Three-Dimensional Phonology : A Historical Implication

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Introduction

The traditional two-dimensional phonology of any language posits a finite set of significant sounds or phonemes and a set of rules governing the admissible sequences of these sound units in the language. Theoretically a 2D phonologist can say whether a construction of sound sequences or a syllable structure of the language understudied is grammatical or ungrammatical. For example, /*gnat/ is ungrammatical but /nat/ is grammatical in English, /*pej0/[1] is ungrammatical but /pem0/ is grammatical in Thai. However, /nat/ never occurs as an English word, neither nor does /pem0/ occur as a Thai word. It has been discussed in the literature that not all the grammatical sound constructions can occur as words (Chomsky 1965, Postal 1968, Fudge 1969,1970, Peng 1972). Those constructions which do not occur as words of the present day language form the *accidental gaps* in the grammar of sound patterns of that language. It has also been observed by scholars who are interested in the phenomenon of accidental gaps that loanwords of foreign origins, expressives, onomatopoeia, and archaic words seem to fill in the accidental gaps of the phonological system nicely (Fudge 1969,1970, Peng 1972, Diffloth 1979, Luksaneeyanawin 1982).

A tripartie distinction of grammaticality has been proposed in earlier literature (Chomsky 1965, Postal 1968). However, considering Peng's proposal of the bipartie distinction of grammaticality in phonology, I would like to suggest that it is theoretically tenable to distinguish constructions of sounds at two different levels :

(1) The phonological level where there are 2 different categories i.e. grammatical and ungrammatical

(2) The phono-lexical level where the grammatical constructions fall into 2 groups i.e. the occurring and the non-occurring

The theory is illustrated in the following schema :

or archaic, and in the same manner any non-occurring admissible syllable may become *occurring* i.e. a word part or a word of the present day language. For example, /fan3/ (to massage, to squeeze), which can be found in the Dictionary of the Royal Thai Academy, is now dated in Thai, and /niŋ3/ (very good) which is a slang word in the year of this writing, is not listed as a word in the dictionary.[2]

(3) It can be explicitly stated what the phonological accidental gaps of the language are like, and how wide the accidental gaps are.

(4) The study of *the distribution of the phonological units in the occurring and non-occuring admissible phonological constructions of the language as the third dimension of phonology* can provide solid evidence from the synchronics which will contribute to the diachronic study of the language.

Three-Dimensional Phonology

The three dimensions of a 3D phonology are :

(1) The systems of the significant sound units in the language.

(2) The rules governing all grammatically admissible sound constructions or syllables of the language, of which the number is finite.

(3) The statistical distribution of the significant sound units in all the occurring admissible syllables and in all the potential non-occurring syllables.
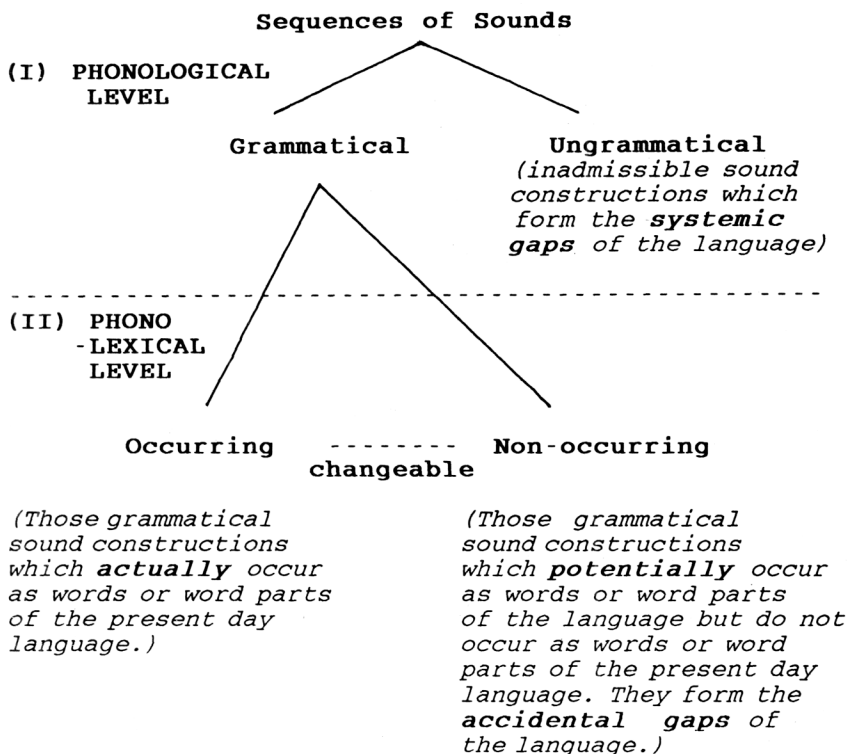
The Bangkok Thai, refered here as Thai, will be used to exemplify the 3D Phonological Theory.

The first dimension : the Thai sound systems.

Thai syllables are composed of 3 different sound systems :

(a) The system of consonants consists of 33 consonantal units, they are 21 consonants and 12 consonant clusters as follows :

p*	t*	c	k*	ʔ*
ph	th	ch	kh	
b	d			
m*	n*		ŋ*	
f	s			h
w*	r, l	j*		

Sequences of Sounds

(I) PHONOLOGICAL
    LEVEL

Grammatical

Ungrammatical
*(inadmissible sound
constructions which
form the systemic
gaps of the language)*

- -

(II) PHONO
    -LEXICAL
     LEVEL

Occurring   - - - - - - - -   Non-occurring
              changeable

*(Those grammatical
sound constructions
which **actually** occur
as words or word parts
of the present day
language.)*

*(Those grammatical
sound constructions
which **potentially** occur
as words or word parts
of the language but do not
occur as words or word
parts of the present day
language. They form the
accidental gaps of
the language.)*

Peng (1972,82) stated, "The so called accidental gaps and systemic gaps do not a priori belong to two genetically distinct and self-contained stocks of sequences of sounds; rather they form a field of sequences of sounds, *The number of which is probably infinite*." (My italics.)

It is argued here that :

(1) The number of admissible syllables or phonological constructions of a language is *finite*,[2] because these admissible sound constructions are generated from a finite set of phonemes in the language, and a finite set of rules governing the construction of them.

(2) The number of the occurring syllables (those actually occurring as words or word parts in the language) and the non-occurring (those potentially occurring as words or word parts but do not actually occur in the present day language) are *changeable*. Any occurring admissible syllable may become *non-occurring*

Only 9 consonants (those with asterisks) can occur at syllable final positions .

The consonant clusters can occur only at syllable initial positions. They are as follows :

pr   tr   kr

phr   thr   khr

pl   kl

phl   khl

kw   &   khw

(b) The system of vowels   consists of 18 monophthongs and 6 diphthongs. The monophthongs are qualitatively 9 different vowels, each of which has 2 members, short and long. Qualitatively, there are different diphthongs, each of which has 2 quantitatively different members. They are as follows :

i, i: ɯ, ɯ: u, u:

e, e: ɤ, ɤ: o, o:

æ, æ: a, a: ɔ, ɔ:

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ia, i:a   ɯa, ɯ:a   ua, u:a

(c) The system of tones consists of 5 tones There are 3 kinetic or relatively level tones, the high the mid, and the low, and 2 dynamic or contour tones the fall and the rise. Traditionally, they are ordered as follows :

0	1	2	3	4
mid	low	fall	high	rise

0 = the common tone /sa:4 man0/
1 = the primary tone /ʔe:k1/
2 = the secondary tone /tho:0/
3 = the tertiary tone /tri:0/
4 = the tetrad tone /cat1 taʔ1 wa:0/

The second dimension : Rules governing the constructions of the sound units

The smallest constructions of sounds o syllables in Thai composed of one vowel unit or on

diphthong; one or more than one but not more than 3 consonants; and tone. The construction can be represented with this structure :

(Ci)Ci (V)V (Cf) T

Ci = initial consonants, consonants can be either a one unit consonant or two unit cluster.
Cf = final consonants, all syllables with short vowels must have a consonant. Open syllables are with long vowels only.
V = vowels, vowels can be either short or long, : is used to mark length. The vowel units can be either monophtongs (V or V:) or diphthongs (VV or V:V).
T = tones.
        According to the rules governing tone assignments in Thai syllables, we can classify two types of syllable structures :
        The sonorant ending syllables (traditionally known as Live or Non-Checked Syllables) of which the five tones can be assigned.
        The obstruent ending syllables (traditionally known as Dead or Checked Syllables) of which only 3 tones, the low, the high, and the fall can be assigned.
The sonorant ending syllables are of 3 types :
        (1) *Open syllables* , these syllables are composed of only long vowels and long diphthongs, they can take any of the five tones. With 33 initial consonantal units 12 long vowel units, and 5 tones, there are 1980 syllables of this type in the language :
        33 C & CC x 12 V: & V:V x 5 T = 1980
        Out of this number, there are 40 syllables that are not admissible due to the inadmissible co-occurrence between the labialized consonant clusters /kw,khw/ and the 4 rounded vowel units /u:,o:,ɔ:,u:a/ , illustrated below.
        *2 CC   x   4 V: & V:V   x   5T = 40
        /kw,khw/   /u:,o:,ɔ:,u:a/
        Excluding the 40 inadmissible open syllables, there are 1940 (1980-40) admissible open syllables in Thai.
        (2) *Short syllables ending with sonorant consonants*, these syllables are composed of short vowels and short diphthongs, they can take any of the five tones. With 33 initial consonantal units, 12 short vowel units, 5 sonorant ending consonants, and 5 tones, there are 9900 syllables of this type in the language :
        33 C & CC x 12 V & VV x 5 C x 5 T = 9900

Out of this number, there are 1480 syllables that are
not admissible due to the 3 inadmissible co-occurrences
between the significant sound units stated as follows :
The inadmissible co-occurence between
labialized initial consonant clusters /kw, khw/ and the
4 rounded vowel units /u,o,ɔ,ua/.

$$*2 \text{ CC } \times \text{ 4 V \& VV } \times \text{ 4 C } \times 5T = 160$$
/kw,khw/   /u,o,ɔ,ua/   /m,n,ŋ,j/

The inadmissible co-occurrence between the 4
rounded vowel units /u,o,ɔ,ua/ and the labialized
sonorant consonant /w/.

$$*33 \text{ C\&CC } \times \text{ 4 V \& VV } \times \text{ 1 C } \times 5T = 660$$
/u,o,ɔ,ua/   /w/

The inadmissible co-occurrence between the 4
front vowel units /i,e,æ,ia/ and the palatalized
sonorant consonant /j/.

$$*33 \text{ C\&CC } \times \text{ 4 V \& VV } \times \text{ 1 C } \times 5T = 660$$
/i,e,æ,ia/   /j/

Conclusively,there are 1480 inadmissible short
sonorant ending syllables (*160 + *660 + *660).
Excluding the 1480 inadmissible syllables,
there are 8420 admissible short sonorant-ending
syllables in Thai (9900-1480).
(3) *Long syllables ending with sonorant
consonants*, these syllables are composed of long vowels
and long diphthongs, they can take any of the five
tones. With 33 initial consonantal units, 12 long vowel
units, 5 sonorant ending consonants, and 5 tones, there
are 9900 syllables of this type in the language :

$$33 \text{ C\&CC } \times \text{ 12 V: \& V:V } \times \text{ 5 C } \times \text{ 5 T } = 9900$$

Out of this number, there are 1480 syllables
that are not admissible due to the 3 inadmissible co
occurrences between the significant sound units. The
inadmissible co-occurrences are the same as in the shor
syllables ending with sonorant consonants.
Excluding the 1480 inadmissible long sonoran
ending syllables, there are 8420 admissible lon
sonorant-ending syllables in Thai (9900-1480).
The Obstruent Ending Syllables are of 2 types:
(1) *Short syllables ending with obstruen
consonants*, these syllables are composed of short vowel
or short diphthongs, they can take only 3 tones (th
low-1, the high-3 and the fall-2). With 33 initia
consonantal units, 12 short vowel units, 4 obstruen
ending consonants, and 3 tones, there are 4752 syllable
of this type in the language :

$$33 \text{ C \& CC } \times \text{ 12 V \& VV } \times \text{ 4 C } \times \text{ 3 T } = 4752$$

Out of this number, there are 72 syllable
that are not admissible due to the inadmissible co

occurrence between the significant sound units stated as follows :
   The inadmissible co-occurrence between labialized initial consonant clusters /kw, khw/ and the 4 rounded vowel units /u,o,ɔ,ua/.

   *2 CC   x   4 V & VV   x   4 C   x 3T = 96
   /kw,khw/   /u,o,ɔ,ua/   /p,t,k,ʔ/

   Excluding the 96 inadmissible short obstruent ending syllables, there are 4656 admissible long obstruent ending syllables in Thai (4752-96).
   (2) *Long syllables ending with obstruent consonants*, these syllables are composed of long vowels or long diphthongs, they can take only 3 tones (the low-1, the high-3 and the fall-2). With 33 initial consonantal units, 12 long vowel units, 3 obstruent ending consonants, and 3 tones, there are 3564 syllables of this type in the language :

   33 C & CC x 12 V: & V:V x 3 C x 3 T = 3564

   Out of this number, there are 72 syllables that are not admissible due to the inadmissible co-occurrence between the significant sound units stated as follows :
   The inadmissible co-occurrence between labialized initial consonant clusters /kw, khw/ and the 4 rounded vowel units /u:,o:,ɔ:,u:a/.

   *2 CC   x   4 V & VV   x   3 C   x 3T = 72
   /kw,khw/   /u:,o:,ɔ:,u:a/   /p,t,k/

   Excluding the 72 inadmissible short obstruent ending syllables, there are 3492 admissible short obstruent ending syllables in Thai (3564-72).
   It can be summarized that there are 26,928 grammatical syllables in Thai, the details are as follows :
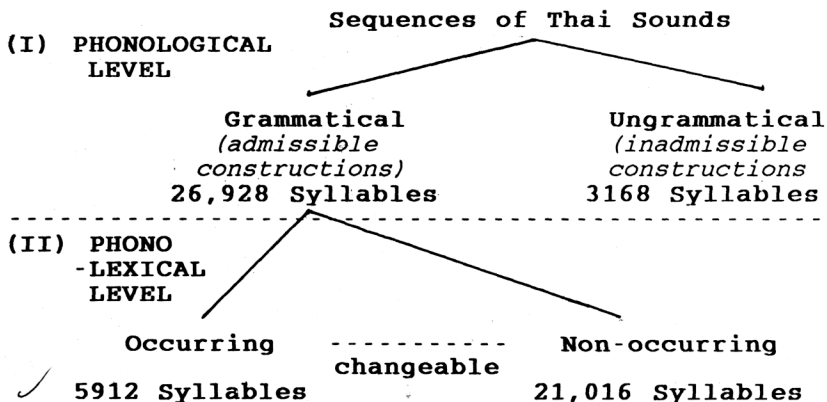
Type I   Sonorant Ending Syllables
  1.*Open Syllables*   1,940
  2.*Short Sonorant Ending Syllables*   8,420
  3.*Long Sonorant Ending Syllables*   8,420
Type II   Obstruent Ending Syllables
  1.*Short Obstruent Ending Syllables*   4,656
  2.*Long Obstruent Ending Syllables*   3,492

                                  Total   26,928

The third dimension : The study of the distribution of the phonological units in the occurring and non-occurring admissible phonological constructions of the language

   A Data Base Programming was used to generate all the 26,928 admissible syllables. These syllables were then examined by 3 research assistants,each of whom

examined all the generated grammatical syllables in Thai,and specified whether the syllables occur in their lexical repertoire or not. If the syllable occurs as a word or a word part, they had to specify the syllable as *occurring* and put all the occurring written forms called "orthographic syllables" in the DBase. If the syllable does not occur as a word or a word part, they had to specify the syllable as *Non-occurring*. After merging the DBase files of the 3 research assistants, the data was examined by two other speakers of Thai including myself. The DBase of the admissible occurring syllables was used as the knowledge base for the Thai Text to Speech System (Luksaneeyanawin 1989, 1991).

Using the schema put forward in the theoretical discussion in the introduction part of this paper, we can illustrate the third dimension of Thai phonology as follows :

Sequences of Thai Sounds

(I) PHONOLOGICAL LEVEL

| | Grammatical
*(admissible
constructions)*
26,928 Syllables | Ungrammatical
*(inadmissible
constructions*
3168 Syllables |

(II) PHONO -LEXICAL LEVEL

| | Occurring
5912 Syllables | - - - - - - - - - - -
changeable | Non-occurring
21,016 Syllables |

5893 ✓

5979

Out of the 5912 occurring syllables, there are 1061 syllables (18.2 %) that occur only as word parts, 1054 syllables (17.8 %) that occur as words with limited use ,and 3797 syllables(64%) that occur as words, or words and word parts as well. These occurring syllables are in the phono-lexical repertoire of the 5 speakers working for this knowledge representation.

The study of the distribution of the vowel units in the occurring admissible phonological constructions of the Thai language will be used to exemplify the theory of 3D Phonology

The following table shows the number of occurrences of the 12 different vowel units in the 5912 occurring admissible syllables :

	Number of Occurrences			Percentage of Occurrences		
	long	short	total	long	short	total
i	182	360	542	3.08 %	6.09 %	9.17 %
u	189	391	580	3.20 %	6.61 %	9.81 %
e	229	187	416	3.87 %	3.16 %	7.04 %
o	308	261	569	5.21 %	4.41 %	9.62 %
æ	362	163	525	6.12 %	2.76 %	8.88 %
ɔ	443	247	690	7.49 %	4.18 %	11.67 %
a	626	665	1,291	10.59 %	11.25 %	21.84 %
ɯ	109	147	256	1.84 %	2.49 %	...4.33 %
ɤ	213	87	300	3.60 %	1.47 %	5.07 %
ia	299	14	313	5.06 %	0.24 %	5 29 %
ɯa	167	0	167	2.82 %	0.00 %	2.82 %
ua	256	7	263	4.33 %	0.12 %	4.45 %
Total	3,383	2,529	5,912	57.22 %	42.78 %	100.00.%

The statistical distribution of the occurrences of the Thai vowel units ,which will be used for the discussion on the historical implication of 3D phonology, is given in a 3 dimensional distribution chart in the following figure :
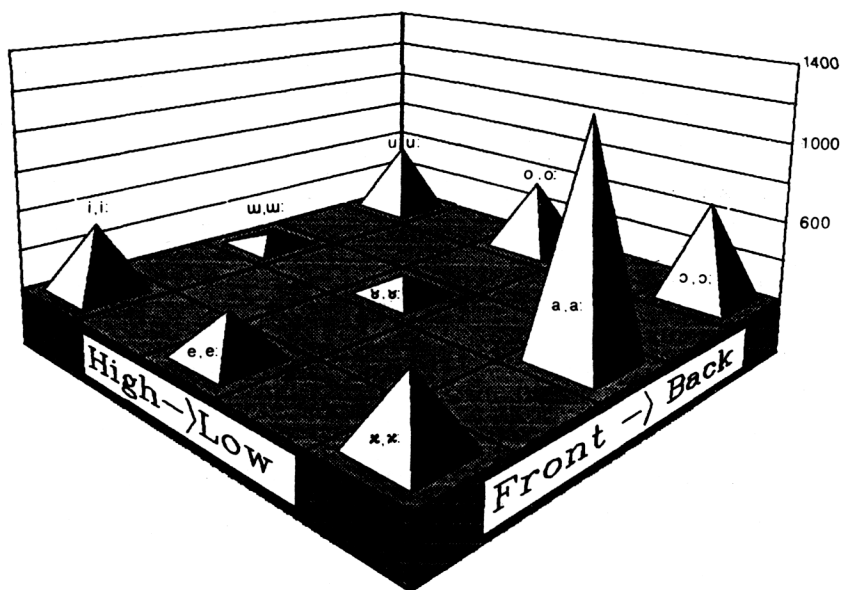
Figure 1 *the statistical distribution of the qualitatively different monophthongal vowel units.*

A Historical Implication of 3D Phonology
Background of the historical aspect of the Thai Vowels.

Thai can be classified a dialect of the Tai family. The question whether the Tai family belongs to which superstock will not be discussed here. Thai and languages related to Thai[3] have 2 main types of vowel systems as follows :

i		u		i	ɯ	u
e		o		e	ɤ	o
	a			æ	a	ɔ

The 5 vowel system in Tong, Li.Sui,

The 9 vowel system in Lue, Tai-Nuea, Thai.

The functional load of the Thai vowel units has been of a great interest among comparative and historical linguists. Li (1964) noted that the functional load of the contrast of long and short vowels, except /a/ and /a:/, in 'native Tai' or cognate words is very light even in Thai and Laos where length distinction is most evident.

Li's statement has started many arguments and different hypothetical explanations of the vowel system of Proto Tai. It also gives rise to the speculation of the Ancient Thai Vowel System (Hartman 1976, Brown 1965, 1979).

Brown (1979) has made a very interesting explanation of the evolution of the length distinction in the Thai Vowel System. His hypothesis was illustrated clearly by the following diagram.
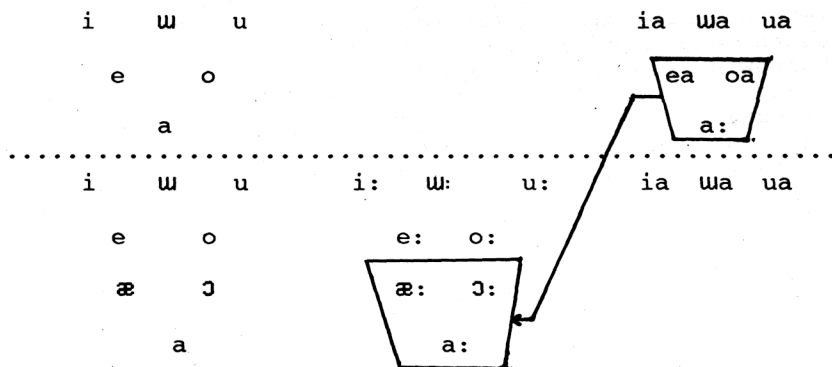
(*Adapted from Brown's 1979.*)

The lower part of the diagram shows the present situation of the vowel system, where length distinction is fully developed. Length distinction in diphthongal vowel units is not noted because of his theory on the two part tone and the two part vowel.'the Head and Tail' of the tone and the diphthong.

Hypothethical explanation of the development of the present Thai vowel system by Brown has been given from the study of the distribution of the vowels in cognate words. The hypothesis is that :

(1) Length distinction was not found in the Proto Tai Vowel System, the only length distinction was hypothesized for the /a a:/ set.

(2) Length distinction, found in the modern dialects, is a subsequent development and can be explained in terms of complementary distribution, conditioned by (a) syllable type (obstruent ending, or

sonorant ending.), (b) tones, orthographically unmarked tones and those marked by "maj thoo" are hypothesized to be two part tones,whereas those marked by "maj eek" are hypothesized to be one part tones.
　　　The development of length in monophthongal vowels is either a product of two part vowels becoming one part vowels which effect quality of vowels as well as quality of tones,for example, *ea > æ (unmarked)> æ' (short),and æ:(long) with changes of tone systems, or *oa > ɔ (unmarked) > ɔ' (short) and ɔ: (long) with changes of tone systems (see Brown's diagram above).
　　　Length distinction is also hypothesized to be a product of one part tones becoming two part tones, for example the development of /i:/ and /u:/, i.e. *i (unmarked) > i' (short) and i: (long), *u (unmarked)> u' (short),and u: (long)..
　　　Brown (1965,1979) also hypothesized that once length distinction occurred, the space in the system of short-long distinction would also be filled in by borrowings, and new formations. His analogy of the change in the Thai vowel system to the change of 'mountains' is very interesting. This kind of change explains the development of the system of language in terms of something wearing down, as well as something building up. The process was affected by the within factor (the linguistic conditioned change) and the without factor (the change conditioned by language contact).
　　　The statistical distribution of the present Thai vowel units in all the occurring admissible syllables has been given as the third dimension of the Thai vowel system. It is very interesting to find that the pattern of the distribution of short/long in the /i,u/(short<long) are remarkably different from those of the /æ,ɔ/(short>long) .The /e,o/ pattern is more similar to the /æ,ɔ/ pattern than the /e,o/ pattern. The /ɯ/ pattern of distribution is similar to the /i,u/ pattern.Whereas the /ɤ/ pattern is more similar to the /æ,ɔ/ pattern. This description is based on the details given in the table on page 9 and 10 above, and is illustrated by Figure 2 below.
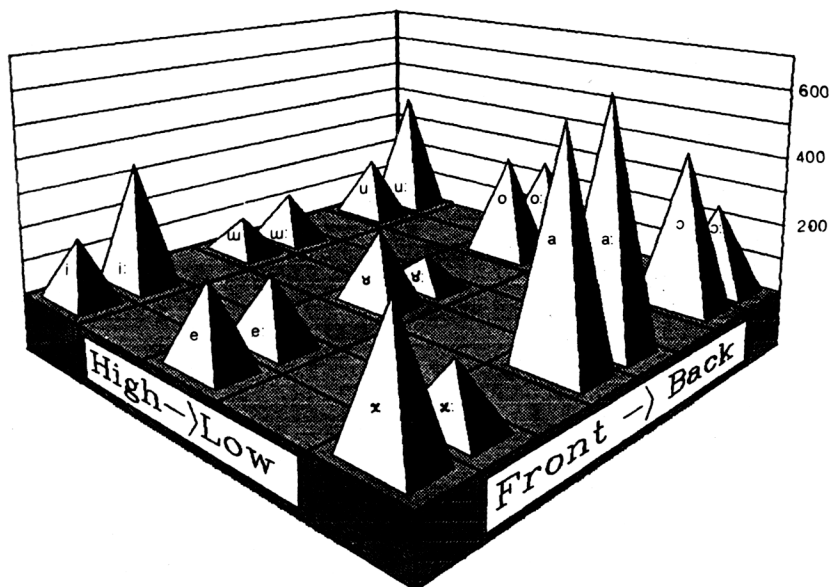
Figure 2 *the statistical distribution of the qualitatively and quantitatively different monophthongal vowel units.*

It is very interesting to find that the picture of the vowel system of the present day language, which *includes everything that does exist*, does not look very much different to the picture of the vowel system of historical linguists who always put words of foreign origins, expressives, new formations, slangs etc. aside.One surprising finding is that the amount of the /æ, ɔ/, and /e, o/, especially the back set /ɔ, o/ is quite high. It can be concluded from this study that the process of wearing down is slower than the process of building up.A further study in terms of the statistical distribution of the significant sound units in words of foreign origins will clearly show how strongly the Mon-Khmer, the Indic, and other foreign languages affect the picture of the present day language.

Traditional synchronic studies have always been based on a word list of cognates known among scholars of the language family understudied. Borrowed

words, expressives, and new formations are always put aside. I have always been interested in these *outcaste words* (Luksaneeyanawin 1982, 1984).It was Henderson (1951) who has long pointed out that the charactersitics of loanwords, always shed light on the phonological system of the borrowing language.

A lot of attention has already been paid to the comparative and historical study of cognate words. This may due to the fact that if we want to include every word in the language, the number is *infinite*. We do not know **where** to start, i.e. which dictionary to use, and **when** to start, i.e. how far away in the time domain we should start. And in my opinion there is no such list of words, since old words die, and new words exist everyday through the lexicalization process. However, if we start with *a finite number of admissible constructions of sound sequences* or the admissible syllables, as proposed in this work, we know where we can start.

It is argued here that we will have a better understanding of language change by a thorough 3D-phonological study across related languages. Comparison of the 3D phonology of the present stage of these languages, and comparison of the 3D phonology of loanwords of known origins in these related dialects should be done to give a better understanding of the historical aspect of the related languages. The remaining occuring constructions in words of unknown origins, the *'leftover'*, of which can be explicitly pointed out may give a good list of words for those historical linguists who have different hypotheses about the origin of the language.

Historical linguists usually give a clear explanation of **how** languages change, the change in terms of *the within factors*, the process of change conditioned by the change of the sound systems itself, and the change in terms of *the without factors*, the process of change affected by the language contacts.

I would like to give a final speculation that I have never found a good answer to the answer of the question,"**Why** do languages have to change?". Actually one can explain the change in terms of adaptation of living things, namely in this case, languages, to their environments, or changing of habitats. We accept the truth that language change is a natural process and is a must of any living language to survive, and language contact is usually the keyword for the explanation, but is there another keyword to this question - the physiological aspect of the human capacity in storing

the 'auditory images' of the language he is speaking? Is that the answer to the question why words have to die?

I want this article to contribute towards development of the 3D Phonology across langages.It is suggested that the cooperation of 3D Phonology with Historical Linguistics and Psycho-Neurolinguistics will provide a better understanding to the problems of historical changes in language.

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Notes

1 0 stands for the mid tone in Thai, tone is a constituent of a syllable construction in Thai.
2 These types of words are sometimes called 'deviant words' (Fudge 1969) "potential words" (Aronoff 1982), These words are less productive and pervasive. That is why they are usually used for the purpose of foregrounding in poetic language,as well as advertising language,technical terms, jargons, slangs, and academes.
3 Data from Kullavanijaya (et al), 1984.

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