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Modularity and Modality in Phonology

Harry van der Hulst

1. Introduction

In this chapter, I claim that the innate abilities that underlie phonology are neither modular nor modality specific. The phonology of a language emerges from the interplay between innate (linguistic and perhaps even more general cognitive) principles and formats and the phonetic domain of the language modality. I will propose an account of the formation of phonological primes, phonological structure, and phonetic implementation for both spoken and signed language that is based on such principles and formats. I then discuss differences (involving the notions segment and syllable) between the two kinds of phonology, which I explain as *modality effects*.

As a working definition, I define phonology (as a subdiscipline of linguistics) as the study of the perceivable form of language and its cognitive representation. The term 'phonology', when used as a name for a component of the internalized grammar of language users, refers to a cognitive reality only. These definitions make no reference to the notion 'sound' because, in my view, sound is just one of the media that make linguistic forms perceivable, the most obvious other medium being the visual image.[1]

Most students of phonology, and language in general, will agree that signed languages are, in fact, natural human languages just like spoken languages. As such, signed languages are acknowledged to have the property of dual patterning (or dual articulation), which means that (the cognitive representation of) the perceived form of signed utterances has an internal compositional organization

I wish to thank all those with whom I have collaborated on developing the approach to phonology that I take in this chapter. This includes my colleagues Colin Ewen, Norval Smith, Nancy Ritter, and Elan Dresher and my former and present Ph.D. students Claartje Levelt, Helga Humbert, Rob Goedemans, Els van der Kooij, and Onno Crasborn. Michael Studdert-Kennedy, Onno Crasborn, Nancy Ritter, and the editors of this volume offered helpful comments on an earlier draft of this chapter. Finally, I especially wish to thank Nancy Ritter for the many discussions that we had on the subjects covered in this chapter. Where I am full of doubt, she points me in the right direction.

[1] In this chapter, I will not discuss any form of tactile languages.

that is independent from its morphosyntactic organization, and its meaning. The latter aspect is often captured by referring to the 'arbitrary relationship' between form and meaning. In this chapter, I claim that the innate abilities that underlie phonology are neither modular nor modality specific. The focus, however, lies on examining the consequences of designing a phonological theory that covers both spoken and signed languages. This enterprise will lead me to pose questions regarding the nature and scope of phonological theory. Specifically, I will defend the idea that phonology is not different from syntax, and therefore not somehow 'outside UG' (see Burton-Roberts, this volume). On the contrary, I will develop a view on phonology and syntax that makes them fully parallel. I will also address the question as to what the difference is between phonology and phonetics, arguing against a full fusion of both modules. I will develop a view on the relationship between phonetic categories and phonological primes, on the one hand, and between phonological structure and phonetic implementation, on the other hand. With respect to the issue of sign languages, I will subscribe to the view that phonologies in that modality are essentially parallel to the phonologies of spoken languages and thus that phonological theory must generalize over both modalities.

The structure of this chapter is as follows. In Section 2, I discuss two widespread beliefs about phonology (involving modularity and modality) that I will question in this chapter. Section 3 provides a proposal for the compositional organization of both spoken and signed language phonology. Here I also discuss differences between these two kinds of phonology, which I explain as MODALITY EFFECTS. Section 4 offers a brief summary and my main conclusions.

2. ON MODULARITY AND MODALITY

In most conceptions of the subject, phonology both at the universal (innate) and language-specific (acquired) level is both modular and, at least implicitly, modality specific (specific to spoken language). In this section, following van der Hulst and Ritter (forthcoming), I argue that the innate abilities that are relevant to phonology are specific neither to phonology, nor to spoken language.[2] However, these principles are *instantiated* in language-specific phonologies and these instantiations *are* both modular and modality specific.

2.1 Modularity

In this section, I wish to argue that phonology is 'module free'. In other words, I reject the spirit behind the claim that 'phonology is different'. This claim has been defended most explicitly in Bromberger and Halle (1989). What they mean is that 'phonology is different from *syntax*' in that the former appeals to mechanisms like extrinsic rule ordering of a list of phonological 'transformations', an idea that

[2] Even though I use the first person singular pronoun in this section, the proposals are directly drawn from van der Hulst and Ritter (forthcoming).

generative syntax has moved away from many years ago. With this view, Bromberger and Halle implicitly take issue with theories of phonology such as Dependency Phonology (Anderson and Ewen 1987), Government Phonology (Kaye *et al.* 1985, 1990), and Head-Driven Phonology (Ritter 1995; van der Hulst and Ritter 1999; forthcoming), which make the opposite claim and argue that phonology and syntax are organized in parallel ways.[3] Anderson and Ewen (1987: 283–4) write: 'Quite simply, we expect, *ceteris paribus*, different levels to display the same basic structural properties. Conceptual economy demands no less.' They argue, in particular, that the recurrence of the notions of *headedness and dependency* in both syntax and phonology is a manifestation of what they call structural analogy (see also Taylor 1995 on this point). Clearly, structural analogy (unlike modularity) militates against the idea that the internal organization of the grammatical modules is entirely different. My view is that the Structural Analogy Hypothesis, and thus the idea that grammar recapitulates, rather than proliferates, structures and principles, is on the right track. The Structural Analogy Hypothesis does not, of course, imply that the actual phonology and syntax of specific languages are identical, or that there is only one component. We *do* have two different components, each accounting for the well-formedness of hierarchical constructs. Why, then, are the phonological and the syntactic constructs different? The answer is that both types of constructs take different sets of basic units as their starting point. In phonology, these basic units are phonetic categories, whereas in syntax the units are semantic categories. The notion of CATEGORY here means that the relevant units are (mental) concepts of real world phenomena, phonetic events, and, non-phonetic events, respectively.[4]

The two different domains of phonetic and non-phonetic events, being different in themselves, project different sets of categories, and this means that the structures (although not their structural properties), which must accommodate these categories, will be different too. Thus, the phonological and syntactic components will, in part, instantiate different (rules for) hierarchical structures, which (I claim) merely reflect differences in the domains from which the basic categories are formed. This is why we need two components.

The conception of grammar that I have committed myself to here can be diagrammatically represented as follows (I will refine the conception below):

[3] Michaels (1991) also capitalizes on the fact that phonology and syntax are structurally similar.

[4] See Jaeger (1980), Jaeger and Ohala (1984), and Miller (1995) for empirical discussions of phonological categorization, and of the structure of phonetic categories.

(1)

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        phonetic events        non-phonetic events
                     \          /
             categorization principles
                    /           \
phonetic categories               semantic categories
                     \          /
                structural principles
                    /           \
phonological structures           syntactic structures
```

What *are* the categories in both domains? Following linguistic terminological practice, these units must be '-emes', and thus syntactemes and phonemes, respectively. Tradition, however, gives us the term 'word' instead of syntacteme, and I will follow this practice. The stock of words (the primes of syntax) constitutes the lexicon. The syntax of words involves several layers. First, words form phrases (XPs), then phrases are combined into (simple) sentences, and, finally, simple sentences form complex sentences.

So where is morphology? Again, I adopt a traditional point of view and assume that morphology deals with the internal form-meaning structure of words. Words thus have an internal syntax (morphology) and an external syntax (syntax).[5] The building blocks of morphology are, of course, morph*emes*. Hence morphemes rather than words are linguistic *labels* for basic semantic categories.

Can we make parallel distinctions for phonology? The basic building block, or the prime of phonology, is said to be the phoneme. If the phoneme is parallel to the word, as I suggest here, we expect to find a phoneme-internal organization that parallels morphology. Indeed, according to theories such as Dependency and Government Phonology, phonemes must be decomposed into buildings blocks, referred to as 'components' or 'elements', respectively (Schane 1984 calls them 'particles'). We can understand elements now as labels for basic phonetic categories, just like morphemes are labels for semantic categories. The inventory of phonemes that each language has constitutes, then, a 'lexicon of phonemes'.

What about features? Elements are phonological units, but they are not, as understood here, the same thing as features. Elements are building blocks, whereas features are attributes. One could argue, however, that elements (or rather the phonetic category that they represent) can be described in terms of phonetic features (that is, attributes), just like the semantic category represented by morphemes can be analysed into semantic features. Indeed, Kaye, Lowenstamm, and Vergnaud (1985) proposed that their elements were characterized in terms of set of phonetic features (like [±round], [±back] and so on). Since these features do not seem to play a direct role in phonology, Government Phonology

[5] I do not address here the different forms of morphology (that is inflectional, derivational, compounding).

subsequently abandoned them. Analogous, perhaps, is the debate as to whether semantic features (like [±animate]) are relevant to syntax. The features mentioned here (in both domains) can be seen as *content* (or *substance*) features. Morphemes, in addition, also have distributional features, like [±N] and [±V]. Where do these come from, and are there comparable distributional features for phonological elements? With respect to the latter question, the answer is that a feature like [±syllabic], and perhaps also [±consonantal] and [±sonorant], is probably equivalent to [±N] and [±V] in so far as the former features essentially encode whether an element (or the phoneme it heads) projects an onset or a rhyme, just like the syntactic features [±N, ±V] encode whether the morpheme (or the word it heads) projects a VP, NP, or other major phrase type. In fact, we can think of distributional features as diacritics that indicate how a particular unit in the inventory of elements or morphemes is restricted in its occurrence in the syntactic or phonological structural organization. Golston and van der Hulst (1999), in fact, argue that distributional features are to be eliminated as features of elements, since they are in essence structural, a claim that is equivalent to the minimalist idea that morphemes or words do not have inherent syntactic features.

Thus, it would seem, then, that phonology and syntax show a perfect structural analogy:

(2)

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              phonetic events     non-phonetic events      (real world)
                          \        /
                  categorization principles
                         /         \
                  elements           morphemes
           (phonetic features)   (semantic features)
                          \        /
                    structural principles          (morphology)
                         /         \
      segments (phonemes)           words (syntacteme)      (lexicon)
            (Cs, Vs)[6]                  (Ns, Vs)
                          \        /
                    structural principles
                         /         \
      syllabic constituents            phrases
 (CPs [onsets], VPs [rhymes])        (NPs, VPs)
                          \        /
                    structural principles
                         /         \
                  syllables        (simple) sentences
                (CPVP-units)         (NPVP-units)
                          \        /
                    structural principles
                         /         \
                  feet, words      complex sentences
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[6] I use the labels C and V for consonant and vowel. Below CP and VP stand for onset and rhyme constituent, respectively.

Two further issues need to be dealt with. How do phonology and syntax come together, and how does phonetic (and semantic) interpretation (or implementation) come about?[7]

With respect to the first issue, I adopt the traditional position that overt (that is, audible) morphemes are listed in the lexicon with phonological a form. Inaudible (so-called zero) morphemes also exist. Logically, the next smallest phonological form would be a single element, such as the element *nasal* or *high* (*tone*), characterizing, for example, an inflectional morpheme. More typically, however, morphemes are provided with phonological forms that are constituted by units higher up in the phonological hierarchy, that is complete (or near complete, so-called archi-)phonemes, syllabic constituents, syllables, feet, and words.

Following van der Hulst and Ritter (1999), I adopt the view that the phonological word is a *bounded* constituent (maximally comprising two feet), like feet are maximally bisyllabic. Thus, we expect that morphemes typically do not exceed a certain size (that is, four syllables). This seems correct, in general. In English, however, a morpheme like *hippopotamus* exceeds that size, so it must consist of more then one phonological word.[8]

I will furthermore assume then that the lexicon is constrained in the following way: all syntactic words are phonological words. The issue of what constitutes a well-formed phonological word depends, however, on the type of syntactic word. Words belonging to open (that is, morphologically extendable) classes typically are at least a minimal word (that is, a branching foot) and maximally two (bis)yllabic feet (that is, a branching phonological word); in other words, they must be branching at some level. Closed class words, on the other hand, can be smaller than that, although they must contain at least an audible rhyme.[9]

The second issue can be seen as follows: the outputs of the syntactic component are morphosyntactically structured sequences of words (internally structured by morphology, and externally structured by syntax). Most of these words have a phonological specification, although there are also inaudible words (formed from inaudible morphemes); these are the 'abstract' words that have no phonological form (like 'small' *pro*), while expressing a semantic concept and having syntactic features. These sequences form the input to the phonetic implementation (or interpretation). I distinguish two types of implementation rules. First, there are rules that attribute a rhythmic-temporal structure to the morphosyntactic sequences. These rules have access to the morphosyntactic (that is, grammatical) properties of the structure (like major phrase boundaries). A second class of rules

[7] An issue that is not addressed in this chapter is that of 'levels'. In HDP (as in Government Phonology) there is no distinction between an underlying and a surface level and thus no notion of derivation. Opacity effects are treated in terms of a discrepancy between the phonological representation and the phonetic implementation; see van der Hulst and Ritter (2000).

[8] One might therefore consider including a level above the phonological word in the phonological hierarchy—that is, a phonological phrase.

[9] See Dresher and van der Hulst (1998) for an explanation of this difference between open and closed class words.

implements the phonological elements. These rules are context-sensitive in that elements are implemented with reference to other (locally accessible) elements, and the head-dependent relations that form part of the phonological structure.

Thus, by including the first category of implementation rules, I incorporate into phonetic implementation the kind of grouping rules that have been proposed for forming the prosodic hierarchy.[10] By regarding the 'grouping rules' as a special class, we prevent rules that the interpretation of the phonological elements can be sensitive to grammatical information as well.

We can, of course, talk about phonetic implementation only if we conceptualize this implementation in terms of a phonetic model of the actual production and perception of linguistic utterances. This model is *not* a part of the phonology, although it may 'look like' it, in that it will probably make use of units that are somewhat similar to elements, syllables, feet, and larger groupings. Thus, we get a distinction between phonological structure and phonetic structure. Elsewhere (van der Hulst 1999*b*), I have argued that so-called structure paradoxes arise when phonological structures and phonetic structures turn out to be non-isomorphic (as they often do). Such situations are experienced by linguists as problematic only if both structures are, erroneously, placed within the same component, in which case we have a real contradiction. If, on the other hand, the non-isomorphic structures are located in different components, there is an apparent contradiction (that is a paradox) only. To give one example, ambisyllabic consonants (which form an embarrassment for theories of phonological structure that typically do not allow overlapping constituents) exist in my view only in the phonetic structure. The option of delegating certain structural proposals to the phonetic representation not only prevents structural contradictions, it also keeps phonological structure in line with syntactic structure, as required by the structural analogy hypothesis.[11]

Parallel to phonetic implementation, I assume a semantic implementation that likewise operates on the output sequences of the syntactic component:

(3) Phonological Component—morphemes, words (lexicon, morphology)

|

Syntactic Component

|

phonological-syntactic structures

/ \

Phonetic Implementation Semantic Implementation

[10] Note that I make a theoretical distinction between a phonological hierarchy (formed in the phonological component) and a prosodic hierarchy (formed in the phonetic interpretation component).

[11] At the level of primes, we might say that so-called gestures (as used in Articulatory Phonology, (Browman and Goldstein 1989)) form, as phonetic units, the phonetic counterpart of phonological elements. (See Clements 1992.)

With respect to the relationship between phonology and phonetics, we have here argued that the former is, in some sense, connected to phonetics 'on two sides'. At the deepest level, phonological elements are labels for mental categories of phonetic events, while at the most surface level phonological structures (being encapsulated in the syntactic structures) receive an implementation in terms of (a model of) real world phonetic events.

In this section, then, I have argued for a set of module-free abilities that enable the language learner to construct a grammar:

(4) (*a*) Categorization
(*b*) Structure building
(*c*) Implementation

Each of these abilities specifies a set of principles or formats to construct (in the course of acquisition) the two components, syntax and phonology,[12] including for each the relevant set of basic categories and implementation system.[13]

Differences, then, between the two components are a consequence of the fact that the domains from which the basic categories are formed are different. However, this being said, I have not subscribed to the viewpoint that 'phonology can be reduced to phonetics'. On the contrary, the three parts in (4) have nothing to do with phonetics. To this I should add that they also have nothing to do with phonology *per se*. What we call 'phonology' arises from the interplay of these general abilities and the specific domain to which they are applied. In my view, the language-specific categorization of phonetic events, phonological structure, and phonetic implementation *emerge* in the process of language acquisition.

This view is totally different from the view of Halle and Bromberger, and, in fact, most other work in generative phonology. Proponents of generative phonology attribute phonological categories and phonological structures to an innate system (Universal Grammar (UG)). Thus, one prevailing idea is that there is a list of innate, phonetically defined *phonological features* (often organized in a hierarchical tree structure) from which language learners allegedly make a choice that is driven by the language input. In Optimality Theory (OT) (Prince and Smolensky 1993; Kager 1999), in addition, we must reckon with an innate list of constraints that make reference to preferred or dispreferred constellations of these phonetically defined features. The idea that the innate abilities are not module specific is incompatible with such views on innateness. In order to further undermine such views, I now turn to a discussion of modality effects.

[12] I refer to van der Hulst and Ritter (1999; forthcoming) for an extensive proposal concerning the general, non-modular principles that account for the well-formedness of phonological structures and 'processes'.

[13] I ignore here two huge issues. First, if we say that semantic and phonetic categories result from categorization principles, we seem to imply that these categories as such are not innate. This is controversial, especially with regard to semantic categories or concepts. Secondly, we might wonder whether the abilities in (4) are specific to language or are, in fact, of a more general cognitive nature.

2.2 *Modality*

With reference to the model sketched in the preceding section (see 2), I claim, of course, that there is no innate set of phonological 'features'. The claim that whatever is innate, is not intrinsically defined in phonetic terms, is further supported by referring to the existence of sign languages. I assume that deaf-language learners construct a grammar, including a phonology, in the process of language acquisition, being guided by the same innate cognitive abilities that guide hearing people in constructing their grammar. Then, surely, whatever these abilities are, it must follow that they cannot be modality specific, in the sense of being exclusively specialized in the production and perception of the speech signal.

Thus, it follows that the relevant innate abilities must be A-MODAL (modality free, modality neutral), as well as being A-MODULAR,[14] creating for the phonology, a system of phonetic categories, a combinatory calculus for building representations and an implementation system. The argument developed in the preceding section, that innate abilities and principles are not intrinsically phonetic, is complemented by the present argument that these abilities must generalize over the phonetics of both spoken and signed languages.

Returning now to the working definition of phonology we can be more precise and define phonology as the study of the phonological instantiations of the abilities in (4), as well as of these abilities themselves. In covering the abilities themselves, phonology (as a discipline) overlaps with the discipline of syntax that (as per the Structural Analogy Hypothesis) also studies these same abilities, in addition to their syntactic instantiations. Phonology, I conclude, includes categorization (normally totally ignored in so far as the end result is simply postulated as a list of features or elements), structure (uncontroversially included by all phonologists in some form or other, often rather unrestricted though), and phonetic implementation (normally presupposed and/or referred to Laboratory Phonology).

3. CATEGORIZATION, STRUCTURE, AND IMPLEMENTATION IN PHONOLOGY

3.1. *Spoken language*

3.1.1. Introduction

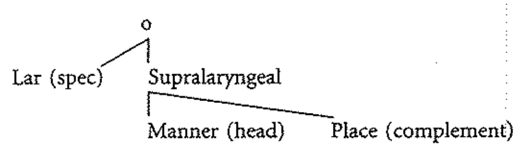
This section sketches a theory of categorization, phonological structure, and phonetic implementation, up to and including the level of the syllable. This theory, called RADICAL CV PHONOLOGY (RcvP) has been developed in a series of articles (van der Hulst 1988*a*,*b*, 1989, 1994*a*,*b*, 1995*a*, 1996*c*, 1999, forthcoming *b*). RcvP reconstructs mostly well-known and widely accepted ideas about phonological

[14] See Sandler (1993*b*) for a discussion of modularity in the context of sign languages.

primes and their phonetic correlates, as found in works on binary feature theories (Hyman 1973; Keating 1987), or in theories based on unary components (Anderson and Ewen 1987), elements (Kaye *et al.* 1985), or particles (Schane 1984). Likewise, RcvP incorporates ideas about segment-internal (class node) organization, various forms of 'complex' segments (Clements 1985; Sagey 1986), and syllable structure (notably Anderson and Ewen 1987; Kaye *et al.* 1990). A full-blown presentation of the theory is offered in van der Hulst (forthcoming *b*).[15] RcvP embodies the ideas presented in Section 2.1 in offering an account of phonology that is based on general principles and formats, that are not specific to the construction of the phonological module. Their independence of modality is discussed in Section 2.2.

With respect to phoneme structure, I adopt the idea that a phoneme has a tripartite design (Clements 1985), here modelled as a headed X-bar structure. Each node represents a class

(5)



MANNER forms the head of the phoneme because manner properties (here taken to include major class distinctions) determine the external syntax of segments—that is, their distribution in the syllable. Precisely for this reason it is justified to consider *manner* primes as a class (on a par with place and laryngeal primes). The argument that *manner* primes do not form a functional unit in ('dynamic') phonological insertion, deletion or movement processes (whether correct or wrong) does not invalidate their unity as a class if we consider the ('static') distributional regularities. Laryngeal (tone and phonation) is arguably the 'outer shell' of the phoneme, the most suprasegmental (that is mobile or moveable) and, at the same time, most optional class, which motivates its specifier status. Thus place must then, as the complement, form a unit supralaryngeal together with *manner*.

RcvP acknowledges that the X-bar scheme represents a universal non-modular structural scheme that is instantiated in those cases where *unlike* categories are combined to form a complex expression (see Dresher and van der Hulst (1998); van der Hulst and Ritter (1999, forthcoming).

In each of the three classes we find an array of possible elements (in fact, as we will see, exactly *two* elements, encoding *four* phonetic categories or features). A

[15] Van der Hulst (forthcoming *b*) details and supports many proposals that are put forward here. I will refrain from repetitive statements like 'see van der Hulst (forthcoming)'. In that work, I also discuss in detail the relationship between RcvP and related ideas that can be found, firstly in DP, but also in Shapiro (1972), Kiparsky (1979), and Farmer (1979).

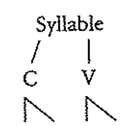
major goal of RcvP is to propose that the set of phonetic categories can be derived from general principles, rather than being postulated in the form of an (innate) set of distinctive features. These general principles, in a sense, can be regarded as principles that guide the categorization of the space of (linguistically relevant) phonetic events into mental phonetic categories. The principles impose a structure on the phonetic substance, a structure, however, that recapitulates itself in other domains, both above the syllable and, I presume, in the syntactic component. Hence, these principles are a-modular. When we discuss sign language phonology, we will learn that these principles are also a-modal.

As we will see, the principles of RcvP allow two syllabic constituents, corresponding to the traditional onset and rhyme. Instead of using the labels O(nset) and R(hyme), I use the labels 'C' and 'V' instead (see n. 16). Both syllabic constituents can be branching and non-branching:

(6)

Following Dependency Phonology (DP) (Anderson and Ewen 1987), Government Phonology (GP) (Kaye *et al.* 1985, 1990), and Head-Driven Phonology (HDP) (van der Hulst and Ritter 1999, forthcoming), I assume that all constituents (phonological and syntactic) are binary and headed. Head positions are indicated by a vertical line, dependent positions by a slanting line. This implies that the maximal syllable is as in (2):

(7)



As is apparent from (7), I adhere to the widespread idea that the rhyme is the head of the syllable. This makes sense for two reasons. First, the structure of rhymes (or their heads) determines the external syntax of syllables—that is, their role in foot structure. Quantity-sensitive and sonority-driven stress is dependent on the complexity of rhymes and the ('sonority') properties of rhymal heads, respectively (see Dresher and van der Hulst 1998). Secondly, rhymes form the obligatory units in the syllable. Note that onsets and rhymes are universally head-initial, while the syllable itself is universally head-final.

3.1.2. The phoneme

In each of the three class nodes of the phoneme, we find a set of phonetic categories. These categories are encoded in terms of phonological elements. As stated, rather than simply listing the relevant categories and elements, I will propose to derive them from a parsing strategy, which I view as a form of categorization. This strategy follows the spirit of Jakobson's (1968) idea that phonological contrast arises from a polarization principle. First we assume that the whole phonetic space that is available for phonemes constitutes the value of one element. At this point there is, in fact, no phonological contrast, and only one type of phonological utterance is possible. Its phonetic value is variable, but favours those phonetic events that later, when the space has been cut up in a variety of categories, turn out to be the value of unmarked elements (I discuss the notion of markedness below). Thus, a child might utter [pa], [ta], or [da], the prototypical syllables, but, even though she seems to produce a /p/, /t/, /d/, and /a/, she really produces the unit /syllable/, which is paradigmatically distinctive with silence at best.

The next step involves acquiring a syntagmatic contrast between onset and rhyme. This appears to happen before the development of paradigmatic distinctions that we associate with distinctive features. In order to make the first paradigmatic contrast, the child locates, within the phonetic space of both onset and rhyme two extreme (that is, maximally dispersed) categories, and then, if the need for further distinctions arises, she takes each of the phonetic subspaces and divides them again. How often division can be applied seems an empirical rather than a formal matter, although I will argue below that the reason for limiting division to maximally two times (as I will demonstrate is the case) may be theoretical.

There is, or must be, a step in between the syntagmatic division into onset and rhyme, and the division of each of these into paradigmatically contrastive categories. Accepting the intrasegmental structure in (5), we must assume that the formation of contrastive phonetic categories takes place per class node. Hence the categorization of the whole speech space into a *laryngeal*, *manner*, and *place* must intervene. It seems intuitively obvious that the division into *laryngeal*, *manner*, and *place* is formally different in kind from the division of, say, stricture into obstruent and sonorant. Rather than involving a binary split producing two polar categories of the same kind, it produces three categories that are different in kind. I have suggested that the possibility of imposing an X-bar scheme on this tripartite categorization is not an accident. The tripartite specifier–head–complement structure is, I proposed, another example of an a-modular (and a-modal) structure that (together with binarity and headedness) dictates that structure in (5). Thus, the X-bar design is both a structural principle and a principle that drives, or limits, the categorization of the phonetic space.

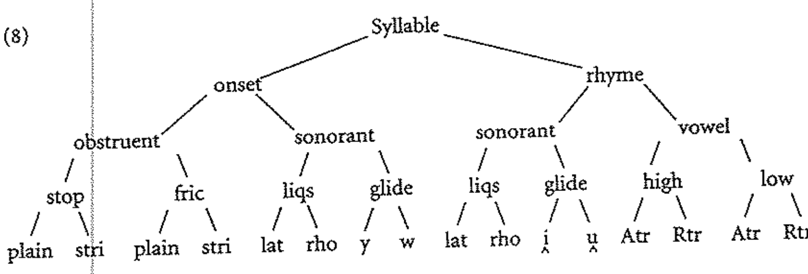
I will now turn to the categorization of class nodes. The specific proposals that I incorporate into RcvP for the division of the phonetic spaces corresponding to *laryngeal*, *manner*, and *place* are not at all unlike typologies of features that are available in the literature, although the particular combination of typologies is unique to this theory. That I can rely on existing proposals, of course, only strengthens my case. I have no desire to ignore empirically well-founded proposals for (partial) feature sets. Nor do I attempt to repeat, in this chapter, the empirical

motivation for these proposals. My goal, rather, is to organize (and, in some sense, formally motivate) these proposals within an integrated theory of phonological structure.

3.1.3. Manner and syllable structure

In this chapter (for reasons of space), I will discuss only *manner* distinctions, while, at the same time, explaining the basic line of thinking, including notational issues. The RcvP treatment of *place* and *laryngeal* distinctions can be found in van der Hulst (forthcoming *b*). The typology in (8) is close to the one that I eventually will propose for the *manner* class:

(8)



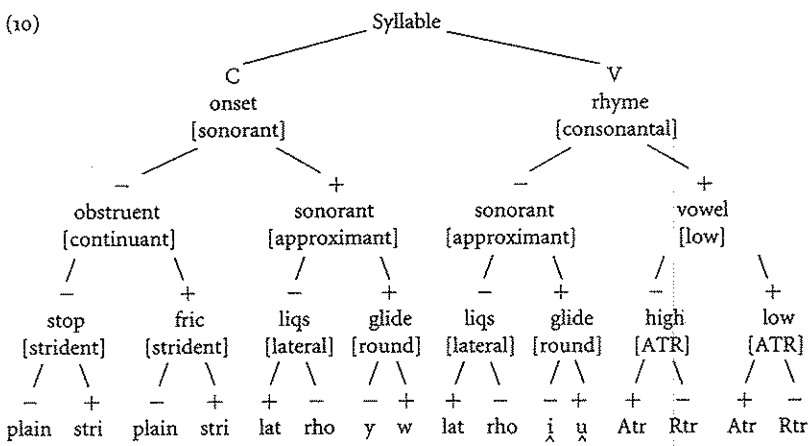
My use of terminology is perhaps not completely unquestionable. The problem is, of course, that there is no full agreement on terminology in our field. The term 'sonorant' is used here in two different ways—that is, in opposition with 'obstruent' (the traditional use) and in opposition with 'vowel'. The same holds for the term 'glide'. Some, in fact, will avoid this term altogether and refer to /y/ and /w/ as 'approximants', and to /i̯/ and /u̯/ as semi-vowels. Note, incidentally, that (as in the case of glides) terms such as 'lateral' and 'rhotic' refer to rather different phonetic events, depending on whether we look at onsets or rhymes. From my point of view, all terms in (8) are 'pre-theoretical' anyway, so I will not worry about terminological matters at this point. My concern is with the specific categorization that is implied in (8).

The typology in (8) seems to involve the following more or less traditional binary features:

(9) [±syllabic]
[±sonorant], [±consonantal] (or [±vocalic])
[±continuant], [±approximant], [±low] (or [±high])
[±strident], [±lateral], [±round] (or [±back]), [±ATR]

With respect to calling all these features 'manner features', at least four issues arise here. First, the feature [approximant] has not been so widely used. Clements (1990) introduces the feature to separate nasals from, what he calls, glides. For want of a better name, I use the feature here to separate liquids from glides. A related issue is that liquids, like glides, occur twice. These apparent duplications, however, simply reveal that the distinctions made in (8) are distinctive *within* the syllabic constituents, or subconstituents (that is, head or dependent position). It will become clear in a moment that the two lower levels in the structure in (8) encode the 'true' manner distinctions that are required per syllabic position. Secondly, no mention is made of nasality. I will not discuss nasality in this chapter (see van der Hulst, forthcoming *b*). Thirdly, it would seem that some of the distinctions involve *place* rather than *manner*. This is especially so for the distinction between /y/ and /w/, and between /i̯/ and /u̯/. To interpret these distinctions as *manner* will turn out to have the advantageous consequence that the property of *place* can be restricted to heads of syllabic constituents. Fourthly, collapsing height and ATR into a manner (a dimension involving aperture) may seem strange at first. A similar proposal is made in Clements (1991). For the moment, I will step over these points and continue to focus, in this section, on the method, the line of reasoning, and the notational conventions. Putting such issues aside, then, we can repeat (8) with the features as annotations in the structure:

(10)

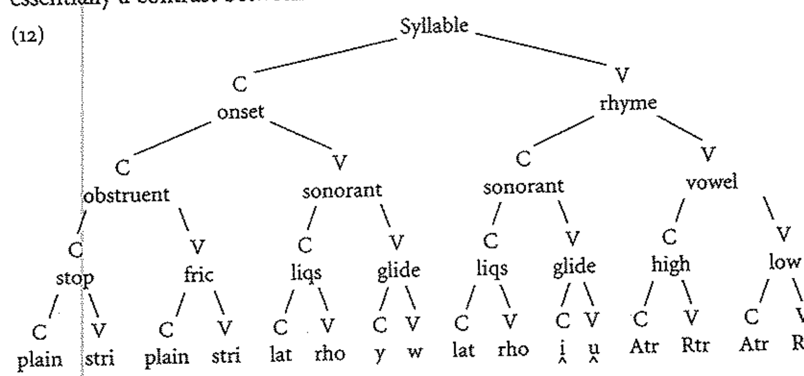


Assuming that the terminal layer of this structure gives us all and only the segment classes that we wish to distinguish (manner-wise), we notice immediately that, for economy reasons, we *could*, in principle, represent all distinctions with just three binary features, one for each decision layer below the onset/rhyme split. A consequence would be that each feature would have several phonetic interpretations, depending on the domain (in terms of higher-level decisions) it operates in. We would then also have to make a choice with respect to 'name' the three features, making perhaps arbitrary decisions; for example:

(11) [+sonorant] means *sonorant* for onsets and *vowel* for rhymes
[−sonorant] means *obstruent* for onsets and *sonorant* for rhymes
[−continuant] means *stop* for obstruents, *liquid* for sonorants and glide, and *high* for vowels
[+continuant] means *fricative* for obstruents, *approximant* for onset sonorants, *semi-vowel* for rhyme sonorants, and *low* for vowel

This method leads to terminological friction (that is, rhymal sonorants are [−sonorant]). Especially, at the lowest level, a choice seems semantically arbitrary, also because the plusses and minuses for the original features do not seem to line up in the correct way. Hence it is difficult to replace [strident], [lateral], [back], and [ATR] by one of them. The problem is not dependent on the distribution of plusses and minuses, because, after all, the assignment of specific values is simply dependent on the 'name' of the feature. Had we chosen the feature name [high], rather than [low], the assignment of plusses and minuses would be reversed. An alternative would be to replace plusses and minuses by markedness values such as 'm' and 'u' (as in Chomsky and Halle 1968: ch. 9). This approach might succeed if one worked out the appropriate markedness theory. Seemingly, I will adopt another route, although, as we will see, I am, in fact, incorporating a theory of markedness in the RcvP notation. Instead of making arbitrary decisions about feature names, I will simply use a *single* terminology for all levels in the typology, thus achieving even greater economy. Instead, however, of choosing one *binary feature*, I will adopt two unary labels—that is, C and V—because these adequately express that in each opposition, we basically encounter the type of contrast that we also make for the syntagmatic contrast between onset and rhyme—that is, essentially a contrast between a closure and non-closure state:[16]

(12)



[16] At this point, C and V are still just classificatory labels. Later in this section, I will make the conceptual change of regarding C and V as two *phonological elements*. In the end, it will turn out that the labels C and V simple stand for *head* and *dependent*. Whether C or V is the head depends on the domain within which the distinction is made; see below.

Including the onset/rhyme division, C clearly refers, from an articulatory point of view, to (relative) closure in the oral cavity at the first three levels. At the lowest level, however, we encounter a seemingly heterogeneous collection of oppositions.

Strident. In the opposition strident/plain (or *mellow*) for fricative, one might object to taking stridency to be the V (that is relative open) choice; indeed Anderson and Ewen (1987: 166) give non-strident fricative an extra C. In the case of strident stops, however, which I take to be affricates (following Jakobson *et al.* 1952, Jakobson and Halle 1956), stridency *does* involve non-closure. In the case of fricatives, on the other hand, V foremost expresses the extra acoustic energy that strident fricatives have. If, then, in the end, the C/V opposition is taken to represent a head-dependency relation, expressed in terms of acoustic salience (and its articulatory correlates), rather than simply relative stricture or aperture, the problem with stridency involving an extra obstruction rather than lesser constriction does not exist anymore.

Lateral. Anderson and Ewen (1987: 163) give lateral an extra C, because, as they say, laterals have an extra, secondary central closure. Rhotics do not have this closure, although they have a *repeated closure* (with the tip of the tongue or with the uvula). The critical difference, then, is that the closure for lateral is persistent. Most so-called sonority scales will, as expected, have rhotics as more sonorous than laterals.

Round. Why would front unrounded glides be more closed ('more C') than back rounded glides (assuming that both are of the same height)? Apparently we have to pay attention here to what happens in the oral cavity. Front glides have a palatal constriction in the oral cavity, while rounded glides have a dorsal constriction. We predict that labial-dorsal glides have a greater acoustic salience than palatal glides.

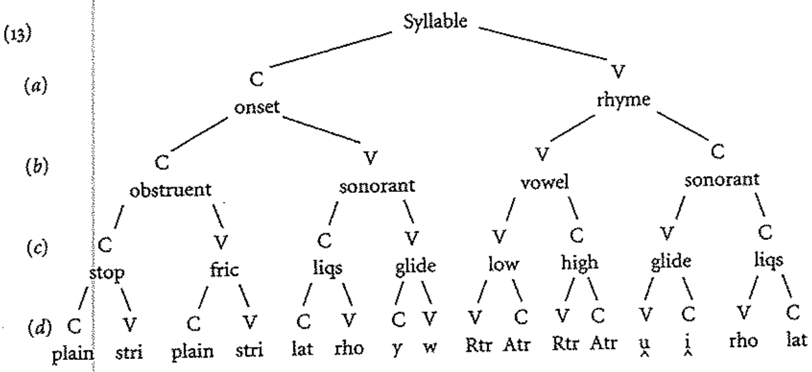
ATR. Advanced vowels have a relative greater degree of oral closure. I take this to be the decisive factor, even though one might argue that this closure is really an epi-phenomenon of the fact that the tongue root is advanced. We predict that ATR vowels have greater acoustic salience than RTR vowels.

The phonetic polysemy of C and V is evident from the structure in (12). A potential objection to the proposed economy could be that we now predict natural classes for which there is no support (such as the class of plain stops, lateral, and high advanced vowels). This may be so, although the unlikelihood of the inclusion of vowels in this class may simply lie in the fact that they occur in different syllabic positions. On the other hand, this proposal allows reference to natural classes that traditional feature systems cannot capture, such as strident fricatives and rhotic liquids (in processes of rhoticization). In this chapter, I do not discuss (counter-)evidence for the RcvP proposals that involve syntagmatic phonological processes, the focus being on paradigmatic distinctiveness.

We can 'transform' the typological structure in (12) into a syllable template

(somewhat *à la* Kiparsky 1979) by reversing all the branches under the rhyme node, so that the left-to-right ordering of segment types on the lowest level reflects a sonority curve (see also Farmer 1979):

(13)



We see that the typology of manner categories has a depth of three layers (excluding the onset/rhyme split). As a first step towards proposing phonological manner elements, let us represent manner segment types in terms of chains of Cs and Vs:

(14)(*a*) *Manner*: onsets

(*b*)	C	C	C	C	V	V	V	V
(*c*)	C	C	V	V	C	C	V	V
(*d*)	C	V	C	V	C	V	C	V
	t	ts	Θ	s	l	r	y	w

(*b*) *Manner*: rhymes

(*b*)	V	V	V	V	C	C	C	C
(*c*)	V	V	C	C	V	V	C	C
(*d*)	V	C	V	C	V	C	V	C
	a	ə	I	i	u̯	i̯	r	l

The syntagmatic contrast (encoded in syllabic structure) extends over the first two layers—that is, the onset/rhyme split and the further division into branching onsets branching rhymes:

```
(15)                    Syllable
                       /        \
(a)                   C          V
                    onset       rhyme
                    /   \       /   \
(b)                C     V     V     C
```

At this point, we observe a redundancy in the notation. Layer (*b*) is incorporated in (14) as well as in (15); hence it occurs twice. This raises the questions as to whether layer (*b*) must be understood as belonging to the phoneme or to the syllable? A crucial consideration for taking this level to encode a phoneme-internal property is that sonorants can form onsets by themselves. If we strip level (*b*) from the segment-internal paradigmatic specification, then the distinction between stops and laterals disappears, and hence the distinction between a simple onset with either a stop or a lateral also becomes inexpressable. To avoid this, and indeed stripping level (*b*) from the phoneme structure, I propose that a syllable that starts with a liquid is really empty-headed, just like a so-called syllabic liquid may be taken to correspond to an empty-headed rhyme (van der Hulst and Ritter 1999):

```
(16)      onset              rhyme
          |   \              |   \
          C    V             V    C
               |                  |
               C                  C
               |                  |
               C                  C
```

We thus explain a parallelism: syllabic liquids acquire phonetic properties of vowels by being more sonorous, while liquids that form onsets by themselves acquire properties of obstruents by having a more forceful articulation.

By adopting this approach, I delegate the distinctions between obstruent and sonorant, and between vowel and glide, to the realm of syllable structure. This being the case, we end up with the following system of manner distinctions in each of the four syllabic positions:

```
(17)     Onset head       Onset dependent     Rhyme head       Rhyme dependent
         /        \        /       \          /       \         /        \
(c)     C          V      C         V        V         C       V          C
       stop       fric   liqs     glide     low      high    glide       liqs
       /  \       /  \   /  \     /  \      /  \     /  \    /  \        /  \
(d)   C    V     C    V C    V   C    V    V    C   V    C  V    C      V    C
    plain stri plain stri lat rho y   w   Rtr  Atr Rtr  Atr u̯    i̯     rho  lat
```


Thus, in each syllabic position the phonetic space that is available to manner is categorization in accordance with the following template:

```
(18)          manner
              /    \
             C      V
            / \    / \
           C   V  C   V
```

Note that this (paradigmatic) categorization is identical to the (syntagmatic) categorization that we have attributed to syllable:[17]

```
(19)          syllable
              /    \
             C      V
            / \    / \
           C   V  C   V
```

I propose that the template in (18)/(19) *is* the template for categorization of phonological spaces. Its driving principle is binary polarization (or dispersion).

I will now make the theoretical step from categorization to phonological elements by proposing that, in fact, we need only *two phonological elements* to represent all the relevant phonetic categories. These elements will (following DP) simply be called 'C' and 'V', a choice that was anticipated by the use of the C/V labels that I used thus far. We need only two elements, instead of four, if we adopt the fundamental DP idea that elements can occur by themselves or can be combined, and that, if combined, elements enter into a head-dependency relation (the levels refer back to 13 and 14):

```
(20)      Onset Head Manner

   (c)  C    C    V    V     (Head)
             |    |
   (d)       V    C          (Dependent)

        t    ts   θ    s
```

[17] An implication of the proposals for manner and syllable structure is that syllabic complexity is more limited than what is usually assumed. First, there are no monosyllabic long vowels. A branching rhyme can only be a diphthong, a vowel followed by a liquid l or r, or a nasalized vowel. The nasal option, introduced in Section 3.1.6, could materialize as a true nasal in case an onset consonant follows it from which the nasal glide snatches the consonantal place properties (Humbert 1995). We might perhaps wish to allow the rhyme dependent (that is, coda) to be empty to accommodate geminates. In any event, the present model does not allow obstruents or (unassimilated) nasals in coda position; see van der Hulst and Ritter (1999), van der Hulst (forthcoming *b*).

A 'flat' shorthand for these representations will sometimes be used:

(21) C Cv Vc V

The idea that phonetic categories can be encoded by single elements and by combinations, in a sense, explains why categorization has a depth of two layers. More categories could not be accommodated by the fundamental principle of binary combination that only allows the structures in (20). Indeed, I propose that dependency structures (formed by combining units of the same type, like elements) are limited to those in (20).[18]

Being able to occur as a head or a dependent, each element has a dual interpretation (van der Hulst 1988*a*). However, since every element can occur in four syllabic positions, elements actually have eight phonetic interpretations:

(22)

		onset head	*dependent*	*rhyme head*	*dependent*
C	*head*	stop	liquid	high	liquid
	dependent	mellow	lateral/y	ATR	lateral/i̯
V	*head*	fricative	glide	low	glide
	dependent	strident	rhotic/w	RTR	rhotic/u̯

Note that the interpretations in both 'syllabic dependent' positions are identical, at least in terms of the traditional labels that I have been using. In phonetic reality, the rhyme dependent (or coda) occurrences of sonorants are much weaker than the onset dependent occurrences. The syllabic head positions, however, bring out more significant differences. This is exactly what one would expect, if head positions enforce the phonetic realization that best serves the syntagmatic contrast within the syllable.[19]

Let me point out at this juncture that the notation that is used here expresses two important concepts that remain unexpressed in traditional feature systems: markedness and enhancement. I will briefly comment on how these concepts are expressed in the notation.

Markedness. We might say that each choice that repeats the identity of the category that it splits represents the *unmarked* option. In the dependency notation with elements, this same idea returns: if the dependent is identical to the head, the dependent is unmarked. Thus obstruents are unmarked onsets, stops are unmarked obstruents, and plain stops are unmarked stops. On the vowel side, we see that retracted, low vowels are unmarked vowels. Markedness could be

[18] Recall that the three-level X-bar structure is reserved for combinations of units of a different type. Also, to avoid confusion, the structures in (14) represent paths of the typology in (13) and not dependency structures of elements.

[19] The proposal here does not imply that every syllabic position will have the same number of phonological contrasts in a particular language. Contrastive manners for each language must be specified (and learned) per syllabic position.

expressed in an 'ink-saving' way by adopting the convention that, in a situation of *contrast*, the unmarked symbol is suppressed, being predictable in terms of the following universal redundancy rule (with E ranging over C and V):

(23) Universal Redundancy Rule

$$E \rightarrow \begin{array}{c} E \\ | \\ E \end{array}$$

Thus, for example, mannerwise we refer to 'C' and 'V' instead of 'Cc' and 'Vv' for stops and vowels, respectively (see (20) and (21)).

Enhancement. This notion, introduced in Stevens and Keyser (1989), is related to markedness. For example: stridency is said to enhance fricativeness. In terms of the structure in (12) this means that enhancement involves the redundant addition of an unmarked element. At the vowel side, we see that is it correctly predicted that, in the absence of an ATR contrast, low vowels are retracted, while high vowels are advanced. It would seem, then, that in the *absence of contrast*, rule (23) can operate as well, now, as a *Universal Enhancement Rule.*

3.1.4. Conclusions

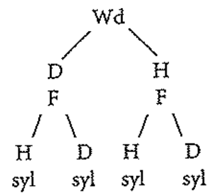
By deriving the set of phonological primes from the basic structural principles of head-dependency and binarity, RcvP avoids the arbitrary list-character of most feature theories. RcvP, then, is compatible with the idea that the phonological component of UG does not contain an arbitrary list of features (possibly grouped in an arbitrary number of feature classes) from which individual languages make a choice, but rather a module-free 'parsing strategy' (determined by general structural principles) for dividing phonetic spaces into a well-defined set of categories. This approach is supported by the fact that the number of syllabic positions as well as distinctions (per class) that is needed for the analysis of spoken languages does not seem arbitrary; they all result from the same parsing template.

Strictly speaking, RcvP recognizes only *two* phonological elements. As shown in van der Hulst (forthcoming *b*), C and V are also used in the place and laryngeal class. The two elements have a variety of phonetic interpretations, depending, first, on the dominating class node, secondly, on the occurrence in an onset or a rhyme, and, thirdly, on being a head or a dependent. In achieving maximal economy, RcvP exploits the use of structure in guiding the phonetic implementation of phonological elements.

We can extend RcvP into higher levels of organization in the lexical phonology, up to the phonological word. Foot structure is obviously binary and the head–non head relationship holds here as well. The word can also be seen as a binary constituent (see Section 2.1). We would not be inclined to encode the head-dependent relationship in terms of Cs and Vs. Rather we would simply use the labels H(ead) and D(ependent). This merely indicates that we should use those labels at the lower levels as well. The C/V-labelling reflects the segmental/syllabic 'origin' of RcvP (see n. 16).

In fact, the foot and word structure together reiterate the characteristic parsing template:

(24)



The location of heads at the level of feet might also be universally fixed (see van der Hulst, forthcoming), while headedness at the word level is parametric.

As I argued earlier, the abstract (a-modular, a-modal) RcvP approach makes all the more sense if one considers the existence of sign languages. Learners of those languages also construct a phonology, being guided, I assume, by the same UG that hearing learners put to use. Clearly, a list of actual features (such as [consonantal], [coronal], and so on) will not be very helpful in constructing the phonology of a sign language. Let us now investigate, then, whether RcvP also produces an adequate set of phonetic distinctions and phonological elements for sign language phonology.

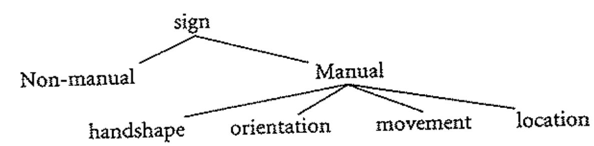
3.2. *Sign Language*

If RcvP is an a-modal theory, its principles must be appropriate for constructing a phonological organization for sign languages. In this case, we do not have the advantage of being able to rely on a long tradition of proposals for feature sets and higher constructs. If linguistics is a young (and, some would say, immature) discipline, then sign linguistics has just been born. It essentially started in 1960 with the publication of Stokoe (1960), anticipated by earlier work that recognized the linguistic, communicative status of signing (e.g. Tervoort 1953). As might be expected from explorative proposals for feature sets, there has been a strong focus on the great richness of phonetic diversity of signs, and much less on phonological distinctiveness. As a consequence, most proposals for feature sets involve rather large sets of features, minutely encoding many phonetic details, and giving the impression that the feature structure of signed languages is much richer than that of spoken languages.

Having said this, I do not wish to underestimate the enormous advances that have been made in the short period of forty years by a relatively small group of linguists. In the early 1970s we find foundational work in Klima and Bellugi (1979), reflecting the research of a group of influential researchers. In addition, several very detailed dissertations on the phonology of American Sign Language (ASL) appeared around that time, and throughout the 1980s (e.g. Friedman 1976; Battison 1978; Mandel 1981; Sandler 1989; for overviews, see Wilbur 1987, Crasborn *et al.*, forthcoming). In the mid-1990s, when I started applying RcvP to SIGN PHONOLOGY, having little insight into the subject matter based on personal empirical research, I could interpret detailed models that by that time had been proposed for sign languages in terms of the principles of (polar) binarity and headedness, and by using unary elements (e.g. Liddell and Johnson 1989; Sandler 1986, 1989; see Brentari 1998 for an extensive overview and proposals in this area). The first results can be found in van der Hulst (1993*a*, 1995*b*,*c*, 1996*a*,*b*). The model proposed there has been empirically tested and developed in subsequent and ongoing research (Crasborn, forthcoming; van der Kooij, forthcoming). Here I discuss a proposal that is in the line of this type of work.

Since the pioneering work of Stokoe (1960), signs are said to be composed of NON-MANUAL properties and MANUAL properties. The former *can* play a role at the level of lexical distinctions, but seem more active at the post lexical level.[20] Here, I have no proposals concerning non-manual categorization of phonological elements. Manual properties involve a characterization of the HANDSHAPE, the MOVEMENT of the hand, and a LOCATION (where the action takes place). Battison (1978) added ORIENTATION (of the hand) as a fourth manual property. Each unit in (25) can be instantiated by a finite set of values, features, or elements:

(25)



Stokoe put forward the idea that the difference between a sign (for example, meaning CAT) and the English word *cat*, was that the former was essentially a simultaneous event, whereas the latter had a temporal organization. Thus, the basic elements of a sign (*movement*, *handshape*, *location*, and so on), which he called 'cheremes' (and later phonemes) were noticed by Stokoe to be linearly *unordered*, whereas the phonemes of speech are linearly sequenced. Note, however, that the structure in (25) seems to have formal properties that make it look like the structure of single phonemes in spoken language (see 5). After all, the class units that make up a phoneme are not linearly ordered either. Hence, if one would compare (25) to single phonemes it would seem that the difference between spoken and signed languages is not whether or not use is made of linear order, but rather that monomorphemic words in sign language appear to be monosegmental (van der Hulst 1995*a*), whereas words in spoken languages (except for some closed class words—for example, certain prepositions or pronouns) are typically

[20] Non-manual properties at the postlexical level encode distinctions that, in spoken languages, are often encoded in terms of intonational tones (boundary tones, pitch accents). The functional correspondence between *non-manual* and *laryngeal* is supported here by a formal correspondence in terms of their place in the phonemic structure.

polysegmental. I will return to this issue below. First let us look at some more history (see also Corina and Sandler 1993).

After Stokoe's ground-breaking work, later researchers (e.g. Suppala and Newport 1978; Newkirk 1981; Liddell and Johnson 1984) felt that it was necessary to be able to make reference to the beginning and end point of the movement of signs, for example, for morphological inflectional purposes, or to express assimilations involving a switch in the beginning and end point of the movement (for a discussion of the arguments, see Sandler 1989 and van der Hulst 1993*a*). Without *formally recognizing* the beginning and end point in the linguistic representation it would be impossible to formulate rules that refer to these entities. These considerations led to the adoption of some kind of skeleton to which the other units of the sign associate in an autosegmental fashion (as explicitly proposed in Sandler 1986). Most researchers (Liddell and Johnson 1989; Sandler 1989, 1993*a*; Perlmutter 1992; Brentari 1998) proposed a skeleton that represented not only the INITIAL LOCATION and FINAL LOCATION, but also an INTERMEDIARY MOVEMENT:

(26) L M L

Several researchers have assigned a central perceptual status to the movement unit (see Perlmutter 1992; Corina and Sandler 1993; Sandler 1993*a*; Brentari 1998 for relevant discussions) and it then seemed obvious to refer to the LML sequences as analogous to a CVC-syllable (see Chinchor 1979; Coulter 1982). Following up on these earlier ideas, Perlmutter (1992) explicitly compares the M to the vowel in speech and also adds a moraic layer to the representation.

The model that was proposed in van der Hulst (1993*b*), however, denies movement as a unit on the skeleton, following several other researchers (e.g. Stack 1988; Hayes 1993; Wilbur 1993), and replaces the LML-SKELETON by a bipositional XX-SKELETON. Having reduced the skeleton to two positions, we could, as I suggest here, interpret these positions as the syllabic onset/rhyme (offset) structure of the sign, assuming here without argument that the second position in the skeleton is the most salient one (on this claim, see Brentari 1998 and van der Kooij, forthcoming).

Before we turn to the question as to how we can understand the autosegmental relation between the skeleton (with or without a movement unit) and the primes that specify the 'content' of signs, we have to go into more detail concerning the required set of primes. As mentioned, I will limit myself to the manual part of (25). (What follows is discussed in more detail in Crasborn forthcoming, Crasborn *et al.* forthcoming, and van der Kooij, forthcoming.)

Place. In order to indicate where a movement starts and where it ends, we need to assign place specifications to the skeletal positions. However, these specifications (whatever they are) do not exhaust the specification of place, since it appears that each individual movement (limiting ourselves to monomorphemic signs) is restricted to occur within a certain area—for example, in front of the chest, or in front of the upper or lower part of the face, or alongside the lower arm of the non-articulating hand, and so on. Sandler (1986) therefore proposes to distinguish between two notions of place. Here I refer to the restricted area as 'location' (for example, *chest*, *head*, *arm*, and so on) and to the specific beginning and end within these areas as 'settings' (for example, high, low and so on). The specification for location takes scope over the whole sign, while the setting values bear on the initial and final skeletal position. Here, I have no proposal to make for the categorization of place, which would hopefully develop along the lines of the schema in (19) (see (27) below). I will return to setting values below.

Handshape and orientation. On the basis of joined behaviour in assimilation processes, Sandler (1986, 1989) proposed that *handshape* and *orientation* (of the hand) form a class that I will here call ARTICULATOR (following Brentari 1998). With reference to *handshape*, as with *place*, we also find properties that remain constant throughout the signs, as well as properties that can change. One constant property is FINGER SELECTION (*fingsel*). *Fingsel* refers to the fingers that are 'foregrounded' (selected), as opposed to the 'backgrounded' (non-selected) (see Mandel 1981: 81–4). Mostly, foregrounded fingers are the EXTENDED FINGERS, while backgrounded fingers are folded, and for our present purposes I will simply adopt this simplification (see Sandler 1989; Kooij, forthcoming, for a detailed discussion). *Fingsel* involves three finer class nodes. First, there is a node (*fing*) that bears on the four fingers, allowing the extension of [one] or [all] fingers.[21] Secondly, we specify the SIDE of the hand in case less than all the fingers are selected as [radial] or [ulnar] (thumb and pinky side, respectively). Thirdly, we can specify the selection of the THUMB separately as [in] or [out]. During the articulation of a (monomorphemic) sign, the specifications of all three *fingsel* nodes are constant. *Fingsel* does not fully determine the *handshape*, however. The selected fingers occur in a certain CONFIGURATION (*config*). *Config* also has three finer class nodes. First, we consider here the bending of the fingers in terms of FLEXION (*flex*) of the finger joints. We distinguish between the joints that connect the fingers to the hand ([base]), and the two 'higher' finger joints, jointly ([non-base]). A second dimension of *config* is APERTURE—that is, an [open]–[close] relationship between the thumb and the selected fingers. Thirdly, selected fingers can be SPREAD [open] or held against each other [close]. Of these three nodes, flex must remain constant, while both aperture and spreading can change.[22]

Turning now to *orientation*, it turns out that the value for this node may change—that is, a sign can involve a rotation of the underarm such that, for example, the palm faces the signer at the beginning while the back of the hand faces

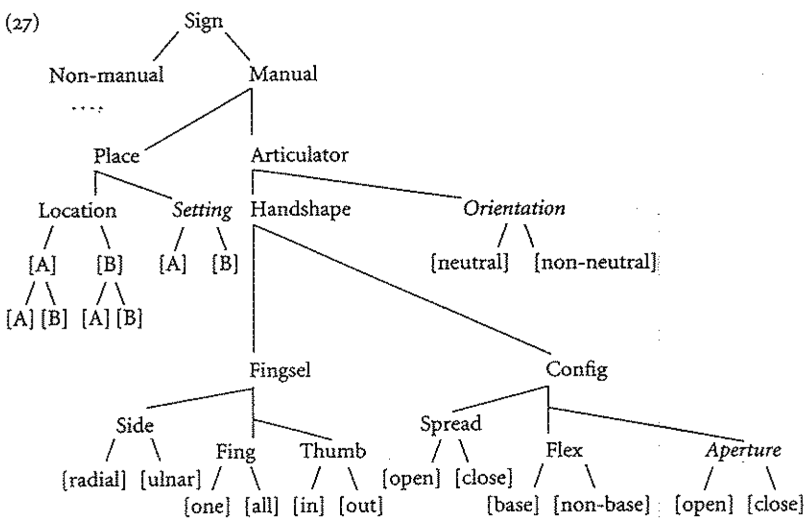
[21] Henceforth, I use square brackets to indicate relevant phonetic categories. An interpretation in terms of elements follows in the text below.

[22] Dynamic spreading/non-spreading can be found in the sign for SCISSORS (in ASL and many other sign languages). This dynamic aspect may simply be an iconic trait of signs in this particular semantic field.

her at the end of the sign. I will refer to the values of orientation as [neutral] and [non-neutral]. The neutral value specifies the 'natural' (that is most 'comfortable') position of the underarm wherever the hand is placed.[23]

With this much detail, we can state precisely what remains constant and what may vary in the articulation of a monomorphemic sign. *Place*, *fingsel*, and *flex* are constant. Dynamic aspects of the manual part of the sign may involve *setting*, *orientation*, *aperture*, and perhaps (but very marginally) *spreading*. Figure (27) summarizes the categorization of the sign in class nodes, and of the class nodes in phonetic categories. Italicized nodes may involve a potentially dynamic specification, which I discuss below:[24]

(27)



Although I have not motivated that here, we see that all nodes within the *handshape* unit are categorized in terms of two polar categories—that is, no further division seems necessary. At this juncture, (27), with all its distinctions, represents our best hypothesis (and partly: guess) with respect to what the phonologically relevant categories for sign language are. If we now equate each category (that results from a binary split of the relevant phonetic space) with an element, this implies that no combination (including head-dependency) of elements is required in most cases. We suspect that things will be more

[23] Perhaps, orientation changes should also include flexion and sideward movements of the wrist. It is also possible that such changes are really (reduced) path movements.

[24] I have not discussed here the distinction between one- and two-handed signs. In two-handed signs, the two hands cannot operate independently. Both hands are either copies of each other, or one of the hands is the place of articulation for the other; see van der Hulst (1996*b*).

complicated for *place* and we know that in the case of the node *Fing* we encounter a more complex situation, since, as said, there are in fact more options for finger selection than just [one] or [all]. Handshapes can also have two or three foregrounded fingers. Hence the elements corresponding to [one] and [all] can enter into combinations (and dependency relations). I will not, however, discuss, these combinations, and their interpretation here (see van der Hulst 1995*c*, 1996*a*; van der Kooij, forthcoming). The categorization of each phonetic subspace into polar categories is precisely what we expect given the principles of RcvP. That in most cases the division of the phonetic space is limited to two categories indicates, perhaps, that a more detailed parsing is less likely to occur in more 'refined' classes.

So how do we name the elements? Our first inclination is simply to extend the use of the C and V. It does not seem sensible, however, to use these labels, which betray their spoken language origin and bias. Rather, we might directly make use of a head-dependent labelling. In all cases, I assume that one of the elements is unmarked and thus a head (see Crasborn *et al.*, forthcoming; van der Kooij, forthcoming, for further discussion). The head choice is phonetically manifested as the more salient phonetic category. Thus, we would expect that the categories [all], [out], and [open] are heads. The choice seems less clear for the nodes *side* and *flex*.

Turning from elements to structure, we note that, in the spirit of RcvP, the structure in (27) is headed at every level. Given the (perceptual) centrality of the articulator, I have represented *non-manual* and *place* as dependents. Within place, location is taken to be the head, because it encodes the major place distinctions, with *setting* making subdistinctions. Within *handshape*, I take *fingsel* to be the head, since *config* clearly modifies the selected fingers, and within each of these nodes I have proposed to regard the property that is crucially defining the handshape as the head—that is, *fing* and *flex*. Notice that, if this is correct, invariance (that is, being constant across the sign) is a diagnostic property of heads. I realize that all these decisions need further motivation and I remind the reader of the tentative nature of this proposal.

Let us now turn to the dynamic aspects. There appear to be three types of movement:

(28) *Types of movement*
(*a*) Path movement
(*b*) Aperture change
(*c*) Orientation change

Path movement is movement of the articulator as a whole. We represent it in terms of *setting* values under the *place* node.

'Movement' of *orientation* is called orientation change, which is brought about by rotation of the underarm. Finally, movement in the *aperture* node is called aperture change.[25] Orientation change and aperture change have also been called 'local changes' as opposed to the 'global path movement'.

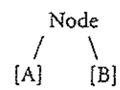
Each of these dynamic events may occur by itself and be the only movement of the sign. Path movement may also be combined with either aperture or orientation change. In that case the *global* path movement is called 'primary', while the other local movement is called 'secondary'. The beginning and end state of primary and secondary movements must coincide (as discussed in Perlmutter 1992).

The typology of movements for *orientation* and *aperture* is simple. In fact, for *orientation*, as said, we need an element that denotes the [neutral] state and one that represents the [non-neutral] state (but see n. 23). The beginning state of the sign is either neutral or non-neutral, while the end state (if there is an orientation change) is the opposite. For *aperture* we have the choices [open] and [close]. Again the beginning state can be either, while the end state (if there is an aperture change) is the opposite. A path movement can be specified in terms of polar settings on the three cubic axes (vertical, horizontal, and away from the signer), the 'movement' (if present) being the transition between a beginning and an end state:[26]

(29)	Orientation	[neutral]–[non-neutral]
	SelFing	[open]–[close]
	Config	[high]–[low], [ipsi]–[contra], [distant]–[proximate][27]

With these features we can represent movements as branching structures:

(30)



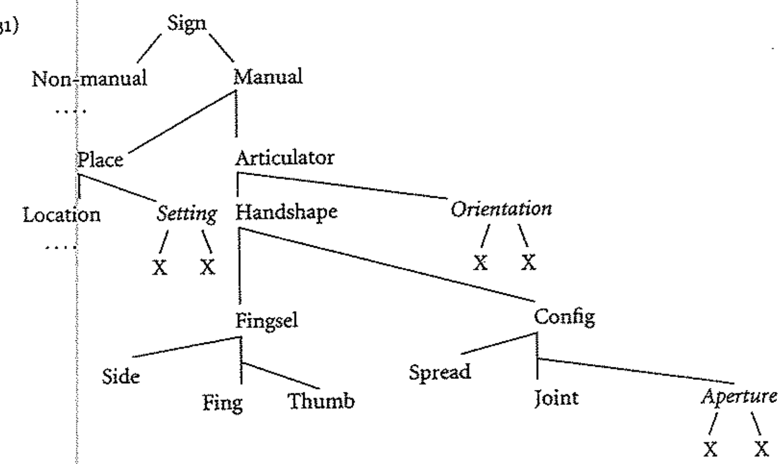
The variable 'Node' in (30) can be *setting*, *orientation*, or *aperture*. So where do we locate the elements for [A] and [B] in the formal representation? The obvious locus for these elements is the X-positions on the skeleton. However, since we can have branching feature specifications for *setting*, *orientation*, and *aperture*, it would seem that we really have three skeletons:

[25] Aperture change is also sometimes subsumed under HAND-INTERNAL CHANGE, another type of hand-internal change being WIGGLING, which I have left out of consideration here.

[26] In some cases, however, the movement seems too complex to be understood as simple interpolation between the settings assumed here (for example, involving diagonal, curved, circular, or zigzag paths). This probably means that the categorization of the place space is more complex than what we have assumed here. It is also possible that some of these more complex paths are due to iconicity (see Section 4.3).

[27] [ipsi] means 'side of the articulating hand'; [contra] refers to the opposite side. Distant-proximate is probably the same as no-contact—contact (for example with the body).

(31)



The understanding here is that the initial and final X (that is, onset and rhyme) in each case is synchronized in the phonetic implementation of the sign. By locating the primes that determine a dynamic event on the 'onset' and 'rhyme' slots we derive that their ordering is crucial because syllabic constituents *are* linearly ordered. If the branching structures were a proper part of the content specification of the sign, we would have to introduce linear order (not needed so far) at that level. It is more satisfying that we can keep the content structure free from linear order, and introduce linear order not until the syllabic organization starts. A consequence of the proposal here is that, in some sense, a sign with two movements is bisyllabic, the syllables being simultaneous. This conclusion converges with ideas expressed in Wilbur (1993) and Brentari (1998).

With respect to branching setting there may actually be an interesting alternative. Since *fing* is the ultimate head of the articulator, we might also decide to make the setting values dependent on this node. The conceptual advantage of that move would be that all movement would then be formally *movement of the articulator*. Below, we will see that we can then also achieve a unified notion of *manner of articulation* for both spoken and sign structure.

3.3. *A comparison between spoken and signed language*

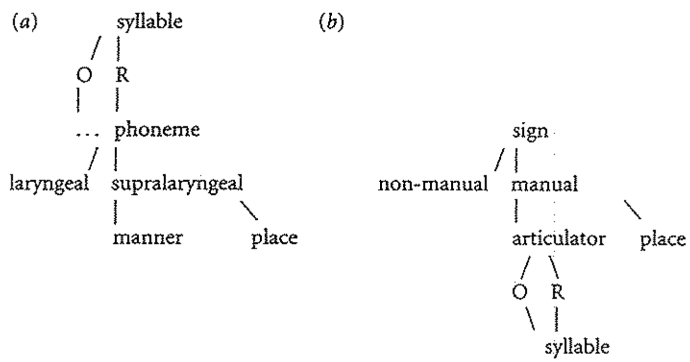
3.3.1. The articulator and manner

An important difference between signing and speech is that in speech the articulator does not have distinctive properties.[28] The speech articulator is

[28] See Studdert-Kennedy and Lane (1980) for an intriguing comparison making some of the same points that I make here.

predictable from the place of articulation. If the place is labial, the articulation is the lower lip or lower teeth (the difference is not distinctive).[29] When the place is within the oral cavity, the articulator is the tongue, the front part if the place is dental/alveolar, the back part if the place is velar[30] and the lower part if the place is pharyngeal. This is why we do not find an articulator node in the representation of the phoneme of spoken languages, or why phonologists have come to use articulator and place terminology almost interchangeably. In sign languages, as we have seen, the articulator is far from redundant. On the contrary, it can have a wide variety of properties.[31] Thus, where the phoneme of spoken language has *manner* (that is, movement of the articulator) as its head, we find the *articulator* in head position in the structure of signs. This does not mean that sign language has no *manner*. In fact, for sign language, we can look upon movement (of the articulator) as manner, since, as in speech, movement *is*, in fact, movement of the articulator with respect to a place.[32] The difference between manner in speech and in sign seems to be that, while, in the former, manner is partly in the content and partly in the syllabic structure, manner in sign is wholly in the syllabic structure (I have lined up the parallel parts of the structures):

(32)



The extra architecture that the sign phoneme has apparently lies in the structure of the articulator, which, in fact, recapitulates the general X-bar template three

[29] The difference between bilabial and labiodental fricatives can be understood as a difference in manner—that is, stridency.

[30] The difference between velar and uvular, I assume, is one of complex or double articulation. Palatals also involve double articulation.

[31] It follows that sign language phonologies may, for that reason, have more phonologically relevant phonetic distinctions than spoken language phonologies.

[32] One might argue that an additional difference between sign and speech articulators is that signing has two articulators—that is, two hands. However, even though a distinction between one-handed and two-handed signs can be distinctive, the choice of which hand to use in one-handed signs cannot be used distinctvely. In this sense, then, the mind recognizes only one articulator.

times. In the next section, I will explore the notions of segment and syllable in both modalities in greater detail.

3.3.2. The segment and the syllable

Sign linguists have been investing a lot of energy in asking whether the sign is a syllable or a segment (see Corina and Sandler 1993; Wilbur 1993; van der Hulst 1995*a*; Brentari 1998). Several researchers, indeed, have suggested that the morphological simple sign is like a syllable (e.g. Chinchor 1978; Coulter 1982; Perlmutter 1992).[33] I have here arrived at the conclusion that this is, in fact, correct, and the two structures in (32) illustrate this. Sign language syllables are, in a sense, all 'CV' (that is, simple OR) syllables. In both cases, the total structure comprises both the syllabic and the phonemic structure. The structure in (32*b*), however, seems to imply that, in the structure of signs, certain portions of the phonemic class node structure dominate the syllabic structure. This is not just a consequence of designing the diagram. In sign language, most elements (except potentially those for *setting*, *orientation*, and *aperture*) have scope over the whole sign. In the syllabic organization of spoken language, however, the syllabic onset/rhyme division takes precedence over the distribution of elements, that, as a consequence, have scope over the onset or rhyme only. In spoken language, the syllable is suprasegmental, while in signed language the segment is suprasyllabic.

Let us now, subsequently, try to understand why the speech syllable is primarily a syntagmatic sequencing syllabic structure and, secondarily, per syllabic position a paradigmatic structure involving features or elements, while the sign syllable (in the spirit of Stokoe 1960 stated) seems primarily a paradigmatic featural structure that spreads out over a secondary sequencing structure. I wish to suggest that this difference is a true modality effect.

I believe that the reason for the difference lies in a crucial difference between auditory and visual perception. Not being an expert in perception, I none the less venture to suggest that the perception of signs is more 'instantaneous' than the perception of auditory speech input. The latter reaches the ear sequentially, in temporal stages. If this is so it does not come as a surprise that the temporal, syntagmatic organization of speech is perceptually salient and takes precedence over the paradigmatic organization. Turning to the sign syllable, Stokoe was right in saying (and seeing) that the notion of time-span is perceptually less important in the visual signal. Consequently, it does not seem plausible to assume that the structure of signs would depend foremost on separating the beginning and end phase of signs. Rather, the paradigmatic structure takes precedence over the syllabic, syntagmatic division in onset and offset (rhyme). The temporal structure of signs comes in as secondary structure, giving rise to the bipositional skeleton as a kind of afterthought.

[33] Often suggesting that the syllable = morpheme = word relationship in sign is like that in Chinese languages.

We can understand the difference in terms of Goldsmith's (1976) notions of vertical and horizontal slicing of the signal:

(33)

Speech	Signing
vertical (syntagmatic)	horizontal (paradigmatic)
|	|
horizontal (paradigmatic)	vertical (syntagmatic)

I now wish to point to a difference between monomorphemic words in spoken languages and in signed languages that involves the monosyllabicity of signed words, as opposed to the typical polysyllabicity of spoken words.

In spoken languages, the need for going beyond simple CV words lies in wanting to have a sufficiently large number of semantic distinctions in the lexicon, without having to go into morphology. Thus spoken languages either elaborate the syllabic structure, allowing branching onsets and rhyme, and/or utilize polysyllabic units such as feet and prosodic words. A third option lies in invoking a complex tone system in terms of rhymal laryngeal distinctions.

We have seen that the notions of branching onset or branching rhyme do not apply to sign languages. Also it seems that most basic words are, syntagmatically, monosyllabic.[34] One does not typically encounter the additional layer of foot structure. I would like to suggest that this is so because of the availability, in sign, of the articulator (which is distinctively missing in speech). I noted that the articulator in signed languages, unlike that in spoken language, is a richly compositional unit. This means that lexical elaboration of the formational possibilities can easily be found in combining the extensive set of *handshapes* with every combination of *orientation*, *place*, and all the types of *movement*. We might add several other ways in which the compositional world of signs is richer than that of speech units. First, the type of manner (that is, movement) that is allowed in speech towards the constriction target is always predictable—that is, it is the shortest path. In sign, however, we note that movement of the whole hand (between an initial and a final state) can be performed in a variety of ways (straight, arced, circular, and so on). It seems to be the case that such differences are indeed used contrastively.[35] Secondly, sign language uses *iconicity* as a means of differentiating signs. From a functional point of view, then, there is simply less reason to complicate the structure of lexical entries by allowing for combinations of syllables into feet and beyond. The phonetic space that is available to the manual aspect of signing is more elaborate than the supralaryngeal aspects in speech, and

[34] Recall that signs with two movements can be regarded as being polysyllabic.

[35] I say this, realizing that I do not really have a well-developed set of really contrastive possibilities in any sign language.

this, combined with the other extra means mentioned, apparently, allows a rich enough inventory of monomorphemic words (or morphemes).[36]

4. SUMMARY AND CONCLUSIONS

In this chapter I have started out by developing an understanding of phonology that is both non-modular and modality free. In its non-modularity, phonology is not *different* from syntax, but rather, as per the Structural Analogy Hypothesis, *identical*. Thus, UG is just as much 'phonology free' as it is 'syntax free'. My view on the relationship between 'phonology' and 'phonetics' is that phonology emerges from the interaction between general categorization and structural principles and formats, and the specific phonetic domain of the modality. The primes of phonology (that is, the elements) are cognitive categories of phonetic (articulatory and perceptional) events that arise in the process of language acquisition. Phonological representations are phonetically implemented in terms of (a model of) the articulatory and acoustic properties of speech and sign events.

I continued by sketching models of both spoken language phonology and sign language phonology that, indeed, seem to be based on such principles. My account of sign phonology is, of necessity, more speculative (and theory-driven) than the account of spoken language, which is based on a long and rich tradition of feature theories. None the less, I subscribe to the view that sign languages have a phonology, just like spoken languages, and that the phonological component in both modalities is the result of the same innate abilities.

Finally, I discussed a number of specific differences between the phonologies of signed and spoken languages, trying to explain these differences in terms of modality-effects.

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[36] Sign languages do not make abundant use of non-manual distinctions at the lexical level. In this sense (and to the extent that we can compare *non-manual* to *laryngeal*), sign languages are quite unlike Chinese languages.

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