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Kadooka, Ken-Ichi

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Defining the Symmetry of Vowel Systems

Ken-Ichi Kadooka

Ryukoku University

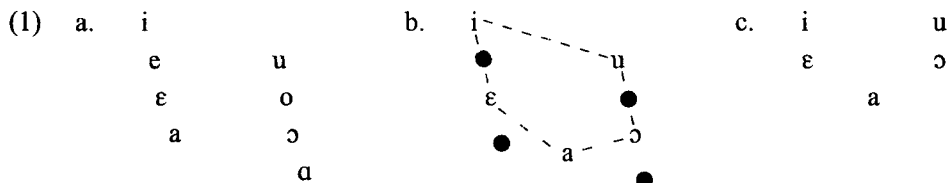
1. INTRODUCTION

The purpose of the present paper is to consider some articulatory and/or acoustic prerequisites underlying the configurations of vowel systems across languages, and to present an explicit definition of the symmetry of vowel phonemes. Here the notion 'symmetry' refers to the numbers of the phonemes in each of the front and the back series. The first idea of this topic is as follows¹, which discusses the phonological and phonetic aspects of the symmetry as systems:

The number of the front vowels and that of the back series are identical, except for the low vowel when a system contains only one low phoneme. When there are two low phonemes in a given system, one is [front] and the other [back].

We will take this as the starting point of the following discussion. Later in section 4, the latter half of this statement on two low phonemes will be augmented with the detailed data and discussion.

Below are the figures of the typical vowel phonemes arranged in ways which have not been found in the traditional literature in phonology. (1a) is a chart presenting the highest positions of tongue in the eight Cardinal Vowels, simplified from the original illustration in Catford (1988: 132) in that neither the shapes of the tongue nor the oral cavity is overtly shown as reference points; the canonical five vowel system is plotted in (1b), that of Ainu [i ε a ɔ u] (the Ainu low vowel [a] is [low, central], different from the Jones' Cardinal Vowel /a/ with the feature [low, front, unrounded], which should be indicated as [ä] following Crothers' transcription), and the phonemes other than these five are indicated by dots; in (c) the same set of the phonemes are presented in a phonologically traditional way:



Though each of the front and back series is not arranged completely linearly in the figure in Catford (1988: 132), the above configuration (1a) is substantially similar to the illustration of the highest points of the tongue in the articulation of these vowels except that [u] and [o] are lower than [e] and [ɛ] respectively; the highest point of the tongue in [u] is lower than that of [e] but higher than that of [ɛ], and that of [o] is between [ɛ] and [a]. The most close geometrical shape to (1a) above is a parallelogram, not a rectangle or an uneven quadrilateral as in Jones (1956: 21, figure II, where he claims that the illustration is based on X-ray films). The canonical five-vowel system plotted in (1b) above is not a shape like a baseball home plate as of (1c), from the articulatory perspective.

If we draw lines linking the four apexes of [i]-[a]-[ɑ]-[u] in the illustration in Catford (1988: 132), the figure is not a parallelogram; nor is the figure connecting the eight vowels, but it is an irregular convex. This can be confirmed from the acoustic point of view when the formant frequencies of the eight Cardinal Vowels are plotted on what is called the Mel scale.

What I would like to emphasize in the following sections is that the geometrical symmetry is not the case with the figure plotted within the frame defined by the Cardinal Vowels as in (1a) above. What is meaningful when we say that a particular vowel system is symmetrical is that there are the same numbers of the phonemes in each of the front and the back series.

When plotted with the broad transcriptions and arranged with the simplified distinctions of the height levels [high], [mid] and [low] as in (1c) above, *phonological symmetry* is geometrically actualized. The concept of the *phonological symmetry* refers to a geometrical configuration of vowel systems like a triangle, a rectangle, or a pentagon. These simplified illustrations are catchy in that some essential natures of vowel phonemes, such as symmetry or the relative height within each of the front-back series, are suggested in contrast to the phonetic diagrams which lack such implication. But this is the consequence of neglecting the minute difference of the tongue position.

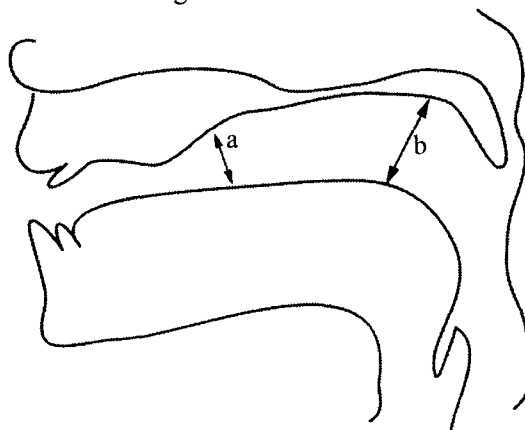
This paper consists of six sections including introduction and conclusion. After looking at the anatomical shape of the oral cavity in section 2, we will examine phonetic properties of vowel phonemes. Special attention is concentrated on low vowels in section 4.

2. SHAPE OF THE ORAL TRACT

As shown in any of the phonetics textbooks, the shape of the oral cavity is undoubtedly complicated; it is not so simple as a wine bottle². This seems the most important factor of the asymmetry of vowel systems. Therefore we will examine the shape of the oral tract as the first step of the physiological research here.

Below is an illustration of the oral tract modifying the one in Ladefoged (1982: 3), which depicts 'neutral' position of the tongue:

(2)



As far as observing this picture, it is irrefutable that the distance between the tongue body and the palate is wider in back vowel area (b) than in the front area (a), which may be opposite to a naive intuition that the tongue tip can move more freely in the front vowel area. This intuitive observation may be derived from the articulatory fact of the flexibility of the tongue body; tongue tip is more freely movable than tongue root. It follows then that the high and front vowels are less marked than the low and/or the back counterparts. In that regard, the [high, front] phonemes are the most unmarked and the [low, back] ones most marked. In my observation, [low, front] vowels are more marked than [high, back] ones. Marked phonemes need more articulatory burden than the unmarked ones.

In summary, the vowel charts such as (1a) above or (7) below do not necessarily reflect the physical shape of the oral cavity. It is apparent that the symmetry of vowel systems, the main topic of this paper, does not derive from the shape of the oral tract. What is deterministic for the specifications of vowel phonemes is articulatory prerequisites such as tongue positions, and lip rounding to a lesser extent, which are the subject of the next section.

3. ARTICULATORY ASPECTS OF THE VOWEL PHONEMES

This section deals with the articulatory aspects of *canonical vowels systems* in some of the languages of the world. Here the term *canonical* designates those systems which are most prevalent from the typological viewpoint. Among the oral, short, monophthongal – referred to as *basic* in that all of the languages of the world include this type of vowels – phonemes, the configuration /i e a o u/ is the most typical.

From the articulatory viewpoint, this configuration with two high, two mid and one low vowels is most *staple* in that the only low phoneme – typically [a] in many languages –, with the feature neither [+front] nor [+back] but [central], needs least muscle tension or articulatory

effort, while such muscle tension is not necessary for [+front] and [+back] in high and mid height sounds.

Since the time of Trubetzkoy (1939), typological studies on vowel systems have been one of the major topics in phonology. Geometrical figures like triangles and rectangles originated in Trubetzkoy (1939). Crothers (1978) highlights the dichotomy between peripheral and interior vowels and posits implications among these two types of vowel phonemes. The legitimacy of the dichotomy is argued in section 5 below. The background of Maddieson (1984), another important typological work on vowel systems, is phonetic rather than phonological.

Observing more minutely, however, some subtypes are found which are slightly deviated from each of the canonical phonemes [i e a o u]. The most diversified patterns among the three height categories [high], [mid] and [low] are found with mid vowels of [higher-mid], [mid] and [lower-mid], while the deviation of [lower-high] from [high] and [higher-low] from [low] are much less frequent. In other words, the high and the low vowels are less likely to be phonemically contrasted because the upper and lower limits are physiologically constrained; mid area, on the other hand, is relatively wide.

One of the reasons of discrepancies or deviance from the canonical phonemes derives from the height distinction as frameworks for the description of the vowel sounds, together with the different typographies adopted by the authors. Below are the seven-level distinction of the vowel height in Crothers (1978: 137) (3a) and the four-height first Cardinal Vowel series in Jones (1956) (3b), both presented in a phonological/traditional way, or disregarding the minute phonetic difference of the tongue height between the front and back series for the sake of simplicity:

(3)	a.	i	u	: high	}	high	b.	i	u
		I	U	: lower-high	}				
		e	o	: higher-mid	}			e	o
		E	O	: mid	}				
		ɛ	ɔ	: lower-mid	}			ɛ	ɔ
		æ	ʌ	: higher-low	}				
		ä	ɑ	: low	}	low		a	ɑ

The one and the only disaccordance found between these two sets of the systems is [ɑ] in (a) and [a] for the latter in (b). This is because the back series of the first Cardinal Vowels are [rounded] except [a] while [ɑ] is with the feature [rounded]. The other seven phonemes in (b) are identical with their articulatory features except the typographical dissimilation of [a] and [ä].

In order to describe all of the vowel phonemes of the languages of the world, the Crothersian model needs as precise and minute model as possible, while the Jonesian system intends to be a relative criterion to a particular phoneme in certain languages. As a result, some systematic difference can be pointed out between the two ways of the indication. Take the Crothersian notation [mid] phonemes [E O] for an example. In the Jonesian framework, these two vowels should be described as 'half way between [e]-[ɛ] and [o]-[ɔ],’ respectively. Strictly speaking, only a few of the existing vowels are exactly similar to the Cardinal Vowels, and the great majority of the others should be notified in their degree of deviation from them. In that sense it would be inappropriate for the direct comparison.

This is not to say that either of the two models is more excellent than the other. Each of them is designed to suit a specific purpose. The first series of the Cardinal Vowels are, for instance, idealistic from the articulatory standpoints in that all of them are peripheral, and that the whole set of them is almost exact as in some natural languages, such as the peripheral phonemes of French*³. In a sense, Cardinal Vowel systems are not devised for a typological purpose which should gather a great volume of data and analyze them. In other words, they are 'practical' in that the articulatory instruction is intended for each sound.

The phonemes listed in (3) above, either in (a) or in (b), are the outermost boundary of the vowel sounds. It would be needless to mention that there are more variations of sounds within the oral space circumscribed by the phonemes in (3). In what follows, the two axes of the height and frontness/backness of the tongue will be the most important criteria to define the vowel sounds.

From the height distinction in (3) and the databases consulted, we can deduce some implicational tendency across languages such as follows:

- (4) If there are n height distinctions in a given language, they are typically:
- | | | | | |
|----|---|-----------------------------|--|-----|
| a. | 2 | : high, | | low |
| b. | 3 | : high, | mid, | low |
| c. | 4 | : high, | higher-mid, lower-mid, | low |
| d. | 5 | : high, <i>lower-high</i> , | higher-mid, lower-mid, <i>higher-low</i> , | low |

The levels 2 through 4 are straightforward, but with a few exceptions such as the two-height distinction of [mid]-[low] in Caucasian languages (Colarusso (1988) argues phonological structure of Caucasian languages). The fifth alternative in (d) is either of lower-high or higher-low, indicated with italics, in addition to the four levels in (c).

We can find only one occurrence of six-level height distinction, but no seven-stage instance in the database in Maddieson (1984). That is to say, no languages discern [higher-mid]-[mid]-[lower-mid] phonemically. Below is the illustration of the six-height instance of the phoneme inventory of Amo:

- (5)
-

For all of the [high], [mid] and [low] levels, the subdivisions into two sub-levels are made, and the only category missing from the seven levels of the height is [mid]. The Amo system is the most interesting case among the database in UPSID in that the subtlest height distinction is made.

We can assume an implicational order among the tongue height as follows:

$$(6) \left\{ \begin{array}{c} \text{high} \\ \text{low} \end{array} \right\} > \text{mid} > \left\{ \begin{array}{c} \text{higher-mid} \\ \text{lower-mid} \end{array} \right\} > \left\{ \begin{array}{c} \text{lower-high} \\ \text{higher-low} \end{array} \right\}$$

Aside from the co-occurrence restriction of [higher-mid]-[mid]-[lower-mid], this table (6) well demonstrates the relation between the tongue height across languages.

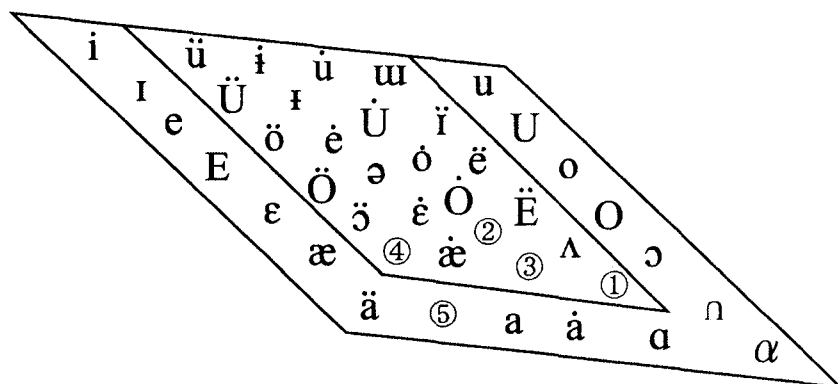
If we refer to the implication presented in Crothers (1978) as 'peripheral precedence condition,' it will help rank each phoneme on the marked-unmarked scale; that is to say, peripheral phonemes are the more unmarked in general. Put in another way, interior vowels fulfill the gaps left vacant by peripheral phonemes in a given system. This ordering relation is well illustrated with Figure 10 in Crothers (1978: 114).

In my observation, low vowels among both of the front and the back series compel muscle tension, hence the low phonemes are likely to be centralized in many languages and realized typically as [a]. This can be considered as one instance of a tug of war between the serialization of the front-back phonemes and the ease of articulation. If the system contains both [low, front] and [low, back] vowels, each of the front and the back series is completely symmetrical from [high] to [low]. As is exemplified with the high and mid area, vowels are divided into the front and the back series. But in the low area, it is blocked by the articulatory prerequisite of either of the lowering and fronting of the jaw in [ä] or the retraction of the tongue root in [ɑ].

It can be asserted then that each vowel system is on the balance of these two forces. That a system requires symmetry may lead to another precondition that more phonemes are necessary within the system; if there are two low vowels in a particular language, the symmetry is realized and greater is the number of phonemes. Seen from the typological perspective, however, majority is those which give priority in articulatory ease and contain one low vowel. Those with two low phonemes, on the contrary, put first concern on the symmetry as the system at the sacrifice of stress on muscle tension.

Now, let us look at an illustration of a phoneme catalog depicting the dichotomy between peripheral and interior based on the Crothers' notations (1978: 137)*⁴, but adapted to the frame of a parallelogram.

(7)



Though it reflects the physiological reality of the highest point of the tongue, this diagram may pervert the naive intuition, or traditional illustration as in (1c) above, of the right-angled crossing of the horizontal and the vertical axes, where the degrees of height and frontness are presented straightforwardly. In (7), on the other hand, the position each phoneme occupies is relative in the sense that, for example, a back vowel [u] and a central [a] are placed approximately alike in regard to frontness of the tongue.

Here we can find 17 peripheral and 20 interior phonemes. The encircled numbers 1 to 5 in (7) designate the blanks in the Crothers' (1978: 137) table of the vowel categories: ① is for the vowel [back, higher-low, unrounded]; ② [central, lower-mid, rounded]; ③ [central, higher-low, rounded]; ④ [front, higher-low, rounded]; ⑤ [front, low, rounded]. These five phonemes are not ascertained of their existence in the Stanford Phonology Archive, on which the database of Crothers depends; that is to say, those phonemes with the features [-back, low, rounded] are the least canonical.

When we observe these vowels, it seems that low phonemes are more marked in that there are some 'missing' phonemes — those encircled ones in the above chart — while no such vacancy in the high and only one in the mid vowel area. It is likely that the two possibilities lie beyond these absent vowels. One is that these five sounds may be merged to the neighboring phonemes, because the difference(s) between these neighboring sounds are so small; another is that such sounds are not found in any of the languages attested.

This peculiarity of the missing phonemes is not found solely in Crothers (1978). Maddieson (1984) is another typological study concerning both of vowels and consonants, with the database of the phoneme inventories of 317 languages. There the seven levels of height distinction are made, and the horizontal divisions of front-central-back, with the subdivision of rounded and unrounded in each of the three. That is to say, the framework for cataloguing the possible vowel phonemes is exactly identical with that of (7) above. Interesting is a coincidence of the fact that five phonemes are missing from the tables of the vowel inventory. Though the number of the missing phonemes is the same as in Crothers (1978), two phonemes are not overlapped: ① in place of [back, higher-low, unrounded] in (7) above is indicated as [q̠] in Maddieson (1984: 204); instead [central, low, rounded] [ä] is absent in Maddieson. Throughout the following discussion, the Crothersian transcriptions will be adopted and [q̠] will be added to the inventory.

Out of the five missing phonemes in (7), four are interior and only one is peripheral. In Maddieson's account, three are interior and two peripheral. In either version, interior vowels are more marked.

Altogether 37 phonemes are distinguished among the 42 possible sites in both of Crothers (1978) and Maddieson (1984).

The position of the tongue can also be represented by articulatory terms of stricture, jaw position and lip position (Crothers (1978: 97)). When we replace the three phonemes /i a u/ with the tongue positions [front low back] respectively, the following correspondences are acquired: first for the stricture, [front]-[palatal], [low]-[pharyngeal], and [back]-[velar]; second for the jaw position, [i u]-[closed], [a]-[open]; third for the lip position, [i]-[spread], [a]-[half open] and [u]-[rounded]. The fundamental concept of Dependency Phonology (Anderson and Ewen (1987)) is based on the atomic phonemes /i a u/ representing these articulatory features, and the other phonemes are synthesized by combining these features.

The concept of the three-element atomic phonemes within the Dependency Phonology framework seems to verify the predominance of the triangular configuration with the one low vowel over the quadrangular shape with the two phonemes.

Another important articulatory factor concerned with the vowel qualities, as well as the tongue position, is lip rounding. The lowering of the jaw and the lip rounding are difficult to co-occur; the lip rounding for the low vowels is [half-open]. Acoustically, '[t]he degree of lip rounding also affects the frequencies of the formants' (Ladefoged (1982: 179)). Articulatorily, rounding and protrusion of the lips make the oral cavity longer which cause all the formants to be lower. Among the phonemes, lip rounding is less marked with the [high, back] phonemes and more marked with the front and low counterparts.

Though two values are posited in general for opening of mouth, it may be more appropriate to assume that the central low vowel is with the feature [half-open], neither [fully-open] nor [closed]; the state of [half-open] needs least muscle tension in the low vowel phonemes. It is necessary for the jaw to open as widely as possible in articulating low vowels. The extreme fronting or backing of the tongue and/or the rounding of the lips require extra force in addition to lowering of the tongue.

From another articulatory viewpoint, protruding and rounding of the lips entail muscle tension. With that regard, [unrounded, high, back] sounds like Japanese /u/ require less muscle stress but such phonemes are minority among the languages. This may suggest that the change of the vowel quality by rounding the lips with the back vowels increases the ease of auditory distinction between the front and the back series, and hence typologically occupy majority.

4. THE STATUS OF LOW VOWELS

In this section, we will pursue the articulatory description of the low vowel phonemes, in regard to the muscle tension.

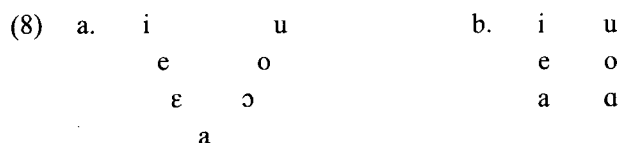
It has been evident that the relative scarcity of the phonological distinction of the low phonemes between the [low, front] phoneme such as [ä] and the [low, back] one such as [ɑ] (both are Crothers (1978)'s notations) across languages is not due to the shortness of the distances between the low and high/mid phonemes. As pointed out in this paper, the distances between the frontmost and the backmost phonemes are virtually the same in all of the high, mid and low areas.

Watanabe (1996: 113) testifies the statistic inclination from the database UPSID (UCLA Phonological Segment Inventory Database) of 317 languages (a brief summary of UPSID in Watanabe (1996) is in the concluding section in this paper). In UPSID, /a/ is found among 289 systems while /æ/ in 36, /ɑ/ in 21 and /ɒ/ in 11. Only a few languages contain these three low vowels (or the phonemes with resembling features) simultaneously. The detail will be below in this section.

Then, what is the cause of the scarcity of the phonemic contrast in the low phonemes, in comparison with the almost obligatory distinction of [front] versus [back] phonemes in high and mid vowels?

The answer seems to lie in the articulation in the [low, front] and [low, back] phonemes. The low vowels themselves, although they be [central], demand greater muscle tension than in high and mid counterparts because of the opening of the mouth. This muscle tension is much stronger in [ä] with fronting and lowering of the lower jaw, and in [ɑ] with the backing of the tongue root (my observation). Consequently, [a] with the feature [low, central] is the most suitable candidate as a low phoneme, and the more peripheral [front] and [back] counterparts are less likely to be contained in the vowel inventories of the languages. In the case of the high and mid area of the oral tract, on the other hand, peripheral phonemes of [front] and [back] require less muscle stress than in pronouncing the low vowels.

From the viewpoint of typology, the following tendency is ascertained: if there is only one phoneme with the feature [low], it typically is [central]; if there are two, one is [front] and the other is [back]. Statistically, the languages with one low-vowel overwhelm the latter in approximately seven to one. Kadooka (1998a: 41-42) points out that those languages with the distinction [front]-[back] are 24 in the database containing 167 systems. Below are typical examples of the one-low-phoneme model Italian (a), and two-phoneme system in English (b)*⁶:



Comparing these two forms of triangle (a) and rectangle (b), the form more similar to the phonetic entity diagrammed in (7) above is the latter in that the Trubetzkoyan configuration of triangles is likely to be interpreted that the distances between the phonemes of the same height in the front and the back get narrower in the lower area, which is contrary to the physiological reality. In the Trubetzkoyan vowel typology, all the systems with one low phoneme are represented as triangles while those with two phonemes are rectangles. Seeing a triangular figure like (8a), it is likely to be misunderstood that the distance between /i/-/u/ is greater than that between /ε/-/ɔ/. When we transform the quadrangle (b) into a parallelogram (7), it will be more nearer to the phonetic reality.

From the phonetic viewpoint, however, the matter is not so straightforward, in particular for the systems with the two low vowels. This will be a topic later in this section.

As for the status of the low vowels, I found significant discrepancies between the databases consulted. It is not one of the aims of the present paper to conclude the legitimacy of the data after comparing them, but just to point out the problem.

The first problem here is concerned with the systems with three low phonemes presented in Maddieson (1984). Below are the illustrations*⁷ not diagrammed within a parallelogram framework such as (1a) or (7) above, and the symbols adjusted to the Crothersian system:

(9) a. Panjabi *⁸ (019),
Luo (205, without /ə/)

i u
I U
E ə O
æ
a α

b. Dan (106)

i u
ε ɔ
ä a α

c. Nambakaengo (626)

i ù u
E ə O
æ
a α

Panjabi and Luo have analogous vowel systems except that the latter lacks one central phoneme /ə/. The vowel inventory of Nambakaengo is similar to those of Panjabi and Luo except the lower-high [I U].

Now we will contrast each of these four systems with other databases.

As for Panjabi, Crothers (1978: 143) postulates ten phonemes of /i I E æ a α O U u ə/ and ten nasals each of which corresponds to its oral counterpart. This is exactly similar to that of Maddieson's. This coincidence is no wonder because both of Crothers (1978) and Maddieson (1984) are based on the same source, aside from the difference in typographies. On the other hand, Mizogami (1992) thinks the vowel subcategories of Panjabi as quite different: three short /i a u/, seven long /i: e: ε: a: ɔ: o: u:/, and seven nasal /ĩ ē ĩ ã õ ã ũ/. To name only major discrepancies: the contrast of short and long in the oral vowels in Mizogami (1992); the numbers of the phonemes are not coincident in the data.

For the vowel system of Luo, Hieda (1992) postulates as /i I e ε a ɔ o U u/ and their long counterparts /i: I: e: ε: a: ɔ: o: U: u:/, while Crothers (1978: 142) regards it as /i I E ε a ɔ O U u/ and no long phonemes with a note that '[t]he vowels can be divided into tense and lax, or advanced and retracted sets' (*ibid.*, p. 145). Though the number of the phonemes is the same (nine), the configuration is at variance; both Hieda (1992) and Crothers (1978) posit five-height, one low-phoneme, while Maddieson (1984) thinks of it as a shape of a trapezoid, or a coffee cup, as in (9a) above.

Observing closely, we must pay attention to the detail that [æ] is [higher-low], while the other two [a α] are [low], if we adopt the Crothersian notations and Maddieson's data. This may be to avoid the three-low pattern as in Dan. In either case, those systems with three [low] vowels are absolutely rare, hence it would be difficult to draw any significant conclusion.

The data of the Dan language is not included in Crothers (1978). But if Maddieson's assertion is correct, the low vowel system in Dan is more unified than the other three in that all of the three phonemes are [low].

The data of Numbakaengo is not included in Crothers (1978) either, but the three low vowels are nearly similar to those of Panjabi and Luo, except [unrounded] [ɑ] instead of the rounded counterpart [α]. The vowel inventories of these three languages resemble one another, especially in the mid and low area. Though absolutely minority in the typology, they display a certain inkling of the patterns with three low vowel systems; each language must contain more than seven phonemes.

The second problem is about the two-phoneme contrast of the low vowels. In the database of Maddieson (1984), the following 10 patterns of the combination of the neighboring low phonemes are found*9:

- (10)
- a – u : Khirgiz 020
 - a – ɑ : Khalaj 062, Temne 109, Ashuslay 814
 - a – α : French 010
 - a – ɔ̃ : Selepet 607
 - a – a : Sinhalese 020
 - æ – a : Lithuanian 007, Bengali 017, Ostyak 050, Finnish 053, Korean 070, Somali 258, Awiya 259, Maranungku 355, Thai 400, Taishan 501, Hakka 502, Changchow 503, Yao 517, Andamanese 600, Wantao 615, Nez Perce 706, Mixe 715, Otomi 716, Quileute 732, Hopi 738, Seneca 754, Yuchi 757, Auca 818, Ket 906
 - æ – æ : Tuareg 257
 - æ – ɑ : Norwegian 006, Bashkir 063, Chamorro 416
 - ä – ɑ : Farsi 013, Azerbaijani 059, Khmer 306
 - æ – α : Hungarian 054

These 10 patterns can be subdivided into the three groups of [central]-[back], [front]-[central] and [front]-[back]. The first type consists of four variations, and the second and the third groups three, respectively. Besides these transverse patterns, two languages with the two low phonemes are distinctive only with the feature of height: [a]-[æ] in Amo (122) and Dizi (263). Though this topic seems interesting in that the two phonemes of the neighboring height are adjacent with similar horizontal longitude, it would not be further pursued here. The illustration of the Amo vowel system is (5) in section 3 above.

Contrary to the expectation that the two low phonemes in a given language be [front] and [back], this pattern is less prevalent than the [front]-[central] counterparts. This is mainly because [æ]-[a] occurs in as many as 24 languages.

The reason may be as follows why the expected [front]-[back] low phoneme pairs are relatively rare; if the two low vowels are both peripheral—one is [front] and the other is [back]—, the articulatory stress on each sound is dual. Prevalent occurrences of the pair [æ]-[a] are construed as the mitigation of such double compulsion of burdensome articulation with the substitution of one [back] phoneme with the less cumbersome [a]. In other words, the pair [æ]-[a] is less marked than [æ]-[ɑ] or [ä]-[α].

Considering the aspects of the front-back distinction in high and mid vowels, it seems improbable that many languages, approximately 90% among the languages of the world, do not phonemically contrast more than two low phonemes. If vowel systems of many languages contain two low phonemes, it was expected that they are completely symmetrical—in other words, the front and the back series have exactly the same numbers of phonemes. Statistic researches, however, verify that this is not the case, as concisely reviewed in this section. The disparity

between the presupposition in terms of symmetry and the actual tendency can be explained by the articulatory load of the low vowel phonemes, as a conclusion.

5. PLAUSIBILITY OF THE DICHOTOMY/ [LOW, CENTRAL] VERSUS [HIGH, CENTRAL] PHONEMES

We will begin this section with a seemingly simple but a never-asked question in regard to the peripheral/interior dichotomy in Crothers (1978): Why are the [low, central] vowels classified as peripheral while the [high, central] counterparts as interior?

When introducing the dichotomy of the peripheral and the interior vowels, Crothers (1978: 100) does not explicate the basis of the categorization. Figure 6 in Crothers (1978: 100), depicting the five peripheral /i e a o u/ and the three interior phonemes /ü i ə/, induces a suggestion that the [low central] phonemes are defined as peripheral because /a/ is in the position of the 'rivet' of the triangle of the oral cavity or the confluence of the front and the back series. As a conclusion, however, Crothers gives no explanation for the foundation of the dichotomy.

It has been evident through the discussion in section 3 that the [low central] phonemes are [a á ɑ] and the [high central] [ü i ü u], not in a particular language but as specimen in a catalog. That the number of the [low central] vowel is smaller than that of the [high central] counterparts is because of the articulatory strain in the low area.

With that regard of the articulation, it seems that the [low] phonemes are marked, whereas the [high] counterparts are not. But when we examine vowel inventories in the databases, it is doubtless that the reverse is true; [low central] vowels are included in virtually all of the vowel inventories of the languages, but [high central] phonemes are much less prevalent.

Taking the typological fact into account that approximately one third of the languages attested are with the canonical five-phoneme system /i e a o u/ (Kadooka (1998a: 69)), it is preferable for the [low central] phonemes to be classified as the same category as the 'genuine' peripheral high and mid vowels [i e o u]. Crothers (1978: 114, Figure 10) observes that [high central] phonemes, except /i/ which is prevalent among the 4:1 type sub-categories, occupy much later positions in the implicational orders of appearance/existence.

6. CONCLUDING REMARKS

As suggested in the previous works in this field of phonological typology, though not explicitly, the phonetic descriptions of the vowel phonemes plotted realistically are not like shapes of triangle, quadrangle, or pentagon. Still the phonologists insisted that they are symmetrical. To remedy such discrepancy, a redefinition is needed in regard to the concept of the symmetricity of the vowel phoneme configuration.

Here in this section we will integrate the discussions so far and confirm why the canonical system /i e a o u/ is so prevalent, and can be regarded as *de facto* standard consequently, among the languages of the world. We have examined this issue from the articulatory precondition of

the tongue position of two-dimension, i.e. from the viewpoint of the vertical and the horizontal axes.

As an integration of the two-dimensional framework, let us review the phoneme-based vowel frequency survey in Watanabe (1996). Table 2 in Watanabe (1996:113) presents the summary of UPSID, though the degrees of the height distinction are reduced to five; both [higher-mid]-[mid] and [higher-low]-[low] are merged claiming that there are no languages with phonemic contrast between each of the two levels. All of the canonical five vowels [i e a o u] are found in more than 200 languages out of 317, followed by [lower-mid] pair [ɛ ɔ] in slightly over 100 languages. The other phonemes can be found in much fewer systems. What can be estimated from these figures is the high frequency of the system [i e a o u] occurring in considerable proportion of the languages of the world, and followed by the seven-phoneme system [i e ɛ a ɔ o u].

The lawfulness of Watanabe's merge of seven height levels to five is another dispute. Though they are rare cases, both patterns of the contrast [higher-mid]-[mid] and [higher-low]-[low] are testified in Maddieson (1984).

It seems that the reason has not been explicit up to now why low vowels are unconditionally classified as peripheral. Generalizing the consideration in this paper, it can be concluded to this problem in terms of distribution that virtually all of the languages attested have [low] phonemes while the [high, central] vowels are much rarer. Supporting this hypothesis are the facts that the [low, central] phonemes are less marked than the [low, front] and the [low, back] counterparts, and that all of these three categories do not co-occur in a given language except only a few instances.

An inevitable difficulty idiosyncratic with typological studies is the source of the data, particularly if there is more than one source. Emerged in section 4 is the existence of the three low-vowel systems.

NOTES

1. From Kadooka (1999).
2. A Bordeaux type wine bottle is straight, but a Burgundy type is not. In that sense a Bordeaux type is preferable as an example here. A similar kind of a bottle analogy is in Johnson (1997: 96).
3. There are altogether 11 basic phonemes postulated in French: besides the eight phonemes almost similar to Jones' Cardinal Vowels, three interior vowels /i ü ö œ/ (Kadooka (1998a: 82), Crothers (1978: 143)).
4. The three columns from the left, though they are not vertical in this particular illustration, represent front, central, and back respectively. The left-hand phonemes in each column are unrounded while the right-hand ones are rounded. The seven levels of height distinctions is also shown in the table (3).
5. Notice that here the phoneme /æ/ include /ä/, because these two vowels are merged in Watanabe (1996). So does /ɑ/ include /ɑ/ in the Maddiesonian system, and /b/ (Crothers' /k/) does /p/ (Crothers' /n/).
6. There are some descriptive alteration for the English sounds, while no such trouble for Italian. Crothers' (1978: 140) transcriptions are /I E æ æ̃ α U/. Jones (1956: 23) assigns the following symbols for

them: /i ɛ a ɔ ʌ u/. But they are not always identical with the Cardinal Vowels even though the same transcriptions are adopted. It seems quite strange that Maddieson (1984) does not include the data for English.

7. The three digits in the parentheses following the names of the languages designate the code tagged to represent the language family which a given language belong to. The affiliation of the four languages listed in (9) are:

Panjabi: Indo-European Luo: Nilo-Saharan
 Dan: Niger-Kordofanian Nambakaengo: Indo-Pacific

See note 9 below and Maddieson (1984: 174-183) for the detail.

8. The name of this language *Panjabi* is also spelled as *Punjabi*. The former is adopted in this paper.

9. Maddieson (1984: 174-177) gives the list of genetic classification of the languages attested as follows:

Indo-European	000-049	Ural-Altaic	050-099	Niger-Kordofanian	100-199
Nilo-Saharan	200-249	Afro-Asiatic	250-299	Austro-Asiatic	300-349
Australian	350-399	Austro-Tai	400-499	Sino-Tibetan	500-599
Indo-Pacific	600-699	Amerindian I	700-799	Amerindian II	800-899
Other families	900-999				

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