atomic, as everyone knows, or at least believes. It is made up of three subconcepts called phonemes, viz. /k/, /æ/ and /t/, and each of these concepts is made up of smaller atomic concepts, called features. Obvious as this may seem, it is (if correct) pretty remarkable. Why would the phonology of the sign *cat* be complex, if this complexity does not correspond to a complexity in its meaning, such that the meaning can be compositionally derived from the meaning of /k/, /æ/ and /t/? I am sure that some people believe that this phonological particulate compositionality is a fiction, brought about by the use of use of an alphabetic writing system. I believe that they have it backwards. The units of writing systems (whether they represent words or morphemes, syllables, or segments) are parasitic on linguistic concepts, not the other way around.

I am not sure that I fully understand *why* the phonology of basic signs is necessarily compositional, and why there are meaningless building blocks that occur in some orderly arrangement to form the phonological side of signs. It appears to be the case that *call systems* of certain other animal species (like the notorious *vervets*) do not show evidence for a similar compositionality (nor do these systems show any evidence for syntax, i.e. combinations of signs). Going into this issue more deeply will bring us to the highly interesting, yet speculative, domain of language evolution. I'll limit myself to a few remarks.

It may very well be that the memory space of the human mind, as well as its ability to quickly search in this space, is virtually unlimited. Thus, we cannot be sure that the evolutionary leap from holistic forms (assuming that such a 'vervet' stage preceded language as we know it) to compositionality took place for reasons of storage and retrieval necessity as, over time, the number of basic signs increased. However, it does seem obvious that a compositional system *is* superior to a holistic system in at least three ways. Firstly, it comes automatically with a recipe that provides new forms. If the 'phonology' of every sign is a unique holistic thing, new forms must be randomly chosen from the set of available noises that an organism can produce. Secondly, it provides a notion of wellformedness, making it possible to characterize a form as belonging or not belonging to the mental lexicon of the language. Thirdly, it facilitates retrieval because the stored collection can be ('alphabetically') organized in terms of the atomic building blocks. Without being able to prove the point, it seems obvious to me that these factors must have stimulated the emergence of compositionality in phonology, *especially if it is the case that compositionality was already a faculty of the human mind*. We will never know whether the evolutionary emergence of compositionality in phonology preceded (as

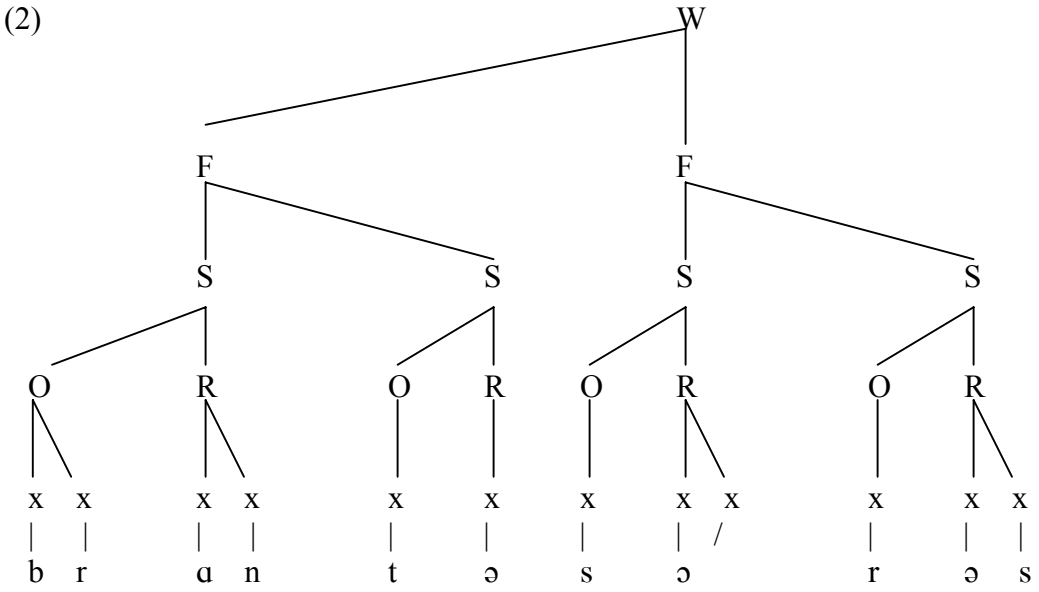
Andrew-Carstairs 1999 believes) or followed the emergence of syntax; whichever was first probably borrowed it from somewhere else. Bickerton (1990) suggests 'social intelligence' as a source for syntax. Lieberman (2002) has suggested that the human ability for syntax (in the general sense of constructing complex expressions out of basic units) may itself have developed from the cognitive structures that underlie the complex motor activity that is necessary for sound production or other forms of behavior (like hand movements), and this may very well be the case; seemingly, this position is even supported by neuronal evidence concerning the location in the brain of speech planning and grammatical syntax. In a similar spirit, Lenneberg (1967) discussed the relevance of general rhythmic organization as a model for the organization of linguistic structures.

4. Phonology as a particulate system

Whatever the evolutionary reasons may be for its emergence, phonology forms a particulate system in itself, which means that linguistic utterances have a dual structure, famously referred to as *duality of patterning* (by Hockett), or confusingly as *dual articulation* (by Martinet). Of course, if Jackendoff is right, utterances have *three* patterns including a semantic or conceptual pattern; see (1). Or perhaps, everyone is right in a way, if the semantic-conceptual system is not regarded as specifically linguistic, a position that Jackendoff adheres to. (Ironically, others, like Burton-Roberts (2000), regard the conceptual system as the essence of a fully innate universal grammar, regarding what other people call phonology and syntax as conventional systems that constructs expressions that represent thoughts or conceptual structure, much in the way a painting represents some real world object; see van der Hulst, in press b for further discussion.)

Being a particulate system, the phonological component of a grammar must come with a finite set of building blocks and a finite set of combination rules. In other words, phonology has a syntax of its own, i.e. rules that account for the orderly arrangement of atomic elements. It turns out that this phonological syntax produces several hierarchical layers of structure. Firstly, there is a system of rules that accounts for the way that features can be combined to form phonemes. Phonemes, then, form units like *onsets* and *rhymes* that occur in alternation to make up words. These units, according to most linguists, in turn enter into larger units, called *syllables*. The emerging hierarchical structure does not stop there. Words are not just linear arrangements of syllables. Research in the seventies, basing itself on traditional notions stemming from the study of metrical patterns in poetry, established the need for binary groupings of syllables into what were called *feet*. Words, then, consist of feet. The following illustration suppresses the internal organization of phonemes:

(2)



The syntax of phonology appears to be rather similar to the syntax of 'morpho-syntax,' not only in forming a hierarchical system, but, more specifically, in displaying a fundamental *asymmetry* within each constituent type. This asymmetry has been indicating here by using vertical and slant lines. Consider rhymes. It is usually taken for granted that the syllabic rhyme must contain a vowel, whereas it *may* contain a consonant. The vowel, in other words, appears to be the most characteristic, and, at the same time, obligatory unit. Likewise, the rhyme itself appears to perform a similar function as part of the syllable. A syllable can consist of a rhyme alone, while it can, in addition, have an onset. Moving up the hierarchy, we note that within the foot, one syllable (the one on the left in English) differs systematically from its sister in two ways. Firstly, it must contain a full vowel, whereas the sister must contain a schwa. Secondly, the first syllable is rhythmically stronger than its sister. At the word level, we note that one, and only one, rhythmically strong syllable is the carrier of primary stress, a property that every word must have.

It would appear that some kind of asymmetrical relationship exists at each level in the hierarchy. In each case, one daughter has a special status in being the most characteristic or most salient part of the constituent, while being obligatorily present. Students of morpho-syntax have noticed similar effects. Syntactic constituents appear to also always contain a privileged daughter, which, in that domain, is called the *head*. For example, in a Noun Phrase (*the three big houses in the valley*), the noun *houses* determines the category label of the whole phrase, which would have been complete with just the noun, but never without it. Likewise, complex words can be analyzed in terms of heads, i.e. those morpheme or word categories that determines the category of the complex word.

The view on phonology, and indeed grammar as a whole, that I subscribe to incorporates the claim that this resemblance between the morpho-syntax and phonology is non-accidental. In fact, to make the picture complete, I would have to discuss semantic structures as well and show that the organization of this subsystem also displays similar

kinds of properties. I will not do that here, however, for space reasons and also for feeling less than qualified to make coherent claims about this system.

The central idea of what is called *Dependency Phonology* (Anderson and Ewen 1987), and *Dependency Grammar*, is what John Anderson has called the *Structural Analogy Assumption* (Anderson 1992):

(3) **The Structural Analogy Assumption**
Representations belonging to different components of grammar, or to different levels in any given component, incorporate the same structural properties.

Hence, rather than believing that 'modularity' implies fundamental differences between components, the idea here is that the mind applies the same tricks as often as it can. This means that not only are the different components of grammar all particulate systems (making use of finite means to generate complex structures, possibly an infinite array of them), more specifically they all produce structures that share non-trivial properties, the most important of which is that of being 'headed'. Another shared property might be binarity. Van der Hulst and Ritter (2002, to appear) express these two properties in terms of two elementary principles:

(4) a. **The Binarity Principle**
All units are at most binary branching

b. **The Head Principle**
All units have a head

Both principles, I believe, are deeply rooted in human cognition, and it is most likely that these principle are not specifically phonological or linguistic (or even cognitive). Following the spirit of Volk (1995), we suggest that principles of this kind are instantiations of 'metapatterns.' Interestingly, both principles are envisaged as being at the absolute core of grammatical principles within a 'minimalist approach' to grammar, namely 'merge' and 'symmetry breaking', respectively (Michael Starke, p.c.).

I view the two principles given above as major examples of the *Structural Analogy Hypothesis* which, I might add, is not generally accepted in generative grammar; see van der Hulst, in press b for extensive discussion of this point. In particular, it has been suggested that 'phonology is different' (from syntax) in fundamental ways (Bromberger and Halle 1989).

Dependency phonology (DP; Anderson and Jones 1974, Anderson and Durand 1986, Anderson and Ewen 1987, van der Hulst 1988, 1989, in prep b) offers an approach to phonology that has been followed, with significant additions and modifications, in another approach called Government Phonology (GP; Kaye, Lowenstamm, and Vergnaud 1985, 1990, Kaye 1989, 1995, Brockhaus 1995, Ritter 1995, van der Hulst 2003). A further development of both approaches has lead to the framework of Head-driven Phonology (HDP) in which the head-dependence relation is seen as the 'driving force' behind most, if not all, phonological phenomena (van der Hulst and Ritter 1999, 2000a, 2002, to appear, in prep.; van der Hulst, in press e, Dresher and van der Hulst 1998). Phonological models of this sort have proposed important changes in the conception of

phonology as initially set up in Chomsky and Halle (1968; SPE) and maintained in (Bromberger and Halle 1989). Both Dependency and Government Phonology, as well as Head-driven Phonology (the latter more explicitly than the former two), move away from the idea that there are two phonological levels, one underlying and the other more surface-like, that are mediated by a set of partially ordered rules. Instead, a single phonological level is postulated. DP, GP and HDP differ from the SPE-conception not only in terms of rejecting the notion of 'rule ordering' and 'derivation', but they also have dramatically different views on the nature of the phonological representation itself. In SPE, features are binarily valued and articulatorily defined entities, packed together into unordered bundles that are merely sequentially organized. DP and GP postulate instead *monovalent* acoustically defined primes; HDP is also committed to a monovalent perspective. DP and HDP, in addition, postulate a *grouping organization* of the primes (similar to a conception that was later popularized in the idea of 'feature geometry'), a notion that only a few proponents of GP accept. In addition, constellations of primes that characterize phonemes associate with slots that are terminal nodes of hierarchical structures whose lowest constituents are onsets and rhymes (and/or nuclei); see (2). These notions (monovalent primes, intrasegmental grouping and surprasegmental grouping) were initially proposed in DP in the early seventies (Anderson and Jones 1974). All three, by the way, have also found their way into more 'mainstream' models of phonology, often as re-inventions, since work in DP has not been widely read (or at least quoted); see van der Hulst in press c for a short history of generative phonology.

The dependency/government based models discussed here embody an idea of segments that provides a beautiful illustration of the Structural Analogy Assumption. The SPE-traditions, following the tradition initiated by Roman Jakobson, views subphonemic units as binary features that combine in terms of simple addition. In Dependency Phonology (and later in Government phonology), this idea is replaced by an alternative in which the segmental primes are themselves monovalent units that can occur alone to form a segment or in a combination. For example, many languages have a vowel inventory

(5) /i/ /u/ /e/ /o/ /ɛ/ /ɔ/ /a/

DP postulates three primitives |I|, |U|, and |A|. In isolation, these primitives constitute the three vowels /i/, /u/ and /a/, generally considered to be the most basic vowels, present in practically all languages and the only vowels in many. Mid vowels are represented as combinations of the primes. Thus mid front vowels /e/ and /ɛ/ contain both |I| and |A|, whereas /o/ and /ɔ/ contain both |U| and |A|. The differences between the high mid vowels and the low mid vowels are represented by invoking the headedness relation:

(6)

/i/	/u/	/e/	/o/	/ɛ/	/ɔ/	/a/
I	U	I	U	A	A	A
		|	|	|	|	
		A	A	I	U	

These (headed) combinations of element do not involve linear order, although they do involve an orderly arrangement, expressed in terms of the head-dependency relation. In /e/ and /o/, the elements |I| and |U| are heads because in these vowels these elements are more salient than the element |A|. In the low mid vowels, however, the element |A| is more salient.

As might be expected, several different proposals for the set of monovalent phonological primes are around. GP work has concentrated on reducing this set to as few as six 'elements'. In my own 'Radical CV Phonology,' just two primes ('C' and 'V') are claimed to be sufficient, granted that we allow a fair amount of grouping. We refer to van der Hulst (2000, in press d, in prep. a) for full statements of this position, which entails the position that phonological primes have a variety of *contextually determined* phonetic interpretations. It is important to see that restricting the number of primes has significant empirical consequences. Restrictions of this sort are *substantive* rather than *formal* in nature, but they embody real claims about the human language faculty and human languages. It goes without saying that such substantive proposals need to be stated within a framework that is formally as restricted as possible.

It is usually assumed that the phonologies of languages may differ along two axes, viz. in their inventory of phonemes and in their set of permissible phoneme combinations. Within dependency and government-based approaches, all variation is due to differences in (phonological) syntax. Intrasegmentally, languages differ in terms of allowing or disallowing combinations of elements and in invoking or not invoking a contrast in headedness. Extrasegmentally, languages differ in allowing or disallowing binary syllabic constituents, left- or rightheaded feet and so on.

The intrasegmental relationships between primes can be seen as *paradigmatic* in nature in the sense that head-dependency relationships in this domain characterize the wellformedness of phonemes, irrespective of their position in words. Constraints on the phoneme combinations that can form syllabic units such as onsets and rhymes, on the other hand, represent a syntagmatic dimension of phonology. An important innovation of GP has been the idea that many additional aspects of phonological wellformedness can be stated in terms of syntagmatic (or 'lateral', cf. Scheer, in press) relations between the syllabic constituents onset and rhyme. A variety of such relationships have been proposed within various variants of Government Phonology, and I refer to van der Hulst and Ritter (in prep.) for a fuller discussion and many applications of Head-driven Phonology. In Van der Hulst (in press e) I suggests that all these interconstituent lateral relationships (which do not define a constituent of any sort) can be subsumed under a single, overarching principle: they all serve the common goal of restricting the markedness of phonological sequences. This proposal reveals that, in all cases, the occurrence of a marked syllabic constituent (which is marked because it is either empty-headed or branching) requires the local presence of a full-headed (and perhaps, in some cases, non-branching) constituent. My common denominator for this class of head-dependency relationships is *interconstituent licensing*.

It seems obvious to me, and I hope that the preceding survey has convinced the reader of this too, that the essential vocabulary of phonology is pretty remote from the vocabulary that is needed to talk about the articulation and perception of speech sounds (in other words from 'phonetics') while being pretty close to the vocabulary of sentence syntax and, even though we didn't go into that, semantics.

6. The treatment of allomorphy

We need to consider one further, quite crucial aspect of phonology. Apart from characterizing the inventory of segments (in terms of element combinations) and their possible syntagmatic combinations (which is what is often regarded as the *static* part of phonology referred to as *phonotactics*), there seems to be one more important phenomenon that falls within the scope of the phonological component, viz. *allomorphy*. This is the phenomenon that morphemes appear to vary their phonological shape depending on the shape of morphemes that they combine with. Allomorphy seems to call for rules that alter some basic shape of morphemes, and it is therefore often referred to as the *dynamic* part of phonology. Consider a textbook example that all linguistic students encounter in their 'Phonology 101' course. The following standard text book examples from a language called Yawelmani are cited from Kenstowicz and Kisseberth (1979: 83 ff.):

(7)				
	logw- ol	' might pulverize'	logiw - hin	'pulverizes'
	lihm - al	'might run'	lihim - hin	'runs'

In traditional terms, the form of the base morphemes must either contain the vowel /i/ that is then deleted in certain circumstances, or it does not contain such a vowel in which case there must be a rule that inserts the /i/. An epenthesis analysis is more likely than a deletion analysis since there are otherwise no CVCVC roots in the language. This is explained if one assumes that there are, in fact, no such roots in the language and that the surface pattern CVCiC is derived through epenthesis. The rule of epenthesis breaks up a cluster of three consonants. Now consider the following data:

(8)	Nonfuture	Imperative	Dubitative	Future	gloss
	dos - hin	dos - k'o	do:s- ol	do:s - en	report
	lan - hin	lan - k'a	la:n - al	la:n - en	hear

Roots that invariably have short vowels (i.e. show no vowel length alternation) show that the above roots have underlying long vowels that apparently shorten before two consonants (which amounts to closed syllable shortening in some models). Thus we have two rules, an epenthesis rule and a shortening rule. The two rules are extrinsically ordered, as shown by the following data:

(9)		
	sonl - ol	'might put on the back'
	so:nil - mi	'having packed on the back'

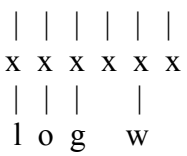
The underlying form for these roots must be CV:CC. A standard derivation of both forms shows that epenthesis must precede shortening:

(10)	(a)			(b)		
		so:nl - ol	so:nl - mi		so:nl - ol	so:nl - mi
	Ep.	---	so:nil - mi	Short.	sonl-ol	sonl - mi
	Short.	sonl -ol	----	Ep.	---	*sonil - mi

By standard reasoning, the rules must be extrinsically ordered: epenthesis precedes shortening. The need to adopt extrinsically ordered rules that 'transform' the shape of morphemes makes phonology look different from syntax, at least theories of syntax that do not admit a class of extrinsically ordered transformational rules. Even though early versions of generative grammar included such mechanisms, recent versions have abandoned extrinsic ordering or, indeed, transformations altogether. According to some (e.g. Bromberger and Halle 1989) phonology is indeed different from syntax in precisely this respect, the claim being that phonology *must* have extrinsically ordered transformations in addition to the particulate apparatus that we discussed earlier.

Government Phonology offers a perspective that takes care of allomorphy without phonological transformations. An analysis of the above facts would run as follows. Needless to say, I have to cut a view corners here; I refer to van der Hulst and Ritter (2002, in prep.) for a fuller statement and more examples. Vowel - zero alternations are handled by assuming that the morphemes showing this alternation contain so-called empty rhymes, rhymes whose head dominates no vowel elements. In fact, the morphemes that we are looking at here contain two such empty (or empty-headed) rhymes; the second is at the end following the apparent final consonant, which otherwise would be left dangling:

(11)



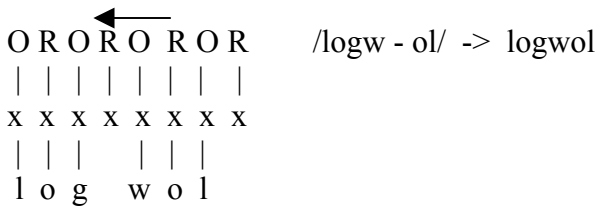
/logw/

At first sight, it may seem rather odd to postulate syllables with empty rhymes. Earlier, I stated that vowels are the obligatory part of syllables and are therefore considered to be their heads. We now see that this statement was too strong. The part that is obligatory is the head *position* (here called the rhyme). This strikes some as perversely abstract since phonology is supposed to be about 'sounds'. Recall, however, that there is no reason to believe that all phonological concepts must correspond to phonetic material. Here we see a striking case of that.

To limit random proliferation of empty categories, we will now adopt a simple licensing principle that says that an empty rhyme must be followed by a rhyme that is not empty (below we modify this formulation a bit). In addition, we stipulate that final empty rhymes are tolerated as such. In other words, a distinction is made between 'edge licensing' (for final, and perhaps initial empty rhymes) and interconstituent licensing (for medial empty rhymes); cf, van der Hulst (in press e). The interconstituent relationship can, like all other relationships, be seen as a head - dependent relationship. This relationship, by the way, is reminiscent of principles that play an important role in sentence syntax where so-called empty categories must be linked to non-empty categories in a local fashion.

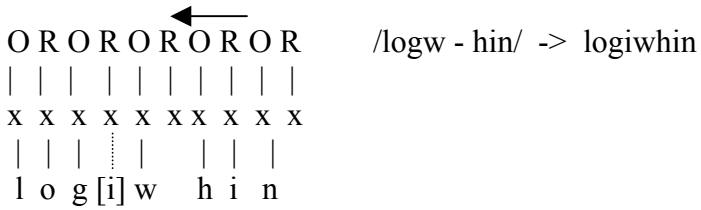
Now let us see how the two forms *logwol* and *logiwhin* can be derived:

(12)



/logw - ol/ -> logwol

(13)

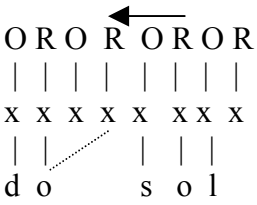


/logw - hin/ -> logiwhin

The form in (12) is wellformed because it is in accordance with the licensing constraints, but the form in (13) presents a problem. The first empty rhyme is not licensed. Thus, the form seems to be ill-formed as it stands. We might say that the form is now 'saved' or 'rerpaired' by adding a vowel to the first empty rhyme, as indicated in (13). This is, of course, in some sense our epenthesis rule, but note that, in this analysis, epenthesis is an automatic consequence of the way in which the phonological syntax is set up. In fact, in Government Phonology, it is proposed that sound [i] is not inserted at all in terms of a phonological operation, a repair rule of some kind. Rather the appearance of [i] is attributed to what is called 'phonetic interpretation.' I refer to van der Hulst and Ritter (2000a, to appear) for an extensive discussion of the role that phonetic interpretation plays in dealing with allomorphy and, more generally, so-called opacity effects. What is important to know, however, is that the 'epenthetic' [i]'s are subject to rounding harmony in Yawelmani. This, I take it, implies that in this language epenthetic [i]'s are, in fact, part of lexical entries as floating elements which will or will not be associated to the rhyme depending on the licensing constraints that are discussed below. If an element is not associated it will remain uninterpreted. At the end of this second and in the next section, I will return to the notion of phonetic interpretation and its role and place in the phonological system.

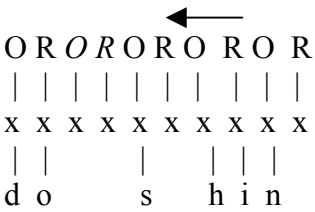
Let us now consider how shortening is handled. I assume without discussion that long vowels are represented as two rhymes with an intervening empty onset. (Once a language allows empty onsets, there appear to be no licensing constraints that limit their distribution; cf. van der Hulst, in press e):

(14)



/do:s/ - ol/ -> do:sol

(15)



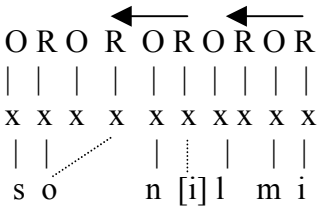
/do:s - hin/ -> doshin

Note that in (14) all is well. The second rhyme (i.e. the one that constitutes the second half of the long vowel) is licensed. One might expect that it therefore can stay silent. However, since there is no intervening onset consonant, we assume that it is interpreted in terms of the vowel structure /o/; this is what gives the appearance of a long vowel. In other words, licensed empty nuclei do not have to be silent, and in fact they are not if local spreading is possible.

In (15), the second half of the long vowel is not licensed. Thus one might argue that it will be interpreted with an [i] sound (like the form in 13), but this is not what we see. Rather the empty OR sequence remains completely uninterpreted. In van der Hulst (in press e) I argue that a completely empty syllable (i.e. OR sequence) violates a licensing constraint which demands that empty onsets are licensed by non-empty rhymes. (This implies that the second half of the long vowel in (14) no longer counts as empty.) However, 'epenthesis' is only one possible response to illformedness; 'removal' (or non-interpretation) of structure is another. Elsewhere, I argue that 'removal takes universal precedence over 'epenthesis'. One can see this as a *universal* ranking relation between two constraints, and this triggers association with Optimality Theory, an approach that capitalizes on the notion of constraint ranking. In the next section, I will explain that we are not doing OT here, since no appeal is made to *language-specific* ranking. The approach advocated here also differs from OT because our constraints are firmly grounded in an explicit theory of phonological representations, rather than being loosely grounded (if at all) in implicit theories of phonetics or what have you.

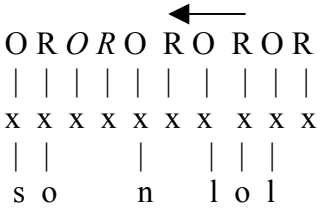
Finally, we have to show how both epenthesis and shortening co-occur in a single form (cf. 9 and 10):

(16)



/so:nl - mi/ -> so:nilmi

(17)



/so:nl - ol/ -> sonlol

In (16), the second half of the long vowel is licensed by a rhyme that is itself empty, but *unlicensed*. This shows that un unlicensed empty rhyme can license a preceding empty rhyme to be silent. We can thus conclude that appropriate licensors do not have to be lexically associated to elements. In other words: licensors are simply and merely required to be themselves unlicensed. Since a licensor as well as an unlicensed rhyme are heads (the latter because it is not a dependent), the generalization is that licensors must be heads. In (17), the 'italic' OR sequence will be removed as it was in (15).

As shown, the alternations in Yawelmani follow from certain simple and well-defined properties of the syntax of phonological representations, in particular empty syllabic constituents (whose distribution is properly constrained). In addition, GP relies on a mechanism called phonetic interpretation. This mechanism warrants a few extra comments. It might be argued that phonological structures (and, I assume semantic structures as well) must indeed be interpreted in the sense that these structures must be connected to the outer world of perceptible events (sounds or bodily signs) on the one hand, and the inner world of thought on the other hand.

It would seem then that only the syntactic system involves uninterpreted structures, whose sole raison d'être is to mediate between the phonological and the semantic structures. This may sound like a bit of a retreat from the parallel view discussed in section 3, but it really isn't. By saying that syntax mediates between sound and meaning, we are not adopting the syntactic-centric view of traditional generative grammar (cf. Jackendoff 2002).

In so-called possible world semantics, the interpretation of semantic structures would not concern a link to an inner world of thoughts as I assume here, but rather to entities and events in some conceivable outer world. Of course, I do not deny that some link can be made between whatever goes on in our mind, i.e. our thoughts, emotions and the real world, but I assume here *that* link falls outside the scope of linguistics. Another issue is that one might argue (as Jackendoff 2002 does) that semantic representations *consist of* elements of thought, such that no interpretation is called for (although there would still be the other type of link to the outside world that I just mentioned). I am not sure that this is a tenable position, as I like to believe that the semantic concepts that make up linguistic meanings are 'grammaticalized' versions of the wider set of 'thought concepts', but since I am way out of my depth here, I will refrain from further discussion on this tricky subject. A parallel point could, however, be made for phonological concepts. One could argue that the phonological elements (like |A|, |I| and |U|) need not be interpreted as such, except for the fact that they need to be linked to perceptible events such as sounds and signs. However, the GP notion of 'phonetic' interpretation does not strike me as involving a true externalization (or what some people call 'phonetic implementation'). Rather it would seem that GP-style phonetic interpretation delivers 'inner speech' or what van der Hulst and Ritter (to appear) call the 'idealized realization' of a phonological expression. If this is the way to look at 'phonetic interpretation', one might want to object to the use of the term 'phonetic' and simply call this aspect of the phonological system 'phonological interpretation'. Also, we now expect that there is a further step to be made explicit, which is the externalization of the idealized phonological form. The question arises whether this further step of phonetic implementation is part of the linguistic system or rather falls outside of it, just like the link between thoughts and the outside world were said to fall outside the realm of the grammar. I will return to this

issue in the next section, after having made a few remarks about the constraint-based nature of the type of analysis that we have seen in this section.

7. One or two phonological levels?

In van der Hulst and Ritter (2002, to appear) it is made explicit that HDP (much like GP; DP is less explicit on, or concerned, with the matter) is a *constraint-based approach*. There are no serial derivations resulting from extrinsic rule ordering. The constraints are referred to in different ways: universal constraints are called *principles*, while constraints that involve a language-specific option are called *parameters*. The labels indicate functional differences with respect to language acquisition or the workings of the synchronic grammar, but there can be no question about the fact that all express 'true generalizations'. As such, all constraints in HDP are 'hard constraints', a position that HDP shares with Declarative Phonology (cf. Scobbie 1997, Scobbie, Coleman and Bird 1996, van der Hulst and Ritter, to appear). There can be no surface violations, except in cases where a universal precedence relation (a 'ranking') is imposed. In addition, correspondence (or interface) constraints (in the sense of Jackendoff 2002) are required, i.e. constraints that specify the co-occurrence of phonological expressions, syntactic expressions and semantic expressions.

Constraint-based approaches are popular these days (see LaCharité and Paradis and Prunet 1993 for an overview), especially because one specific constraint-based approach, called Optimality Theory (OT; Prince and Smolensky 1993, Kager 1999, McCarthy 2003), has been adopted by the majority of phonologists. Even non-phonologists seem to favor it over other approaches for reasons that are seldomly made explicit. In fact, it turns out that OT has many properties in common with the SPE model; cf. van der Hulst and Ritter 2000b. The central, and in fact defining, property of OT is that all constraints are universal, which entails the idea that differences between languages must be accounted for in terms of language-specific ranking. This idea, although feasible in principle, when combined with the freedom to formulate an abundance of constraints and an almost complete lack of commitment to what constitutes the vocabulary or syntax of constraints allows for a lot of uninteresting results. I maintain that the case for language-specific ranking has not been made in a convincing manner; see van der Hulst and Ritter (2000, 2002, to appear). Other constraint-based approaches do not assume that all constraints are universal which allows for a parametric view on differences between languages, i.e. the presence of constraints in grammar is the result of a parametric choice.

The biggest challenge for constraint-based approaches is to deal with allomorphy, which, as we have seen in the preceding paragraph, calls for apparent repair rules. Constraint-and-repair approaches indeed assume that constraints have to be supplemented by repair rules (Paradis 1988, Calabrese 1986, 1995, to appear). Declarative phonology avoids repair rules, especially deletion rules, and seeks a solution in 'building the alternations into the lexical representation of morphemes' using underspecification and good-old listing of the choices in an 'item-and-arrangement' style (Scobbie, Coleman and Bird 1996). Government Phonology appeals to the mechanism of phonetic interpretation (see above) and, finally, OT, introduces a class of special 'faithfulness' constraints that

compare the grammar's output with the underlying form. In fact, this strategy *necessitates* the adoption and reference to a non-output level which we otherwise do not need. In short, it would seem that various solutions have been proposed to maintain a constraint-based approach in the face of the apparent need for rules that change things. I refer to van der Hulst and Ritter (to appear) for further in depth discussion and evaluation of the various approaches.

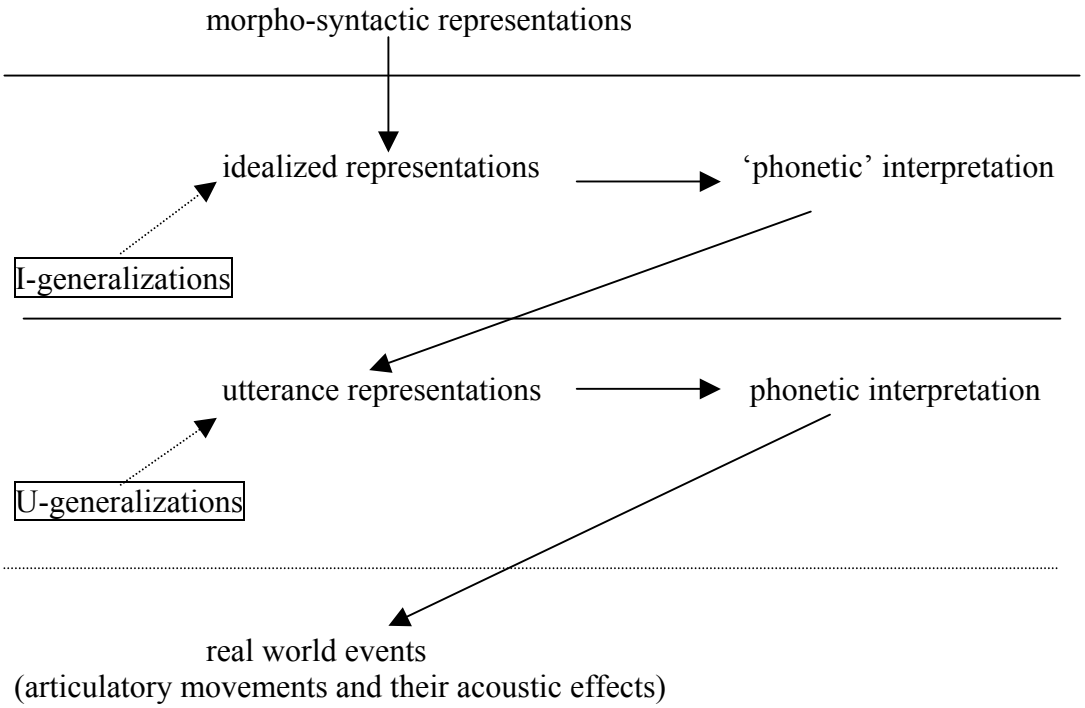
The adoption of a constraint-based approach suggests that one admits only one level of representation, and indeed so far I have assumed that there is just one phonological level within the approach that I adopt. However, this position cannot be maintained, as argued in van der Hulst and Ritter (to appear), although saying this does not entail a return to SPE two- or multi-level theories with rule ordering. We suggest the following. Firstly, we assume that for each phonological expression (word, phrase or sentence) there is a level of representation (*cum* interpretation) that cognitively characterizes the expression in its *idealized form*. A particular kind of pronunciation, often called 'careful pronunciation' probably most closely corresponds to this representation. Assuming, as we must, that there is a mapping from the idealized form to an *actual realization*, a second level represents a particular actual realization of the phonological expressions, one that suits the communicative context. It is, of course, well-known that particular realizations of phonological expressions (which we call *utterances*) can differ from the 'idealized' form in a bewildering numbers of ways. Consider the following examples, taken from Shockey (2003):

(18) a. And the suspicious cases were excluded
b. ændðəsəˈpɪʃəskeɪsɪzweɻɛksˈkludɪd
c. n̥əsːˈpɪʃs̥keɪsɪsəʷxsˈkludɪt

Whereas, as Shockey says, a speaker of English (possible a phonologist) might think he is saying what is (broadly) transcribed in (18b), he most likely says something as in (18c), a transcription that is narrower, but more importantly much shorter than the one in (18b). In many cases, surprisingly little is left of what a phonologist might consider to be the idealized phonological output representation, as anyone who inspects transcriptions of actual speech will be able to verify. More to the point, many generalizations that a phonologist might have postulated with reference to the idealized level (let us call them I-geneneralizations) could be obscured (i.e. rendered opaque) in the actual realizations of the expression, assuming that utterance realization rules (let us call these U-generalizations) may 'counterfeed' or 'counterbleed' them; I will not further explain these two 'horror notions' from Phonology 101. To maintain the I-generalizations, one would have to introduce extrinsic ordering between the generalizations that hold of the idealized level and those that characterize any particular utterance realization. Now one *could* think of the two notions of output as different 'levels' that stand in a derivational relation that is reminiscent of the SPE-model, but van der Hulst and Ritter propose that it is more adequate to say that we are dealing here with two different *planes* of representation, each plane being monostratal and subject to its own set of generalizations. The utterance plane is, in fact, a set of planes, one for each specific realization. With some subtle difference, this point of view is, in fact, also adopted in Anderson and Ewen (1987).

Both systems, the idealized system and the utterance system, operate as constraint-based 'checking devices.' Thus, both systems simply define a (infinite) set of well-formed expressions. The idealized system checks whether a linguistic expression (traditionally thought of as resulting from morpho-syntactic combination and lexical insertion) is well-formed as far as the phonological dimension is concerned. We have seen that, to the extent that this is not so, the interpretation system will respond appropriately by either assigning audibility or inaudibility to unlicensed structures or elements. Likewise, we regard the utterance system as a checking device which, given the constraints that characterize some stylistic register, check the wellformedness of expressions that are submitted by the idealized system. It turns out that typically many properties of the idealized input representation cannot be implemented, and this accounts for the differences between such examples as (18a) and (18b). We thus end up with the following diagram:

(19)



Everything in this diagram is 'internal' except for the result of the phonetic interpretation (or phonetic implementation) of utterance representations. We can now return to the question that was raised at the end of section 6. The part in diagram (19) that comprises the U-generalization and the phonetic interpretation at that level could be argued to fall outside the realm of the linguistic system, but that would perhaps entail that everything that we find there must be both universal and outside the control of the speaker. But this must be wrong for the reason that we already mentioned: many aspects of utterances are under the control of the speaker. This applies to, firstly, as we have stressed, the choices that speakers make in order to fit their style of speech to the speech situation. Secondly, even when we focus on matters of phonetic detail that pervade all styles of speech, we encounter many examples in which languages differ from each other. Anderson and Lightfoot (2002), chapter 6, discuss such examples and indeed conclude that a lot of

'phonetics' is part of the linguistic system. It is still possible that some aspects of the interpretation of utterance representation is truly universal and thus outside the linguistic system. The diagram in (19) does not encode that, however.

8. Conclusion

I hope to have made clear that phonology forms a subsystem (component, module) of grammar that, despite its close relationship to sound, has a structure that is quite parallel to that of the other grammatical components, notably, as shown here, the syntactic component. I have also tried to convince you of the fact that explanations for phonological phenomena rely on abstract properties of phonological representations, including empty positions, rather than on direct reference to phonetic properties of linguistic utterances. However, it has also been shown that the relation between phonological representations and phonetic interpretation forms part of the cognitive system to a point where of lot of phonetic detail is accounted for within the cognitive system. This approach is labeled *Cognitive Phonology* (cf. Kaye 1989) to emphasize its reliance on understanding phonology to be a grammatical subsystem rather than a mere description of the articulation and acoustic properties of sounds and their perception.

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