4 Markedness

ELIZABETH HUME

1 Introduction

Markedness is one of the most widely used concepts in phonology and other areas of linguistics. The picture is complicated, however, by the fact that the term is used in different ways, as summarized in (1) (see also Haspelmath 2006).

(1) *Markedness usages*

a. *Descriptive markedness*
An abstract relation holding over members of a set of observations displaying asymmetry, such that one subset is unmarked and the other is marked.

b. *Theoretical markedness*
A universal principle or laws that guide language acquisition, loss, inventory structure, processes, rules, etc. toward the unmarked form.

c. *Markedness constraints*
A technical term in Optimality Theory referring to a category of constraints that evaluate the well-formedness of output structures.

As stated in (1c), one usage of markedness appears in Optimality Theory (OT), where the term describes a category of constraints that evaluate output structures. The technical use of markedness in OT is distinct from other usages: "A markedness constraint in OT may produce results related to [the] descriptive or typological sense of markedness, but the formal constraint and the typological observation are two different things" (McCarthy 2002: 15). Markedness constraints are not discussed in this chapter; the reader is referred to CHAPTER 63: MARKEDNESS AND FAITHFULNESS CONSTRAINTS, where the topic is addressed in detail.

A more common usage of the term, given in (1a), is descriptive in nature, referring to an abstract relation holding over a set of language observations. Descriptive markedness has served as an analytic tool to categorize sounds and other linguistic elements. It has also been commonly used as an instrument for comparing different language systems leading to the creation of language typologies. This concept of markedness dates back to linguists from the Prague School, most notably Nikolai Trubetzkoy and Roman Jakobson. Trubetzkoy (1939) used the term in order to

describe the relations among members of a sound opposition: one member of the opposition bears some property or "mark" that the other member lacks. For example, given the set of consonants [m n b d], the nasal sounds [m n] can be described as being in opposition to the oral sounds [b d] regarding the property *nasal*: [m n] bear the "mark" of nasality, while [b d] do not. Thus, nasal consonants can be referred to as the marked category and oral consonants the unmarked category (see also Jakobson 1932; Jakobson and Pomorska 1990; CHAPTER 11: THE PHONEME).

In contemporary linguistics, the terms "marked" and "unmarked" have come to carry much more meaning than simply "bearing some property," as exemplified in (2) by terms drawn from the literature. (See §5 for discussion of some of these terms, including the noted contradiction regarding perceptual salience.) Thus, describing an observation as *unmarked* is often taken to mean that it is, for example, more frequent, natural, simple, and predictable than the marked observation of the comparison set. The unmarked is also often referred to as the *default* member of a class; that is, it is the member to be assumed, the most basic member of the set, barring further requirements or information.

(2) *Markedness descriptors*

unmarked	*marked*
natural	less natural
normal	less normal
general	specialized
simple	complex
inactive	active
more frequent	less frequent
optimal	less optimal
predictable	unpredictable
acquired earlier	acquired later
more phonetically variable	less phonetically variable
articulatorily simple	articulatorily difficult
perceptually strong	perceptually weak
perceptually weak	perceptually strong
universal	language-specific
ubiquitous	parochial

A further meaning of the term "markedness" is theoretical in nature, referring to a universal principle or laws that guide language toward the unmarked, (1b). The theoretical use of markedness has been at the core of modern phonology and the focus of much debate. It is also the main focus of this chapter. Some key areas of controversy are listed in (3), though it should be pointed out that given the enormity of this topic, it is difficult to do justice in a single chapter to all the debates surrounding markedness. Consequently, the reader is encouraged to consult the references cited throughout and related *Companion* chapters for additional discussion.

(3) *Some key areas of controversy*

a. General approaches to predicting markedness patterns.
b. The relation of markedness to phonological theory.
c. The formal expression of markedness.
d. Criteria for predicting markedness patterns.

2 General approaches to predicting markedness patterns

It is uncontroversial that asymmetrical patterns exist within and across languages. Consider vowel epenthesis, for example (CHAPTER 67: VOWEL EPENTHESIS). It has been widely observed that in some languages, one vowel from the language's inventory is consistently used by speakers to break up ill-formed consonant clusters. In English, this vowel is typically schwa or [ɪ] (CHAPTER 26: SCHWA). For example, as a native English speaker, I pronounce the Polish city name *Gdansk* as [gadænsk], with schwa inserted in the [gd] cluster, rather than [i e a o] or any other English vowel. Thus, we can say that, given the set of English vowels, schwa patterns asymmetrically from other vowels within that set. Expanding our investigation to include other languages, we observe that the epenthetic vowel is [i] in Maltese, [e] in Spanish, and [œ/ø] in French. By defining the set of observations as the epenthetic vowels in English, French, Maltese, and Spanish, we can observe a further asymmetry (among possibly others) having to do with the nature of the vowel selected: in three languages (English, Maltese, Spanish) the epenthetic vowel is unrounded, and in one (French) it is rounded (see §5.5 for additional discussion). Asymmetrical patterns such as these are commonly called markedness observations. That asymmetries such as these exist is not in question; the controversy surrounds how to predict them.

There are two general approaches to this issue. The first draws on markedness itself as the explanation for the asymmetries. In this sense, markedness laws form part of a person's innate knowledge of language (i.e. *competence*; Chomsky 1965, 1986), the position widely adopted by generative phonologists. In this view, markedness forms part of Universal Grammar, and is thus predetermined for speakers of all languages. Further, markedness is a formal issue, in that markedness patterns are predicted from the formalism. For simplicity, I will refer to this as the *markedness-through-formalism* approach.

An alternative, which I will call the *markedness-through-mechanism* approach, attributes markedness patterns to a confluence of factors that interact with grammatical systems, and relate to physical, cognitive, and social mechanisms shared by all humans (e.g. Lass 1975; Stampe 1979; Comrie 1983; Menn 1983; Boersma 1998; Blevins 2004; Hume 2004b; Mielke 2008; Bybee, forthcoming). Comrie (1983), for example, argues that markedness can be explained in terms of human interaction with other humans and with the world, and not as an accidentally inherited or a purely formal property of language. Since independent factors are able to explain the patterns, he argues, there is no need for recourse to Universal Grammar, and markedness as a universal guiding principle need not exist.

Asymmetrical patterns in syllable structure exemplify the nature of the debate. It has long been observed that there are preferred syllable types cross-linguistically (e.g. Cairns and Feinstein 1982; Vennemann 1988). For example, onsets with sonority rising into the nucleus (e.g. [blV]) are more common than those with sonority falling into the nucleus (e.g. [lbV]) (CHAPTER 33: SYLLABLE-INTERNAL STRUCTURE; CHAPTER 49: SONORITY; CHAPTER 55: ONSETS). Such cross-linguistic preferences for syllable type are commonly described in markedness terms: an onset cluster with rising sonority is less marked than one with falling sonority. Berent *et al.* (2007) tested the claim that listeners have innate knowledge of such patterns. Results from their perception experiments indicate that the asymmetrical patterning of

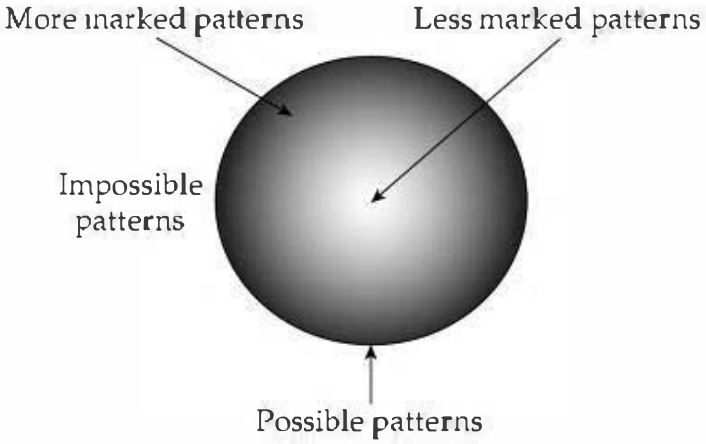
syllable types observed cross-linguistically is reflected in the linguistic behavior of their English listeners: the more an onset cluster is marked (i.e. onsets with sonority falling into the nucleus), the more likely it is to be perceived with an illusory epenthetic vowel (presumably as a means of creating a less marked onset) (see also CHAPTER 98: SPEECH PERCEPTION AND PHONOLOGY). Their interpretation of the findings is in keeping with the markedness-through-formalism approach to predicting markedness patterns: the results provide evidence that knowledge about the markedness of onset clusters is part of Universal Grammar (UG). Proponents of the markedness-through-mechanism approach would interpret the findings differently, as expressed in Peperkamp's (2007: 634) response to Berent *et al.*'s conclusion: "A possible account of the reported markedness effect that makes no appeal to innate knowledge lies with phonetic differences across onset clusters with varying sonority profiles." In particular, the human perceptual mechanism is responsible for a human's ability to detect phonetic differences, rather than assuming that the individual is born with knowledge about these differences.

It is important to note that it is not the notion of innateness that differentiates these approaches; both assume innateness. Rather, the difference lies in *what* is considered innate. In the markedness-through-mechanism approach, it is the physical, cognitive, and, for some, social mechanisms guiding language acquisition, loss, and usage that are innate. In the markedness-through-formalism approach, on the other hand, it is the formalism from which markedness patterns are derived that is innate. Depending on the particular theory, the formalism may be rooted in the physical and cognitive mechanisms assumed in the former approach.

3 The relation of markedness to phonological theory

Markedness has played an important role in the development of phonological theories; however, approaches have differed with regards to where the domain of explanation for markedness patterns resides. In one approach, markedness observations are directly expressed in a theory of phonology, while in another, they are the basis for a separate theory of markedness. By means of illustration, assume that the sphere in (4) contains all possible sound patterns; impossible patterns reside outside of the sphere. Further, the space within the sphere is graded, with more marked patterns occurring further away from the core.

(4) *Language patterns*



One approach assumes separate theories to account for the set of language patterns in (4): a theory of markedness and a formal theory of phonology (or grammar). Examples include Chomsky and Halle (1968: ch. 9), Kean (1975), Cairns and Feinstein (1982), Mohanan (1993), Calabrese (1995), Steriade (1995), and Boersma (1998). The goal of markedness theory, according to Chomsky and Halle (1968), is to distinguish between more and less natural segments and rules, and to determine the degree of admissibility of a given lexical item. In other words, the domain of markedness theory is internal to the sphere in (4). A theory of grammar serves a different purpose: to distinguish between possible and impossible items, i.e. between elements that do and do not occur within the sphere (see Mohanan 1993 and Calabrese 1995 for related discussion).

This model of markedness was first proposed for phonology in chapter 9 of Chomsky and Halle (1968; *SPE*). Like Jakobson (1971a) and Greenberg (1966), *SPE* treats markedness as a universal principle which guides language acquisition and the formation of phoneme inventories. In addition, it serves as an evaluation metric on the selection of analytic options in the formulation of phonological rules and underlying representations: "children construct grammars to account for the data they are exposed to within the constraints imposed by the formalism, and an evaluation metric selects the simplest possible grammar for the given data" (Mohanan 1992: 639, based on *SPE*). Marked options impose a cost on an analysis, while unmarked ones do not; qualifiers such as *simpler, preferred, optimal,* and *more highly valued* are commonly used to convey the less costly nature of the unmarked option. Steriade (1995: 118) suggests that a theory of markedness should also be able to "document the validity of . . . universal statements" such as feature co-occurrence constraints, "and seek an explanation for their universal status."

A second approach to predicting markedness patterns assumes a single theory. In this view, the goal of an adequate theory of grammar is to be able to predict not only possible grammars (inside vs. outside the sphere), but markedness observations as well (gradations within the sphere). Such an approach is seen in, for example, Archangeli (1984), Prince and Smolensky (1993), Calabrese (1995), Rice (1996), de Lacy (2002, 2006), and made explicit in Sagey's (1986: 9) influential dissertation on feature organization:

> It should be possible to represent within [a theory of phonology] any phonological process or form that is a possible human language, and it should be impossible to represent phonological forms and processes that do not exist in human language . . . Another requirement on the theory is that the relative simplicity of describing in the representation each process or form that occurs should reflect its relative naturalness, in the sense of its frequency of occurrence in the languages of the world. That is, more marked forms and processes should be correlated with more marked representations.

As discussed further below, this perspective is fundamental to some theories of underspecification (e.g. Archangeli 1984; CHAPTER 7: FEATURE SPECIFICATION AND UNDERSPECIFICATION) and feature organization (e.g. Clements 1985; Avery and Rice 1989; CHAPTER 27: THE ORGANIZATION OF FEATURES).

4 The formal expression of markedness

The representation of markedness, in a theory of markedness or grammar, typically assumes two components: (i) a formal device denoting whether an element is marked or unmarked, and (ii) a mechanism encoding the relative markedness of the elements in question. Examples of each are given in (5). Implicational statements (§5.2) can be viewed as incorporating both components.

(5) *Representing markedness*

a. *Formal devices*
Feature values (e.g. Jakobson *et al.* 1952; Jakobson 1971a; *SPE*)
Diacritics (e.g. *SPE*; Calabrese 1995)
Distributional statements (e.g. Mohanan 1993)
Redundancy rules (e.g. *SPE*; Archangeli 1984)
Constraints (e.g. Prince and Smolensky 1993; Calabrese 1995; Boersma 1998; Causley 1999; de Lacy 2002, 2006)

b. *Relational mechanisms*
Ordering (e.g. Calabrese 1995; CHAPTER 74: RULE ORDERING)
Constraint ranking (e.g. Prince and Smolensky 1993)
Subset relations (de Lacy 2002, 2006)
Quantitative measures (e.g. *SPE*; Archangeli 1984; Clements 1985; Kiparsky 1985; Avery and Rice 1989).

Given space limitations, the discussion below provides an overview of only some of these components.

In *SPE*, the diacritics *m* and *u* are formal devices assigned to features in order to indicate whether a feature value is intrinsically "marked" or "unmarked," respectively. All phonemes are assigned a value for each feature, thus *m* and *u* values are present in the lexicon. The combination of feature values within a segment determines whether that sound is marked or unmarked. Prior to the application of phonological rules, markedness conventions, as in (6), translate *m* and *u* into the values + and −. For example, the redundancy rule in (6a) states that the unmarked value of the feature [high] for vowels is [+high], while (6b) states that the unmarked value for [back] when coupled with [+low] is [+back]. Importantly, unmarked rules are considered universal statements that cannot be violated, while marked rules can be violated, but add a cost to the grammar; unmarked values do not contribute to the complexity of a grammar.

(6) *Sample marking conventions for vowels*

a. [u high] → [+high]

b. [u back] → [+back] / $\left[\frac{\quad}{+\text{low}}\right]$

In *SPE*, the relative markedness among elements in a system is a quantitative issue, in that the complexity of a system is equal to the sum of the marked features of its members. However, as the authors point out (Chomsky and Halle 1968: 409ff.), counting features alone is not sufficient to predict optimal systems; other considerations, such as system symmetry and simplicity, also need to be taken into account.

Correlating markedness with quantity is also central to some theories of underspecification, in that the least marked element is represented with the least amount of theoretical machinery (e.g. Kiparsky 1982; Archangeli 1984; Pulleyblank 1988; Archangeli and Pulleyblank 1989; CHAPTER 7: FEATURE SPECIFICATION AND UNDERSPECIFICATION). Most models of feature geometry adopt a similar approach (Clements 1985; McCarthy 1988; Avery and Rice 1989; Clements and Hume 1995), as exemplified by Clements's (1985) proposal that natural (unmarked) phonological rules are expressed as single operations. As such, an unmarked rule of assimilation involves the addition of a single association line (CHAPTER 81: LOCAL ASSIMILATION), and an unmarked deletion rule is presented by the delinking of a single line (CHAPTER 68: DELETION). In this light, predicting markedness patterns is a representational problem (Rice 1999).

Associating quantity of structure with unmarkedness is generally linked to the view that unmarked feature values are absent in underlying representation (for discussion see, e.g. Archangeli 1984; Steriade 1987, 1995; Clements 1988, 1993; Odden 1992; Rice 1992; Mohanan 1993; Calabrese 1995; CHAPTER 1: UNDERLYING REPRESENTATIONS; CHAPTER 7: FEATURE SPECIFICATION AND UNDERSPECIFICATION; CHAPTER 27: THE ORGANIZATION OF FEATURES). Thus, underlying representations provide the vehicle for determining markedness relations. For example, Paradis and Prunet (1991: 3) argue that "the special status of coronals lies in the fact that they lack specifications for place features in UR" (see also CHAPTER 12: CORONALS). Similarly, Rice (1992: 64) remarks: "Segment structure combined with absence of universally unmarked features at a node . . . indicates markedness relations, with more structure indicating a more marked segment and less structure a less marked segment." This approach can be traced to early writings by Jakobson and colleagues (e.g. Cherry *et al.* 1953; see §5.5), who sought to maximize the efficiency of phoneme systems by minimizing redundant information, a view reflected in *SPE*. These ideas are further developed in Kiparsky (1982), Archangeli (1984), Pulleyblank (1988), and Archangeli and Pulleyblank (1989), and is expressed in the following quote (Kiparsky 1982: 54–55) (see also CHAPTER 8: SONORANTS):

> The theory of grammar will provide a set of universal redundancy rules functionally analogous to the markedness principles of Chomsky and Halle (1968), but formally identical to ordinary phonological rules. In particular, assume that for every feature F there is minimally a rule
>
> (42) [ ] → [α F]
>
> Where α (+ or −) is the "unmarked" value. In addition, other rules may be applicable in specific syntagmatic or paradigmatic contexts. For example, for voicing we may have the rules
>
> (43) a. [ ] → [+voiced]
> b. [+obst] → [−voiced]
>
> putting the unmarked value as [−voiced] for obstruents and [+voiced] elsewhere. We now say that voiceless obstruents and voiced sonorants are represented as [0 voiced], that is, unspecified for voicing, and that their respective specifications for voicing are filled in by the application of rule (43). This much is quite in the spirit of traditional markedness theory.

Critical discussion of the connection between underspecification and markedness can be found in e.g. Mohanan (1993) and Steriade (1995). Among the critiques, Steriade (1995: 199–200) questions:

> whether the asymmetric distribution between the marked and the unmarked value justifies eliminating the unmarked value from underlying structure. Is underlying privativity the faithful representation of markedness facts? . . . Should the unmarked value be represented at all on the surface?

In response to these questions, she suggests that there are segments in most languages that start out and end up without features, such as place of articulation in the case of the laryngeal consonants [h] and [ʔ] and schwa-like vowels.

A further issue concerns the assumption that only one member of a class can be unmarked and thus least specified. For example, Kiparsky (1985) argues that coronal nasals are unmarked for place in Catalan, since only coronals assimilate to the place of articulation of any following consonant (Mascaró 1976). Rice (2007), however, points out that this approach is untenable, a claim supported by evidence in Hume (2003) showing that virtually any combination of dorsal, labial, and coronal can be unmarked, given their patterning as targets of assimilation, a common markedness diagnostic (see §5).

In the 1990s, the shift in focus from underlying to surface representations further impacted the use of underspecification as a means of expressing markedness. Instead, surface-oriented devices were developed. Calabrese (1995: 374) proposes the use of marking statements, similar to the marking conventions of *SPE*, though formalized as constraints rather than rules. He argues that "the structure of inventories is determined by restrictions on phonological segments in the form of constraints on pairs of features." Co-occurrence restrictions occur within marking statements, as shown in (7). The property of being marked is encoded by underlining of the relevant feature in the statement, as is the case for value $\underline{\beta}$ of feature G in combination with another feature value αF, where α and β range over + and –.

(7) *Marking statement* (Calabrese 1995)

$[\alpha F, \underline{\beta G}]$

Constraints are also central to accounts of markedness developed within the framework of Optimality Theory (e.g. Prince and Smolensky 1993; Steriade 1995; Hamilton 1996; Lombardi 1997; Causley 1999; de Lacy 2002, 2006; Hayes and Steriade 2004). For example, Hayes and Steriade (2004: 1) propose that "markedness laws characterising the typology of sound systems play a role, as grammatical constraints, in the linguistic competence of individual speakers."

In some constraint-based approaches, degrees of markedness are expressed through formal devices that organize constraints hierarchically. Calabrese, for instance, draws on constraint ordering to create a hierarchy of markedness statements. In some OT approaches, markedness relations are expressed through the harmonic ordering of members of a correlational set which imposes a universally fixed order on a set of constraints (Prince and Smolensky 1993). For example, as shown in (8), it is claimed that the harmonic ordering for place of articulation expresses the markedness relations provided by UG, such that dorsal is more marked than labial, which is more marked than coronal, and so forth. The corresponding grammatical

constraints and ranking appear in (8b). Despite the assumed universality of such rankings, this approach also provides a formal means for describing the observation that a given feature need not be unmarked in all languages: an additional constraint may dominate the fixed ranking, thus having the effect of overruling the unmarked status of a lower-ranked constraint (see e.g. Lombardi 1997 for an analysis along these lines; also CHAPTER 22: CONSONANTAL PLACE OF ARTICULATION).

(8) a. *Harmonic ordering for place of articulation* (> = "is less marked than")
glottal > coronal > labial > dorsal

b. *Corresponding fixed universal ranking* (>> = "is ranked above")
*dorsal >> *labial >> *coronal >> *glottal

De Lacy's (2002, 2006) OT-based theory of markedness makes use of markedness hierarchies tied to sets of constraints. Place of articulation features are represented by the hierarchy in (9a), which projects onto the output constraint sets in (9b).

(9) a. *Markedness hierarchy*
(hierarchy enclosed by | |; > = "is more marked than")
| dorsal > labial > coronal > glottal |

b. *Each hierarchy is related to a set of constraints:*

i. *[dorsal]
Assign a violation for each [dorsal] feature.

ii. *[dorsal, labial]
Assign a violation for each [dorsal] and each [labial] feature.

iii. *[dorsal, labial, coronal]
Assign a violation for each [dorsal], each [labial], and each [coronal] feature.

iv. *[dorsal, labial, coronal, glottal]
Assign a violation for each [dorsal], each [labial], each [coronal], and each [glottal] feature.

Unlike (8b), the ranking of the constraint sets in (9b) is not fixed. Instead, de Lacy proposes that markedness patterns are generated by virtue of the subset relations present in each set of constraints. For example, since in (9) the marked feature [dorsal] is listed in each constraint of the entire set, a violation of any of the constraints will necessarily target [dorsal]. Conversely, the absence of [glottal] in all constraints but *[dorsal, labial, coronal, glottal] preserves the feature, except when all other feature types are involved. In other words, [dorsal] is least preferred, while [glottal] is most preferred. I refer the reader to de Lacy (2006) for discussion concerning the predictive power of the approaches represented in (8) and (9).

5 Criteria for predicting markedness patterns

Determining what constitutes reliable evidence for markedness relations remains an area of controversy. One issue concerns whether one can actually diagnose markedness: are markedness diagnostics to be treated as "criterial for determining asymmetry or as merely correlative" Battistella (1996: 14)? Generative phonological approaches have tended to view markedness diagnostics as criterial.

Others view such diagnostics as correlative, to the extent that they reveal reliable statistical tendencies (e.g. Lass 1975; Menn 1983; Ohala 1990; Bybee 2001; Hume 2004a, 2004b; Haspelmath 2006; Mielke 2008).

Controversy also surrounds the issue of whether evidence for markedness comes from synchrony or diachrony (CHAPTER 93: SOUND CHANGE). In theories of generative phonology, the status of synchronic patterns is considered paramount, given the fundamental premise that such observations provide a window into an individual's innate knowledge of language. Further, since the individual does not have direct access to knowledge of changes from the past, only synchrony can provide valid sources of evidence for markedness patterns (see e.g. Rice 1999; de Lacy 2002, 2006). Conversely, Blevins (2004: 20) argues that

> there is *no* clear role for markedness within synchronic phonology. Absolute universals and universal tendencies in sound patterns emerge from general pathways of language change, and have no independent status in the grammar . . . most proposed universals and their counterexamples have straightforward diachronic explanations.

(See also Mielke 2008; CHAPTER 17: DISTINCTIVE FEATURES.)

Another area of debate concerns which criteria are appropriate for determining the markedness value of a given element. The types of evidence used to support claims about phonological markedness include those in (10).

(10) *Types of evidence for predicting markedness patterns*

a. Acquisition.
b. Phonological patterns, e.g. alternations, inventory structure, distribution, implicational relations.
c. Phonetics, e.g. quality of acoustic/auditory cues to the identification of a pattern, articulatory difficulty in producing a pattern.
d. Usage factors, e.g. statistical patterns.
e. Cognitive factors, e.g. information content, entropy.

In the remainder of this section we take a closer look at these criteria.

5.1 *Language acquisition*

Since Jakobson's seminal papers on language acquisition (1971a, 1971b), the view that there are universal principles, such as markedness, that guide the order in which a child learns language has been highly influential (CHAPTER 101: THE INTERPRETATION OF PHONOLOGICAL PATTERNS IN FIRST LANGUAGE ACQUISITION). Central to this approach is the proposal that acquisition of a marked sound category, defined in terms of distinctive features, presupposes the acquisition of the corresponding unmarked category (see implicational relations: §5.2). According to Jakobson (1971b: 11), the order in which children acquire sound categories "corresponds exactly to the general laws of irreversible solidarity (implication) which govern the synchrony of the languages of the world." For example, under the assumption that dorsal place of articulation is more marked than coronal, the acquisition of dorsals presupposes that of coronals. Jakobson (1971b: 7) acknowledges in places that the term *general laws* might be "more prudently formulated"

as *tendencies*, though his proposed orders of acquisition have typically been interpreted as absolutes: all children acquire sounds in the same order, regardless of the language that they are learning.

Controversy has surrounded at least two issues arising from the proposed link between acquisition and markedness: (i) the extent to which there is a universal order of acquisition such that the marked implies the unmarked; and (ii) whether acquisition data should be used as evidence for claims regarding markedness.

With regard to the first point, experimental evidence indicates that there is considerable variability in the order of acquisition across languages. For example, Morrisette *et al.* (2003) tested the claim that dorsal place of articulation is more marked than coronal by examining inventory structure and substitution patterns from 211 English-learning children. They found that

> the full range of logical possibilities was found to occur with regard to inventory structure; that is, some children included both coronals and dorsals in their inventories, others included coronals but not dorsals, and yet others included dorsals but not coronals. In terms of the children's substitution patterns, dorsals were replaced by coronals . . . in a large proportion of the cases. However, a small proportion of the children replaced coronals with dorsals. (Morrisette *et al.* 2003: 351)

(See also Menn 1983; Vihman 1993; Beckman *et al.* 2003.)

Beckman *et al.*'s (2003) study of the acquisition of place of articulation also challenges the view that there is a universal order of acquisition for place of articulation. Japanese-learning children made more than twice as many "backing" errors for /t/ (i.e. /t/ pronounced as /k/) as they made "fronting" errors for /k/ (/k/ pronounced as /t/), which runs counter to the claim that back consonants like /k/ are universally marked and likely to be replaced by front consonants like /t/.

However, Beckman *et al.* (2003) also suggest that some universals may exist, "if we take the term 'universal' to mean a strong numerical tendency rather than an absolute rule." They suggest that the best example involves laryngeal features, thus supporting Jakobson's claim that voiceless unaspirated stops are mastered before aspirated or voiced stops. Drawing on evidence from Kewley-Port and Preston (1974), they propose that this universal of acquisition is phonetically grounded in the relative difficulty of satisfying aerodynamic requirements for the different stop types.

A second issue concerns whether or not observations from acquisition, including second language acquisition, should be used as evidence for a theory of markedness at all. In other words, if there is empirical evidence that children acquire one class of sounds prior to another, should these observations be used as evidence for or against a theory of markedness? There has been less of an overt debate regarding this issue; rather, authors typically assume one position or the other. For example, Calabrese (1995) draws on the order of acquisition of segments (and segment loss) in his markedness theory to establish the order of marking statements. Conversely, de Lacy (2006) assumes that acquisition data do not in and of themselves provide evidence for a markedness pattern. He takes issue with the findings of Beckman *et al.* (2003), who argue that velar /k/ patterns are unmarked among Japanese-learning children, claiming that in the absence of synchronic alternations in the language that also attest to the unmarked status of

velars, the apparent unmarked behavior of velars could be explained by phonetic factors. A crucial difference between de Lacy's and Beckman *et al.*'s approaches is that in the former, markedness constitutes a fundamental part of an individual's grammatical competence, independent of performance factors. In this view, any observations that might be explained by factors external to the grammar and not supported by synchronic processes do not constitute empirical evidence for a formal theory of markedness. Conversely, in the latter approach, there is no strict division between competence and performance; linguistic knowledge comprises and is influenced by both types of information.

5.2 *Phonological patterns*

From the earliest discussion of markedness in Trubetzkoy (1939) to more recent research on the topic, the asymmetrical patterning of features and sounds in inventories and phonological processes has served as the basis for predicting markedness relations. Indeed, in Rice's (1999) evaluation of markedness criteria, she concludes that the strongest and most compelling arguments come from phonological processes (see also de Lacy 2006). Thus, when comparing features within a class, if one feature patterns asymmetrically with respect to the others, it is this feature that is deemed the unmarked member of the relation. Consider an example from Yoruba. There are three tones in the language's tonal inventory (High, Mid, Low) (CHAPTER 45: THE REPRESENTATION OF TONE). The Mid tone, unlike High and Low, never appears in the structural descriptions or changes of phonological rules. Mid thus patterns asymmetrically with respect to other members of the tonal class and, as a result, is considered the unmarked member (Akinlabi 1985). The following discussion provides an overview of the types of evidence used in diagnosing markedness, but cannot do justice to the vast literature that has been devoted to this topic. Additional works that discuss the different types of evidence include Battistella (1990, 1996); Rice (1999, 2007); de Lacy (2002, 2006); Hume (2004b, 2006, 2008); Haspelmath (2006).

In terms of phonological patterning, it is widely assumed that, to the extent that there is asymmetry, the unmarked member of an opposition patterns differently than other members in being the *target* of phonological processes, such as reduction, deletion, and assimilation (though cf. de Lacy 2006). With regard to assimilation (CHAPTER 81: LOCAL ASSIMILATION; CHAPTER 77: LONG-DISTANCE ASSIMILATION OF CONSONANTS), for example, Rice (1999: 4) points out:

> the unmarked pole of an opposition is lost or obscured, with the marked pole remaining . . . In assimilation, the marked features within a class are active . . . the unmarked features, on the other hand, are passive, or inert . . . overridden by other features.

Put another way, marked features are assumed to resist modification, while unmarked features are subject to change. Rice (1999, 2007) labels this criterion "submergence of the unmarked." Recall the Catalan example from above, in which only coronals assimilate to the place of articulation of a following consonant (Mascaró 1976); in this case, coronal is considered unmarked. A more complex yet frequently cited example comes from place assimilation in Korean, as shown in (11), where a final obstruent stop assimilates in place to a following consonant,

with the following restrictions. A morpheme-final coronal assimilates to a following dorsal or labial consonant (11a). A morpheme-final labial also assimilates to a following dorsal, but fails to assimilate to a following coronal, as in (11b). As the examples in (11c) show, a final dorsal consonant does not assimilate to either a following labial or coronal consonant. According to the view that markedness is correlated with resistance to modification, the dorsal consonant is considered most marked, followed by labial, then coronal (Iverson and Kim 1987), i.e. dorsal > labial > coronal.

(11) *Korean place assimilation*

a.	/mit+ko/	[mikk'o]		'believe and'
	/mit^{h}+pota/	[mipp'ota]		'more than the bottom'
b.	/ip+ko/	[ikk'o]		'wear and'
	/nop+ta/	[nopt'a]	*[nott'a]	'high'
c.	/nok+ta/	[nokt'a]	*[nott'a]	'melt'
	/kuk+pota/	[kukp'ota]	*[kupp'ota]	'more than soup'

The *output* of certain phonological processes including epenthesis and neutralization has also been drawn on as evidence for identifying the unmarked member of a class. The output of *neutralization* (CHAPTER 80: MERGERS AND NEUTRALIZATION) is one of the original diagnostics for markedness, proposed in Trubetzkoy (1939): the result of neutralization does not bear the mark of the relevant property, i.e. it is unmarked. For example, in languages with final devoicing such as German, Maltese, Polish, and Russian, the contrast between voiced and voiceless consonants is arguably neutralized in word-final or coda position; only one member of the opposition survives, the voiceless consonant, and thus this member is considered unmarked. There is lack of consensus, however, regarding the use of the output of neutralization as evidence for the unmarked. Croft (2003), for example, claims that there is no uniformity across languages concerning which value is to be considered unmarked (see also de Lacy 2002, 2006; Vaux and Samuels 2005). And for epenthesis, de Lacy (2002, 2006) considers consonant, but not vowel, epenthesis to be a valid criterion for markedness.

Distributional evidence has also long been considered a criterion for determining markedness relations. Battistella (1990) distinguishes between paradigmatic distribution and syntagmatic distribution. With regard to the former, it is claimed that the unmarked category of a contrastive pair is used to distinguish more words than the marked category (see also Waugh and Lafford 1994). As for syntagmatic distribution, it is widely held that the unmarked segment (or feature) is more widely distributed than its marked counterpart (see, e.g. Trubetzkoy 1939; Hockett 1955; Greenberg 1966; Battistella 1990; Stemberger 1992; for related discussion, see Rice 1999). In fact, Hockett (1955: 166) proposes that distributional differences underlie the unmarkedness (simplicity, in his terms) associated with the result of neutralization (see also Trubetzkoy 1939; Hume 2004b). In this light, the view that voiceless obstruents in languages such as Russian are simpler (unmarked) as compared to their voiced counterparts is explained in terms of their wider distribution: the voiceless member of the contrast occurs in non-final contexts, as does the voiced member, but also in word-final or coda positions.

One of the original sources of evidence for markedness comes from *implicational relations*, as noted in §5.1: the presence of *x* implies the presence of *y* (Trubetzkoy

1939; Greenberg 1966; Jakobson 1971a). Jakobson (1971a) treats implicational relations as a cornerstone of markedness, in that they state a compulsory connection between two related properties of language; for example, the occurrence of nasal vowels implies that of nasal consonants. Implicational relations have been claimed to reveal markedness patterns in sound change, acquisition, and inventories. Thus, in sound change, the loss of a marked category implies the loss of the corresponding unmarked one (Bailey 1973). Similarly, in child language acquisition, the acquisition of a marked category implies prior acquisition of the corresponding unmarked category (Jakobson 1971a).

Yet it has been in phoneme inventories that implicational relations have been most widely cited as evidence for markedness patterns (see e.g. Chomsky and Halle 1968; Kean 1975; Lass 1975; Cairns and Feinstein 1982; Calabrese 1995; Hamilton 1996; Causley 1999; de Lacy 2002, 2006). For example, Kean (1975) claims that if a language has voiced obstruents, it also has voiceless obstruents. Conversely, Rice (1999) considers implication problematic as evidence for markedness relations given the assumption that language learners do not have access to implicational relationships between segments in consonant and vowel inventories. Rather than being a part of an individual's knowledge of language, implication in Rice's view is a consequence of properties relating to phonetics and usage.

Interestingly, Lass (1975: 501), who opposes the claim that markedness observations provide evidence for innate properties of language, nonetheless views implicational relations as relevant for a theory of "universal phonetics." He suggests that there is a hierarchy made up of

> necessary choices which appear to be universal, and a larger (unordered) set of contingent choices which any language can make after it has made the non-contingent ones. This reflects such facts as the apparent lack of languages without vowels, the lack of languages with nasalized vowels but no oral ones, or glottalized consonant but no non-glottalized one . . . and so on. . . . Under this view we return to something very like the Praguian notion of "marking," in which (at least in some cases) the relation U : M presupposes not "optimalness" or "simplicity" vs. "non-optimalness" or "complexity," but rather (irreflexive) implication: If M, then U; but not vice versa.

Structural asymmetries in phoneme inventories have also been used to identify the unmarked member of the inventory (e.g. Rice and Avery 1993; Rice and Causley 1998; Causley 1999). Building on insights from Trubetzkoy (1939) and Jakobson (see Battistella 1990), Rice and Causley argue that non-contrastive features are inactive, and that such inactivity signals the unmarked status of features and segments. To illustrate, compare two hypothetical sound systems in (12). System A is comprised of six segments; we may assume that each of the following pairs are distinguished by some feature [F]: /a – d/, /b – e/, and /c – f/. System B is made up of five segments; like system A, feature [F] is contrastive for /b – e/ and /c – f/, but not for segment /a/.

(12) *Structural asymmetries*

System A			*System B*		
a	b	c	a	b	c
d	e	f		e	f

Dyck (1995) proposes that phonological patterns occur in which the /a/-like segment in system A triggers processes, whereas the /a/-like segment in system B does not (see the discussion in Rice 2007). Further, there is some support for the role of contrast in predicting markedness in vowel place specifications. Causley (1999: 76–77) argues that vowel systems that

> lack a central vowel have a front or back vowel patterning as unmarked. When a language has a front–central–back contrast, the central vowel is chosen as the least marked. Thus the markedness status of different vowel specifications is linked to the inventory.

Using contrast as a predictor of markedness values is not consistently reliable, however. Rice (2007) presents a number of cases showing variation in the segment that emerges as unmarked among languages with similar systems of contrast.

5.3 *Phonetic properties*

There is general consensus that phonetic factors play a role in predicting markedness patterns, a view dating back to the earliest writings on the topic (e.g. Trubetzkoy 1939; Jakobson and Halle 1956; Greenberg 1966; Chomsky and Halle 1968). Acceptance of this view is seemingly independent of whether or not one associates markedness with Universal Grammar. Hayes and Steriade (2004) note that universal markedness laws are rooted in phonetic knowledge. Consistent with this view, Mohanan (1993) assumes that phonological patterns are influenced by three phonetic principles: minimize the number of articulatory gestures; minimize the deviation of articulatory gestures from configurations of least effort; maintain the phonetic distinctions that distinguish between different words. Similarly, Boersma (2000: 18) notes that markedness, in the sense of cross-linguistic rarity, "emerges from an interaction between principles of articulatory effort and perceptual confusion, and [are] not encoded directly in our phonological language device." Further, Bybee (2001: 14) proposes that the "underlying explanation for sound changes that create markedness relations is phonetic in nature." A more nuanced approach appears in de Lacy (2002, 2006: 1), where two theories of markedness are assumed: a performance theory and a competence theory. "Markedness is part of grammatical Competence (I-language). Markedness in Competence is distinct from sometimes apparently similar Performance-related phenomena." While asymmetrical patterns are assumed to exist in both competence markedness and performance markedness, according to de Lacy their explanations lie in different domains: the former are explained in terms of Universal Grammar, and the latter by factors external to the grammar, such as those relating to phonetics and usage.

The remainder of this section focuses on the phonetic factors most commonly used as criteria for identifying markedness values, as listed in (13).

(13) *Phonetic factors*

a. phonetic variability in production
b. articulatory simplicity
c. perceptual distinctiveness

5.3.1 *Phonetic variability in production*

The unmarked member of an opposition has been claimed to be produced with greater phonetic variability than the marked counterpart, a view first attributed to Trubetzkoy (1939). Similarly, Greenberg (1966) considers greater allophonic variability to be a criterion of the unmarked category, and Rice (1999: 19) suggests that fixedness of phonetic realization correlates with markedness such that the marked pole is more clearly defined: marked members show little variation, while unmarked members show more.

5.3.2 *Articulatory factors*

The unmarked member of an opposition is widely considered to be easier and less complex than the marked counterpart in terms of production. Calabrese (1995: 376), for example, states that the less marked nature of certain feature combinations can be explained by ease of articulation and perceptual saliency: for instance, he claims that

> the [+continuant, −strident] coronal fricatives [θ, ð] are complex because of the articulatory adjustments needed to maintain absence of stridency in fricatives. Still other combinations are phonologically simple. For example, the combination [+continuant, +strident] is simple, since stridency is a natural consequence of the type of constriction found in fricatives.

Similar assumptions hold for sequences of sounds. Along these lines, Hamilton (1996: ii) proposes that

> each phonotactic constraint is phonetically grounded. Unmarked clusters correspond to structures which are gesturally and/or perceptually simple and marked structures are gesturally and/or perceptually complex.

For related discussion, see Archangeli and Pulleyblank (1994), Jun (1995), and Boersma (1998), among others.

The use of articulatory simplicity to predict markedness patterns is not without issues. For example, despite wide acknowledgment in the phonological literature that such factors play an important role, the actual phonetic evidence showing *x* to be simpler than *y* is often not rigorously demonstrated. Further, while it may seem intuitively evident in some cases that two elements are appreciatively different in terms of articulatory complexity (e.g. [p] *vs.* [pʰ]), gradations of difficulty are less evident among more similar elements (e.g. [p] *vs.* [t] *vs.* [k]), particularly for adult speakers with years of experience producing the sounds (see Stampe 1979: 10 for related discussion). An additional issue concerns the interaction between articulatory and perceptual factors, a point returned to in the following section.

5.3.3 *Perceptual distinctiveness*

The perceptual distinctiveness of sounds and strings of speech has also been drawn on to predict observed asymmetries in phonological systems (e.g. Trubetzkoy 1939; Jakobson and Waugh 1987; Lindblom 1990; Flemming 1995; Jun 1995; Steriade 1995; Boersma 1998; Hume 1999, 2004a; Hume and Johnson 2001; Blevins 2004; Bybee, forthcoming; CHAPTER 98: SPEECH PERCEPTION AND PHONOLOGY). It is clear

that distinctiveness is important for the correct identification of sounds and strings of speech (e.g. Ohala 1981; Kawasaki 1982; Lindblom 1990). In this regard, Kawasaki (1982) proposes that sharper changes in the speech signal serve to increase the salience of cues in the portion of the signal where the modulation takes place: the greater the magnitude of the modulation, the better a given signal is detected. Interestingly, this proposal relates to claims regarding phonological markedness in two seemingly conflicting ways.

The first concerns the observation that patterns with *larger modulations* tend to recur across languages, since they are more resistant to change than those with smaller modulations. In this case greater syntagmatic distinctiveness correlates with unmarkedness, an interpretation consistent with the common assumption that the CV syllable is universally preferred over other syllable types, e.g. V, CVC, VC (Cairns and Feinstein 1982; Clements and Keyser 1983). Paradigmatically, strong perceptual distinctiveness has also been proposed as the explanation for recurring phonological inventories. Liljencrants and Lindblom (1972) propose that the structure of vowel systems is determined largely by the principle of maximal perceptual contrast, thus favoring systems in which vowels are perceptually distinct, e.g. [i a u] (see Flemming 1995). Perceptual distinctiveness has also been drawn on extensively to account for asymmetries in phonological patterns. As Hamilton (1996: 12ff.) observes, following Jun (1995) and Steriade (1995),

> Simple percepts are unmarked and complex percepts are marked . . . simple speech sounds in perceptual terms are those with robust spectral cues . . . The empirical correlate to this is that perceptually robust speech sounds are highly valued cross-linguistically, while languages only grudgingly elaborate perceptually opaque structures.

The flip side of the coin is that structures with *small modulations* due to weak acoustic/auditory cues will tend to be modified more often than those with larger modulations (Kawasaki 1982). As a result, sounds lacking distinctiveness are subject to phonological processes such as assimilation, reduction, and deletion to a greater degree than sounds with robust cues (see e.g. Kohler 1990; Hura *et al.* 1992; Jun 1995; Steriade 1997; Boersma 1998; Hayes *et al.* 2004). Thus weak perceptual distinctiveness is also correlated with being unmarked. This interpretation is consistent with the claim that the target of phonological processes such as deletion is the unmarked member of the comparison set.

The use of perceptual distinctiveness thus appears contradictory as a markedness diagnostic: unmarkedness is associated with *strong* perceptual distinctiveness as well as *weak* perceptual distinctiveness. Consequently, it is seemingly impossible to predict a priori whether a sound is marked or unmarked given its salience. Hume (2006), and Hume and Mailhot (forthcoming) propose that these observations are consistent with a model of markedness conceptualized in terms of entropy, a measure of the uncertainty in a system (Shannon and Weaver 1949); see §5.5 for discussion.

A further issue concerns the interaction between production and perceptual demands, and the role of these interactions in predicting markedness observations. Given the complexity of this issue, it is understandable that the topic has received less attention in the literature than the roles of perception and production in markedness independently. The subject is addressed in considerable detail in Boersma (1998), who proposes a production theory of markedness and a perception theory

of markedness. He observes (Boersma 1998: 17) that production and perceptual constraints can make conflicting predictions regarding markedness, citing fricatives as an example:

> In gestural terms, fricatives are complex, since the correct spatial relationship between the active and passive articulators must be very precisely controlled in order to maintain turbulent airflow . . . At the same time, fricatives are spectrally very robust. Their random high frequency energy patterns are very distinct from the spectral properties of the other manners of articulation, and also act as a very salient cue to place of articulation.

To resolve such conflicts, Boersma claims (1998: 17) that languages adopt different strategies:

> They may follow the [production theory of markedness] and elaborate gesturally harmonic features, or follow the [perception theory of markedness] and elaborate perceptually harmonic features, or opt for some combination of the two. Therefore in the case of fricatives some languages have more stops than fricatives while others (including English) have fricatives which lack stop counterparts.

5.4 *Usage*

The most common usage factor cited in relation to markedness is the statistical frequency with which a particular pattern occurs, a criterion dating back to Zipf (1932), Trubetzkoy (1939), Hockett (1955), and Greenberg (1966), among others. The claim is that the unmarked is more frequent cross-linguistically than the marked (CHAPTER 90: FREQUENCY EFFECTS). Despite its long history, the relation between frequency and markedness remains controversial. Three of the main issues are given in (14).

(14) *Issues regarding frequency and markedness*

a. whether or not frequency should play a role in predicting markedness patterns;
b. to the extent that frequency is used as a predictor of markedness, whether frequency should be calculated across all languages, within a single language, or involve both calculations; and
c. what type of frequency measure is relevant.

Trubetzkoy (1939), inspired by Zipf (1932), drew a link between unmarked status and frequency: since the unmarked member of an opposition emerges in cases of neutralization, the distributional asymmetry would contribute to the unmarked sound's greater frequency over the marked sound (see also Hume 2004b). For Jakobson, frequency was foundational to the use of markedness in modern linguistics, reflected in the frequency of a sound across languages, and through implicational relations. This view continues to be commonly accepted today, though not uniformly so. Hume and Tserdanelis (2002) point to the higher frequency of labial place in Sri Lankan Portuguese Creole nasals as support for the unmarkedness of the labial nasal in that language. Rice (1999), however, considers a pattern's frequency to be a consequence of emergent properties

(i.e. factors influencing language change), rather than a diagnostic for markedness (see also de Lacy 2002, 2006).

Nonetheless, the link between frequency and markedness is widely attested in the generative phonology literature. Citing cross-linguistic frequency as evidence for markedness, Kean (1975) states that since almost all languages have [t a] but fewer have [kp y], [t a] are unmarked and [kp y] are marked. Further, as noted in §4, Sagey (1986: 9) claims that a requirement of a theory of phonology

> is that the relative simplicity of describing in the representation each process or form that occurs should reflect its relative naturalness, in the sense of its frequency of occurrence in the languages of the world. That is, more marked forms and processes should be correlated with more marked representations.

Similarly, Paradis and Prunet (1991: 10) point to three types of statistical patterns which, they argue, support the view of the feature coronal being unmarked. As listed in (15), the evidence comes from cross-linguistic measures (typological frequency) as well as language-specific ones (inventory frequency, token frequency).

(15) *Evidence from frequency for the unmarked status of coronal* (Paradis and Prunet 1991: 10)

a. Inventory frequency: the number of coronals in the consonant inventory of a given language.
b. Typological frequency: the number of coronals attested in a universal phonemic inventory.
c. Occurrence frequency (i.e. token frequency): the number of times coronals are produced in a representative speech corpus.

Paradis and Prunet's broad use of frequency measures relates to another area of controversy: whether frequency should be calculated across all languages, within a single language, or both. Trubetzkoy (1939) considered the frequency of one member of an opposition within a language as a signal of unmarked status. Greenberg (1966) used statistical methods to claim that the frequencies with which phonemes show up in languages are the expression of a universal tendency to avoid marked phonemes; unmarked phonemes have higher cross-linguistic frequencies. This view is also reflected in more recent literature; Hamilton (1996: 5–6) states that "unmarked features are more frequent than marked features . . . features with a wider cross-linguistic distribution also occur at higher frequencies language-internally." Yet Meier (1999) challenges the view that cross-linguistic frequency is a valid criterion for markedness, arguing that "presumably marked values (e.g. glottality in stop consonants) have a very different distribution in different languages" (cited in Élšík and Matras 2006: 16). In this view, frequency is best calculated on a language-specific basis (see also Hume 2006).

The use of statistical measures is complicated by a number of issues. One has to do with what the appropriate measure is, e.g. type or token frequency. Type frequencies are calculated over a lexicon, for example, how frequently a phoneme occurs in the dictionary of a language; see for example Trubetzkoy (1939). Token frequency is calculated over a written or spoken corpus, for example, how frequently a phoneme occurs in a corpus of natural speech. Type frequencies generally provide more information about the structure of a language, whereas

token frequency reveals patterns of usage. The extent to which the two properties affect phonological patterns differently remains an empirical question (see e.g. Munson 2000 for related discussion). A further issue concerns which elements and levels of language frequency should be measured over, for example, features, segments, syllables, words. Does frequency affect all elements of language uniformly? If not, what are the empirical consequences for a language's phonological system? A further issue concerns the interaction of statistical patterns with other factors such as production, perception, word structure, and word similarity. For additional discussion see, for example, Bybee (2001), Phillips (2006), and CHAPTER 90: FREQUENCY EFFECTS.

5.5 *Entropy and information content*

The concepts of entropy and information content have been connected to markedness in at least two ways: as a foundational concept for the dichotomous view of the unmarked and marked, and as a predictor of markedness patterns. Information content and the more widely used term "entropy" are tools of Information Theory (IT; Shannon and Weaver 1949), and well established in the field of computational linguistics. IT is concerned with representing mathematically how much information, measured in terms of binary choices (bits), is needed to efficiently convey a message given the constraints imposed on the system. Entropy is a measure of the amount of uncertainty associated with selecting outcomes in a given system. A higher entropy value is associated with greater uncertainty among a set of possible outcomes; those outcomes that are relatively unexpected contribute more information, or complexity, to a message.

Jakobson's theory of distinctive features and the binary nature of markedness were inspired by Information Theory. According to Cherry *et al.* (1953: 34), analyzing a language requires that "we must determine the minimum set of [distinctive] features that the listener needs in order to recognize and distinguish all except homonymic morphemes, without help from context or situation." Each binary feature represents a choice regarding a particular sound (is it voiced? is it nasal?), with the response encoded as plus (yes) and minus (no) (zero indicates redundant information). A plus value is generally interpreted as marked, and minus as unmarked. The goal of this approach was to determine how many binary choices were needed to identify a given phoneme within the language system. Consistent with Information Theory, the most efficient system was the one that required the fewest number of binary questions (i.e. features) to convey the identity of a particular phoneme. Many of these ideas became cornerstones of subsequent theories of feature specification, and the information-theoretic concept of binarity emerged as a fundamental assumption of markedness theories.

Entropy has also been applied to other aspects of phonological knowledge; for applications of information-theoretic concepts to sound patterns, see Hockett (1955), Broe (1996), Goldsmith (1998, 2002), Hume and Bromberg (2005), Hume (2006), Hall (2009), Goldsmith and Riggle (forthcoming), Hall *et al.* (forthcoming), Hume and Mailhot (forthcoming); also CHAPTER 6: SELF-ORGANIZATION IN PHONOLOGY. For example, Hume (2006), Hall *et al.* (forthcoming), and Hume and Mailhot (forthcoming) suggest that entropy and information content can be used to make predictions about the preferred contexts and likely outcomes of a range of phonological processes, hence markedness patterns. Specifically, the most likely

targets are predicted to be those that contribute little to the total entropy of the system, or in the case of repair processes, those that would significantly increase entropy if left unrepaired. The most likely outcomes are predicted to be ones that result in the least change in the pre-existing entropy of the system. One consequence of this approach is that it unites a range of otherwise disparate observations regarding influences on phonological patterns within a given system. For instance, Hall *et al.* (forthcoming) argue that in cognition, the information content of an element is influenced not only by its frequency, but also by its phonetic salience and by the attention a language user allocates to it in context. These are factors that linguists have independently argued influence phonological patterns. Laboratory studies of a number of languages show that listeners tend to allocate more attention to beginnings of words. Correspondingly, many languages restrict marked elements or structures to initial syllables of words (e.g. Beckman 1997).

To briefly illustrate, consider a language system L with a set of elements $X = \{x_i, x_{ii}, \ldots x_n\}$. Predicting which element will occur in a given context can be measured as a function of its probability, determined in part by its frequency of occurrence (see below for the role of acoustic salience in defining information content). Each element thus has its own probability of occurrence: sound x_i has probability $p(x_i)$. The information content of an element x_i is the negative logarithm base 2 of its probability p. This corresponds to our intuition that elements with higher probability are more expected than elements with lower probability; in information-theoretic terms, it takes less information (fewer binary decisions) to determine whether or not it will occur. In the vowel epenthesis example below, for instance, information content is used to compare the probability that a particular vowel occurs in a given context with the probabilities for all vowels in the system that comprise the relevant probability distribution.

Comparisons can also be made at the level of systems, rather than individual items: the total entropy of a system, or its complexity, is the sum of the information contributed by all members. To the extent that systems from different languages are compared, this measure can address questions relating to universal markedness patterns. To measure the contribution of a particular element to the entropy of the system, its information content is multiplied by the probability of its occurrence in that system, that is, $-p(x_i) \log_2 p(x_i)$. Note that an element's probability appears twice in this expression, with opposite effects. As a result, elements with either very high or very low probability contribute little to total system entropy: elements with very low probability have high information content, but contribute little because of their low rate of occurrence; conversely, elements that occur very frequently contribute little because their information content is correspondingly low. Elements with intermediate probability contribute relatively more to the complexity of the system, that is, its entropy, through their balance of moderate information content and frequency of occurrence.

The common markedness diagnostic, epenthesis, illustrates how these concepts can be used to answer the questions: (i) why epenthesize?; and (ii) why epenthesize a particular vowel? Consider the case of English vowel epenthesis as used to repair a non-occurring word-initial cluster. As noted above, a word-initial [gd] cluster as in the Polish city name Gdansk is often repaired as [gəd] (or [gɪd]). The first question concerns the motivation for epenthesis. In this approach, the answer is that adding [gd] to the language would, all else being equal, increase the complexity of the system, measured as entropy. This conclusion derives from

considering the information content of the structures [gd] and [gəd], measured as the negative $\log_2$ of the conditional probability of the respective phonotactic sequences in English and the contribution of each to the entropy of the system. (In this simple case, information content can be approximated solely in terms of the type or token frequency of each sequence in a corpus of English.) Prior to borrowing, [gd] has a probability of zero, and contributes nothing to the entropy of the system; adding this sequence increases systemic entropy sharply. In contrast, increasing the frequency of an already occurring element such as [gəd] has less of an effect on the entropy of the system.

Parallel reasoning can be used to predict why one segment is the preferred epenthetic vowel in a given context over other vowels in the language. Why, for example, is the initial [gd] cluster typically repaired in English as [gəd] or [gɪd], as opposed to [gad], [god], [gid], among other possibilities? Common explanations point to the epenthetic vowel as unmarked, less salient, more frequent, predictable or somehow simpler than other vowels in the language. The information-based approach is consistent with these insights. A simple model takes into account the probability of each vowel in the system as a function of frequency and mutual information (context-dependent frequencies), and the phonetic nature of the sound in the relevant context, measured in terms of the quality of its acoustic cues. In this model, the information content of a given vowel is a function of both its probability of occurrence and its acoustic salience. The results indicate that [ɔ ɪ] have the lowest information content of all vowels in the system, consistent with the observation that these vowels commonly emerge as epenthetic.

While English epenthesis provides a relatively straightforward example, the approach extends to cases such as vowel epenthesis in French where, as noted above, a mid front rounded vowel serves as the epenthetic vowel; as such, the initial [gd] cluster of *Gdansk* would commonly be repaired as [gød] or [gœd]. French epenthesis is of particular interest, given the widely held view that front rounded vowels are universally marked (Chomsky and Halle 1968; Causley 1999; de Lacy 2006). However, the front rounded vowels are not only among the most frequent vowels in French, but also have been shown to be the most confusable with other vowels in the system. The information-based approach correctly predicts the mid front rounded vowels to have the lowest information content among vowels in the language, and to be the preferred epenthetic vowels (Hume and Bromberg 2005).

This approach provides an answer to the conflict regarding perceptual salience noted above: unmarked status is associated both with patterns with strong salience and those with weak salience. The salience of sounds in a system can be calculated as the probability of a given element being correctly identified. To the extent that the probability distribution is asymmetrical such that some sounds have a high probability of being misidentified (weak salience), these sounds will have a low value for information content and thus contribute little to the entropy of the system (as defined by the relevant probability distribution). All else being equal, such sounds are likely candidates for reduction and deletion. Interestingly, the observation that sounds with low information content are prone to deletion as well as epenthesis also addresses another apparent conflict among markedness criteria: the unmarked segment is not only the most likely to be deleted, it is also the most likely to be inserted. As noted above, the proposed explanation is because changes to the entropy of the system would be minimally

affected by those elements that contribute little to its complexity. Sound patterns with strong salience, on the other hand, have higher information content; as a result, their loss would result in a more drastic change to the system. Thus, all else being equal, patterns with stronger salience are predicted to be more stable and avoid change.

6 Conclusion

As should be evident from the discussion above, the concept of markedness has had a long and controversial history in phonology. The goal of understanding why some elements pattern differently from others is at the heart of the linguistic and, more generally, cognitive enterprise. As a result, I suspect that markedness, whatever "it" is, will continue to be a much debated topic for years to come.

ACKNOWLEDGMENTS

My sincere thanks to Marc van Oostendorp, Keren Rice, and an anonymous reviewer, whose valuable comments strengthened this chapter. I would also like to thank Colin Ewen for his assistance in preparing the final version. This chapter is dedicated to the memory of G. Nick Clements who, on my generals exam at graduate school, posed the question of what markedness is, thus starting me on my quest to get to the bottom of it.

REFERENCES

Akinlabi, Akinbiyi. 1985. Tonal underspecification and Yorùbá tone. Ph.D. dissertation, University of Ibadan.

Archangeli, Diana. 1984. Underspecification in Yawelmani phonology and morphology. Ph.D. dissertation, MIT.

Archangeli, Diana & Douglas Pulleyblank. 1989. Yoruba vowel harmony. *Linguistic Inquiry* 20. 173–217.

Archangeli, Diana & Douglas Pulleyblank. 1994. *Grounded phonology*. Cambridge, MA: MIT Press.

Avery, Peter & Keren Rice. 1989. Segment structure and coronal underspecification. *Phonology* 6. 179–200.

Bailey, Charles-James N. 1973. *Variation and linguistic theory*. Arlington, VA: Centre for Applied Linguistics.

Battistella, Edwin. 1990. *Markedness: The evaluative superstructure of language*. Albany: State University of New York Press.

Battistella, Edwin. 1996. *The logic of markedness*. Oxford: Oxford University Press.

Beckman, Jill N. 1997. Positional faithfulness, positional neutralisation and Shona vowel harmony. *Phonology* 14. 1–46.

Beckman, Mary E., Kiyoko Yoneyama & Jan Edwards. 2003. Language-specific and language-universal aspects of lingual obstruent productions in Japanese-acquiring children. *Journal of the Phonetic Society of Japan* 7. 18–28.

Berent, Iris, Donca Steriade, Tracy Lennertz & Vered Vaknin. 2007. What we know about what we have never heard: Evidence from perceptual illusions. *Cognition* 104. 591–630.

Blevins, Juliette. 2004. *Evolutionary Phonology: The emergence of sound patterns*. Cambridge: Cambridge University Press.

Boersma, Paul. 1998. Functional phonology: Formalizing the interactions between articulatory and perceptual drives. Ph.D. dissertation, University of Amsterdam.

Boersma, Paul. 2000. Phonetically-driven acquisition of phonology. Unpublished ms., University of Amsterdam.

Broe, Michael B. 1996. A generalized information-theoretic measure for systems of phonological classification and recognition. In Richard Sproat (ed.) *Computational Phonology in Speech Technology: 2nd meeting of the ACL Special Interest Group in Computational Phonology, Proceedings of the Workshop*, 17–24. Philadelphia: Association for Computational Linguistics.

Bybee, Joan. 2001. *Phonology and language use*. Cambridge: Cambridge University Press.

Bybee, Joan. Forthcoming. Markedness: Iconicity, economy and frequency. In Jae Jung Song (ed.) *The Oxford handbook of language typology*. Oxford: Oxford University Press.

Cairns, Charles & Mark Feinstein. 1982. Markedness and the theory of syllable structure. *Linguistic Inquiry* 13. 193–225.

Calabrese, Andrea. 1995. A constraint-based theory of phonological markedness and simplification procedures. *Linguistic Inquiry* 26. 373–463.

Causley, Trisha. 1999. Complexity and markedness in Optimality Theory. Ph.D. dissertation, University of Toronto.

Cherry, E. Colin, Morris Halle & Roman Jakobson. 1953. Toward the logical description of languages in their phonemic aspect. *Language* 29. 34–46.

Chomsky, Noam. 1965. *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.

Chomsky, Noam. 1986. *Knowledge of language: Its nature, origin, and use*. New York: Praeger.

Chomsky, Noam & Morris Halle. 1968. *The sound pattern of English*. New York: Harper & Row.

Clements, G. N. 1985. The geometry of phonological features. *Phonology Yearbook* 2. 225–252.

Clements, G. N. 1988. Toward a substantive theory of feature specification. *Papers from the Annual Meeting of the North East Linguistic Society* 18. 79–93.

Clements, G. N. 1993. Underspecification or nonspecification? *Proceedings of the Eastern States Conference on Linguistics (ESCOL)* 10. 58–80.

Clements, G. N. & Elizabeth Hume. 1995. The internal organization of speech sounds. In Goldsmith (1995), 245–306.

Clements, G. N. & Samuel J. Keyser. 1983. *CV phonology: A generative theory of the syllable*. Cambridge, MA: MIT Press.

Comrie, Bernard. 1983. Markedness, grammar, people and the world. In Eckman *et al.* (1983), 85–106.

Croft, William. 2003. *Typology and universals*. 2nd edn. Cambridge: Cambridge University Press.

de Lacy, Paul. 2002. The formal expression of markedness. Ph.D. dissertation, University of Massachusetts, Amherst.

de Lacy, Paul. 2006. *Markedness: Reduction and preservation in phonology*. Cambridge: Cambridge University Press.

Dyck, Carrie. 1995. Constraining the phonetics–phonology interface. Ph.D. dissertation. University of Toronto.

Eckman, Fred, Edith Moravcsik & Jessica Wirth (eds.) 1983. *Markedness*. New York & London: Plenum Press.

Elšík, Viktor & Yaron Matras. 2006. *Markedness and language change: The Romani sample*. Berlin & New York: Mouton de Gruyter.

Flemming, Edward. 1995. Auditory representations in phonology. Ph.D. dissertation, University of California, Los Angeles.

Goldsmith, John A. (ed.) 1995. *The handbook of phonological theory*. Cambridge, MA & Oxford: Blackwell.

Goldsmith, John A. 1998. On information theory, entropy, and phonology in the 20th century. Paper presented at the Royaumont CTIP II Round Table on Phonology in the 20th Century.

Goldsmith, John A. 2002. Probabilistic models of grammar: Phonology as information minimization. *Phonological Studies* 5. 21–46.

Goldsmith, John A. & Jason Riggle. Forthcoming. Information theoretic approaches to phonological structure: The case of Finnish vowel harmony. *Natural Language and Linguistic Theory.*

Greenberg, Joseph H. 1966. *Language universals, with special reference to feature hierarchies.* The Hague: Mouton.

Hall, Kathleen Currie. 2009. A probabilistic model of phonological relationships from contrast to allophony. Ph.D. dissertation, Ohio State University.

Hall, Kathleen Currie, Elizabeth Hume, Dahee Kim, Frédéric Mailhot, Adam Ussishkin & Andrew Wedel. Forthcoming. Entropy as an organizing principle in phonology. *Theoretical Linguistics.*

Hamilton, Philip. 1996. Phonetic constraints and markedness in the phonotactics of Australian aboriginal languages. Ph.D. dissertation, University of Toronto.

Hardcastle, W. J. & A. Marchal (eds.) 1990. *Speech production and speech modeling.* Dordrecht: Kluwer.

Haspelmath, Martin. 2006. Against markedness (and what to replace it with). *Journal of Linguistics* 42. 25–70.

Hayes, Bruce & Donca Steriade. 2004. Introduction: The phonetic bases of phonological markedness. In Hayes *et al.* (2004), 1–33.

Hayes, Bruce, Robert Kirchner & Donca Steriade (eds.) 2004. *Phonetically based phonology.* Cambridge: Cambridge University Press.

Hockett, Charles F. 1955. *A manual of phonology.* Baltimore: Waverly Press.

Hume, Elizabeth. 1999. The role of perceptibility in consonant/consonant metathesis. *Proceedings of the West Coast Conference on Formal Linguistics* 17. 293–307.

Hume, Elizabeth. 2003. Language specific markedness: The case of place of articulation. *Studies in Phonetics, Phonology and Morphology* 9. 295–310.

Hume, Elizabeth. 2004a. The indeterminacy/attestation model of metathesis. *Language* 80. 203–237.

Hume, Elizabeth. 2004b. Deconstructing markedness: A predictability-based approach. *Proceedings of the Annual Meeting, Berkeley Linguistics Society* 13. 182–198.

Hume, Elizabeth. 2006. Language specific and universal markedness: An information-theoretic approach. Paper presented at the 80th Annual Meeting of the Linguistic Society of America, Albuquerque.

Hume, Elizabeth. 2008. Markedness and the language user. *Phonological Studies* 11. 295–310.

Hume, Elizabeth & Ilana Bromberg. 2005. Predicting epenthesis: An information-theoretic account. Paper presented at 7èmes journées internationales du réseau français de phonologie, Aix-en-Provence.

Hume, Elizabeth & Keith Johnson. 2001. A model of the interplay of speech perception and phonology. In Elizabeth Hume & Keith Johnson (eds.) *The role of speech perception in phonology,* 3–26. San Diego: Academic Press.

Hume, Elizabeth & Frédéric Mailhot. Forthcoming. Entropy and surprisal in phonologization and language change. In Alan C. L. Yu (ed.) *Origins of sound patterns: Approaches to phonologization.* Oxford: Oxford University Press.

Hume, Elizabeth & Georgios Tserdanelis. 2002. Labial unmarkedness in Sri Lankan Portuguese Creole. *Phonology* 19. 441–458.

Hura, Susan L., Björn Lindblom & Randy L. Diehl. 1992. On the role of perception in shaping phonological assimilation rules. *Language and Speech* 35. 59–72.

Iverson, Gregory K. & Kee-Ho Kim. 1987. Underspecification and hierarchical feature representation in Korean consonantal phonology. *Papers from the Annual Regional Meeting, Chicago Linguistic Society* 23(2). 182–198.

Jakobson, Roman. 1932. *Zur Struktur des russischen Verbums. Charisteria Guilelmo Mathesio qvinqvagenario a discipulis et Circuli Lingvistici Pragensis sodalibus oblata.* Prague. Reprinted as Structure of the Russian verb, in Linda R. Waugh & Morris Halle (eds.) (1984), *Roman Jakobson: Russian and Slavic grammar. Studies 1931–1981*, 1–14. Berlin: Mouton.

Jakobson, Roman. 1971a. The sound laws of child language. In Roman Jakobson (ed.) *Studies on child language and aphasia*, 7–20. The Hague & Paris: Mouton. Reprinted in Waugh & Monville-Burston (1990), 294–304.

Jakobson, Roman. 1971b. Implications of language universals for linguistics. In Roman Jakobson. *Selected writings*, vol. 2, 580–592. The Hague: Mouton.

Jakobson, Roman & Morris Halle. 1956. *Fundamentals of language*. The Hague: Mouton.

Jakobson, Roman & Krystyna Pomorska. 1990. The concept of mark. In Waugh & Monville-Burston (1990), 134–140.

Jakobson, Roman & Linda R. Waugh. 1987. *The sound shape of language*. 2nd edn. Berlin: Mouton de Gruyter.

Jakobson, Roman, C. Gunnar M. Fant & Morris Halle. 1952. *Preliminaries to speech analysis: The distinctive features and their correlates*. Cambridge, MA: MIT Press.

Jun, Jongho. 1995. Place assimilation as the result of conflicting perceptual and articulatory constraints. *Proceedings of the West Coast Conference on Formal Linguistics* 14. 221–237.

Kawasaki, Haruko. 1982. An acoustical basis for universal constraints on sound sequences. Ph.D. dissertation, University of California, Berkeley.

Kean, Mary-Louise. 1975. The theory of markedness in generative grammar. Ph.D. dissertation, MIT.

Kewley-Port, Diane & Malcolm S. Preston. 1974. Early apical stop production: A voice onset time analysis. *Journal of Phonetics* 2. 195–210.

Kiparsky, Paul. 1982. Lexical morphology and phonology. In Linguistic Society of Korea (ed.) *Linguistics in the morning calm*, 3–91. Seoul: Hanshin.

Kiparsky, Paul. 1985. Some consequences of Lexical Phonology. *Phonology Yearbook* 2. 85–138.

Kohler, Klaus J. 1990. Segmental reduction in connected speech in German: Phonological facts and phonetic explanations. In Hardcastle & Marchal (1990), 69–92.

Lass, Roger. 1975. How intrinsic is content? Markedness, sound change, and "family universals." In Didier L. Goyvaerts & Geoffrey K. Pullum (eds.) *Essays on The Sound Pattern of English*, 475–504. Ghent: E. Story-Scientia.

Liljencrants, Johan & Björn Lindblom. 1972. Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language* 48. 839–862.

Lindblom, Björn. 1990. Explaining phonetic variation: A sketch of the H & H theory. In Hardcastle & Marchal (1990), 403–439.

Lombardi, Linda. 1997. Coronal epenthesis and markedness. *University of Maryland Working Papers in Linguistics* 5. 156–175.

Mascaró, Joan. 1976. Catalan phonology and the phonological cycle. Ph.D. dissertation, MIT.

McCarthy, John J. 1988. Feature geometry and dependency: A review. *Phonetica* 45. 84–108.

McCarthy, John J. 2002. *A thematic guide to Optimality Theory*. Cambridge: Cambridge University Press.

Meier, Tinka. 1999. Phonological markedness revisited: Evidence from Caucasian languages. In Helma van den Berg (ed.) *Studies in Caucasian linguistics*, 181–196. Leiden: CNWS.

Menn, Lise. 1983. Language acquisition, aphasia and phonotactic universals. In Eckman *et al.* (1983), 241–256.

Mielke, Jeff. 2008. *The emergence of distinctive features*. Oxford: Oxford University Press.

Mohanan, K. P. 1992. Emergence of complexity in phonological development. In Charles A. Ferguson, Lise Menn & Carol Stoel-Gammon (eds.) *Phonological development: Models, research, implications*, 635–662. Timonium, MD: York Press.

Mohanan, K. P. 1993. Fields of attraction in phonology. In John A. Goldsmith (ed.) *The last phonological rule: Reflections on constraints and derivations*, 61–116. Chicago & London: University of Chicago Press.

Morrisette, Michele, Daniel Dinnsen & Judith Gierut. 2003. Markedness and context effects in the acquisition of place features. *Canadian Journal of Linguistics* 48. 329–355.

Munson, Benjamin. 2000. Phonological pattern frequency and speech production in children and adults. Ph.D. dissertation, Ohio State University.

Odden, David. 1992. Simplicity of underlying representation as motivation for underspecification. *OSU Working Papers in Linguistics* 41. 85–100.

Ohala, John J. 1981. The listener as a source of sound change. *Papers from the Annual Regional Meeting, Chicago Linguistic Society* 17(2). 178–203.

Ohala, John J. 1990. Alternatives to the sonority hierarchy for explaining segmental sequential constraints. *Papers from the Annual Regional Meeting, Chicago Linguistic Society* 26(2). 319–338.

Paradis, Carole & Jean-François Prunet. 1991. Introduction: Asymmetry and visibility in consonant articulations. In Carole Paradis & Jean-François Prunet (eds.) *The special status of coronals: Internal and external evidence*, 1–28. San Diego: Academic Press.

Peperkamp, Sharon. 2007. Do we have innate knowledge about phonological markedness? Comments on Berent, Steriade, Lennertz, and Vaknin. *Cognition* 104. 631–637.

Phillips, Betty S. 2006. *Word frequency and lexical diffusion*. New York: Palgrave MacMillan.

Prince, Alan & Paul Smolensky. 1993. Optimality Theory: Constraint interaction in generative grammar. Unpublished ms., Rutgers University & University of Colorado, Boulder. Published 2004, Malden, MA & Oxford: Blackwell.

Pulleyblank, Douglas. 1988. Vocalic underspecification in Yoruba. *Linguistic Inquiry* 19. 233–270.

Rice, Keren. 1992. On deriving sonority: A structural account of sonority relationships. *Phonology* 9. 61–99.

Rice, Keren. 1996. Default variability: The coronal–velar relationship. *Natural Language and Linguistic Theory* 14. 493–543.

Rice, Keren. 1999. Featural markedness in phonology: Variation. *GLOT International* 4.7: 3–6, 4.8: 3–7.

Rice, Keren. 2007. Markedness in phonology. In Paul de Lacy (ed.) *The Cambridge handbook of phonology*, 79–97. Cambridge: Cambridge University Press.

Rice, Keren & Peter Avery. 1993. Segmental complexity and the structure of inventories. *Toronto Working Papers in Linguistics* 12. 131–153.

Rice, Keren & Trisha Kathleen Causley. 1998. Asymmetries in featural markedness: Place of articulation. Paper presented at the 21st Generative Linguistics in the Old World Conference, Tilburg University.

Sagey, Elizabeth. 1986. The representation of features and relations in nonlinear phonology. Ph.D. dissertation, MIT.

Shannon, Claude Elwood & Warren Weaver. 1949. *The mathematical theory of communication*. Urbana-Champaign: University of Illinois Press.

Stampe, David. 1979. *A dissertation on natural phonology*. New York: Garland.

Stemberger, Joseph P. 1992. Vocalic underspecification in English language production. *Language* 68. 492–524.

Steriade, Donca. 1987. Redundant values. *Papers from the Annual Regional Meeting, Chicago Linguistic Society* 23(2). 339–362.

Steriade, Donca. 1995. Underspecification and markedness. In Goldsmith (1995), 114–174.

Steriade, Donca. 1997. Phonetics in phonology: The case of laryngeal neutralization. Unpublished ms., University of California, Los Angeles.

Trubetzkoy, Nikolai S. 1939. *Grundzüge der Phonologie*. Göttingen: van der Hoeck & Ruprecht. Translated 1969 by Christiane A. M. Baltaxe as *Principles of phonology*. Berkeley & Los Angeles: University of California Press.

Vaux, Bert & Bridget Samuels. 2005. Laryngeal markedness and aspiration. *Phonology* 22. 395–436.

Vennemann, Theo. 1988. *Preference laws for syllable structure and the explanation of sound change: With special reference to German, Germanic, Italian, and Latin*. Berlin: Mouton de Gruyter.

Vihman, Marilyn M. 1993. Variable paths to early word production. *Journal of Phonetics* 21. 61–82.

Waugh, Linda R. & Barbara A. Lafford. 1994. Markedness. In R. E. Asher (ed.) *Encyclopedia of languages and linguistics*, 2378–2383. Oxford: Pergamon Press.

Waugh, Linda R. & Monique Monville-Burston (eds.) 1990. *On language: Roman Jakobson*. Cambridge, MA: Harvard University Press.

Zipf, George K. 1932. *Selected studies of the principle of relative frequency in language*. Cambridge, MA: Harvard University Press.