Complexity Scales and Licensing in Phonology

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Preface

This book is an attempt to demonstrate that the basic principles of phonological organisation boil down to the interaction between the strength of nuclei as licensers of phonological structure and various non-rerankable scales of complexity occurring at different levels of phonological representation. The licensing relation between nuclei and the preceding onsets on the one hand, and governing relations between consonants, which are to a great extent determined by their internal melodic structure, allow us to view the phonological representation as a self-organizing system.

As a starting point of our discussion, we take the theory of Principles and Parameters in phonology, also referred to as (standard) Government Phonology (Charette 1991, Harris 1990, 1994, 1997, Kaye 1990, 1995, Kaye, Lowenstamm and Vergnaud 1985, 1990). The central underlying principle of the self-organization in phonology due to the interaction between complexity scales and licensing strength leads to a number of dramatic modifications of the standard model. Firstly, a lot of most cherished principles and parameters are eliminated or redefined as part of non-rerankable scales. Secondly, a change of philosophy is proposed concerning the employment of empty nuclei in representation: from striving to develop mechanisms of their licensing – muting mechanisms which allow empty nuclei to remain silent – to determining their own licensing properties. Their formal function is viewed as generally the same as that of other nuclei, while their special status stems from the fact that they are substantively empty. And thirdly, the phonological representation is viewed as a consecution of CVs (Lowenstamm 1996, Polgárdi 1998, Rowicka 1999, Scheer 2004), which is not just an assumption. Some arguments for the CVCV structure are also adduced.

Complexity itself is not a new concept in Government Phonology, but it has mostly been discussed in the context of the melodic make-up of segments (Harris 1990, 1994). In Chapter 1, various melodic complexity effects are discussed in Irish, Polish and Welsh. It is shown that such aspects of segmental phonology as sonority effects, relative markedness, segmental inventories and their susceptibility to phonological processes, as well as the interaction between consonants in syllabification may to a great extent be derived from the substantive complexity of segments defined as the number of elements they contain. Additionally, an extension to the Element Theory is proposed in the form of parameterizing the occurrence of some elements. Chapter 2 deals with formally defined complexity – at the syllabic level – and its interaction with the melodic level. The proposal transforms the original idea of Government Licensing (Charette 1990, 1992) into a non-rerankable scale of progressively more complex structures which demand progressively stronger licensers. The resulting model may account for both fairly basic and also quite complex issues connected with syllabification and word structure, such as phonotactics and clustering, syllabically driven phonological processes, syllable typology, markedness, and acquisition. This chapter contains a new analysis of Polish initial consonant clusters. Chapter 3, considers issues connected with phonologically conditioned aspects of word structure. Its first part deals with the interaction between foot structure and syllabic organisation in the context of the historical development in Slavic languages called liquid metathesis. It is shown that the model is fully compatible with the predictions made by the Licensing Inheritance theory (Harris 1997). The interaction between licensing and complexity may now be treated as an organising agent present at all levels of phonological representation which enables us to reinterpret the familiar notion of structural analogy found in Dependency Phonology (e.g. Anderson and Ewen 1987). Finally, the problem of word edges is returned to with a view to demonstrating that the new model predicts such anomalies of word structure as complex clusters at word edges in Polish, or Super Heavy Rhymes in English and Dutch. This allows us to adopt a different view on extra-syllabicity, that is, one in which such notions need no longer be necessary.

I wish to express my gratitude to the following friends and colleagues for their generous assistance and comments at various stages of writing the book. First and foremost, many thanks are due to Edmund Gussmann, who taught me phonology, and whose constant support and interest in my work greatly contributed to the feeling that my efforts may be worth pursuing. His numerous comments on the earlier version of this book were more than helpful. They also saved me form a number of blunders. Of course, I take full responsibility for the remaining ones. I did not take all of Ed's criticisms in to account, but I know I will be forgiven, as always. I am also extremely grateful to Jonathan Kaye and Tobias Scheer who were always more than willing to discuss my proposals and phonology in general, and who have greatly influenced my thinking. Thanks are also due to the friendly, vibrant, and ever-growing group of people working within the broadly understood model of Government Phonology. They provided a lot of inspiration for my research. In particular, I would like to thank Monik Charette, John

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Last but not least, I would like to thank Marta Cyran for her patience and support. This book is dedicated to her.

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1. Introduction

The aim of this chapter is to demonstrate that one of the crucial organizing properties of phonological representation at the melodic level is subsegmental complexity, which is of a scalar character. *Substantive complexity*, as we will call it, will be shown to play a pivotal role in phonological systems, contributing to the understanding of certain static aspects of these systems, for example, segmental inventories, phonotactics, typology, markedness effects etc., as well as a number of dynamic characteristics such as phonological processing, in both its synchronic and historical dimension.

The chapter is organized in the following way. First, in section 2, the Element Theory is introduced and illustrated by focusing on both simple and more complex aspects of sub-segmental representation, and by showing that complexity may successfully replace such concepts as *sonority*, and *strength* in all the areas of phonological theory where they were used to account for phonological systems, including the syllabification of consonants (section 3). Then, in section 4, we look more deeply at the system of modern Irish with a view to illustrating how the model can be practically applied to a range of phenomena within one phonological system. First, we deal with vowel quality alternations and show the advantages of a privative model employing elements over an equipollent feature system in capturing the existing alternations, as well as capturing the peculiar pattern whereby the relative regularity of the phenomenon is strictly dependent on the height distinctions of the target vowels. The second aspect of the phonological system of Irish which is dealt with concerns the role of substantive complexity in determining grammatical coda-onset contacts. Here, a modification of the model will be proposed, which consists in allowing the utilization of a particular melodic prime to be subject to parameterization. This move will be shown to facilitate a better understanding of Irish phonotactics and to have additional, far-reaching consequences for the types of segments that this phonological system may theoretically employ. Some systemic distinctions leading to typological variation between consonantal systems will be proposed, of which the distinction involving internal complexity seems to be the most important. Finally, we focus our discussion on the phenomenon of initial consonant mutations in Welsh – another Celtic language – with a view to showing how this seemingly complex phenomenon can receive a fairly simple analysis within the Element Theory.

2. The Element Theory in Government Phonology

The smallest units of phonological representation in Government Phonology are called elements.[1] The term has been chosen not only to oppose this construct to the traditional features, but also to convey the similarity of their behaviour to physical elements, in that they can occur in isolation – simplex structures, or in compounds – complex structures. In a nutshell, the elements can be characterized as privative, cognitive units which enjoy a stand-alone phonetic interpretability. Privativeness, as opposed to equipollence, means that each relevant property of melodic representation is defined by the physical presence of a given prime, and phonological processes may refer only to actively present elements, rather than to their absence, or to a negative value for them. The term 'cognitive unit' is used to convey the fact that elements which encode lexical contrasts are neither articulatory nor auditory in nature.[2]

> ...continuing the essentially Jakobsonian line of thinking, we consider their phonetic implementation as involving in the first instance a mapping onto sound patterns in the acoustic signal. Viewed in these terms, articulation and perception are parasitic on this mapping relation. That is, elements are internally represented templates by reference to which listeners decode auditory input and speakers orchestrate and monitor their articulations.
>
> Harris and Lindsey (1995: 50)

[1] This section draws heavily on Harris (1990, 1996) and Harris and Lindsey (1993, 1995). Early GP proposals on elements also include Kaye (1989), Kaye, Lowestamm and Vergnaud (1985, 1990), Rennison (1987, 1990). Other contributions are Backley (1993, 1995), Backley and Takahashi (1998), Brockhaus (1995), Charette and Göksel (1996, 1998), Cobb (1993, 1997), Cyran (1996b, 1997), Denwood (1993), Harris (1997), Jensen (1994), Kaye (2001), Nasukawa (1998, 2005), Ploch (1999), Pöchtrager (2006), Ritter (1997), Rennison (1998), Rennison and Neubarth (2003), Scheer (1996, 2004), Szigetvári (1994).

[2] See, for example, Coleman (1998) for a review of various arguments concerning the nature of linguistic primes, in which he arrives at similar conclusions.

As far as autonomous interpretability is concerned, it is assumed that each element that is linked to a skeletal position can be directly realized as a speech sound, either alone, or in combination with other elements. The phonological representations remain privative and redundancy-free througout the derivation. There is no place for any default fill-in procedures. For example, sonorants are non-specified for voice lexically, and they remain so at every stage of the derivation.[3] Thus, there is no need for a level of systematic phonetic representation (Harris and Lindsey 1993, 1995: 46).

The details of the Element Theory will transpire as we proceed. It will also become obvious that some assumptions which are fit for an introduction to the Element Theory must be verified and confronted with particular phonological systems. Let us first look at an exhaustive list of what we assume to be a standard set of elements in GP. The following table defines the elements in terms of their acoustic patterns and the necessary articulatory execution required in their production (adapted from Harris 1996: 314).

(1)

	Acoustic pattern	***Articulatory execution***
A	*Mass*: central spectral energy mass (convergence of F1 and F2)	Maximal expansion of oral tube; maximal constriction of pharyngeal tube
I	*Dip*: low F1 coupled with high spectral peak (convergence of F2 and F3)	Maximal constriction of oral tube; maximal expansion of pharyngeal tube
U	*Rump*: low spectral peak (convergence of F1 and F2)	Trade-off between expansion of oral and pharyngeal tubes
ʔ	*Edge*: abrupt and sustained drop in overall amplitude	Occlusion in oral cavity
h	*Noise*: aperiodic energy	Narrowed stricture producing turbulent airflow
N	*Nasal*: low frequency of first resonance	Lowered velum; air flow through the nasal passage
H	*High tone*: raised pitch on vowels; VOT lag (aspiration) in obstruents	Stiff vocal cords
L	*Low tone*: lowered pitch on vowels; VOT lead (full voicing) in obstruents	Slack vocal cords

[3] The modal voicing of sonorants in the Element Theory may be said to follow from the fact that they are typically represented by the same primes as vowels, that is, resonance elements, to be introduced below. Most sonorants exhibit spectral patterns similar to vowels.

Before we continue the discussion, it must be emphasized that the rough universal cues inherent in the elements listed above become fully meaningful only when they are viewed as part of a particular sound system. As we will see presently, it may be the case that a given phonological representation will not correspond to identical phonetic interpretations across languages. Here we differ markedly from Kaye, Lowenstamm and Vergnaud (1990: 194) who assume that "the same physical object will receive uniform interpretation across phonological systems". Since they made their proposal it has been found that the same representation will not always yield identical phonetic effects or vice versa. That is, identical phonetic objects may have disparate phonological representations across systems.

2.1. Representing vowels

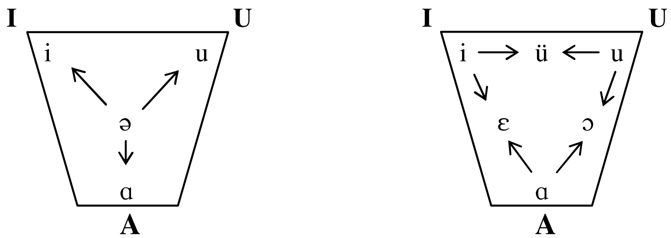
The first three elements (A), (I), and (U) in (1) define vocalic expressions and place of articulation in consonants. The discussion of vowel systems within the Element Theory will serve the purpose of a rather sketchy illustration of some of the points made above. However, in general, more emphasis will be placed on consonantal systems in this work.[4]

A basic three-vowel system, for example [a,i,u], reflects simplex representations involving only one element in each case (2a). These are the least marked vowels which utilize the phonetic vowel space most efficiently. We may define this space either in terms of articulation, using familiar properties like HIGH, LOW, BACK, FRONT, or in terms of acoustic dimensions.[5] At any rate, the simplex character of the three corner vowels reflects their universally unmarked status (Crothers 1978, Maddieson 1984). The schwa vowel represents the neutral state of articulators and, typically, evenly spaced-out formants. In Government Phonology this vowel may be viewed as a realization of a neutral element or nothing, a point which will be returned to when we discuss headedness.

[4] For more extensive studies of how resonance elements function in phonological systems the reader is referred to Backley and Takahashi (1998), Bloch-Rozmej (1998), Charette and Göksel (1998), Cobb (1997), Cyran (1997), Polgárdi (1998), Rennison (1998), Scheer (1996).

[5] See, for example, Ladefoged (2001: 39ff) for a discussion of how, with a certain amount of theoretical gymnastics, the same phonetic space can be defined in terms of F1 and F2 values.

(2) a. b.



Other vowels are combinations of the elements (I), (A), (U), for example, (A-I) = [ɛ], (A-U) = [ɔ], (I-U) = [ü] (2b). It follows from the illustrations in (2) that the more complex and marked vowel systems have more complex representations in terms of combinations of elements. Thus, the relation between markedness and representational complexity is inherent to the model.

The relative markedness of mid vowels is reflected in the fact that they are the first vowels to be eliminated in prosodically weak positions. Let us look at some typically quoted instances of vowel reduction in unstressed positions (Harris and Lindsey 1995).

(3)

	Bulgarian vowels			***Catalan vowels***		
under stress	i e	a	o u	i e ɛ	a	ɔ o u
	↓	↓	↓	↓	↓	↓
unstressed	i	ə	u	i	ə	u

Note that in both languages the surviving melodies in unstressed positions are simplex. We do not wish to make any particular claims concerning the representation of schwa vowels in the two systems, that is, whether they still contain the element (A). However, one thing is clear, compound structures cannot be maintained in prosodically weak positions in some languages.

We must note two immediate advantages of the Element Theory in the description of vowel reduction. Firstly, the relative markedness is directly read-off from the representations rather than extrinsically encoded on the basis of observation. Here, mid vowels are marked because they are complex objects. Secondly, there is a direct and logical connection between vowel reduction and the context where it occurs. Prosodically weak positions simply eschew complex vocalic structures, therefore, the latter must be reduced in complexity.

So far, we have seen how to represent vowel systems possessing between three and six objects, and the obvious question is what happens in systems with more than six vowels, or in those in which there are two types of mid front and mid back vowels as shown in Catalan in (3). At this point, one more aspect of representations in the Element Theory must be introduced. This additional mechanism is called *headedness*.

When two elements combine to form a compound, for example, (A-I), it is assumed that the elements may enter into an asymmetrical relation in which one of the elements may dominate the other, thus yielding a different object than if the situation was reversed.[6] Roughly speaking, a compound structure (A-I) which is I-headed, that is (A.<u>I</u>), may correspond to phonetic [e], while (<u>A</u>.I) should give [æ]. In other words, due to the reversed head-operator relations, we are dealing with an essentially high front vowel which is lowered, and an essentially low vowel which is fronted and raised, respectively.[7]

The use of headedness has been extended to two other situations. One of them concerns simplex structures. Here we find two different representations, that is, a simplex structure which is headed, and a headless one. Thus, the contrast between a lax [ɪ] and a tense [i] may be expressed by referring to a headless (I._) vs. headed (<u>I</u>), respectively. Similarly, a compound as a whole may also be headless, for example, (A.I._). This structure may correspond to the open front mid vowel [ɛ].

Thus, the introduction of headedness is meant to account, among other things, for tense/lax contrasts, introducing greater generative potential into the simple theoretical system which uses only three basic categories. Note that now we are able to define much richer systems, including such contrasts as the one between [e] and [ɛ], which we saw earlier in the system of Catalan. In fact, the introduction of headedness allows the model to define at most twenty independent vocalic objects, and attempts have been made to propose mechanisms or parameters which would restrict the generative power of the Element Theory with respect to individual systems (e.g. Charette and Göksel 1998, Backley 1995, 1998, Cobb 1993, 1997, Kaye 2001).[8]

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[6] This idea is familiar from such models as Dependency Phonology (e.g. Anderson and Ewen 1987). Headedness will be represented by underlining the relevant element.
[7] Throughout this work the elements will be used in parentheses and underlined when headed, unless headedness is irrelevant for the discussion. Compounds in which head specifications are deliberately omitted will be represented as e.g. (A-I).
[8] One must add that apart from the three resonance elements, (L), (H), and (N) may also be used in vowels. They represent tonal patterns – low and high pitch – and nasalization respectively.

As for schwa vowels, there are various options to consider. It is not impossible that some schwas do have an active resonance element in operator position, for example, (A._), (U._), (I._). In other words, the nuclei still contain elements, though they are headless. This would account for the various qualities of schwa vowels, not only across languages but also within one system, for example, English. Within the Element Theory, it has also been proposed that there is an additional, neutral element (@) which is present in all representations but only shows up, as it were, if the full-blooded elements are absent (Harris and Lindsey 1995). Other proposals boil down to the assumption that schwa may have no representation in terms of elements, that is, phonologically speaking it is a phonetically interpreted nuclear position which has no melodic content. Under this proposal, the difference between schwa and an empty nucleus proper lies only in the fact that the former is interpreted phonetically and the latter remains silent.[9] Let us see how these options may be applied to the well-known phenomenon of the rise and fall of jers in Slavic.

(4)

[u] > [ъ] → [ø]

[i] > [ь] → [ø]

Generally speaking the short high back and front vowels [u] and [i] were weakened to the so called jers [ъ] and [ь], which were later lost in particular positions.[10] Given the current assumptions of Element Theory, we may provide three descriptions of the events depending on our view on the structure of schwa and the status of the neutral element.

(5)

	[u/i]		**[ъ/ь]**		**[ø]**
a.	(U/I)	>	(@)	>	(_)
b.	($\underline{\text{U}}$/$\underline{\text{I}}$)	>	(U/I._)	>	(_)
c.	(U/I)	>	(_)	>	(_)

[9] More on empty nuclei can be found in the following chapters.
[10] The development of jers will be discussed at length in chapter 3.

All three options agree in their interpretation of the last stage in which there is no melody left in the nucleus. In (5a), the rise of jers is accompanied by the complete loss of the melodies (U) and (I). What remains in the representation is the neutral element. This analysis assumes that the opposition between back and front jers has been shifted onto the preceding consonant, in that now front jers occur after palatalized consonants, while back jers follow non-palatalized consonants. The interpretation in (5b) assumes that the jers are schwa-like but they still contain the resonance elements as operators, and only when these elements are lost is a phonetic zero possible. Under this view, only after the loss of jers should palatalization be represented on consonants. The last view, represented in (5c), is similar to (5a) in assuming that jers have no active resonance elements and that the opposition between palatalized and velarized or neutral should be represented on consonants. However, it assumes that schwas and schwa-like vowels may be representationally identical to empty nuclei. The difference lies in the context-based interpretation of such constructs.

In this work, we will follow the assumption that there is no such thing as a neutral element, which narrows down the options in (5) to two. However, the problem of the phonological structure of schwa, or of the jers, cannot be dismissed with one sweeping statement. More detailed discussion of these objects will be provided in the relevant contexts in the following chapters. An example of an element-based analysis of a vocalic system will be provided in section 3.1. Let us now turn to the representation of consonants in the Element Theory.

2.2. Representing consonants

In the previous section we saw how vowels are represented in the Element Theory and how a phonological representation may be affected in phonological processing. Vowel reduction, for example, is a phenomenon in which the internal structure of a vowel is decomplexified by means of deducing primes, e.g. (A-I) > (I), or reducing their status from head to operator, e.g. ($\underline{\text{A}}$) > (A._). Both cases are instances of weakening and their direct contextual connection with weak prosodic positions is a welcome effect. Besides *decomposition*, the Element Theory also predicts *composition* as another possible type of phonological event. This process involves element addition, as in vowel harmony or the strengthening of consonants. In both instances a condition must be satisfied whereby the added element is locally present.[11] Let us now look in more detail at the representation of consonants in the Element Theory.

2.2.1. Place

The resonance elements discussed above define primary and secondary places of articulation in consonants.[12]

(6)	(I)	=	*palatal*, e.g. [j, ç, c]
			palatalized, e.g. [p^j, k^j]
	(U)	=	*labial*, e.g. [p, b, v, f, w]
			labialized, e.g. [k^w, g^w]
	(A)	=	*coronal*, e.g. [r, t, s]
			retracted (uvular, pharyngeal), e.g. [ʀ, q, ɢ, ʕ]
	(_)	=	*velar*, e.g. [k, g, x]
			velarized, e.g. dark [ɫ] in English

The categories given in (6) must be taken as rough indications rather than exact representations. It will transpire presently that the best way to talk about the Element Theory is within the context of a particular system. The parsimony of the model must be striking for anyone familiar with the IPA chart. However, it is also true that no language uses all the place, or indeed manner distinctions found in the world's languages. Thus, it must be borne

[11] This is probably too general a statement. Some historical processes of consonant strengthening, for example, [w] > [v] in the history of Slavic languages, require a more complicated, and less idealized analysis (Cyran and Nilsson 1998). In a nutshell, since the weakening processes involve either element deduction or demotion, it is logical that strengthening may involve element addition or promotion to headed status. Cyran and Nilsson claim that in Slavic strengthening in which there is no source for the added elements, two stages are necessary: first element promotion, e.g. (U)>($\underline{\text{U}}$), yielding [w~v] alternations, and then phonological reanalysis of ($\underline{\text{U}}$) as (U,h,L), yielding systems with [v~f] alternations. Mixtures of the two systems are also possible, e.g. in Slovak (Rubach 1993: 244).

[12] There is no agreement as to the use of resonance elements in defining place of articulation. For example, the old dilemma whether coronal or velar consonants should be unmarked for place remains unsolved. See e.g. Backley (1993) and Scheer (1996, 2004). In this work, we assume that velarity has no place element, while coronality is represented by the element (A), or its combination with (I), that is (A-I), as will soon become apparent.

in mind that the actual representations of consonants in a given system must follow an in-depth analysis and should not be assumed a priori.

Before we consider the manner and source elements, let us briefly look at an illustration of how primary and secondary articulations as defined by resonance elements may interact in the description of certain historical shifts in consonantal place of articulation.

In Celtic languages there was regular labialization of Indo-European $*g^w$ to [b] as in, for example, IE $*g^w$*ou-*, ‘cow, ox’ > Old Irish *bó*, Welsh *bu*, or IE $*g^w$*enā*, ‘woman’ > Old Irish *ben*, Welsh *benyw*. A similar phenomenon affected the proto-Celtic voiceless labialized velar $*k^w$, but only in the Brittonic subgroup, thus leading to the linguistic division into the so called P– and Q–Celtic groups.[13]

(7)

			k^wetu̯ores	***k^weis***	***mak^{w}k^{w}o-***
$*k^w$ →	*p*	(Brittonic)	***p**edwar*	***p**wy*	*ma**b***
$*k^w$ →	*k*	(Goidelic)	***c**ethar*	***c**ía*	*ma**cc***
			‘four’	‘who’	‘son’

Given that the representation of velars has no active element, the secondary labialization is best represented as the presence of the (U) element in operator position. The shift from [g^w] to [b] in Celtic in general, or [k^w] to [p/b] in Brittonic, is thus directly captured as a switch in the status of the resonance element from operator to head.[14] For the moment we ignore the other elements making up the velar plosive and concentrate on place only.

(8)

velar		***labialized velar***		***labial***
[g]	vs.	[g^w]	vs.	[b]
(_)		(U._)		(<u>U</u>)

The distinction between the three types of segments can be described as a scale of (U) presence. While it is completely absent in plain velars, it affects the labialized consonants as an operator – adds the labial colouring as it were, or, in the case of the labial, it assumes the head position. Thus, one

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[13] This shift also occurred in other IE languages, e.g. Italic (Oscan and Umbrian $*k^w$ > *p*), and to some extent in Greek.

[14] The [p/b] variation in Welsh is due to lenition which is discussed in some detail in section 4 below.

way to distinguish between primary and secondary articulation of consonants is by referring to the status of the resonance element.[15]

A similar description can be offered for parallel shifts in Slavic. This time the property that affects a velar consonant is the element (I), responsible for palatalization. Typically, three different types of velar palatalization are mentioned in the literature on Polish. These are: *surface velar* palatalization in which, the velar plosives [k, g] and the fricative [x] are palatalized to [kʲ, gʲ, xʲ] before front vowels, as in *bok – boki* 'side, nom.sg. /nom.pl.', *noga – nogi* 'leg, nom.sg. /nom.pl.', *historia* 'history'; the so called *1st velar* palatalization (e.g. Gussmann 1978, 1980, Rubach 1981) in which [k, g, x] alternate with palatal [t͡ʃ, ʒ, ʃ], as in *bok – boczek* 'side nom.sg. /dim.', *noga – nóżka* 'leg, nom.sg. /dim.', *ucho – uszko* 'ear, nom.sg. /dim.'; and the *2nd velar* palatalization, occurring in the dative and locative singular and producing alternations between [k, g, x] and [t͡s, d͡z, ʃ] respectively, as in *rzeka – rzece* 'river, nom.sg. /loc.sg.', *noga – nodze* 'leg, nom.sg. /loc.sg.', *mucha – musze* 'fly, nom.sg. /loc.sg.'.[16] Ignoring the 2nd velar palatalization in which the corresponding sounds have very little in common, let us look closer at a possible representational contrasts between ordinary velars, and those affected by surface and 1st velar palatalization respectively. These contrasts may be given a similar interpretation to the one involving the different degrees of labialization of velars in Celtic.

(9)	***velar***	vs.	***palatalized velar***	vs.	***palato-alveolar***
	[k]		[kʲ]		[tʃ]
	(_)		(I._)		(<u>I</u>)
	lok 'hair lock'		*loki* 'pl.'		*loczek* 'dim.'
	[lok]		[lokʲi]		[lot͡ʃek]

The plain velar is devoid of any secondary articulation. The palatalized velar – through surface palatalization – contains the element (I) in operator

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[15] Another possibility that may be considered for the purpose of capturing secondary articulation is connected with structural distinctions, for example, the use of contour structures.

[16] See Gussmann (1978) for arguments that the so called 2nd velar palatalization has no synchronic reality as a phonological regularity, and Gussmann (1997b) for saying the same about the 1st velar palatalization.

position. On the other hand the element (I) as the head produces a palato-alveolar consonant which concomitantly undergoes affrication.[17]

Let us now turn to the remaining elements defining other dimensions in the representations of consonants.

2.2.2. Manner

The manner dimension in consonants is defined by five elements of which only two (ʔ, h) can be called truly consonantal, in that they are not used in vowels. This has been one of the reasons why the status of these elements is shaky.[18] As mentioned above, nasality, as well as high and low tones are also used in vowel systems. The latter two will be discussed in more detail in the following sub-section.

(10)

(ʔ)	=	*occluded*, e.g. [p, t, k]
(h)	=	*'noisy'*, e.g. [s, ʃ, x]
(N)	=	*nasal*, e.g. [n, m, ŋ]
(H)	=	*voiceless aspirated* [p^h, t^h]
(L)	=	*fully voiced* [b, d, g]

Each of the elements above deserves comment. The occlusion element is assumed to be present in plosives but some researchers also place it in nasal consonants and laterals (Kaye, Lowenstamm and Vergnaud 1985, Harris 1990). The noise element is assumed to be present in all released stops.[19] The status of nasality as an independent prime has been challenged in the work of Nasukawa (1998, 2005) and Ploch (1999). Both researchers attempt to merge nasality with low tone (L) in some way.

Leaving aside the laryngeal elements for the moment, let us observe how some basic consonants may be represented by means of the manner elements

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[17] Some phonological reasons for this affrication, couched in terms of the Element Theory, are provided in Cyran (1997: 214), Harris (1990: 270), Rennison (1998).

[18] For discussion related to 'stopness' and 'noise' see e.g. Cyran (1996b), Golston and van der Hulst (2000), Jensen (1994), Pöchtrager (2006), Ritter (1997).

[19] This view is challenged in Cyran (1996b) who proposes that the noise element may in some systems be completely missing even in released stops. We will return to this idea shortly in the discussion of Irish clustering and Welsh consonant mutations.

just mentioned. The representations below only serve the purpose of illustrating how the Element Theory captures such phenomena as lenition.[20]

(11) ***lenition trajectory of the opening type***

[p] > [f] > [w] > [ø]
U U U
h h
ʔ

Since each element on its own and each possible combination of elements can be independently interpreted in production and perception, each of the stages along the trajectory can be described as the effect of losing one phonological prime, that is, decomposition. Thus there is a logical connection between the fact that lenition is a weakening process and the idea that decomposition leads to progressively less complex structures. Recall that vowel reduction in unstressed position consists in precisely the same procedures though, admittedly, the contexts for consonantal lenition are different from those for vowel reduction. Nevertheless, we can describe both contexts uniformly as prosodically weak (Harris 1997).

It is obvious now that sonority in Element Theory is the inverse of subsegmental complexity.[21] The question is if complexity can successfully replace sonority in all those aspects of phonology where the latter played a central role. For one thing, it seems that the complexity scale captures the lenition trajectory better than sonority. As noted by Harris (1996), if the sonority hierarchy is anything to go by then we should expect nasals to appear along the lenition trajectories of obstruents as they are more sonorous than, say, [p] or [f]. Secondly, it seems that complexity is able to solve two apparent paradoxes connected with the weakening of consonants and vowels. The first one concerns the fact that in terms of sonority the weak-

[20] This discussion of lenition draws heavily on the work of Harris (1990, 1996, 1997) and Harris and Lindsey (1993, 1995). Note that so far we limit ourselves to a discussion of the effects produced on a given segment, and little reference is made to the link between lenition phenomena and the contexts in which they occur. The typical sites for lenition or neutralization can be roughly defined as the intervocalic and coda positions. The latter context is understood in a dramatically different way in Government Phonology than in other current frameworks (see e.g. Kaye 1990, Harris and Gussmann 1998).
[21] See e.g. Rice (1992) for the reversed relationship between sonority and complexity of structure.

ening of vowels, such as the rise and fall of jers in Slavic discussed above ([u/i] > [ъ/ь] > [ø]), results in less and less sonorous objects, in contradistinction to the weakening of consonants which results in more and more sonorous ones. It is interesting that the sonorization of consonants ends with a stage where the object is the least sonorous one, that is silence ([p] > [f] > [w] > [ø]).[22] In terms of complexity, both phenomena receive a uniform interpretation. Simply, all stages of vowel weakening and consonant lenition are of the same nature: depletion of melodic complexity.

The element-based analysis of lenition also bypasses the pertinent problem of major class feature changes.[23] In this model, what remains as the outcome of any decomposition process is as interpretable as the previous stage, as shown in (11) above.

There are two more points to be made here. Firstly, in the model of representations introduced in this section the range of possible processes that a given segment may undergo is logically limited by its phonological structure. For example, a stop may either lose its release (h), be spirantized by losing (ʔ), debuccalized by losing the resonance element defining place, voiced or devoiced. All these will be exemplified in section 5, when we discuss consonant mutations in Welsh. Secondly, the pre-deletion stages typically involve a simplex segment, for example, [h]=(h), [ʔ]=(ʔ), as well as [w]=[U], [j]=(I), and [ɾ]=(A), while their sonority values differ markedly (Harris 1994: 122). Thus, elemental complexity offers a uniform account of such phenomena in contradistinction to sonority scales.

In general, it appears that complexity can quite successfully replace sonority in lenition. On the other hand, complexity may replace another term used with relation to lenition, and indeed syllabification, namely, *strength*.[24] In Element Theory, the plosive seems to be the most complex and at the same time the strongest consonant. This direct relation between complexity

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[22] I was made aware by Péter Szigetvári (p.c.) that the last point may be erroneous, in that that net result of the last stage in the lenition trajectory is the most sonorous stage, because what is left is the vocalic context flanking the consonantal position. Though essentially true, this point does not diminish the merits of the complexity-based treatment of lenition in any way.

[23] For a critical evaluation of various proposals to deal with this issue see Harris (1990, 1996).

[24] The concept of strength has a long history in phonological theory. It typically refers to inherent properties of segments which determine their behaviour in lenition processes as well as phonotactics (e.g. Sievers 1901, Vennemann 1972, Hooper 1976, Foley 1977, Murray 1988).

and strength follows from the internal representation rather than being assumed in an arbitrary fashion on the basis of observation. In the following sections and chapters it will be shown how strength defined as complexity is exploited in syllabification. In the meantime, let us deal with the last two elements, which define the laryngeal distinctions.

2.2.3. Source

The Element Theory uses only two elements to express all the possible phonation types: (L) which is found in fully voiced obstruents, and (H) which is found in voiceless fortis obstruents.[25] It is assumed that laryngeal specification is typically asymmetrical. For example, in a system like English, which exhibits voiceless aspirated stops as opposed to weakly voiced ones, the opposition is expressed by marking the fortis series with the high tone element (H), while the so called lenis series bears no laryngeal element. In other words, the lenis obstruents are neutral. On the other hand, languages like Polish in which the opposition among the obstruents is that of fully voiced as opposed to voiceless, it is assumed that the voiced series is the marked one and contains the low tone element (L), while the voiceless series is unspecified.[26] It follows then that from the phonological point of view, the same phonological representation of, for example, neutral stops, yields quite different phonetic results in Polish and in English. However, we must remember that the respective interpretations belong to two distinct systems in which the neutral stop is perceived and produced with sufficient phonetic difference from the series to which it is opposed in the system. If the marked series is fully voiced, as in Polish, then the neutral series tends towards the voiceless reflex, and conversely, if the opposite series is voiceless then the neutral series tilts towards the voiced one.[27] A simple acoustic analysis of English and Polish plosives reveals that the

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[25] This description is deliberately simplified. The system of H/L tone elements is also able to express more rare laryngeal articulations, e.g. Sahakyan (2006) demonstrates that it is the ejectives in South-East Armenian and not the aspirated voiceless stops that contain the high tone element.
[26] For a discussion of the relationship between tone and voice see Matisoff (1973).
[27] The term *phonetic polarization* may be used to describe this effect. This is reminiscent of the Dispersion Theory (Liljencrants and Lindblom 1972), which has recently been harnessed into Optimality Theory in the form of SPACE constraints (e.g. Flemming 1995, Ní Chiosáin and Padgett 2001).

supposedly distinct neutral series are very similar, thus supporting our views on how the opposition should be represented.

One of the ways to define laryngeal distinctions in phonetics is by means of Voice Onset Time, that is, VOT (Lisker and Abramson 1964). This is the interval between the release of a stop and the start of a following vowel. In general, the neutral obstruents in English have a short VOT and a little voicing occurring before the release, to which we may refer as VOT *lead*. The fortis series has a long VOT, also called VOT *lag* (e.g. Harris 1994, Ladefoged 2001). On the other hand, the neutral series in Polish and Spanish have a short VOT in the voiceless series, as opposed to distinct voicing during closure, that is, a long VOT lead in the voiced series. Generally, the Element Theory assigns elemental representations to the long VOT lead (L), and the long VOT lag (H), but no element defines the short VOT type. The typology of phonation types in obstruents supports the view that the short VOT class is the unmarked one. For example, if a system has only one series of stops it is typically voiceless unaspirated, that is, having short VOT, or, in terms of elements, no laryngeal specification.[28] The majority of languages exhibit the two-way distinction of the two main types: fully voiced vs. plain voiceless, and voiceless aspirated vs. voiced. Let us look at a simple typology of laryngeal distinctions and see how the Element Theory can capture the VOT distinctions. The typology is based on Harris (1994), Ladefoged (2001) and Maddieson (1984). The unmarked series of stops, with short VOT, and their elemental representation is represented as '_', that is nothing.

(12)	***VOT opposition***			***representation***	***examples***
Malakmalak		_		(_)	p
Spanish, Polish	lead	_		(L) , (_)	b, p
English, Irish		_	lag	(_) , (H)	b, p^h
Thai	lead	_	lag	(L), (_), (H)	b, p, p^h
Hindi	lead	_	lag, lead/lag	(L), (_), (H), (LH)	b, p, p^h, $b^ɦ$

It seems that both the VOT and the element system share the ability to capture one important aspect of the above typology, namely, that with the increase of the number of contrasts, the number of VOT combinations and

[28] In fact 98% of such systems in the UPSID data base show this tendency (Maddieson 1984: 28).

the complexity of representations in terms of elements also increase.[29] Thus, once again the relative markedness of particular systems goes hand in hand with the relative complexity of representations. Both the acoustic and elemental models of description have a neutral series in each system of oppositions, and they seem to be able to directly express laryngeal neutralizations in a straightforward fashion: as the simplification of laryngeal activity, giving rise to the unmarked variant. This advantage of privative models over equipollent ones is well-established in phonological theory (e.g. Lombardi 1995, Brockhaus 1995).

Let us look at how the phenomenon of obstruent devoicing is captured in this model. As mentioned above, in Polish the voiced series of obstruents is marked and bears the element (L), while the voiceless obstruents have no specification.

(13) ***voice contrasts in Polish stops*** ***devoicing***

[b]	**[p]**	**[d]**	**[t]**	**[g]**	**[k]**	**[b]**	**>**	**[p]**
U	U	A	A	_	_	U		U
h	h	h	h	h	h	h		h
ʔ	ʔ	ʔ	ʔ	ʔ	ʔ	ʔ		ʔ
L		L		L		L		

In an asymmetrical system of privative specification of voice, devoicing is understood as delinking of the property responsible for voice due to licensing failure in prosodically weak positions. Again, there is a direct relation between the structural description of the phenomenon and the fact that we are dealing with neutralization, or weakening. We do not attempt a full analysis of devoicing in Polish here, suffice it to say that predominantly it is due to the weak licensing that the obstruent receives in a particular context, for example, word-finally.[30]

It appears then that Polish and English have quite different complexity asymmetries in the representation of their obstruents. In the following section we will look at one possible indication in the phonotactics of the two languages which might directly fall out from the different laryngeal speci-

[29] For a more advanced discussion of the relation between the Element Theory and VOT types see Harris (1994: 133).

[30] An exhaustive and satisfactory analysis of all the voice phenomena in Polish within the Element Theory has not been proposed yet. For surveys of all the relevant issues and recent feature-based analyses see Bethin (1992), Gussmann (1992) and Rubach (1996).

fications employed in the two systems. More intricate complexity effects will be described in the ensuing sections.

2.3. Complexity and syllabification

In the above discussion we saw how the concept of complexity is able to capture a number of segmental phenomena, successfully replacing such notions as sonority or strength. The advantage of complexity over the other two concepts is that the scales of relative complexity fall out from the internal composition of segments and, therefore, are directly incorporated into phonological processing, rather than being arbitrarily postulated as look-up scales. Syllabification and phonotactic restrictions is another area of phonology in which sonority and strength play an important role. The aim of this and the following section is to demonstrate that complexity may replace these constructs also here, and also provide some new insights into the nature of syllabification.

In definitions of well-formed branching onsets or good syllable contacts, that is, coda-onset clusters, the sonority profile plays an important role (e.g. Selkirk 1982, 1984, Yip 1991, Itô 1986). A good coda-onset contact is one in which the coda is more, or at least no less sonorous than the following onset (e.g. Harris 1994). In models operating with strength of segments (e.g. Vennemann 1972, 1988, Murray 1988), the preferred contacts are similarly defined as those in which the strength differential between the coda and the following onset is greater, in favour of the latter. The strength scale, however, is the inverse of sonority, therefore, the onset will be stronger, or higher on the scale of strength, and the preceding coda will be weaker.[31] This is no place to introduce the syllabification principles of Government Phonology. Suffice it to say that in terms of phonotactics it is no different from sonority- or strength-based models, in that the best contacts are those with the greatest complexity differential. For ease of comparison with the other models, the most complex segments in the Element Theory are obstruents, that is, they are the least sonorous in the former theory and the strongest in the latter.

Much stricter conditions constrain well-formed branching onsets. Here, the condition of sufficient sonority distance is usually referred to in order to account for the fact that onsets of the type [pl, kl], [pj, kj], or [tr, kr] are better than [ks, pf, kn]. In fact, most of the latter group are normally viewed

[31] This understanding of strength will be returned to in more detail in the following chapter where we take up the problem of syllabification in Government Phonology.

as impossible onsets, at least in English. Thus, the best branching onsets are those which involve an obstruent as the first element and a glide or liquid as the second. What is required then is sufficient distance in terms of sonority, strength, or complexity between the two consonants.

Below, we compare a fragment of the phonotactics in English and Polish, in which the preferences seem to be contradictory. While in the sonority and strength systems this problem cannot be solved without arbitrary reshuffling of the scales, in the complexity-based model the facts fall out directly from what we know about the representation of obstruents in the two languages. Specifically, the differences will depend on the way the laryngeal contrasts are specified.

Both English and Polish have branching onsets of the type [pr, br]. However, once we move down the scale of complexity of the other labial obstruents in the two languages, we encounter restrictions to the effect that while [vr] is a well-formed onset in Polish, for example, *wrota* 'gate', *wróg* 'enemy', *wrona* 'crow', in English this option is not utilized in native vocabulary, except for the onomatopoeic *vroom*, or some obsolete forms and French borrowings. On the other hand, while [fr] is a perfect branching onset in English, for example, *free, front, freak*, etc., in Polish, words beginning with this cluster are mostly borrowings, for example, *fryzura* 'hair-style, *frytki* 'fries', *frykatywa* 'fricative', *frustracja* 'frustration'. Admittedly, [fr] in Polish fares much better than [vr] in English, as most of the borrowings are fully integrated into the language and one might even find some forms which sound native, for example, *fruwać* 'to fly', which appears to be of onomatopoeic origin, like the English *vroom*.[32]

It seems that complexity as understood in the Element Theory may provide some rationale for these asymmetries between English and Polish. The representations below are limited to the relevant labial obstruents and [r], which is the second element of the branching onset.

(14) ***some English consonants*** ***some Polish consonants***

[p]	[b]	[f]	[v]	[r]		[b]	[p]	[v]	[f]	[r]
U	U	U	U	A		U	U	U	U	A
h	h	h	h			h	h	h	h	
H		H				L		L		

[32] The gap in native Polish vocabulary may be due to the fact that most of the modern instances of [f] are either borrowings or due to the devoicing of [v].

Recall, that the specification of the laryngeal contrasts in English involves the presence of high tone in the voiceless obstruents, while in Polish the voiceless series is unmarked. It transpires from the representations above that [fr] in English is parallel to [vr] in Polish in terms of complexity differential, an effect which in sonority-based accounts must result from arbitrary manipulation of the scale. In both languages preference is given to the clusters with the greater complexity differential. Theoretically, neither English [vr], nor Polish [fr] are completely illegal because there is some complexity slope, but their 'toned' counterparts are understandably preferred.[33] In the following chapter the role of complexity in syllabification will be defined in more detail. It is hoped that we will be able to provide an answer to the question why clusters with identical complexity slopes (English [vr] and Polish [fr]) still show a different degree of acceptability. This will be connected with conditions on syllable structure which are of more importance than substantive constraints on well-formed onsets.

The following section discusses some complexity effects in modern Irish in which we try to demonstrate the connection between phonotactics, syllable structure, and phonological processes on the one hand, and subsegmental representations on the other.

3. Substantive complexity effects in Irish

In this section, we bring together a few aspects of the phonological system of Irish in order to demonstrate how the element-based model is employed in concrete analyses of linguistic facts, and how various aspects of one phonological system converge on the internal representation of its consonants and vowels. Since the discussion is limited to substantive complexity effects, some aspects of the data reviewed in this section will receive a fuller interpretation once other principles of phonological organization are introduced in the following chapters.

3.1. Features vs. elements in vocalic alternations

From the presentation of the Element Theory it follows that an element may be equal to a segment, for example, (I) defines the vowel [i] on its own, while some segments contain combinations of elements. In this respect, elements

[33] One might wish to extend this analysis to another asymmetry in English, namely, [θr] vs. *[ðr], or [ʃr] vs. *[ʒr].

are bigger units than features of the SPE type (Chomsky and Halle 1968). Note that in order to get the same vowel in any feature-based model, we need at least two features, for example [+HIGH] and [–BACK], neither of which means anything in isolation, because the former defines all high, while the latter refers to all non-back vowels. On the face of it, it seems that feature systems are able to provide more precise and subtle descriptions of phonological objects. The question however is if analyses in terms of elements fail to cover the empirical facts, and, more importantly, if they can account for the same phenomena better or worse than feature-based systems. Let us briefly look at a comparison of two analyses of vowel quality alternations in Irish, one couched in the equipollent version of feature specification (Ní Chiosáin 1994), and the other within the Element Theory.

In all dialects of Modern Irish consonants are grouped into two quality series: palatalized and velarized.[34] These consonants affect the preceding phonologically short vowels by spreading their secondary articulation property.[35] In the data below (C) refers to Connemara and (M) to Munster Irish.

(15)

a.	(u ~ i)	[muk] ~ [mik´]	muc / muic ‘pig / dat.’	(C,M)
b.	(o ~ e)	[sop] ~ [sep´]	sop / soip ‘wisp / gen.sg.’	(C)
c.	(o ~ i)	[sop] ~ [sip´]	sop / soip ‘wisp / gen.sg.’	(M)
		[kodə] ~ [kid´]	coda / cuid ‘portion, gen.sg./nom.’	(C,M)
d.	(a ~ i)	[f´ar] ~ [f´ir´]	fear / fir ‘man / gen.sg.’	(M)
		[f´æ:r] ~ [f´ir´]	fear / fir ‘man / gen.sg.’	(C)
e.	(a ~ e)	[d´as] ~ [d´eʃə]	deas / deise ‘nice / gen.sg.’	(M)
		[d´æ:s] ~ [d´eʃə]	deas / deise ‘nice / gen.sg.’	(C)

Although the preceding onset is not unimportant, for the sake of simplicity we will limit the discussion to the context VC, in which the quality of the consonant affects the nucleus to its left.

[34] The distinction palatalized vs. velarized is typically represented as C´ vs. C. The consonant inventory of Irish, with a degree of simplification, is as follows: *Labial* (p, p´, b, b´, f, f´, v, v´, m, m´), *Coronal* (t, t´, d, d´, s, ʃ, n, n´, l, l´, r, r´), *Velar* (k, k´, g, g´, x, x´, ɣ, ɣ´, ŋ, ŋ´), *Glottal* (h, h´).

[35] Consonants also affect the following vowels although on a smaller scale. This effect may to some extent be called phonetic. See Ní Chiosáin (1991) and Bloch-Rozmej (1998) for thorough analyses of these effects in Connemara Irish, and Cyran (1995, 1997) for the Munster dialect.