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Suprasegmental Aspects of Icelandic Vowel Quality*

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1. Introduction

The sources for phonological analyses of languages are frequently provided by data found in grammar books, hand-books, or in articles written on particular languages. Data based on instrumental phonetic analyses may not be available. While this is inevitably the case in historical phonology, it is also often true of phonological analyses of contemporary languages.

In abstract phonology phonetic facts are frequently taken for granted, and verification of phonetic facts is largely ignored. This is due in part to the separation of the level of abstract phonological patterning from that of the actual physical menifestation of the pattern in sound. Because of this separation, however, I have often felt that even though a particular phonological solution may be very interesting, the reality of the final surface phonetic forms is questionable. If the resulting surface forms are not attested in the spoken language itself, the phonological analysis loses its credibility.

If a phonologist attempts to take phonetic evidence into consideration, that phonetic evidence is usually based on impressionistic observation. However, phonetic transcriptions of a given language by different researchers frequently conflict. The variations may be due to different backgrounds in phonetic training and degrees of experience, different linguistic backgrounds or differences in perception. In researching a language one often reads conflicting phonological analyses which are based on divergent impressionistic phonetic observations. The validity of these analyses is also questionable.

Because of these conflicts, whether attributed to the theoretical position held by the phonologist or to the kinds of data available, the results of phonology often become something more to be believed <u>in</u> than believed. One alternative which is available is to allow instrumental phonetic data as a source for phonological analyses. These data can be more objective than impressionistic phonetics allows, although they too are subject to interpretation. The optimal situation appears to me to be one in which the predicted phonetic outputs of an analysis are compared to data gained through instrumental phonetics. The resulting fit or lack thereof can be considered as proof or disproof of the phonological analysis.

2. Phonetic Evidence

2.1. Previous Work

The various phonological analyses of the Icelandic vowel system and parts thereof provide an excellent background for a phonetic investigation. The phonological theories attempt to account for the present Modern Icelandic vowel system. However, very little is known about the physiological or physical aspects of the vowels constituting that system. Einarsson (1927, 1931, 1949) based his instrumental phonetic investigations of vowel quality on tracings from palatograms and his studies of vowel quantity on duration measurements based on limited corpora. Garnes (1973) presents formant measurements of the monophthongs. No analysis of the diphthongs had been published until recently.

Pétursson (1969-70) presents radiocinematographic tracings of one token of each monophthong. Recently, Pétursson (1972) has expanded his studies to include spectrograms and measurements thereof for each of the tokens in his 1969-70 article. In addition, he includes one production of each diphthong by the speaker in the 1969-70 article. There is also a complete set of spectrograms and radiocinematographic tracings with measurements for one set of the monophthongs and diphthongs produced by a second speaker. Although the presence of the spectrograms and tracings are a welcome addition to the literature on Icelandic vowel systems, there are serious problems with his measurements.

2.2. Experimental Procedure

In this study I measured the formant structure of five tokens of each of the long and short allophones of the eight monophthongs and five diphthongs--a total of 130 vowel nuclei. All nuclei received primary stress and occurred either in monosyllabic words or in the first syllable of disyllabic words. The informant was Ólafur Ingólfsson, age 27, a native of Reykjavík, who has made only short and infrequent trips out of Iceland. Tape recordings were made in a recording studio at the State Radio Station in Reykjavík. Wide-band spectrograms were produced on a Voiceprint 700 spectrograph.

I based segmentation of plosive consonants, postaspiration, and releases on the criteria presented by Naeser (1970). Nasals were segmented at the onset and release of a low, broad, F_1 band. Nasal releases were often accompanied by a spike release. Liquids were segmented according to major changes in the formant structure. Fricatives were segmented by either the onset and offset of frication in the higher frequencies, major changes in the formant structure, and/or the lack of voicing in the case of voiceless fricatives. The frication in the high frequencies due to preaspiration frequently began before voicing ceased--in these instances the segmentation was made at the last vocal fold flap.

In measuring formant values it is important to distinguish between transitions and steady states. The transitions vary as a function of the place and manner of articulation of neighboring segments. The vocalic steady state is represented by bands which are horizontal to the base line. This state frequently occurs mid-way in the duration of monophthongs. For long allophones of three of the eight monophthongs, /e/, /ö/, and /o/, there was a second steady state of a minimum of three to four periods in duration before the final transition. For short allophones of diphthongs, the expected second steady state was not realized, rather, there was a constant movement throughout the latter portion of the vocalic nucleus. In these instances, measurement was made well before the onset of the final transition.

2.3. Vowel Quality

Table 1 lists the mean values, rounded off to the nearest five Hz, for the first three formants for the long and short allophones, which are indicated by an I.P.A. transcription, of the thirteen vocalic nuclei. The thirteen vowel phonemes are given in traditional Icelandic orthography. Nuclei which were diphthongized have two values for each formant. The durations, rounded off to the nearest five ms., appear in the column on the right.

TABLE 1
Durations (ms.) and Formants (hz.) of Short and Long Allophones

Phonemes	I.P.A.	F_1	F_2	F_3	ms.
Monophthongs					
/í/	[i:]	255	2200	3290	180
	[i]	265	2140	2885	80
/i/	[I:]	350	2055	2915	200
	[I]	345	1960	2835	105
/u/	[Y:]	380	1350	1995	195
	[Y]	385	1390	2185	110
/e/	[eɛ:]	505 > 610	1880 > 1735	2720 > 2685	195
	[ɛ]	640	1710	2590	100
/ö/	[øœ:]	500 > 590	1295 > 1220	2260 > 2015	250
	[œ]	600	1250	2290	105
/a/	[ɑ:]	815	1235	2380	225
	[ɑ]	760	1265	2370	100
/o/	[oɔ:]	545 > 640	805 > 875	1935 > 2020	200
	[ɔ]	660	980	2195	95
/ú/	[u:]	280	620	----	210
	[u]	320	735	----	100
Diphthongs					
/ei/	[ei:]	525 > 305	1915 > 2175	2780 > 2960	185
	[eI]	560 > 395	1880 > 1970	2475 > 2705	100
/au/	[øY:]	490 > 365	1485 > 1665	1980 > 2100	200
	[øY]	525 > 380	1450 > 1495	2250 > 2385	130
/æ/	[ɑI:]	800 > 340	1405 > 1995	2420 > 2850	220
	[ɑɛ]	775 > 685	1405 > 1670	2530 > 2570	105
/á/	[ɑʊ:]	720 > 400	1180 > 785	2580 ----	190
	[ɑɔ]	665 > 605	1070 > 985	2395 > 2250	110
/ó/	[oʊ:]	505 > 370	850 > 735	---- ----	215
	[oʊ]	515 > 385	830 > 805	2000 ----	110

Figure 1 represents an acoustic vowel diagram of the F_1 and F_2 values listed in Table 1. Triangles represent long allophones; circles represent short allophones. Phonemic monophthongs are indicated by filled figures, phonemic diphthongs by unfilled figures. The directionality of formant movement is indicated by lines which terminate in arrows at the point of the measured formant values. A dashed rising line indicates the directionality of formant movement for short allophones of diphthongs which in many cases did not achieve a true second steady state. A solid rising line indicates long allophones of diphthongs and a solid falling line represents three of the phonemic monophthongs which are diphthongs phonetically, having two steady states.

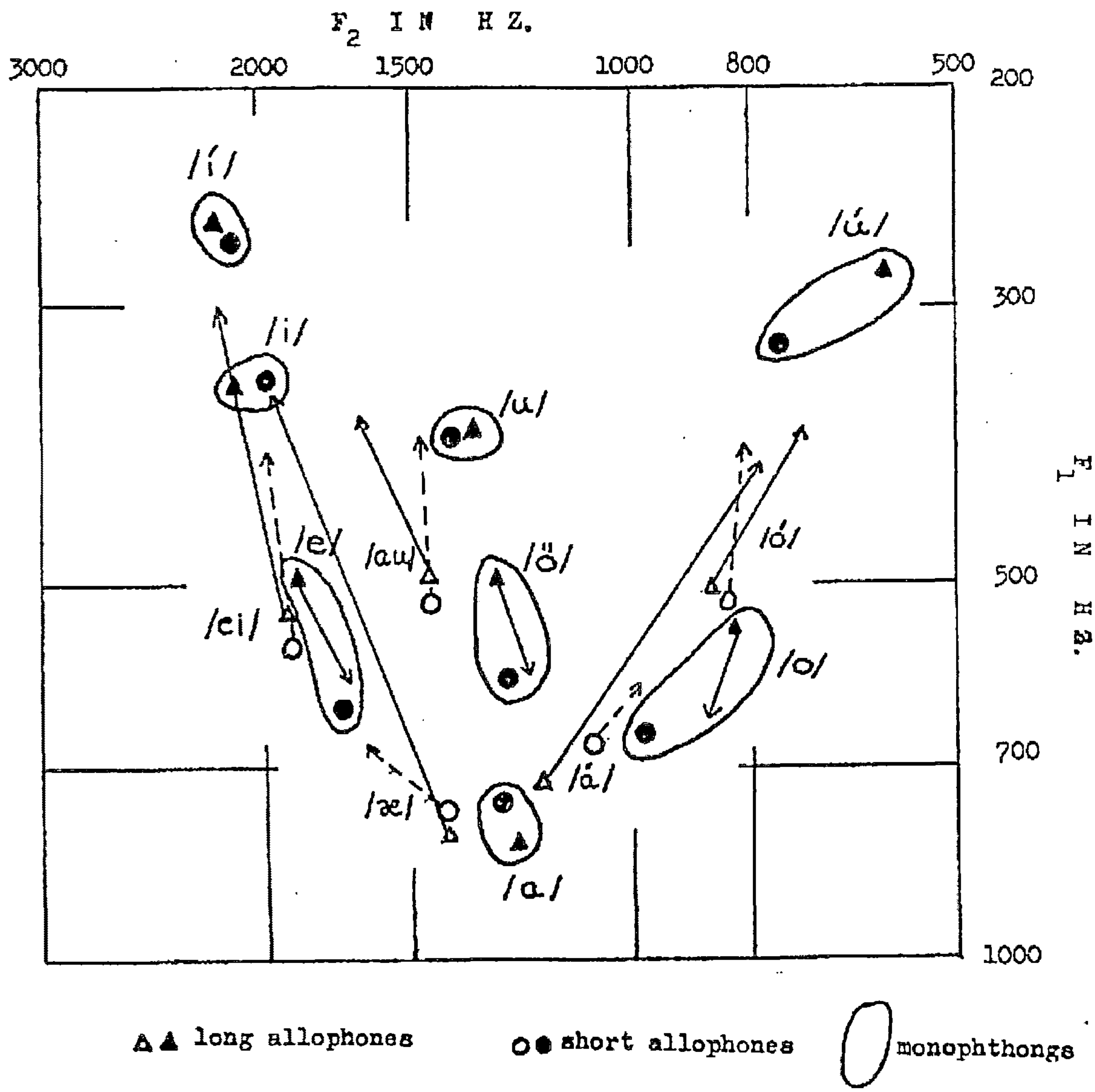


Fig. 1. Acoustic vowel diagram of short and long allophones.

The pattern formed by the phonemic monophthongs in this study is in general similar to that found in an acoustic analysis based on productions by a different informant who was also a native of Reykjavík (cf. Garnes 1973). The long allophones of all monophthongs are more peripheral in quality, e.g. the long allophones of the phonemes indicated by /í/ and /ú/ have lower F_1 values and higher and lower F_2 values, respectively, than do their short allophone counterparts. The long and short allophones of /ú/ vary a good deal in quality, but it is important to note that they represent an end point in the diagram and even the relative freedom of the short allophone does not bring it close to other phonemes. The long allophones of the phoneme /a/ have a higher F_1 value than the short allophones. Perhaps the most interesting phenomenon in the monophthongs occurs with the three mid-low vowel phonemes: /e/, /ö/, and /o/. The long allophones of these phonemes have considerably lower F_1 values than the short allophones. The directionality of the diphthongization is towards the quality of the short allophones in all three cases. It appears that the initial portions of the long allophones have risen in height and are diphthongized towards the quality of the short allophones. The short allophones are in turn closer to the phoneme /a/ than are their long counterparts.

Whereas the diphthongal movement found for the phonemic monophthongs is lower and towards /a/, the movement in the five phonemic diphthongs is rising and moves away from /a/. The initial portions of the long allophones of the diphthongs share a property similar to that found for the monophthongs--they are in general more peripheral than the short allophones which tend to be somewhat monophthongized. Thus the final portion of the long allophones is, not unexpectedly, more extreme than that of the short allophones.

Viewing the vowel system as an integrated whole, it is apparent that the initial portion of the long diphthongs is very similar in formant structure to the long allophones of the nearest monophthong. This relationship holds for all five diphthongs.

These observations regarding the quality of the vowels can be grouped into three classes based on one feature--that is a feature of movement. First, if there is no movement the long and short allophones will be very similar in quality--noting the exception of /ú/ above. Second, if the direction of movement is downward--as we see for the three mid-low phonemic monophthongs, the first steady state of the long allophones differs considerably in quality from their short counterparts. In other terminology--the high and mid-high vowels, /í/, /ú/; /i/, /u/; and the lower vowel /a/, are monophthongal and both allophones are similar in quality. The long allophones of the mid-low vowels, /e/, /ö/, and /o/, are diphthongized according to the feature of gravity, i.e. +low, while the phonemic diphthongs are diphthongized according to the feature of diffuseness, i.e. +high.

2.4. Suprasegmental Properties

As was noted above all vowels in this study receive primary stress. Since there is no evidence of a tonal contrast in Icelandic the remaining suprasegmental feature is quantity. The mean durations of all vowel nuclei listed in Table 1 are illustrated in Figure 2.

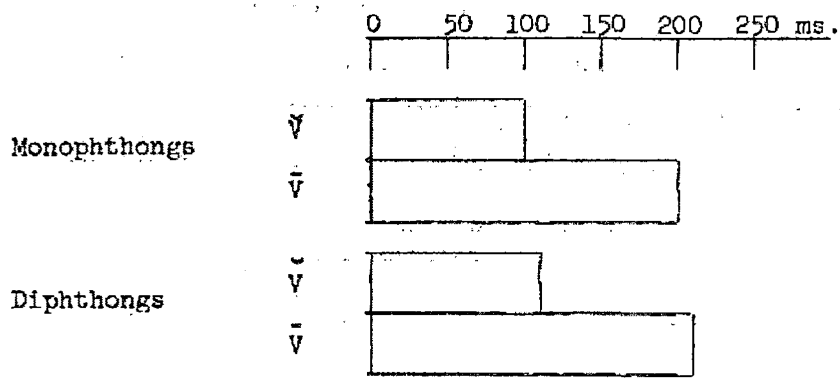


Fig. 2. Durations (ms.) of phonemic monophthongs and diphthongs in monosyllabic and disyllabic words.

The mean duration of short allophones of monophthongs is 100 ms.; the mean duration of long allophones is 205 ms. For diphthongs, the mean durations are 110 ms. and 200 ms. for the short and long allophones, respectively. The duration of short allophones in monosyllabic and disyllabic words constitutes half of the duration of long allophones. This 1:2 ratio of approximately 100 ms. to 200 ms. is perceptually far beyond that required for the difference limen (cf. Lehiste 1970: 10ff.). Furthermore, the 1:2, short to long ratio, holds for the diphthongs as well as for monophthongs.

Table 2 lists the durations found for stressed vowels and post-vocalic consonants in mono- and disyllabic words.

TABLE 2

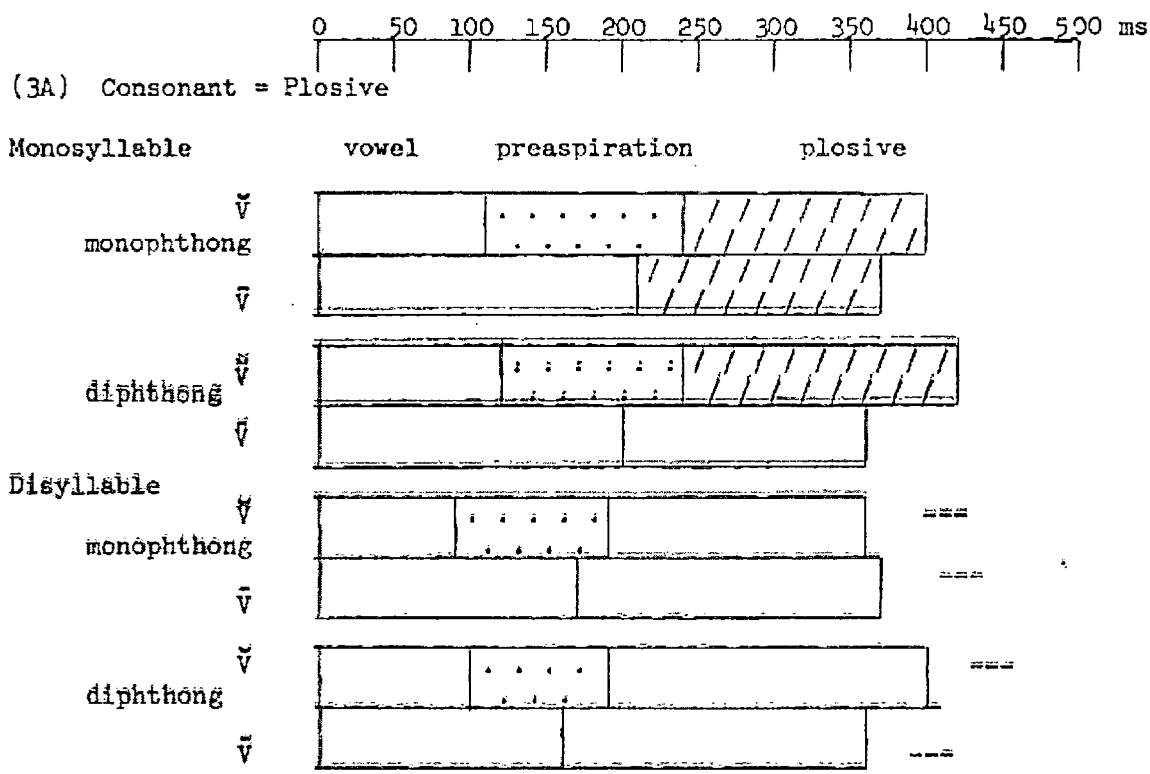
Durations (ms.) of Stressed Vowels and Post-Vocalic Consonants in Monosyllabic and Disyllabic Words

(2A) Consonant = Plosive							
Monosyllabic Words				Disyllabic Words			
Monophthong	Pre-aspiration	Plosive	Total	Monophthong	Pre-aspiration	Plosive	Total
V̌ 110	125	165	400	V̌ 85	110	175	370
V̄ 210	---	155	365	V̄ 175	---	200	375
Diphthong							
V̌ 115	120	180	415	V̌ 95	105	190	390
V̄ 205	---	170	375	V̄ 175	---	195	370

TABLE 2 (continued)

(2B) Consonant = Non-plosive					
Monosyllabic Words			Disyllabic Words		
Monophthong	Non-plosive	Total	Monophthong	Non-plosive	Total
V̆ 115	305	420	V̆ 90	240	330
V̄ 225	200	425	V̄ 200	135	335
Diphthong					
V̆ 105	345	450			
V̄ 235	240	475			

The durations are illustrated in Figure 3.



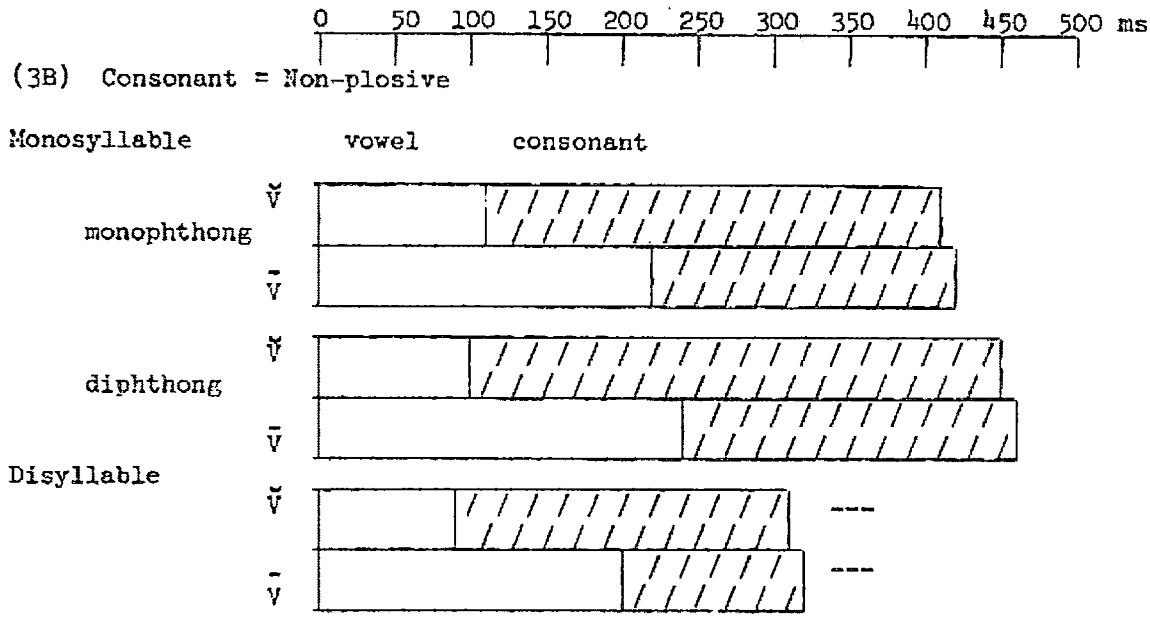


Fig. 3. Durations (ms.) of stressed vowels and post-vocalic consonants in monosyllabic and disyllabic words.

Figure 3A shows durations of vowels and voiceless plosives. Underlying long voiceless plosives are realized by preaspiration plus stop.[1] Figure 3B shows the durations in which the post-vocalic consonant is not a plosive, i.e., a nasal, fricative, or liquid.[2] The duration of short allophones consistently constitutes 50% of the duration of the long allophones maintaining a 1:2 ratio, regardless of absolute durations or the segmental environment or the syllable structure. Also the syllable-like, vowel-consonant sequence is consistently of similar duration.

3. Modern Icelandic Vowel System

In accounting for the Modern Icelandic vowel system I propose the analysis illustrated in Figure 4.

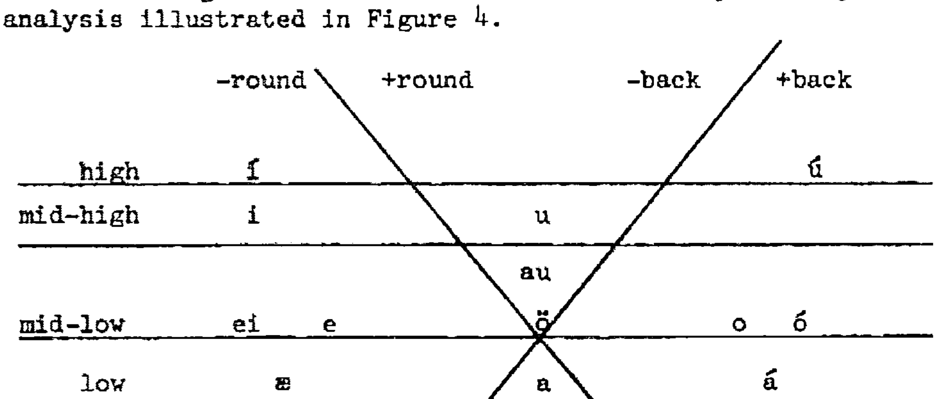


Fig. 4. Modern Icelandic vowel system.

It is based on a combination of the observations of quality and quantity made above. I posit four heights. An alternative would be to posit a tense-lax opposition between the vowels classified here as high and mid-high. However, no durational contrasts which would justify a tense-lax opposition for these vowels is present. These vowels appear to differ on a qualitative not a quantitative basis. The features ±round, ±back are straightforward.

As noted above there are three basic properties of the nuclei--lack of movement, and rising or falling movement. This configuration permits an easy statement of these relationships. All phonemes in the mid-low level are subject to movement--the three internal members, /e/, /ö/, and /o/, are subject to falling movement. The three peripheral members, /ei/, /au/, and /ó/, are subject to rising movement, as are the two peripheral members, /æ/ and /á/, of the low series. The remaining vowels lack movement.

Phonologists have provided terminology for describing vowel systems in general which is helpful for understanding the nature of the relationships found in this particular vowel system. For example, Trubetzkoy (1971 [1958] 95ff) proposes two terms with associated properties, sonority and timbre. Sonority correlates with the degree of aperture; timbre correlates with properties of localization. With reference to vowel space Trubetzkoy's sonority appears to refer to the height or vertical dimension while timbre refers to the place of articulation or to the front-back, horizontal dimension. These relationships are accounted for by Stampe (1972) and Miller (1973) with the terms of sonority, equivalent to Trubetzkoy's sonority, and color, equivalent to Trubetzkoy's timbre. In attempting to account for the changes found in vowel systems they propose the related processes of coloring and bleaching. Bleaching depalatalizes and delabializes vowels while coloring palatalizes and labializes them. Thus, the optimally palatal vowel is [i], the optimally labialized vowel is [u], and the optimally sonorous or bleached vowel is [a].

The structure of the Modern Icelandic vowel system proposed here can be described by these features. The vowels with maximal color or sonority, /í, i, ú, u, a/ are not subject to movement. They appear to provide the anchor points for the synchronic vowel system. Palatality is optimized in /í/ and /i/. Labiality is maximized in /ú/. In the vowel /u/, phonetically [Y], palatality and labiality are combined. /a/ is the most sonorous vowel in the Modern Icelandic system. Thus the most highly bleached and colored vowels do not diphthongize. The remaining, less colored vowels move within the space determined by these anchor points. /e, ö/ and /o/ are subject to the process of bleaching, i.e. their long allophones gain in sonority: [eɛ, øœ, oɔ] while /ei, æ, au, á/ and /ó/ are subject to the process of coloring, especially in their long allophones. The front diphthongs /ei, æ/ and /au/ gain in palatality: [ei, ɑI, øY], while the back diphthongs /á/ and /ó/ gain in labiality: [ɑU, oU].

A physical account of the phonological properties of the vowels in the Modern Icelandic system is possible in acoustic terms. The notion of optimal opposition (Kim 1966, chapter 7) offers an explanation for the oppositions claimed at the phonological level. Liljencrants and Lindblom (1972) use the principle of maximal perceptual contrast to explain the acoustic structure of vowel systems. They claim that the vowels with the greatest differences in formant structure are those which are maximally different at the perceptual level and are, therefore, those found in vowel systems. Thus, in Modern Icelandic the vowel nuclei which are not subject to movement are those which are in greatest perceptual contrast as well as those maximally acoustically opposed. /í/ and /i/ have the highest second formant value and /ú/ the lowest. /a/ has the highest first formant value. The remaining vowels have intermediate formant values to those found for /í, i, ú, u/ and /a/. It is in these non-maximally opposed nuclei that movement is found. The vowels with peripheral values /ei, æ, au, á, ó/ have <u>lower</u> first formants in their second portions, while the value of the second formant is higher for the front members, /ei, æ, au/ and lower for the back members, /á, ó/. The three less peripheral vowels /e, ö, o/ have <u>higher</u> first formant values in the second steady states of the long allophones. The differences in the directionality of the movement of the second steady states is primarily one of the increase or decrease in the value of the first formant.[4]

4. <u>Historical Development</u>

In studying a synchronic vowel system it is often illuminating to look at the preceding diachronic situation. For Modern Icelandic one looks to the Proto-Germanic and Proto-Nordic vowel systems and at the role of the suprasegmental features in these systems. Since the rising diphthongs have been restructured to consonant-vowel sequences in Modern Icelandic, I have not included them in this brief survey.

The Proto-Germanic vowel system presented in the handbooks (cf., e.g. Krahe 1960) appears in Figure 5.

Monophthongs				Diphthongs	
long		short			
ī	ū	i	u		
ē	ō	e		eu	
		a		ai	au

Fig. 5. Proto-Germanic vowel system.

In the monophthongal system there is a long and short vowel series. Five qualities are represented but the system is askew, since there are different distinctions in the low and back vowels. This situation arose when Proto-Indo-European ā and ō merged to ō, whereas Proto-Indo-European a and o merged to a. The three diphthongs are considered to be structurally similar to long vowels.

The next vowel system in a diachronic approach is that of Proto-Nordic illustrated in Figure 6 (cf. e.g. Ranke 1967. Antonsen (1967) argues for a more complex system).

Monophthongs				Diphthongs	
long		short			
ī	ū	i	u		
ē	ō	e	o	eu	
ā		a		ai	au

Fig. 6. Proto-Nordic Vowel system.

It is the typical five vowel system with all qualities appearing in short and long subsystems, plus three diphthongs. ā and o had arisen filling the gaps in the earlier Proto-Germanic monophthongal system. Again, the diphthongs are considered to have been similar in structure to long vowels.

The vowel system of Old Icelandic, see Figure 7, reflects the effects of such phonological processes as i-, u-, and a-umlaut (cf., e.g. Benediktsson 1959, 1972, Haugen 1972).

Monophthongs									Diphthongs	
long			long nasal			short				
í	ý	ú	ĩ	ỹ	ũ	i	y	u		
é	ǿ	ó	ẽ	ø̃	õ	e	ø	o	ei	ey
ę́		ǫ́	ę̃		ǫ̃	ę		ǫ		
	á			ã			a			au

Fig. 7. Old Icelandic vowel system.

At the time of the First Grammatical Treatise, about 1200 A.D., the vowel system is represented by four subsystems: one of long vowels, one of long nasalized vowels and one of short vowels. The fourth sub-system consisted of three diphthongs which are "functionally equivalent to long monophthongs" (Benediktsson 1972:163), as they had been since the Proto-Germanic period.

The quantity system at this earliest stage of Old Icelandic was essentially that which it had inherited, i.e. long or short vowels and consonants could occur in all four possible combinations, see Figure 8.

				Monophthong	Diphthong
1)	$\bar{V}$ $\bar{C}$	******	******	íss 'ice' gen. sg.	steinn 'stone'
2)	V $\bar{C}$	***	******	menn 'men'	----
3)	$\bar{V}$ C	******	***	ís 'ice'	stein 'stone' acc. sg.
4)	V C	***	***	men 'necklace'	----

Fig. 8. Admissible sequences of short and long segments in Old Icelandic.

Sequences resulting in three different durations existed, if it is assumed that the durations of vowels and consonants were similar. Since it is not the purpose of this paper to discuss Icelandic syllabication, only examples of monosyllables are given.

During the time of what has come to be known as the quantity shift which is dated as occurring in the 15th and 16th centuries (Benediktsson 1959:300), the four possible suprasegmental arrangements were reduced to two, yielding syllables of similar length. The shift can be interpreted as an increase in the scope of the suprasegmental feature quantity. At the pre-quantity shift period, the scope of quantity was the segment, whereas in the post-quantity shift period, its scope was the syllable. The two combinations which were eliminated were those which produced syllables of different lengths, i.e. types 1 ($\bar{V}\bar{C}$) and 4 (VC). These now inadmissible syllable types merged with the two surviving syllable types--2 (V$\bar{C}$) and 3 ($\bar{V}$C). Consonant duration dominated vowel duration in the resultant mergers, producing the realignments shown in Figure 9.

2)	V $\bar{C}$	***	******	íss, menn	steinn
3)	$\bar{V}$ C	******	***	ís, men	stein

Fig. 9. Admissible sequences of short and long segments after the quantity shift.

Vowels which had been long developed short allophones before long consonants, e.g. íss [is:] 'ice' gen. sg. Vowels which had been short now developed long allophones in the environment before a single consonant; e.g. men [mɛ:n] 'necklace'. What is perhaps most crucial is the fact that diphthongal vowel nuclei now developed short allophones, e.g. steinn [steidn̥] 'stone'. Before the quantity shift diphthongs had been structurally similar to long vowels. After the quantity shift, diphthongs were integrated into the total quantity system and developed short allophones.

5. Phonological analyses

The Icelandic vowel system has been subject to analyses from scholars representing various theoretical positions.[3] Hreinn Benediktsson (1959, 1972) gives a distinctive feature analysis to the Icelandic vowel system from the time of the First Grammatical Treatise to Modern Icelandic. He claims that the hierarchies of the distinctive features were different for the long, long nasal, and short vocalic subsystems. His analysis is supported by the mergers of different qualities of vowels within different subsystems. For the Modern Icelandic system he introduces the feature tense-lax to distinguish the high vowels í and ú from i and u, although he mentions the possibility of considering the distinctive difference between these nuclei to be one of diffuseness, i.e. height, rather than tenseness, since there is a difference of tongue height between these vowels. He notes that tense vowels should have longer duration than corresponding lax ones but states, "exhaustive measurements of the quantity of vowels in Icelandic have not been made" (Benediktsson 1959:302). Benediktsson posits two separate types of nuclei--monophthongs and diphthongs. He accounts for the diphthongization of Old Icelandic long monophthongs, but does not capture the tendency towards monophthongization of short diphthongs or the diphthongization of some of the long monophthongs in Modern Icelandic. He includes í and ú among the monophthongs, an analysis which is supported here.

Haugen (1958) in his phonemic analysis of Modern Icelandic proposes two sets of vowels, one consisting of a simple set of nuclei, the six historically short vowels: i, e, a, ö, o, u--the other a set of complex nuclei. Included in this set of nine complex nuclei are two nuclei which appear in restricted environments and the five falling diphthongs, ei, æ, au, á, ó, as well as the two high vowels, í, ú, analyzed by Haugen as /ij/ and /uw/. The results of this study indicate that the high vowels í, ú, are not complex nuclei but rather have become alligned with a, a simple nucleus. Haugen does not account for the diphthongization of long allophones of the mid-low monophthongs, e, ö, o, in Modern Icelandic.

Anderson (1969) gives an analysis of the Icelandic vowel system in terms of generative phonology. He posits two sets, one tense and one lax, of five underlying qualities, i, e, a, o, u; í, é, á, ó, ú plus two underlying diphthongs, ai, au. Except for the difference in the number of diphthongs and for the tense-lax rather than long-short opposition, this system is identical to the Proto-Nordic vowel system in Figure 6. Anderson proposes to be able to account for the phonetic level of the Modern Icelandic vowel system. However, his phonological rules produce a phonetic realization of í and ú as diphthongs: [ij], [uw]--productions which were not found to be extant in this study. His rules produce a phonetic realization of these segments which are equivalent to those Haugen posits as phonemic. Anderson dismisses quantity as a surface phenomenon in Modern Icelandic. Thus, it is not surprising that his rules do not provide for the diphthongization of the long allophones of e, ö, and o. By translating the quantity opposition of Proto-Nordic into a tense-lax opposition for Modern Icelandic, Anderson misses the "significant generalization" that quantity still exerts considerable influence on the phonetic realization of the Modern Icelandic vowel system.

Steblin-Kamenskij (1960) views the vowel system of Modern Icelandic as an integrated whole based on one feature which he claims cross-cuts the entire system--that of closing versus opening. Evidence supporting his analysis is found in neutralizations which have arisen since the 14th century (Benediktsson 1961:62-87). These neutralizations occur, e.g. in the environment before velar nasal plus stop--the underlying monophthongs are realized phonetically as allophones of the closest phonemic diphthongs or í and ú. In this velar environment, underlying monophthongal a is pronounced as its back-rounded diphthongal counterpart á [a-ʊ]. Steblin-Kamenskij correctly observes that all diphthongs are 'closing', i.e. that the second part of the nuclei rises in height. However, he claims that í and ú are also closing. In addition he claims that <u>all</u> long allophones of phonemic monophthongs are 'opening', i.e. that the second part of the nucleus is lower in height. The results of this study indicate that 'opening' is applicable only to the three mid-low monophthongs, not to the low and mid-high members.

6. <u>Conclusion</u>

I conclude with the observation that the combination of quality and quantity is responsible for the present vowel system of Modern Icelandic. Of primary importance is the role played by the quantity shift through which syllable types emerged which required the development of short diphthongs. Because of the change in the suprasegmental structure, the earlier subsets of long vowels, short vowels, and diphthongs merged into one integrated vowel system.

I hope that this paper shows that the practice of subjecting phonological hypotheses to phonetic analysis can be used to support or eliminate rival theories and optimally produce answers to old questions as well as to produce new hypotheses as a basis for future research.

Footnotes

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I presented a somewhat shorter version of this paper at the 1973 summer meeting of the Linguistic Society of America in Ann Arbor, Michigan.

1. The durations of the plosive gaps of the underlying long voiceless plosives is similar to the durations of the plosive gaps of the underlying short voiceless plosives. For the four pairs given in Table 2A the differences of plosive gap durations range from 5 ms. to 25 ms., which is below the difference limen for reference durations of 150 ms. to 200 ms. This relationship is similar to that found in an earlier study (Garnes 1972).

2. Some phonemically long nasals and liquids are in fact realized phonetically as plosive plus nasal or liquid, e.g. brúnn 'brown' mas. nom. sg. is transcribed phonetically as [brud·n] (Einarsson 1949), whereas menn 'men' nom., acc. pl. of maður 'man' is [mɛn:]. Since the purpose of this paper is to explore vocalic relationships, not to present data on consonant dissimilations, only the two consonant categories voiceless plosive and non-plosive are used.

3. In addition to the treatments mentioned here Kemp Malone (1923, 1952, 1953) contributed to the subject. Analyses of parts of the Icelandic vowel system have been proposed recently by Henning Andersen (1972), Patricia Miller (1973), David Stampe (1972), and Theo Vennemann (1972).

4. An explanation is proposed for the opposite movements of the first formants of /e, ö/ and /o/ versus /ei, æ, au, á/ and /ó/ on the basis of avoidance of merger in my forthcoming dissertation.

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