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A Study of the Relative Frequency Distribution of Syllabic Components in Mandarin Chinese

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1. Introduction

1.1 *Scope*

The scope of this study is to establish a pattern of frequencies in the syllabic components of Mandarin Chinese. These components are initials, finals (medials, vowels, and endings), and tones as used in the written and spoken language. The statistical counts that have been made and which are tabulated in the paper, are based on the frequency of occurrence of the components in texts or in reported speeches and the counts themselves have been processed by a computer programme.

1.2 *Data*

The input data used was taken from *A Study on the High Frequency Words Used in Chinese Elementary School Reading Materials* 國民學校常用字彙研究[1]. This study was carried out by a consortium of world-famous Chinese linguists over a period of four years. It contains over 750,000 words (or characters),[2] taken from newspapers, Chinese elementary school texts, students' compositions, children's magazine texts, broadcasting manuscripts and adult popular magazines.[3]

1.3 *Previous review*

Not many papers or books have been previously published which discuss the frequency of the syllabic components in Mandarin. A review entitled "To Think about Chinese Vocabulary from a Frequency Count Report" 從一種統計看漢語詞彙 by Zheng Lin-xi 鄭林曦 in 1954,[4] gives us only a small part of the report which it reviewed. The review included the most frequently used initials and finals, such as /d/ (ㄉ) and /e/ (ㄜ) and initials and finals such as /p/ (ㄆ) and /ia/ (ㄧㄚ) of which the latter are rarely used, but it did not mention the syllabic components which do appear with moderate frequency.

1.4 *Uses of this study*

The above mentioned report reviewed by Zheng Lin-xi, in which the data collected amounted to no more than 50,000 characters only, can no longer be found in the literary resources of Hong Kong. Therefore, I have considered it worthwhile to present a newer and more comprehensive report on the relative probability distribution of syllabic components in Mandarin; thus providing a reference work for those who wish to improve the standard of Chinese stenography. It may help in the construction of the keyboard and the arrangement of the most frequently used homophonic characters required in the design of a syllabic Chinese typewriter. I venture to suggest that it may be of value to those who may have in mind the development of a "touch type" shorthand machine for use with spoken Mandarin.

In connection with the analysis of the input of the Chinese language in computer programmes, the present study presents scientific results which will prove useful in the future

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[1] Prepared by the National Institute for Compilation and Translation, Chung Hwa Book Co. Ltd., Republic of China, 1967.

[2] *Ibid*, p. 2, the actual number is 753,940. According to my calculation, the grand total is 754,994, only 1,054 (0.14%) more than reported.

[3] *Ibid*, pp. 1–2, "Introduction."

[4] See *Han-yu-de cir he pin-xie-fa* 漢語的詞兒和拼寫法 (Peking: Zhong Hua Book Co., 1956), pp. 31–39. This book is also available in *Yu-wen-hui-pian* 語文彙編 (Hong Kong: Lung Men Press, 1969), Vol. 6.

encoding of each syllable. This paper may also be considered a significant contribution to linguistic studies in Mandarin.

2. Method of study

2.1 *An earlier associated study in Cantonese*

"A Study of the Frequency of Vocabulary in Cantonese" was the title of my M. Phil. thesis which was finished in 1973, under the supervision of Professor Chou Fa-kao, Professor of Chinese Language and Literature in The Chinese University of Hong Kong.[5] While I was preparing the thesis and counting the Cantonese vocabulary frequency, I established a system of analysis for the syllabic components in Cantonese, derived from the frequency list of vocabulary.

Six tables were utilized to represent the six major tones in Cantonese.[6] Each table consisted of a vertical column of initials and a horizontal row of finals (Fig. 1). Thus each of the thousand odd boxes in each table represented a syllable, i.e., the first box at the upper left corner of the first table indicated the syllable together with the homophones entered in the box to which it belonged. The occurrence of initials of each tone could be calculated horizontally, and the occurrence of the finals vertically. Adding the totals of the six tables produced the total occurrence of initials and finals. In addition, the relative distribution frequency of tones, vowels, endings, and syllables could be derived from the resultant totals.

FIGURE 1. A SAMPLE TABLE FOR CALCULATING THE SYLLABIC COMPONENTS IN CANTONESE

Initials	*Finals*					*Total*
	a	aai	aau	aan	....	
b	bā					
p						
m						
f						
d						
.						
.						
.						
Total						Grand Total

[5] The thesis, written in Chinese, is now available in the library of The Chinese University of Hong Kong.

[6] These six tones in Cantonese are as follows:

1st tone: high-falling and high-level plus the first entering tone, shang-ru (上入).
2nd tone: high-rising.
3rd tone: middle-level plus the second entering tone, zhong-ru (中入).
4th tone: low-falling.
5th tone: low-rising.
6th tone: low-level plus the third entering tone, xia-ru (下入).

This analysis of the frequency of syllabic components in Cantonese finally became a section within my thesis.

The primary data of the Cantonese study was derived from little more than 50,000 characters, an average book length. Realizing that the quantity of data used was small, my next intention was to use the same method applied to more extensive material such as a broadcast manuscript and in addition to use a computer in order to reduce the time scale of the study and achieve more precise results.

2.2 *Secondary data in Mandarin*

In 1974, I discovered the book *A Study on the High Frequency Words Used in Chinese Elementary School Reading Materials*.[7] It occurred to me that it would be useful to shift my research from Cantonese to Mandarin with results reported as secondary data.

The reported vocabulary list which consisted of no more than 5,000 different characters as generated from 750,000 words, was arranged in descending order according to frequency, transcribed by Mandarin Phonetic Letters.

The study included a Mandarin Phonetic Letter index as an appendix. In this index the characters were arranged according to their respective Mandarin Phonetic Letter transcriptions. Characters with the same pronunciation were grouped together. A figure to the right of each character indicated the order number under which the character's frequency could be found in the body of the vocabulary list.

It proved to be more convenient to use the index, since the homophones were already grouped together. In order to make use of the index, the first step was to analyse the actual frequency of each character from the vocabulary list, according to the order number. The second step was to add up the frequencies of characters within each syllable (i.e. homophones). This total occurrence of each syllable was then entered in each box among the five tables representing five tones in Mandarin: 1st, 2nd, 3rd, 4th, and neutral tone.[8] In this way the occurrence of initials and finals could be calculated by exactly the same process as previously used for Cantonese.

2.3 *Application of computer*

As the analysis involved over 750,000 characters, I utilized the computer instead of calculation, in order to reduce errors. To use the computer, no tabulation was necessary, and the programme was designed according to the theory discussed above.

2.3.1 Modified System

Since the computer language is incompatible with Mandarin Phonetic Letters, it was necessary that I devise a new romanization for the preparation of the programme. The romanization was devised mainly from the Pin-yin System[9] since the initials used are the same. However, changes were required for the purpose of writing finals.

Three major points of difference are as follows:

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[7] Refer to n. 1.

[8] See Appendix I for these five tables.

The transcription used here represented the sounds of characters. It was because no tone-sandhi could be found in the secondary data. Characters in neutral tones are those which have neutral tones only.

[9] The Pin-yin System 漢語拼音方案 was established in Mainland China in 1957 and is now widely used.

(a) The vowel /ü/ is written as /y/, so the four members of /ü/ group are changed from ü, üe, üan, ün to y, ye, yan, yn.
(b) Instead of /i/, the /v/ is used as the final (vowel) for /zh/, /ch/, /sh/, and /r/ initials whereas a /-i/ signal is used in /z/, /c/, and /s/ initials. That is, the syllables zhi, chi, shi, ri, zi, ci, and si in the Pin-yin System are written as zhv, chv, shv, rv, z-i, c-i, and s-i here.[10]
(c) The figures 1, 2, 3, 4, 5 at the end of each romanization indicates the 1st, 2nd, 3rd, 4th, and neutral tones respectively, e.g. bā in Pin-yin is written as ba 1.

Apart from these changes, all other basic forms are used in spelling.

In the Pin-yin System, some finals are subject to change under certain conditions. All forms used here must be basic forms, otherwise, the computer will not operate accurately.[11]

The correlation between this Modified System and the Pin-yin System is shown in Table 1 (brackets show the International Phonetic Alphabets [IPA][12] and Mandarin Phonetic Letters [MPL]).

TABLE 1. THE CORRELATION BETWEEN THE MODIFIED SYSTEM AND THE PIN-YIN SYSTEM

A. Initials (same as the Pin-yin System)

b (b̩ ㄅ),	p (p^h ㄆ),	m (m ㄇ),	f (f ㄈ),
d (d̩ ㄉ),	t (t^h ㄊ),	n (n ㄋ),	l (l ㄌ),
g (ġ ㄍ),	k (k^h ㄎ),	h (x ㄏ),	Ø (zero),
j (tɕ ㄐ),	q ($tɕ^h$ ㄑ),	x (ɕ ㄒ),	
zh (tʂ ㄓ),	ch ($tʂ^h$ ㄔ),	sh (ʂ ㄕ),	r (ɹ ㄖ),
z (ts ㄗ),	c (ts^h ㄘ),	s (s ㄙ).	

[10] The application of these two signals is merely for the purpose of calculating those vowels in a more detailed way. It would be unnecessary if used for other purposes.

[11] There are three points about the ways of writing in the Pin-yin System:

1. When /i/, /u/, /ü/, and a final beginning with /i/, /u/ or /ü/ are not preceded by any consonants (zero initial). They must be written as follows:
   yi, ya, ye, yan, you, yao, yin, yang, ying, yong.
   wu, wa, wo, wai, wei, wan, wen, wang, weng.
   yu, yue, yuen, yun (the two dots on u are omitted).
   Here the basic forms are used, they are:
   i, ia, ie, ian, iou, iao, in, iang, ing, iong.
   u, ua, uo, uai, uei, uan, uen, uang, ueng.
   y, ye, yan, yn.
2. When /ü/ or a final beginning with /ü/ spells with /j/, /q/, /x/, they may be written as ju, qu, xu, without the two dots on /ü/, but when the consonants /n/, /l/ are followed by /ü/, the two dots cannot be omitted. Here when the /y/ spells with /j/, /q/, /x/, /n/, /l/, they are written as jy, qy, xy, ny, and ly.
3. /iou/, /uei/, and /uen/ are basic forms, but they must be written as /-iu/, /-ui/, and /-un/ when they are preceded by a consonant. Here, they remain unchanged e.g., use niou 2 (cow) instead of niú.

[12] The IPA for Mandarin used here is according to the charts in Y. R. Chao, *The Grammar of Spoken Chinese* (University of California Press, 1968), pp. 22–24.

TABLE 1 (*cont'd*)

B. Finals

Modified	*Pin-yin*	*IPA*	*MPL*	*Modified*	*Pin-yin*	*IPA*	*MPL*
a	a	A	ㄚ	iou	iou	iou	ㄧㄡ
o	o	o	ㄛ	ian	ian	iɛn	ㄧㄢ
e	e	ɤ	ㄜ	in	in	in	ㄧㄣ
-i	i	ɻ̩	/	iang	iang	iaŋ	ㄧㄤ
v	i	ɹ̩	/	ing	ing	iŋ	ㄧㄥ
er	er	ɚ	ㄦ	iong	iong	iʊŋ	ㄩㄥ
ai	ai	ai	ㄞ	u	u	u	ㄨ
ao	ao	au	ㄠ	ua	ua	uA	ㄨㄚ
ou	ou	ou	ㄡ	uo	uo	uɤ	ㄨㄛ
an	an	an	ㄢ	uai	uai	uai	ㄨㄞ
en	en	ən	ㄣ	uei	uei	uei	ㄨㄟ
ang	ang	aŋ	ㄤ	uan	uan	uan	ㄨㄢ
eng	eng	ʌŋ	ㄥ	uen	uen	uən	ㄨㄣ
ong	ong	ŋ	ㄨㄥ	uang	uang	uaŋ	ㄨㄤ
i	i	ɑi	ㄧ	ueng	ueng	uʌŋ	ㄨㄥ
ia	ia	iA	ㄧㄚ	y	ü	y	ㄩ
iai	iai	iai	ㄧㄞ	ye	üe	yɛ	ㄩㄝ
iao	iao	iau	ㄧㄠ	yan	üan	yan	ㄩㄢ
ie	ie	iɛ	ㄧㄝ	yn	ün	yn	ㄩㄣ
io	io	io	ㄧㄛ				

2.3.2 Programme

The programme (ALGOL) containing approximately 250 cards can be seen in Appendix III. I wish to thank Mr. Wong Kar-lung, a tutor and graduate student of the Electronics Department, The Chinese University of Hong Kong in 1975, for writing the computer programme.

2.3.3 Input data

The secondary data outlined above was first listed out phonetically together with the frequency of its occurrence and then added to the occurrence of homophones to get the frequency of each syllable. The total number of syllables studied was 1,153. Each syllable is part of a relative distribution frequency. This was the input data to be punched. The number of its frequency was punched after the tone of a syllable, e.g. ba 1: 2216 means the first tone of ba syllable occurred 2,216 times in 750,000 characters.

The 1,153 syllables input data can be tabulated in five tables representing five tones in Mandarin (see Appendix I).

In order to ensure that the checking and punching operation was performed correctly, the whole calculation was divided into six running processes. Five of them were used to run the five tones separately, the last to deal with the grand totals.

2.3.4 Output results

The resultant figures of the six running processes were tabulated in Table 2 indicating the relative frequency distribution of initials and finals in Mandarin.

TABLE 2

A. The output results of initials

	1	2	3	4	5	*Total*
b	6211	2076	9983	18863	0	37133
p	913	3323	1089	2243	0	7568
m	1277	8668	5372	6166	6649	28132
f	8170	2728	3432	5055	0	19385
d	9782	3883	4829	28517	28437	75448
t	12372	11243	3623	3100	34	30372
n	10	8626	4285	3470	626	17017
l	755	12275	8632	13257	7203	42122
z	1027	1319	4931	16259	2128	25664
c	1344	3694	1208	2275	0	8521
s	7076	312	2473	6402	0	16253
zh	13722	2180	7449	14556	2153	40060
ch	6325	10013	1609	1632	0	19579
sh	14808	11977	6722	25400	60	58967
r	44	9194	507	4911	0	14656
j	16867	5276	7810	18189	0	48142
q	5784	8493	3432	5501	0	23210
x	11148	8608	6865	13557	0	40178
g	11845	7297	5721	11188	0	36051
k	3521	163	4719	6319	0	14722
h	3034	11804	7058	15986	1	37883
Ø	23282	20998	32579	37072	0	113931
Total	159307	154150	134328	259918	47291	754994

B. The output results of finals

	1	2	3	4	5	*Total*
a	13583	2810	5591	8952	353	31289
o	584	1167	39	1048	0	2838
e	2531	8153	3030	16001	40363	70078
-i	1756	586	1525	6766	2128	12761
v	6542	11148	3483	19933	1	41107
er	0	2555	677	4381	0	7613
ai	2374	9404	3839	13236	0	28853
ei	1925	2366	5355	3995	0	13641
ao	2931	1597	8072	10263	34	22897
ou	4822	1837	3323	5531	2	15515
an	8995	5373	3715	12579	0	30662
en	4885	7441	5415	2386	4325	24452
ang	5588	4724	2433	6643	59	19447
eng	6977	6618	2625	3867	0	20087
ong	12520	5713	3476	4716	0	26425

i	22182	10188	17648	19830	16	69864
ia	4680	510	461	3501	0	9152
iai	0	11	0	0	0	11
iao	1932	1935	4600	10686	0	19153
ie	2447	2368	5288	4047	0	14150
io	8	0	0	0	0	8
iou	981	4480	9438	7814	0	22713
ian	7497	7812	3236	11912	0	30457
in	6942	3671	1119	2904	0	14636
iang	3525	2750	3949	5128	0	15352
ing	7369	8542	2066	6201	0	24178
iong	278	358	451	2698	0	3785
u	6538	8609	10938	23642	0	49727
ua	1135	1116	122	2215	0	4588
uo	5594	8541	11247	8140	10	33532
uai	74	156	11	2617	0	2858
uei	2007	3589	2697	11144	0	19437
uan	3517	2233	1871	2102	0	9723
uen	1366	2038	537	2142	0	6083
uang	1561	1762	1079	1188	0	5590
ueng	74	0	1	0	0	75
y	1356	2392	3882	6473	0	14103
ye	578	4293	155	2892	0	7918
yan	413	4577	907	1021	0	6918
yn	1240	727	27	1324	0	3318
Total	159307	154150	134328	259918	47291	754994

2.3.5 Summary

Figure 2 summarizes the whole process of the calculation.

3. Initials

3.1 *Relative frequency of initials in Mandarin*

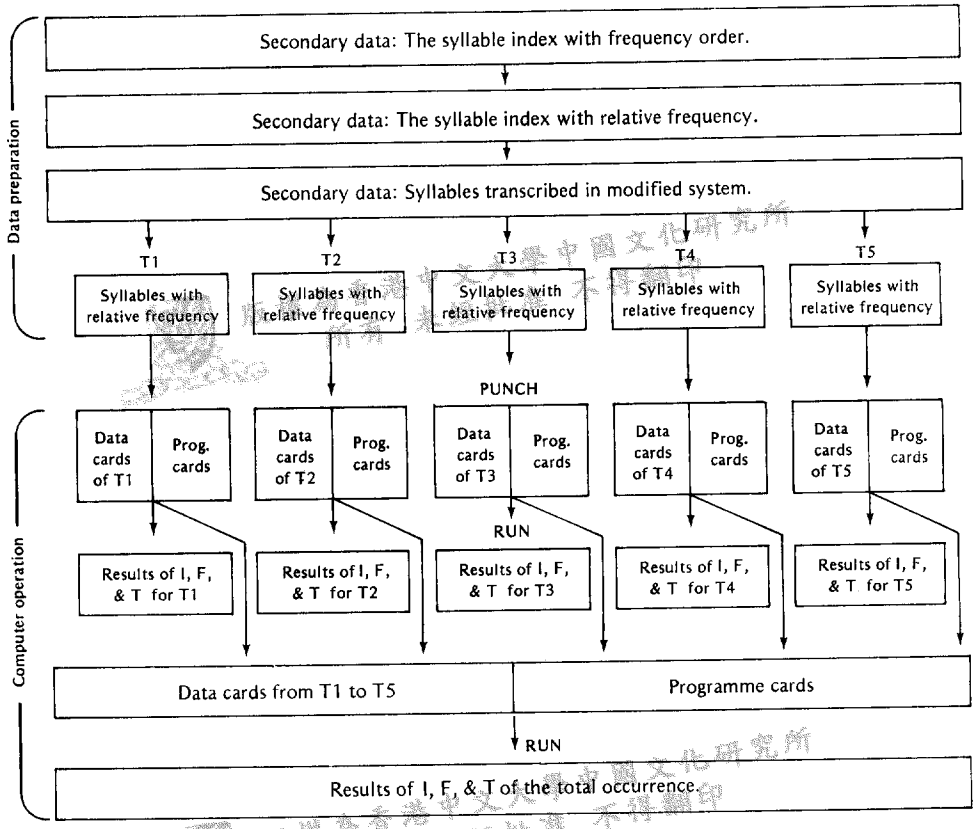
In Mandarin, 15.09% of the syllables have the zero (Ø) initial. The most frequently used initial is /d/ constituting 10% (actually 9.99%) followed by /sh/ constituting 7.81%. The least frequently used initial is /p/ constituting 1.00%. Slightly more common than /p/ are the initials /c/ and /r/ constituting 1.13% and 1.94% respectively (Table 3).

The high frequency of Ø (zero) in the result of this survey is due to the fact that the letters "y", "w" in Pin-yin are written as zero initial here. If the "y", "w" are counted as initials (whose percentage is about 73%, see Section 5), only 2% zero initial is left for the main vowels /a/, /e/, and /o/.

The arrangement in order of frequency shows that, of the 22 initials (including Ø) distinguished:

The first 2 initials make up over 25% of the total.
The first 6 initials make up over 50% of the total.
The first 12 initials make up over 75% of the total.

FIGURE 2. THE PROCESS OF CALCULATION



Key: I=Initials; F=Finals; T=Tones.

TABLE 3. RELATIVE FREQUENCY OF INITIALS IN MANDARIN

A. Arranged in phonetic order.

Initial	*Tone*					*Total*	*Percentage*
	1st	*2nd*	*3rd*	*4th*	*Neutral*		
b	6,211	2,076	9,983	18,863	0	37,133	4.92
p	913	3,323	1,089	2,243	0	7,568	1.00
m	1,277	8,668	5,372	6,166	6,649	28,132	3.72
f	8,170	2,728	3,432	5,055	0	19,385	2.57
Total	16,571	16,795	19,876	32,327	6,649	92,218	12.21%

TABLE 3 (*cont'd*)

Inital	*Tone*					*Total*	*Percentage*
	1st	*2nd*	*3rd*	*4th*	*Neutral*		
d	9,782	3,883	4,829	28,517	28,437	75,448	9.98
t	12,372	11,243	3,623	3,100	34	30,372	4.02
n	10	8,626	4,285	3,470	626	17,017	2.25
l	755	12,275	8,632	13,257	7,203	42,122	5.58
Total	22,919	36,027	21,369	48,344	36,300	164,959	21.83%
z	1,027	1,319	4,931	16,259	2,128	25,664	3.40
c	1,344	3,694	1,208	2,275	0	8,521	1.13
s	7,066	312	2,473	6,402	0	16,253	2.15
Total	9,437	5,325	8,612	24,936	2,128	50,438	6.68%
zh	13,722	2,180	7,449	14,556	2,153	40,060	5.31
ch	6,325	10,013	1,609	1,632	0	19,579	2.59
sh	14,808	11,977	6,722	25,400	60	58,967	7.81
r	44	9,194	507	4,911	0	14,656	1.94
Total	34,899	33,364	16,287	46,499	2,213	133,262	17.65%
j	16,867	5,276	7,810	18,189	0	48,142	6.38
q	5,784	8,493	3,432	5,501	0	23,210	3.07
x	11,148	8,608	6,865	13,557	0	40,178	5.32
Total	33,799	22,377	18,107	37,247	0	111,530	14.77%
g	11,845	7,297	5,721	11,188	0	36,051	4.77
k	3,521	163	4,719	6,319	0	14,722	1.95
h	3,034	11,804	7,058	15,986	1	37,883	5.02
Ø	23,282	20,998	32,579	37,072	0	113,931	15.09
Total	41,682	40,262	50,077	70,547	1	202,587	26.83%
G. total	159,232	154,150	134,328	259,918	47,291	754,994	99.97%

B. Arranged in order of frequency.

Initial	*Occurrence*	*Percentage*	*Initial*	*Occurrence*	*Percentage*
Ø	113,931	15.09	m	28,132	3.72
d	75,448	9.99	z	25,664	3.40
sh	58,967	7.81	q	23,210	3.07
j	48,142	6.38	ch	19,579	2.59
l	42,122	5.58	f	19,385	2.57
x	40,178	5.32	n	17,017	2.25
zh	40,060	5.31	s	16,253	2.15
h	37,883	5.02	k	14,722	1.95
b	37,133	4.92	r	14,656	1.94
g	36,051	4.77	c	8,521	1.13
t	30,372	4.02	p	7,568	1.00

3.2 *Compared with the report reviewed*

These results are in agreement with those quoted in the review in *Yu-wen-hui-pian* of the work done in Mainland China. The researchers in Mainland China found the initial /d/ appeared most frequently (7.83%) and the initial /p/ least frequently (0.35%).[13]

3.3 *Compared with the similar investigation in Cantonese*

Comparison of the above results with frequency of initials in Cantonese[14] shows that /g/ (13.6%) is the most common initial in Cantonese whereas /d/ (9.99%) is the most common in Mandarin. This is a result of the frequent occurrence of a suffix pronounced as ge 嘅 in Cantonese and as dé 的 in Mandarin. However, in both Mandarin and Cantonese /p/ is found to be the least frequently used initial. (In Mandarin 1.00%; in Cantonese 0.53%.)

3.4 *Tabulated in terms of place features*

The distribution frequency of initials can be tabulated in terms of their place and manner features. In terms of place features, the dentals rank highest with 21.84%, followed by the retroflexes with 17.65%, zero with 15.09%, dental sibilants with 14.77%, and labials with 12.21%. The remainder is occupied by the gutturals (11.74%) and palatals (6.68%). (Table 4A, Figure 3A.)

TABLE 4. RELATIVE FREQUENCY DISTRIBUTION OF INITIAL CLASSES

A. Classified by Place Features.

Initial class	*Members*	*Totals*	*Percentage*
Zero	Ø	113,931	15.09
Labials	b, p, m, f	92,218	12.21
Dentals	d, t, n, l	164,959	21.84
Dental Sibilants	j, q, x	111,530	14.77
Retroflexes	zh, ch, sh, r	133,262	17.65
Palatals	z, c, s	50,438	6.68
Gutturals	g, k, h	88,656	11.74
Total	22	754,994	99.98

B. Classified by Manner Features.

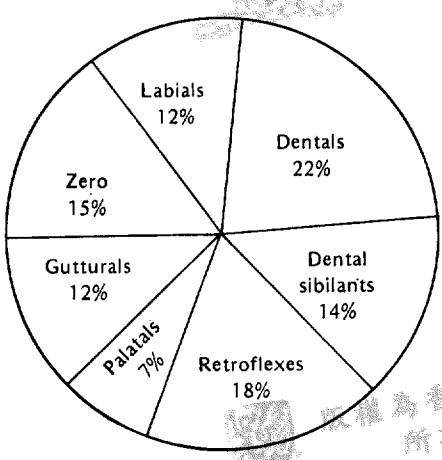
Initial class	*Members*	*Totals*	*Percentage*
Zero	Ø	113,931	15.09
Unaspirated stops	b, d, j, zh, z, g	262,498	34.77
Aspirated stops	p, t, q, ch, c, k	103,972	13.77
Nasals	m, n	45,149	5.98
Fricatives	f, x, sh, s, h	172,666	22.87
Voiced continuants	l, r	56,778	7.52
Total	22	754,994	100.00

[13] Zheng's review in *op. cit.*, p. 39.

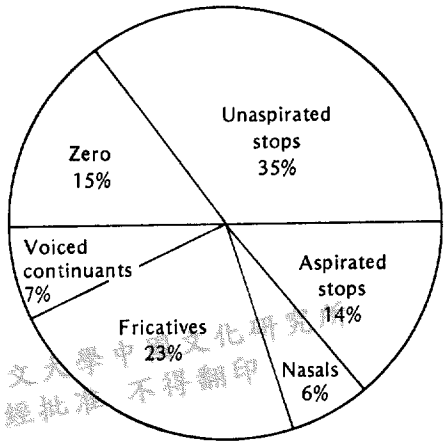
[14] With reference to my M. Phil. thesis presented to The Chinese University of Hong Kong in 1973, V. I.

FIGURE 3. DISTRIBUTION OF INITIAL CLASSES

Total: 754,994



A. Classified by place features



B. Classified by manner features

3.5 *The importance of sibilant sounds in Mandarin and Cantonese*

The term "sibilant sounds" is used here to indicate dental sibiliants, retroflexes, and palatals. Normally they are the most difficult to pronounce for non-Mandarin speakers, especially native Cantonese speakers, and the results show that these sibilants form approximately 40% of the total sample. Thus, it is obvious that, for a student to be competent in speaking Mandarin, much time must be spent in mastering these initials.

Among these ten initials /sh/ is the most frequently used constituting 7.81%. If this initial is mispronounced, 781 words in every 10,000 will be inaccurate and difficult to comprehend. Similarly mispronunciation of /zh/ will result in 531 erroneous words in every 10,000.

The sibilant sounds also constitute a large proportion (33.7%)[15] of the initial found in Cantonese. Hence it appears that in Chinese, at least in Mandarin and Cantonese, the sibilant sounds are of the utmost importance.

3.6 *Tabulated in terms of manner features*

In terms of manner features, however, the stops as a class constitute 48.54% (unaspirated stops 34.77%, aspirated stops 13.77%), followed by fricatives 22.87%, zero 15.09%, voiced continuants 7.52%, and finally nasals 5.98%. (Table 4B, Figure 3B.)

3.7 *The commonest word dė 的 in Mandarin*

The word dė 的 is the most frequently used word in Mandarin and as such constitutes 26,738[16] of the 75,448 characters having the /d/ initial (35%). This is why the unaspirated stops and labials rank highest among the manner features and place features respectively.

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[15] *Ibid.*

[16] See Appendix II.

3.8 *A proposal for encoding Mandarin initials*

The following table sets out one viable method of encoding Mandarin initials based on the work of Mr. Wong.[17]

TABLE 5. RELATIVE PROBABILITY DISTRIBUTION OF INITIALS IN MANDARIN

Initials	*Probability %*	*Binary coding*	*Initials*	*Probability %*	*Binary coding*
Ø	0.1507	000	t	0.0390	11000
d	0.0998	001	z	0.0339	11001
sh	0.0780	0100	q	0.0307	11010
j	0.0637	0101	ch	0.0258	11011
l	0.0557	0110	f	0.0256	11100
x	0.0531	0111	n	0.0225	11101
zh	0.0530	1000	s	0.0215	111100
h	0.0501	1001	k	0.0195	111101
b	0.0499	1010	r	0.0194	111110
g	0.0477	10110	c	0.0113	1111110
m	0.0399	10111	p	0.0100	1111111

4. Finals

4.1 *Relative frequency of Mandarin finals by traditional classification*

Traditionally, finals in Chinese syllables can be classified into four categories, namely, kai-kou-hu, qi-chi-hu, he-kou-hu, and cuo-kou-hu.[18] Of these four categories of final in Mandarin, the final kai-kou-hu occurs in 48.68% of the sample; the qi-chi-hu 29.58%; the he-kou-hu 17.44%; and cuo-kou-hu 4.28% of the same sample (Table 6, Fig. 4).

TABLE 6. RELATIVE FREQUENCY OF FINALS IN MANDARIN

A. Analysed in modified system, arranged in phonetic order.

Final	*Tone*					*Total*	*Percentage*
	1st	*2nd*	*3rd*	*4th*	*Neutral*		
a	13,583	2,810	5,591	8,952	353	31,289	4.14
o	584	1,167	39	1,048	0	2,838	0.38
e	2,531	8,153	3,030	16,001	40,363	70,078	9.28
-i	1,756	586	1,525	6,766	2,128	12,761	1.69
v	6,542	11,148	3,483	19,933	1	41,107	5.44
er	0	2,555	677	4,381	0	7,613	1.01

[17] See § 4.6.

[18] kai-kou-hu 開口呼: finals that do not include /i/, /u/, /ü/ vowels or medials.
qi-chi-hu 齊齒呼: finals that begin with unrounded high front vowel or medial /i/.
he-kou-hu 合口呼: finals formed by a rounded back vowel or medial /u/.
cuo-kou-hu 撮口呼: finals that contain a rounded front vowel or medial /ü/.

TABLE 6 (*cont'd*)

Final	*Tone* 1st	2nd	3rd	4th	Neutral	*Total*	*Percentage*
ai	2,374	9,404	3,839	13,236	0	28,853	3.82
ei	1,925	2,366	5,355	3,995	0	13,641	1.81
ao	2,931	1,597	8,072	10,263	34	22,897	3.03
ou	4,822	1,837	3,323	5,531	2	15,515	2.05
an	8,995	5,373	3,715	12,579	0	30,662	4.06
en	4,885	7,441	5,415	2,386	4,325	24,452	3.24
ang	5,588	4,724	2,433	6,643	59	19,447	2.57
eng	6,977	6,618	2,625	3,867	0	20,087	2.66
ong	12,520	5,713	3,476	4,716	0	26,425	3.50
Total	76,013	71,492	52,598	120,297	47,265	367,665	48.68%
i	22,182	10,188	17,648	19,830	16	69,864	9.25
ia	4,680	510	461	3,501	0	9,152	1.21
iai	0	11	0	0	0	11	0.001
iao	1,932	1,935	4,600	10,686	0	19,153	2.54
ie	2,447	2,368	5,288	4,047	0	14,150	1.87
io	8	0	0	0	0	8	0.001
iou	981	4,480	9,438	7,814	0	22,713	3.01
ian	7,497	7,812	3,236	11,912	0	30,457	4.03
in	6,942	3,671	1,119	2,904	0	14,636	1.94
iang	3,525	2,750	3,949	5,128	0	15,352	2.03
ing	7,369	8,542	2,066	6,201	0	24,178	3.20
iong	278	358	451	2,698	0	3,785	0.50
Total	57,841	42,625	48,256	74,721	16	223,459	29.58%
u	6,538	8,609	10,938	23,642	0	49,727	6.59
ua	1,135	1,116	122	2,215	0	4,588	0.61
uo	5,594	8,541	11,247	8,140	10	33,532	4.44
uai	74	156	11	2,617	0	2,858	0.38
uei	2,007	3,589	2,697	11,144	0	19,437	2.57
uan	3,517	2,233	1,871	2,102	0	9,723	1.29
uen	1,366	2,038	537	2,142	0	6,083	0.81
uang	1,561	1,762	1,079	1,188	0	5,590	0.74
ueng	74	0	1	0	0	75	0.01
Total	21,866	28,044	28,503	53,190	10	131,613	17.44%
y	1,356	2,392	3,882	6,473	0	14,103	1.87
ye	578	4,293	155	2,892	0	7,918	1.05
yan	413	4,577	907	1,021	0	6,918	0.92
yn	1,240	727	27	1,324	0	3,318	0.44
Total	3,587	11,989	4,971	11,710	0	32,257	4.28%
G. total	159,307	154,150	134,328	259,918	47,291	754,994	99.98%

B. Analysed in modified system, arranged in order of frequency.

Final	*Occurrence*	*Percentage*	*Final*	*Occurrence*	*Percentage*
e	70,078	9.28	in	14,636	1.94
i	69,864	9.25	ie	14,150	1.87
u	49,727	6.59	y	14,103	1.87
v	41,107	5.44	ei	13,641	1.81
uo	33,532	4.44	-i	12,761	1.69
a	31,289	4.14	uan	9,723	1.29
an	30,662	4.06	ia	9,152	1.21
ian	30,457	4.03	ye	7,918	1.05
ai	28,853	3.82	er	7,613	1.01
ong	26,425	3.50	yan	6,918	0.92
en	24,452	3.24	uen	6,083	0.81
ing	24,178	3.20	uang	5,590	0.74
ao	22,897	3.03	ua	4,588	0.61
iou	22,713	3.01	iong	3,785	0.50
eng	20,087	2.66	yn	3,318	0.44
uei	19,437	2.57	uai	2,858	0.38
ang	19,447	2.57	o	2,838	0.38
iao	19,153	2.54	ueng	75	0.01
ou	15,515	2.05	iai	11	0.001
iang	15,352	2.03	io	8	0.001

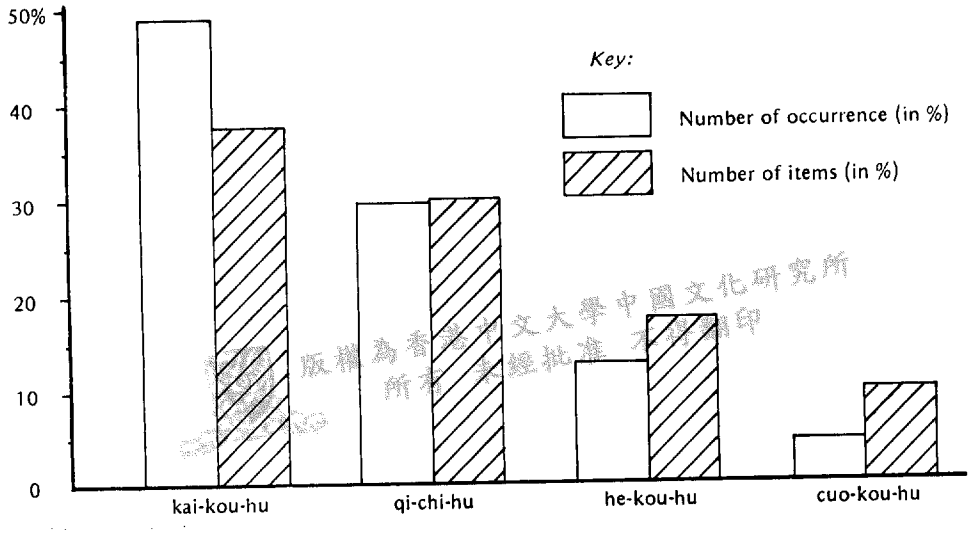
C. Analysed in MPL, arranged in order of frequency.

Final	*Occurrence*	*Percentage*	*Final*	*Occurrence*	*Percentage*
ㄜ	70,078	9.28	ㄧㄣ	14,636	1.94
ㄧ	69,864	9.25	ㄧㄝ	14,150	1.87
ㄨ	49,727	6.59	ㄩ	14,103	1.87
(ㄓ)	41,107	5.44	ㄟ	13,641	1.81
ㄨㄛ	33,532	4.44	(ㄗ)	12,761	1.69
ㄚ	31,289	4.14	ㄨㄢ	9,723	1.29
ㄢ	30,662	4.06	ㄧㄚ	9,152	1.21
ㄧㄢ	30,457	4.03	ㄩㄝ	7,918	1.05
ㄞ	28,853	3.82	ㄦ	7,613	1.01
ㄨㄥ	26,500*	3.51	ㄩㄢ	6,918	0.92
ㄣ	24,452	3.24	ㄨㄣ	6,083	0.81
ㄧㄥ	24,178	3.20	ㄨㄤ	5,590	0.74
ㄠ	22,897	3.03	ㄨㄚ	4,588	0.61
ㄧㄡ	22,713	3.01	ㄩㄥ	3,785	0.50
ㄥ	20,087	2.66	ㄩㄣ	3,318	0.44
ㄨㄟ	19,437	2.57	ㄨㄞ	2,858	0.38
ㄤ	19,447	2.57	ㄛ	2,838	0.38
ㄧㄠ	19,153	2.54	ㄧㄞ	11	0.001
ㄡ	15,515	2.05	ㄧㄛ	8	0.001
ㄧㄤ	15,352	2.03			

*26,500 = 26,425 (ong) + 75 (ueng)

FIGURE 4. RELATIVE FREQUENCY DISTRIBUTION OF FINAL CLASSES BY TRADITIONAL CLASSIFICATION

Total: 754,994



4.2 *Analysis of the frequency of Mandarin finals*

The most frequent single final in Mandarin is /e/ occurring as 9.28% of the sample, followed by /i/ 9.25%, /u/ 6.59%, /v/ [ɪ] 5.44%, /uo/ 4.44%, /a/ 4.14%, and those least frequently used are /io/ and /iai/, each with a sample frequency of only 0.001%. Only slightly more common than /io/ and /iai/ are the finals /ueng/, /o/, and /uai/, constituting 0.01%, 0.38%, and 0.38% of the sample respectively (Table 6B).

The arrangement in order of frequency indicates that, of the 40 finals in Mandarin which have been analysed: (*a*) The first 3 finals make up over 25% of the total; (*b*) The first 9 finals make up over 50% of the total; and (*c*) The first 18 finals make up over 75% of the total.

4.3 *Comparison of these results with the work done in Mainland China*

Considered on a percentile basis, the results given in this paper and those quoted from the previously mentioned review in *Yu-wen hui-pian* of similar work carried out in Mainland China indicate a similar pattern of distribution. In this review, the /e/, /i/, and /u/ were also reported as being the most frequently used finals with quoted percentages of 6.68%, 5.31%, and 3.77% respectively.[19]

The total percentage of the above three finals as generated from 50,000 words is only 15% of the sample, and is 10% less than the total percentage of the respective finals reported in this study, as derived from a 750,000 word sample. The increase now demonstrated derives from use of a greatly enlarged sample.

The least commonly used finals reported in the Mainland China study are /ei/, /o/, /uen/, and /ia/ in descending order of frequency, constituting 0.7%, 0.44%, 0.11%, and 0.03%, whereas this study shows the least commonly used four finals to be /o/, /ueng/, /iai/, and /io/

[19] Zheng's review in *op. cit.*, p. 39.

constituting as they do 0.38%, 0.01%, 0.001%, and 0.001% of the sample. The total percentage of the former is 1.28% while the latter is only 0.4%.

4.4 *The Commonly used characters with /e/, /i/ or /u/ finals (analysed in the modified system)*

According to the report prepared in the Republic of China (see §1.2), the word dė 的 constitutes 26,738 of the 75,448 characters and ranks highest as mentioned above (see §3.7). Other frequently used words (over 1,000 occurrences in the 750,000 character sample) with /e/ vowel are lė 了 (7,176) zhè 這 (3,967), gè 個 (3,776), kě 可 (2,426), mė 麼 (1,998), zhe 着 (1,573), shé 甚 (1,426), kè 課 (1,310), gè 各 (1,228), dé 得 (1,064). The total occurrence of these characters constitutes 70% of the total occurrence of the final /e/.

As for those words containing /i/ or /u/, the analysis is as follows:

/i/	:	ī 一	(14,147)	ǐ 以	(3,500)	dì 地	(2,838)	dì 第	(2,517)
		nǐ 你	(1,981)	lǐ 裏	(1,981)	qǐ 起	(1,584)	qì 氣	(1,113)
		lì 力	(1,074)	lì 立	(1,021)				
/u/	:	bù 不	(6,634)	wǔ 五	(2,800)	chū 出	(1,944)	tú 圖	(1,518)
		bù 部	(1,475)	rú 如	(1,208)	wù 物	(1,134)	zhǔ 主	(1,121)
		lù 路	(1,033)						

4.5 *The relative frequency distribution of* ㄨㄥ

A major difference between the results reported in Mainland China and the results of this present study is the observed frequency of the final ㄨㄥ.[20]

It ranks fourth in the former constituting 2.55% in 50,000 but tenth in the latter, constituting 3.51% in 750,000 (including 0.01% of /ueng/).

If one considers the final /ong/, several commonly used words appear such as:

zhōng 中 (3,905)	gōng 公 (1,537)	dōng 東 (1,535)	zhǒng 種 (1,500)
tóng 同 (1,475)	dòng 動 (1,455)	gōng 工 (1,165)	cóng 從 (1,113)

It was found in this survey, that /uo/, /a/, /an/, /ian/, and /ai/ rank higher than /ong/.[21] They occur more frequently in words like:

/uo/	:	wǒ 我	(7,461)	guó 國	(6,107)	shuō 說	(2,737)	duō 多	(2,159)
		suǒ 所	(1,575)						
/a/	:	dà 大	(4,810)	tā 他	(4,505)	nà 那	(1,698)	fā 發	(1,696)
		bǎ 把	(1,692)	fǎ 法	(1,505)	bā 八	(1,457)		
/an/	:	sān 三	(4,006)	hán 和	(3,519)[22]	nán 南	(1,545)	shān 山	(1,335)
		rán 然	(1,183)						
/ian/	:	tiān 天	(3,280)	nián 年	(2,790)	miàn 面	(1,800)	diàn 電	(1,131)
		qián 前	(1,065)						
/ai/	:	zài 在	(6,631)	lái 來	(4,357)	hǎi 海	(1,389)	kāi 開	(1,297)
		hái 還	(1,154)	tài 太	(1,005)				

[20] The report discussed in the review used the Mandarin Phonetic Letters (see Table 6C for the relative frequency of Mandarin finals in MPL). The final ㄨㄥ in MPL consists of finals/ong/ and /ueng/ in the Pinyin system. Of these two finals, /ueng/ is rarely used, it only occurs 75 times within 750,000 characters.

[21] In the present discussion I have neglected the fourth rank /v/, since the /v/ [ɹ] and /-i/ [ɻ] are not marked in MPL.

[22] This frequently used word is pronounced as hàn and is used both as conjunction and preposition in Taiwan. However, in Mainland China it is pronounced as hé and used only as a conjunction (according to the text *Elementary Chinese* published in Peking, 1972).

It is worthy of note that in the above survey, the /ong/ has a frequency higher than those finals which form part of such frequently used words as: wǒ (I, me), tā (he), sān (three), tiān (sky), zài (in, at), lái (come).

The answer to this paradox did not become evident until I discovered that half of the primary data which the researchers had used was based on the following three essays:[23]

1. "On the Profound Knowledge and Morality of Being a Communist" 論共產黨員的修養: 22,882 words.
2. "The Greatest Friendship" 最偉大的友誼: 977 words.
3. "Anti-liberalism" 反對自由主義: 688 words.

In these articles, those characters with /ong/ like zhōng 中, gōng 共, dōng 東, gōng 工, gōng 公, dòng 動, tóng 同 are extensively used as the components of expressions frequently used in Chinese Communist society. Common examples are Zhōng-guó (China), Zhōng-guó-rén (Chinese), Gōng-chán-dǎng (Communist), dōng-fāng (east), gōng-rén (worker), yùn-dòng (movement), tóng-zhì (comrade), gōng-shè (commune). The final /ong/ is obviously more useful in the speech and writings of Mainland China.

Unfortunately the frequency of those finals such as /uo/, /a/, /an/, /ian/, and /ai/ are not assessable from a study of the review.

The occurrence of hàn is 3,519, or 0.46% of the sample. If for this character the hé pronunciation is adopted to replace hàn, the relative frequency position of the final /an/ will be reduced from seventh to ninth position (see Table 6B, 4.06 − 0.46 = 3.60). At the same time the most frequently used final /e/ will increase to 9.74% (9.28 + 0.46 = 9.74).

This replacement of hàn by hé will produce changes in the relative occurrence of vowels and letters. It will even change the relative frequency order of rimes and letters in MPL (but not the relative frequency order of vowels and letters in IPA, Pin-yin or Modified System).

In terms of the relative frequency of rimes in MPL, the "ㄢ" and "ㄜ" will switch position (see Table 12). The first rime "ㄢ" will revert to third position [a decrease of 0.46% (10.30 − 0.46 = 9.84)]; whereas the rime "ㄜ" increased by 0.46% will advance from third to first position (9.28 + 0.46 = 10.74).

In the relative frequency of Mandarin Phonetic letters, the "ㄢ" will be downgraded from third to fifth position (77,760 − 3,519 = 74,241) and the "ㄜ" remains unchanged (70,078 + 3,519 = 73,597) (Table 19).

[23] Zheng's review in *op. cit.*, p. 32.

A comparative chart of the alternative uses of hàn and hé showing percentage or actual occurrence in the sample is given below.

Final in MS				*Rimes in MPL*				*Letters in MPL*			
hàn	%	hé	%	hàn	%	hé	%	hàn	occ.	hé	occ.
1. e	9.28	1. e	9.74	1. ㄢ	10.30	1. ㄜ	10.74	1. ㄧ	219,674	1. ㄧ	219,674
2. i	9.25	2. i	9.25	2. ㄥ	9.87	2. ㄥ	9.87	2. ㄨ	158,038	2. ㄨ	158,038
3. u	6.59	3. u	6.59	3. ㄜ	9.28	3. ㄢ	9.84	3. ㄢ	77,760	3. ㄌ	75,448
4. v	5.44	4. v	5.44	4. ㄧ	9.25	4. ㄧ	9.25	4. ㄌ	75,448	4. ㄥ	74,550
5. uo	4.44	5. uo	4.44					5. ㄥ	74,550	5. ㄢ	74,241
6. a	4.14	6. a	4.14					6. ㄜ	70,078	6. ㄜ	73,579
7. an	4.06	7. ian	4.03					7. ㄕ	58,967	7. ㄕ	58,967
8. ian	4.03	8. ai	3.82								
9. ai	3.82	9. an	3.60								
10. ong	3.50	10. ong	3.50								

4.6 *A Proposal for encoding Mandarin finals*

Table 7 sets out a viable method of encoding Mandarin finals which is based on the work of Mr. Wong Kar-lung. Detailed discussion of the encoding can be found in his M. Phil. thesis "Phonetic Encoding of Chinese Characters" (1975) in the library of The Chinese University of Hong Kong.

However, two rarely used finals /iai/ and /io/ are not mentioned because they were only noted after the thesis had been completed. In addition, minor corrections of the data had been made on the output result of the thesis. Therefore, the probability (in percentage) listed in this present study differs from that given in the above-mentioned thesis. But it should be noted that this difference can be considered as minimal and unlikely to affect the order of the finals in terms of frequency.

TABLE 7. RELATIVE PROBABILITY DISTRIBUTION OF FINALS IN MANDARIN

Finals	*Probability*	*Binary coding*	*Finals*	*Probability*	*Binary coding*
e	0.0953	000	iang	0.0203	110101
i	0.0912	001	in	0.0194	110110
u	0.0658	0100	ie	0.0187	110111
v	0.0544	0101	y	0.0187	111000
uo	0.0444	01100	ei	0.0180	111001
a	0.0414	01101	-i	0.0169	111010
an	0.0406	01110	uan	0.0129	1110110
ian	0.0403	01111	ia	0.0121	1110111
ai	0.0381	10000	ye	0.0105	1111000
ong	0.0350	10001	er	0.0101	1111001
en	0.0323	10010	yan	0.0092	1111010
ing	0.0320	10011	uen	0.0080	1111011
ao	0.0303	10100	uang	0.0074	1111100
iou	0.0300	10101	ua	0.0061	1111101
eng	0.0266	10110	iong	0.0050	11111100
uei	0.0257	10111	yn	0.0044	11111101
ang	0.0257	11000	uai	0.0038	11111110
iao	0.0253	11001	o	0.0038	111111110
ou	0.0205	110100	ueng	0.0001	111111111

4.7 *Relative frequency of the form types in Mandarin finals*

Finals in Mandarin can be further analysed into medials, vowels, and endings. In terms of their combinations, they may be classified into four form types as follows:

1. V: Finals with a single vowel, e.g. chá (tea).
2. MV: Finals with a medial plus a vowel, e.g. shuō (to speak).
3. VE: Finals with a vowel plus an ending, e.g. kàn (to see).
4. MVE: Finals with a medial and a vowel plus an ending, e.g. biāo (watch).

The analysed occurrence of these four forms is tabulated according to the modified system in Table 8.

From the observed results, there was an obvious difference in frequency of the various

form types, with emphasis toward the occurrence of the two form types without medials, the V and VE. The ratio of total occurrence of these two types, compared with the other two with medials, the MV and MVE, is approximately 2.5 to 1. Again, those containing endings, the VE and MVE, and those without endings, the V and MV, both constituted about half of the total character sample.

It would appear that the most favoured final form type in Mandarin is V (Table 8).

TABLE 8. RELATIVE DISTRIBUTION OF THE FOUR FORM TYPES OF MANDARIN FINALS

A. Arranged in order of frequency (Total: 754,994).

1	*2*	*3*	*4*
V	*MV*	*VE*	*MVE*
e 70,078	uo 33,532	an 30,662	ian 30,457
i 69,864	ie 14,150	ai 28,853	iou 22,713
u 49,727	ia 9,152	ong 26,425	uei 19,437
v 41,107	ye 7,918	en 24,452	iao 19,153
a 31,289	ua 4,588	ing 24,178	iang 15,352
y 14,103	io 8	ao 22,897	uan 9,723
-i 12,761		eng 20,087	yan 6,918
o 2,838		ang 19,447	uen 6,083
		ou 15,515	uang 5,590
		in 14,636	iong 3,785
		ei 13,641	yn 3,318
		er 7,613	uai 2,858
			ueng 75
			iai 11
291,767	69,348	248,406	145,473
38.64%	9.19%	32.90%	19.26%

B. Summary

	Final form type	*Occurrence*	*Percentage*
1	V	291,767	38.64
2	MV	69,348	9.19
3	VE	248,406	32.90
4	MVE	145,473	19.26
Total	4	754,994	99.99%

The relative frequencies of initials and finals in Mandarin, which have been discussed above, are based on the output results listed in 2.3.4. From 4.8 onward, some calculation is needed to derive the relative frequency of final components: medials, vowels, and endings. The figures used in the calculations are also based on the previously mentioned output results.

4.8 *Medials*

The syllables without any medials (zero medial Ø) constitute 71.98% of the total character

sample, as compared to 15.20% for the syllables with medial [-i-] and 10.85% for the medial [-u-].[24] Syllables with medial [-y-] occupy the remaining 1.97% (see Table 9, Fig. 5).

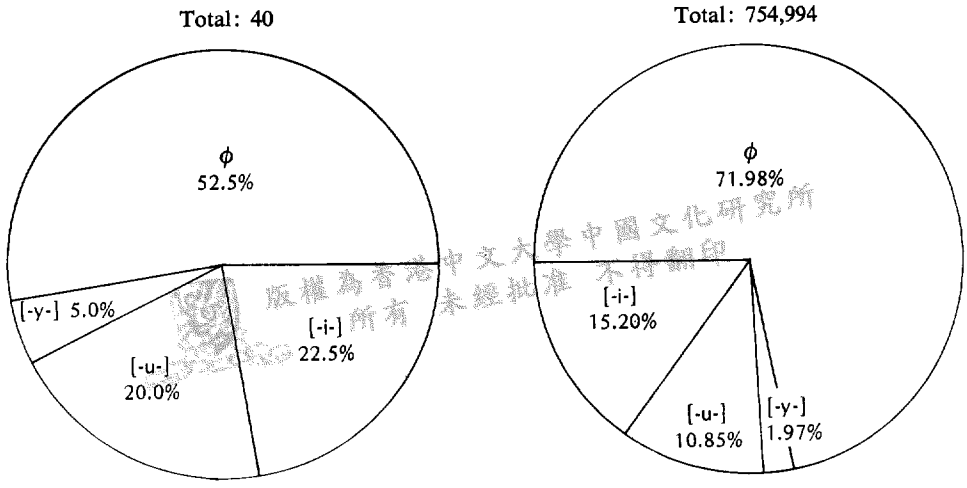
The low frequency of syllables with medial [-y-] is due to the fact that only two finals contain the medial [-y-], ye and yan, and that they rank 28, 30 respectively in the total of 40 in the order of the relative frequency of finals.

Syllables without any medials (with 71.98%) are far more frequent than those containing medials, which together account for about 28% of the total number of sample character. The ratio between the number of syllables without any medials and those with [-i-], [-u-], [-y-] is approximately 3 to 1 (Fig. 5B).

TABLE 9. DISTRIBUTION OF MANDARIN MEDIALS IN THE IPA SYSTEM

Medials	*Items*		*Occurrence*	
	Number	*Percentage*	*Number*	*Percentage*
Ø	21	52.5	543,491	71.98
[-i-]	9	22.5	114,781	15.20
[-u-]	8	20.0	81,886	10.85
[-y-]	2	5.0	18,436	1.97
Total	40	100.0%	754,994	100.00%

FIGURE 5. DISTRIBUTION OF MANDARIN MEDIALS



A. Items B. Occurrence

4.9 *Vowels (and rimes in MPL)*

4.9.1 Relative frequency of Mandarin vowels analysed in IPA

According to Y. R. Chao's *Grammar of Spoken Chinese*,[25] there are fifteen vowels in Mandarin if analysis is based on the IPA system. Among these vowels, the first four most

[24] The relative frequency of finals which begin with /i/, /u/ or /y/ is discussed in §4.1.

[25] *Op. cit.*, p. 24.

frequently used are unrounded vowels [i], [ɤ], [ɑ], and [a] which together account for about 50% of the sample. Individually, the respective percentages are 14.39, 13.72, 10.91, and 10.47, whereas those least frequently used are the [y] and [z] with respective frequencies of only 2.31% and 1.69% (Table 10A).

TABLE 10A. RELATIVE FREQUENCY OF MANDARIN VOWELS IN THE IPA SYSTEM, IN ORDER OF FREQUENCY

(Total: 754,994)

Vowel	*Ending*						*Total %*
	Open	*-ɹ*	*-i*	*-u*	*-n*	*-ŋ*	
i	9.25				1.94	3.20	14.39
ɤ	13.72						13.72
ɑ				5.57		5.34	10.91
a			4.20		6.27		10.47
ɛ	2.92				4.03		6.95
u	6.59						6.59
A	5.96						5.96
ɪ	5.44						5.44
o	0.38			5.06			5.44
ə		1.01			4.05		5.06
e			4.38				4.38
ɑ						4.00	4.00
ʌ						2.67	2.67
y	1.87				0.44		2.31
z	1.69						1.69
Total %							99.98%

4.9.2 Relative frequency of Mandarin vowels in the Pin-yin System

Phonemically, there are only six basic vowels in Peking dialect: /a/, /o/, /e/, /i/, /u/, and /ü/. If calculated according to their basic forms, the unrounded vowels /a/, /e/, and /i/ which together account for about 80%, are far more frequently used than the rounded ones /o/, /u/, and /ü/ which represent only 20% of the total sample. Individually, the percentages are 31.37, 24.31, and 21.52 for /a/, /e/, /i/ as compared with 13.88, 6.59, and 2.31 for /o/, /u/, /ü/ (Table 11A).

If calculated in Pin-yin's written form, the same pattern results in the basic form, with the major difference that the percentage of /ü/ vowel has greatly decreased from 2.31% to 0.18% (Table 11A, Fig. 6).

4.9.3 Relative frequency of rimes in Mandarin Phonetic Letters

In MPL, there are sixteen rimes. The arrangement in order of frequency indicates that the first three rimes make up over 25%, and the first six rimes make up over 50% of the total. It is apparent that the ㄢ contains over 10% of the total sample (Table 12).

The least frequent rimes are ㄩ and ㄦ, with frequencies of 1.87% and 1.01% respectively. Despite its low frequency, ㄦ has a high functional yield in speech, and, the percentage shown indicates only those words which utilise the rime ㄦ.

TABLE 10. ANALYSIS OF MANDARIN FINALS IN THE IPA SYSTEM (IN PERCENTAGE)

Total: 754,994

Key: F: final

Ending / *Medial*		*Open ending*									*-ɹ*	*-i*		*-u*		*-n*					*-ŋ*				*Total %*
Ø	F	ʐ	ɹ	i	u	y	A	o	ʁ		ɚ	ai	ei	*a*u	ou	an	ən		in	yn	aŋ	ʌŋ	ɑŋ	iŋ	71.97
	%	1.69	5.44	9.25	6.59	1.87	4.14	0.38	9.28		1.01	3.82	1.81	3.03	2.05	4.06	3.24		1.94	0.44	2.57	2.66	3.50	3.20	
Row-i	F						iA	io		iɛ		iai		i*a*u	iou			iɛn			ia ŋ		i ɑŋ		15.19
	%						1.21	0.001		1.87		0.001		2.54	3.01			4.03			2.03		0.50		
Row-u	F						uA		u ʁ			uai	uei			uan	uən				ua ŋ	uʌŋ			10.85
	%						0.61		4.44			0.38	2.57			1.29	0.81				0.74	0.01			
Row-y	F									yɛ						yan									1.97
	%									1.05						0.92									
Total %		1.69	5.44	9.25	6.59	1.87	5.96	0.38	13.72	2.92	1.01	4.20	4.38	5.57	5.06	6.27	4.05	4.03	1.94	0.44	5.34	2.67	4.00	3.20	99.98%

TABLE 11. ANALYSIS OF MANDARIN FINALS IN THE PIN-YIN SYSTEM (IN PERCENTAGE)

Ending / *Medial*		*Open ending*						*-r*	*-i*		*-o*	*-u*	*-n*				*-ng*				*Total %*
Ø	F	i	u	ü	a	o	e	er	ai	ei	ao	ou	an	en	in	ün	ang	eng	ong	ing	
	%	16.38	6.59	1.87	4.14	0.38	9.28	1.01	3.82	1.81	3.03	2.05	4.06	3.24	1.94	0.44	2.57	2.66	3.50	3.20	71.97
Row-i	F				ia	io	ie		iai		iao	iou	ian				iang		iong		
	%				1.21	0.001	1.87		0.001		2.54	3.01	4.03				2.03		0.50		15.19
Row-u	F				ua	uo			uai	uei			uan	uen			uang	ueng			
	%				0.61	4.44			0.38	2.57			1.29	0.81			0.74	0.01			10.85
Row-ü	F						üe						üan								
	%						1.05						0.92								1.97
Total %		16.38	6.59	1.87	5.96	4.82	12.20	1.01	4.20	4.38	5.57	5.06	10.30	4.05	1.94	0.44	5.34	2.67	4.00	3.20	99.98%

TABLE 11A. RELATIVE FREQUENCY OF MANDARIN VOWELS IN THE PIN-YIN SYSTEM (Total: 754,994)

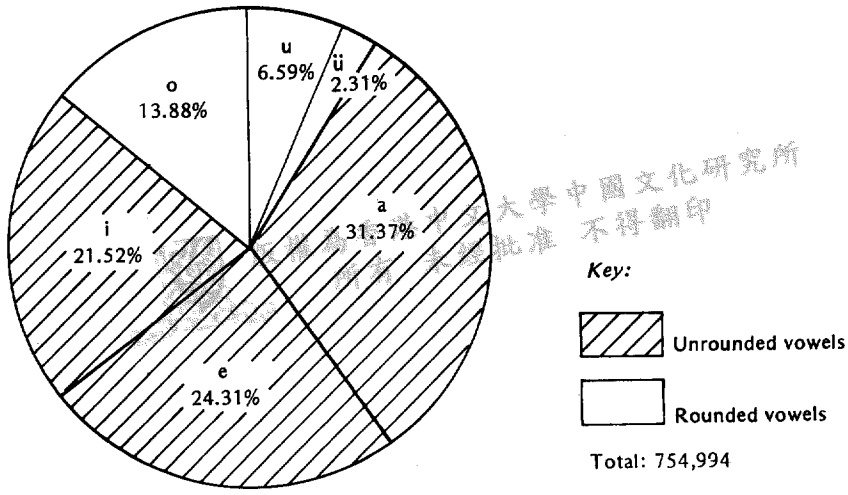
Vowel		*Ending*							*Total percentage*	
		Ø	*-r*	*-i*	*-o*	*-u*	*-n*	*-ng*	BASIC	WRITTEN
Unrounded	a	5.96		4.20	5.57		10.30	5.34	31.37	31.37
	e	12.20	1.01	4.38			4.05	2.67	24.31	21.96[a]
	i	16.38					1.94	3.20	21.52	21.52
Total									77.20	74.85
Rounded	o	4.82				5.06		4.00	13.88	12.38[b]
	u	6.59							6.59	8.72[c]
	ü	1.87					0.44		2.31	0.18[d]
Total									22.78	21.28
Grand total %									99.98	96.13

[a] 21.96 = 24.31−2.35; [b] 12.38 = 13.88−1.50; [c] 8.72 = 6.59+2.13; [d] 0.18 = 2.31−2.13.

In Pin-yin's written form, two finals / ü / and /ün/ (which consist of main vowel /ü/) are written as /u/ and /un/ (the two dots are omitted) except when preceded by /n/ and /l/; /uei/, /uen/, and /iou/ are written as /ui/, /un/, and /iu/ if preceded by a consonant (see also 2.3.1).

The percentage for the vowel /ü/, rewritten as /u/ is 2.13% (16,107); for /uei/ and /uen/ with consonants is 2.35% (17,742); and for /iou/ is 1.50% (11,324).

FIGURE 6. RELATIVE FREQUENCY OF MANDARIN VOWELS IN PIN-YIN'S BASIC FORM



4.10 *Endings*

According to the survey under discussion, nearly half of the syllables (47.82%) are not followed by any ending (open ending). The remaining 52.18% are syllables with endings /-n/, /-ŋ/, /-u/, /-i/, and /-ɪ/. In descending order of frequency, the percentages of these endings are 16.73, 15.21, 10.63, 8.58, and 1.01 respectively (Table 13). Among the latter five endings, the nasals /-n/, /-ŋ/ predonminate, constituting 31.94% of the total sample (Table 13, Fig. 7).

TABLE 12. RELATIVE FREQUENCY OF RIMES IN MANDARIN PHONETIC LETTERS, IN ORDER OF FREQUENCY (Total occurrence: 754,994)

Vowel	*Medial* Ø	ㄧ	ㄨ	ㄩ	*Total percentage*
1. ㄢ	4.06	4.03	1.29	0.92	10.30
2. ㄥ	2.66	3.20	3.51[a]	0.50	9.87
3. ㄜ	9.28				9.28
4. ㄧ	9.25				9.25
5. ㄨ	6.59				6.59
6. ㄣ	3.24	1.94	0.81	0.44	6.43
7. ㄚ	4.14	1.21	0.61		5.96
8. ㄠ	3.03	2.54			5.57
9. ㄤ	2.57	2.03	0.74		5.34
10. ㄡ	2.05	3.01			5.06
11. ㄝ	0.38	0.001	4.44		4.821
12. ㄟ	1.81		2.57		4.38
13. ㄞ	3.82	0.001	0.38		4.201
14. ㄝ		1.87		1.05	2.92
15. ㄩ	1.87				1.87
16. ㄦ	1.01				1.01
/-i/[b]	1.69				1.69
/v/	5.44				5.44
Total %					99.982%

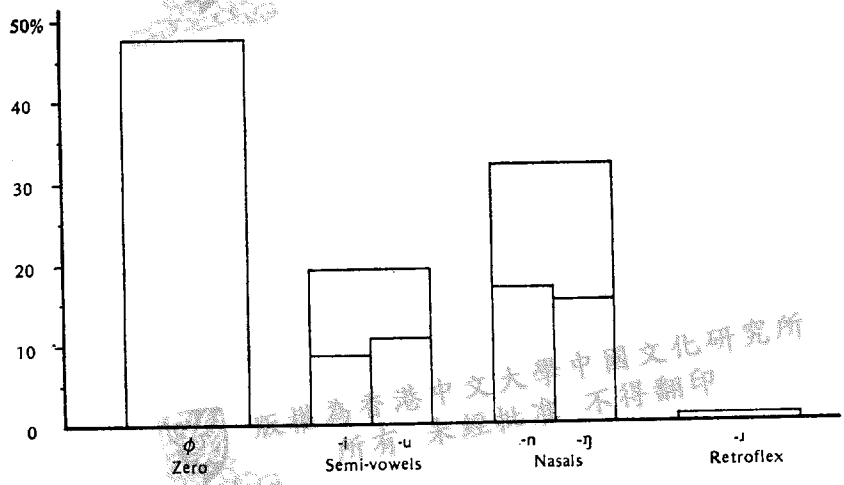
[a] The final ㄨㄥ in MPL consists of /ong/ and /ueng/. The relative frequency of ㄨㄥ is /ong/ 3.50% + /ueng/ 0.01% = 3.51%.

[b] In MPL, the vowels /-i/ and /v/ are not marked.

TABLE 13. RELATIVE FREQUENCY OF MANDARIN ENDINGS

Class	*Member*	*Total percentage in IPA*	*Total percentage in Pin-yin*	*Grand total*
Zero	Ø	47.82	47.82	
Total				47.82%
Semi-vowels	-i	8.58	8.58	
	-u (-o)	10.63	5.57	
	-u		5.06	
Total				19.21%
Nasals	-n	16.73	16.73	
	-ŋ (-ng)	15.21	15.21	
Total				31.94%
Retroflex	-ɹ (-r)	1.01	1.01	
Total				1.01%
Grand total				99.98%

FIGURE 7. RELATIVE FREQUENCY OF MANDARIN ENDINGS, CLASSIFIED IN IPA
(Total: 754,994)



4.11 *Tones*

4.11.1 Relative frequency of tones and the number of characters of which they consist

There are five tones in Mandarin (including the neutral tone). The first four tones are usually numbered 1st, 2nd, 3rd, and 4th tones. The neutral tone, in the survey discussed above, is numbered as 5th tone.

In terms of the relative frequency of the five tones as they occur, that most favoured is the 4th tone, which constitutes 34.43% of the total sample, followed by 1st, 2nd, 3rd, and 5th in descending order of frequency. Individually, their respective percentages are 21.10, 20.42, 17.79, and 6.26 (Table 14A).

On the basis of tonal behaviour, the calculations are made not only in terms of actual occurrence but also take into account the number of different characters which go to make each tone (Table 14B). It is worthy of note that both methods of calculation show the same general pattern of distribution, with predominance in the 4th tone.

Despite the character pronunciation of the secondary data used here, the 2nd and 5th (neutral) tones will normally be increased in actual speech because of the extensive use of tone sandhi,[26] and this is worthy of separate analysis.

The analysis of average occurrence of each character in different tones, shows a contrasting pattern of distribution when compared with the last two results (occurrence and characters) mentioned above. The characters in 5th tone would appear to be more predominant when compared with characters in the other four tones, showing 2,150 average occurrence against the others which average 150 (Table 14C).

However, it is interesting to note that over 99% of the actual occurrence of the 5th tone uses kai-kou-hu (including the [ʐ̩] and [ɹ̩]) (Table 14A) and in the respective character chart, the number of the neutral tone characters in kai-kou-hu also occupies a large proportion of the sample (19 out of 22) (Table 14B).

Among these characters, some are very frequently used suffixes such as: dė 的 (26,738), lė 了 (7,176), mėn 們 (4,325), zi 子 (2,128), mė 麼 (1,998), zhė 着 (1,573), etc.

[26] For example, when a 3rd tone is followed by another 3rd, the first one changes into a 2nd tone, e.g. zǔ-mǔ (grandmother) changes to zú-mǔ.

TABLE 14. RELATIVE FREQUENCY OF MANDARIN TONES AND THE NUMBER OF THEIR RESPECTIVE CHARACTERS, IN ORDER OF FREQUENCY

A. Tabulated in terms of occurrence.

Tone	*Final class*[a]				*Total*	*Percentage*
	Kai	*Qi*	*He*	*Cuo*		
4	120,297	74,721	53,190	11,710	259,918	34.43
1	76,013	57,841	21,866	3,587	159,307	21.10
2	71,492	42,625	28,044	11,989	154,150	20.42
3	52,598	48,256	28,503	4,971	134,328	17.79
5	47,265	16	10	0	47,291	6.26
Grand total	367,665	223,459	131,613	32,257	754,994	100.00%

[a] *Cf.* §4.1.

B. Tabulated in terms of their number of characters.

Tone	*Final class*				*Total*	*Percentage*
	Kai	*Qi*	*He*	*Cuo*		
4	639	472	380	135	1,626	33.45
2	507	430	240	100	1,277	26.25
1	502	360	218	52	1,132	23.29
3	315	264	188	38	805	16.56
5	19	1	2	0	22	0.45
Grand total	1,982	1,527	1,028	325	4,862[a]	100.00%

[a] The total number of different characters reported in the book mentioned above (see §1.2) is 4,864.

C. Tabulated in terms of the average occurrence of each character in different tones.

Tone	*Number of occurrence*	*Number of characters*	*Average*
5	47,291	22	2,150
3	134,328	805	167
4	259,918	1,626	160
1	159,307	1,132	141
2	154,150	1,277	121

4.11.2 A proposal for encoding Mandarin tones

Table 15 sets out another viable method of encoding Mandarin tones also based on the work of Mr. Wong (see §4.6).

TABLE 15. PROBABILITY DISTRIBUTION OF MANDARIN TONES

Tone	*Probability*	*Binary coding*
4	0.3438	00
1	0.2133	01
2	0.2039	10
3	0.1765	110
0	0.0626	111

5. Mandarin "alphabets"

5.1 *Relative frequency of Mandarin letters*

The "alphabets" are actually systems of alphabetical segments used here to describe the components which represent syllables in Mandarin. There are several systems used to transcribe Mandarin sounds. Only the Pin-yin system (including the modified system) and Mandarin Phonetic Letters are considered in the following calculation.

All the calculations contained in this Section are based upon the resultant figures previously derived in Sections 3 and 4.

Within Mandarin Chinese language structure, a letter may appear in the position of consonant, medial, vowel or ending. For example, the letter "i" may occur in medial position (e.g. tian), vowel position (e.g. di) or ending position (e.g. tai). The frequency of occurrence of each letter in each different position is tabulated in Part A of each of the following tables in addition to notes to indicate the process of calculation. Letters are rearranged in order of frequency in Part B of each of the respective tables.

In the Pin-yin system, some modification is required to allow for the various rules governing written syllables.

5.2 *Relative frequency of Mandarin letters in the Pin-yin and Modified Systems*

If Table 16B is compared with Table 17B, it is of interest to note that each of the first ten letters, from "i" to "s" occupies nearly the same relative position in descending order of occurrence and have approximately the same distribution in the sample.

The first 2 letters in the Modified System made up 24% of the total.
The first 2 letters in the Pin-yin System made up 25% of the total.

The first 5 letters in the Modified System made up 51% of the total.
The first 5 letters in the Pin-yin System made up 51% of the total.

The first 10 letters in the Modified System made up 78% of the total.
The first 10 letters in the Pin-yin System made up 77% of the total.

The five general vowel letters "a, e, i, o, u" in these two systems are contained within the first ten, with "i" being the most favoured, constituting 12.88% in the Modified System, 13.75% in the Pin-yin System. The total occurrence of these five vowel letters constitutes 45% of the total letter occurrence (45.96% in Modified, 45.62% in Pin-yin). Slightly less frequently used letters are "n, a, e, u" (in Modified, "n, a, u, e" in Pin-yin) when considered in relation to the descending order of frequency.

5.3 *Comparison of the relative frequency of Mandarin and English letters*[27]

Let us compare the relative frequency of English letters (Table 18) with those in Chinese as analysed in the Pin-yin System (Table 17B). The distribution is similar, for in English, the first 2 letters make up 22%, the first 6 letters 52% and the first 11 letters 78% of the total letter sample as analysed (*cf.* §5.2). The first 10 letters in Pin-yin (with the sole exception of "g") can be found in the first 12 letters in the English alphabet. One major difference that becomes apparent concerns the letters "g, z, j" as commonly used in Chinese which together account for 11.70% but are rarely found in English, and together only constitute 2.03% of the sample. However, the second most commonly used letter "t" in English (constituting 9.78% of sample)

[27] The frequency of English letters discussed here is based upon Dewey's work *The Relative Frequency of English Speech Sounds* (Harvard University Press, 1923).

TABLE 16. RELATIVE FREQUENCY OF MANDARIN LETTERS IN THE MODIFIED SYSTEM

A. Arranged in alphabetical order.

Letter	*Consonant*	*Medial*	*Vowel*	*Ending*	*Total*	*Percentage*
a	—	—	236,950	—	236,950	10.59
b	37,133	—	—	—	37,133	1.66
c	28,100[a]	—	—	—	28,100	1.26
d	75,448	—	—	—	75,448	3.37
e	—	—	186,852	—	186,852	8.35
f	19,385	—	—	—	19,385	0.87
g	36,051	—	—	114,939[b]	150,990	6.75
h	156,489[c]	—	—	—	156,489	6.99
i (i)	—	114,781	108,678	64,800	288,259	12.88
i (-i)	—	—	12,761	—	12,761	0.57
i (v)	—	—	41,107	—	41,107	1.84
j	48,142	—	—	—	48,142	2.15
k	14,722	—	—	—	14,722	0.66
l	42,122	—	—	—	42,122	1.88
m	28,132	—	—	—	28,132	1.26
n	17,017	—	—	241,188[d]	258,205	11.54
o	—	—	104,816	42,050	146,866	6.56
p	7,568	—	—	—	7,568	0.34
q	23,210	—	—	—	23,210	1.04
r	14,656	—	—	7,613	22,269	0.99
s	75,220[e]	—	—	—	75,220	3.36
t	30,372	—	—	—	30,372	1.36
u	—	81,886	49,727	38,228	169,841	7.58
x	40,178	—	—	—	40,178	1.80
y	—	18,154	14,103	—	32,257	1.44
z	65,724[f]	—	—	—	65,724	2.94
Total					2,238,302	100.03%

[a] 28,100 = 8,521 (c) + 19,579 (ch)
[b] 114,939 (-ng)
[c] 156,489 = 37,883 (h) + 40,060 (zh) + 19,579 (ch) + 58,967 (sh)
[d] 241,188 = 126,249 (-n) + 114,939 (-ng)
[e] 75,220 = 16,253 (s) + 58,967 (sh)
[f] 65,724 = 25,664 (z) + 40,060 (zh)

B. Arranged in order of frequency.

Letter	*Percentage*	*Letter*	*Percentage*
i	12.88	d	3.37
n	11.54	s	3.36
a	10.59	z	2.94
e	8.35	j	2.15
u	7.58	l	1.88
h	6.99	v	1.84
g	6.75	x	1.80
o	6.56	b	1.66

TABLE 16 (*cont'd*)

Letter	*Percentage*	*Letter*	*Percentage*
y	1.44	r	0.99
t	1.36	f	0.87
c	1.26	k	0.66
m	1.26	-i	0.57
q	1.04	p	0.34

TABLE 17. RELATIVE FREQUENCY OF MANDARIN LETTERS IN THE PIN-YIN SYSTEM

A. Arranged in alphabetical order.

Letter	*Consonant*	*Medial*	*Vowel*	*Ending*	*Total*	*Percentage*
a	—	—	236,950	—	236,950	10.46
b	37,133	—	—	—	37,133	1.64
c	28,100[a]	—	—	—	28,100	1.24
d	75,448	—	—	—	75,448	3.33
e	—	—	169,110[g]	—	169,110	7.47
f	19,385	—	—	—	19,385	0.86
g	36,051	—	—	114,939[b]	150,990	6.67
h	156,489[c]	—	—	—	156,489	6.91
i	—	83,977[h]	162,546	64,800	311,323	13.75
j	48,142	—	—	—	48,142	2.13
k	14,722	—	—	—	14,722	0.65
l	42,122	—	—	—	42,122	1.86
m	28,132	—	—	—	28,132	1.24
n	17,017	—	—	241,188[d]	258,205	11.40
o	—	—	93,492[i]	42,050	135,542	5.98
p	7,568	—	—	—	7,568	0.33
q	23,210	—	—	—	23,210	1.02
r	14,656	—	—	7,613	22,269	0.98
s	75,220[e]	—	—	—	75,220	3.32
t	30,372	—	—	—	30,372	1.34
u	—	59,570[j]	80,524	38,228	180,322	7.96
ü	—	—	1,460	—	1,460	0.06
w	35,908[k]	—	—	—	35,908	1.59
x	40,178	—	—	—	40,178	1.77
y	72,832[l]	—	—	—	72,832	3.22
z	65,724[f]	—	—	—	65,724	2.90
Total					2,264,856	100.08%

[a–f] See respective notes on Table 16A.

[g] 169,110 = 186,852 − 17,742 (number of occurrence of /uei/ and /uen/, preceded by a consonant)

[h] 83,977 = 114,781 (-i) − (59,609 − 28,805)

[i] 93,492 = 104,816 (/o/) − 11,324 (/iou/ preceded by a consonant)

[j] 59,570 = 81,886 − 22,316

[k] 35,908 = 29,112 + 6,796

[l] 72,832 = 59,609 + 13,223

TABLE 17 (*cont'd*)

B. Arranged in order of frequency.

Letter	*Percentage*	*Letter*	*Percentage*
i	13.75	l	1.86
n	11.40	x	1.77
a	10.46	b	1.64
u	7.96	w	1.59
e	7.47	t	1.34
h	6.91	c	1.24
g	6.67	m	1.24
o	5.98	q	1.02
d	3.33	r	0.98
s	3.32	f	0.86
y	3.22	k	0.65
z	2.90	p	0.33
j	2.13	ü	0.06

is rarely used in Pin-yin in which its frequency is only 1.34%. The five English vowel letters "a, e, i, o, u" which together account for 38.19% of the total letter occurrence do not, in English, occur as frequently as they do in Chinese (45.62%, Tables 17B and 18). Of these five English vowel letters, "e" predominates in English (constituting 12.68% of the sample) whereas Mandarin favours the letter "i" (13.75%).

TABLE 18. RELATIVE FREQUENCY OF ENGLISH LETTERS (DEWEY 1923)

Letter	*Percentage*	*Letter*	*Percentage*
e	12.68	f	2.56
t	9.78	m	2.44
a	7.88	w	2.14
o	7.76	y	2.02
i	7.07	g	1.87
n	7.06	p	1.86
s	6.34	b	1.56
r	5.94	v	1.02
h	5.73	k	0.60
l	3.94	x	0.16
d	3.89	j	0.10
u	2.80	q	0.09
c	2.68	z	0.06

5.4 *Relative frequency of Mandarin Phonetic Letters*

The symbols used in MPL differ from the romanized letters used in English. There are 37 letters in MPL, 11 more than the 26 letters in English. Of these 37 letters, ㄧ and ㄨ are far more frequently used constituting 13.54 and 9.74 respectively whereas ㄢ accounts for only 4.79%. The least frequently used letters in MPL are ㄆ and ㄦ each only constituting 0.47% of the total letter occurrence (Table 19).

TABLE 19. RELATIVE FREQUENCY OF MANDARIN PHONETIC LETTERS

Letter	*Occurrence*	*Percentage*	*Letter*	*Occurrence*	*Percentage*
ㄧ	219,674[a]	13.54	ㄜ	36,378	2.24
ㄨ	158,038[b]	9.74	ㄍ	36,051	2.22
ㄢ	77,760	4.79	ㄇ	36,042[c]	2.22
ㄌ	75,448	4.65	ㄟ	33,078	2.04
ㄦ	74,550	4.60	ㄞ	31,722	1.96
ㄝ	70,078	4.32	ㄊ	30,372	1.87
ㄕ	58,967	3.63	ㄇ	28,132	1.73
ㄣ	48,489	2.98	ㄗ	25,664	1.58
ㄐ	48,142	2.97	ㄑ	23,210	1.43
ㄚ	45,029	2.78	ㄝ	22,068	1.36
ㄌ	42,122	2.60	ㄔ	19,579	1.21
ㄠ	42,050	2.59	ㄈ	19,385	1.19
ㄤ	40,389	2.49	ㄋ	17,017	1.05
ㄒ	40,178	2.48	ㄙ	16,253	1.00
ㄓ	40,060	2.47	ㄎ	14,722	0.91
ㄡ	38,228	2.36	ㄖ	14,656	0.90
ㄏ	37,883	2.34	ㄘ	8,521	0.53
ㄅ	37,133	2.29	ㄆ	7,568	0.47
			ㄦ	7,613	0.47
Total				1,622,249	100.00%

[a] 219,674 = 69,864 (main vowel) + 149,810 (medial)
[b] 158,038 = 49,727 (main vowel) + 108,311 (medial)
[c] 36,042 = 14,103 (main vowel) + 21,939 (medial)

6. Syllables and homophonic characters

6.1 *Relative frequency of Mandarin syllables and homophonic characters*

The relative frequency distribution of Mandarin syllables and their homophonic characters as discussed here is derived from the same five tables of secondary data set out in appendices. The total number of syllables counted in the sample is 1,153, and the total number of characters utilised is 4,862 (two words less than reported, see Table 14B). Among the four tones (excluding neutral), it is of interest to note that the 3rd tone embraces the largest number of syllables although its occurrence and the number of included homophonic characters rank as the lowest. The distribution of different characters in conjunction with number of syllables and their occurrence in relation to tones is tabulated as follows:

Characters		*Syllables*		*Occurrence*	
Tone	*Number*	*Tone*	*Number*	*Tone*	*Number*
4	1,626	4	325	4	259,918
2	1,277	1	295	1	159,307
1	1,132	3	275	2	154,150
3	805	2	242	3	134,328
5	22	5	16	5	47,291

6.2 *The 100 most frequently used syllables in Mandarin*

The following 100 most frequently used syllables (romanized in the Pin-yin System) are listed in their order of frequency. The actual occurrence of each syllable is followed by the number of associated homophonic characters.

dè	28437/3	shì	15499/25	yī	15102/7	shí	9438/8	bù	9389/9
zài	7465/3	wǒ	7461/1	yǒu	7391/4	lè	7176/1	guó	6707/1
tā	6477/5	dì	6370/9	rén	5694/4	dào	5571/8	gè	5008/4
dà	4810/1	yǐ	4746/8	zhōng	4406/7	lái	4392/2	èr	4388/2
mén	4325/1	shàng	4290/2	jiù	4203/9	zhè	4140/3	jiā	4108/8
lǐ	4071/10	sān	4007/2	hàn	3999/13	zuò	3966/7	shēng	3965/9
wǔ	3878/9	gōng	3808/12	lì	3796/30	hé	3591/15	yào	3541/6
sì	3409/12	hòu	3383/4	xúe	3313/1	zhī	3309/15	tiān	3303/2
hùi	3246/13	chéng	3214/13	yuán	3036/14	jiāo	3076/7	yì	3011/37
nián	2835/3	jí	2791/24	shuō	2727/1	yòng	2698/2	jiàn	2659/24
xī	2648/24	ér	2555/2	xià	2552/5	xiǎo	2541/2	míng	2509/6
qù	2498/4	měi	2482/3	hě	2469/3	xiào	2455/8	xíng	2446/5
xiàn	2417/14	yě	2439/3	xīn	2391/10	dōu	2380/2	xiàng	2378/9
zì	2360/3	jīng	2330/13	cháng	2327/7	shī	2280/9	jī	2280/25
chū	2279/3	zhèng	2261/6	hǎo	2262/1	zhǐ	2248/20	bā	2216/8
wéi	2215/14	yóu	2207/9	qí	2196/22	jì	2188/23	duō	2159/1
zhè	2153/1	zi	2128/1	hěn	2124/2	yuè	2119/10	fù	2073/18
tóng	2063/9	huà	2050/6	rì	2049/1	kè	2024/6	jiāng	2021/8
nǐ	2018/3	biàn	2016/7	kàn	1976/2	nán	1969/6	yú	1963/23
mín	1958/2	tú	1953/8	jìn	1907/9	fāng	1886/3	jiǔ	1876/5

6.3 *The 100 syllables in which the number of homophonic characters rank highest*

The following 100 syllables as romanized in the Pin-yin system are listed in descending order according to the number of homophones for that syllable. The number of homophones is followed by their total occurrence in the sample.

yì	37/3011	lì	30/3796	yù	30/1821	jī	25/2280	shì	25/15499
bì	25/955	xī	24/2648	jí	24/2791	jiàn	24/2659	jì	23/2188
yú	23/1963	qí	22/2196	fú	22/1147	zhì	20/2248	bó	19/635
fù	18/2073	wèi	17/3301	jù	17/1166	yí	17/847	yán	17/1443
júe	17/980	zhī	15/3309	yàn	15/392	lí	15/578	jié	15/1150
jiāo	14/856	jiān	14/1028	xiàn	14/2417	líng	14/416	wéi	14/2215
yán	14/3036	jiǎo	14/508	mò	14/515	è	14/733	xiāo	13/484
qiān	13/829	jīng	13/2330	chéng	13/3214	huáng	13/878	hàn	13/3999
shù	13/1516	hùi	13/3246	xù	13/477	fēng	12/1210	gōng	12/3804
yīng	12/1240	xía	12/228	xián	12/186	yíng	12/462	hú	12/703
jiǎn	12/581	sì	12/3409	qì	12/1865	jìng	12/1113	mù	12/1176
zhù	12/1710	wù	12/1751	kē	11/687	zhēn	11/1014	zhū	11/450
shū	11/1250	zhí	11/1294	méi	11/1640	lín	11/1082	zhuó	11/107
yǔ	11/1427	dài	11/1568	bèi	11/1429	dàn	11/1498	lù	11/1689
shān	10/1378	gān	10/689	zhēng	10/571	yān	10/158	xīn	10/2391
tán	10/467	lán	10/434	róng	10/681	xí	10/1236	dié	10/172
lián	10/1120	lǐ	10/4071	fǔ	10/751	jiě	10/986	xiè	10/276

diàn	10/1329	sù	10/671	huò	10/1079	yuè	10/2119	shī	9/2280
sī	9/1449	zī	9/288	shēng	9/3965	qī	9/1632	gū	9/163
mó	9/312	fán	9/330	chén	9/644	tóng	9/2063	dí	9/324

6.4 *Average length of the syllable in Mandarin*

The average length of the syllable in Mandarin varies with the system used. Only Pin-yin, MPL and the Modified System are used in the present calculations. The figures used are based on the total number of letter occurrence as shown in Tables 16A, 17A, and 19. The tones are not however counted as one letter.

In the Modified System: $\frac{2,238,300}{754,994} = 2.964$

In the Pin-yin System: $\frac{2,264,856}{754,994} = 2.999$

In Mandarin Phonetic Letters: $\frac{1,622,249}{754,994} = 2.15$

It is worthy of note that in MPL, the average length is the shortest, with only 2 letters constituting one syllable, whereas the average for the other two systems is 3.

7. Conclusion

The above survey cannot be considered as completed. At this stage it cannot be fully completed since it would be imprudent to state that it will meet the total needs of the varying categories of reader who may use it as a reference work. As I have mentioned in the Introduction (§1.4), the results of the present study do provide a basic reference work for the future modification of Chinese stenography, improvement of the Chinese electronic typewriter, and the analysis of the input of the Chinese language into computer programmes. Different readers may require different results for these different aspects of their work. After all, this survey presents a large amount of data tabulation to support the results in order that the reader may quickly locate items in which they are interested and which will allow them to perform further research according to their own requirements.

Of those uses mentioned above, the studies of the application of Chinese language in computer programming and the Chinese electronic typewriter has become a very encouraging recent trend. In August 1973, a computer conference was held in Taiwan. Viable methods governing the application of Chinese to computer programming had been proposed by certain Chinese scientists and linguists. They succeeded in using the Mandarin Phonetic Letters (zhùyīn fúhào) and the character roots in analysing the input data and printout of the Chinese characters in computer work.

A new machine "Matrix impact printer" which can print Chinese characters under computer control with a speed of 165 characters per second, was introduced recently by Dr. Hong Yi-yuan who works in Mohawk Data Science Corporation.[28] Dr. Hong pointed out that the technique of designing a wholly Chinese language computer is no longer a problem. Researches should keep abreast of the current trends in science. He believes that romanization

[28] Hong Yi-yuan 洪義源, "The Analysis of the Input and Output of Chinese Characters in Computer" 電腦輸入輸出的漢字化, *Dou Sou* 抖擻, March 1975.

(including MPL) is the only reasonable way to deal with the input of Chinese language in computer programmes.[29]

As for the use of syllabic components in representing characters, Prof. Chou Fa-kao put forward two proposals for use in transcribing Cantonese and Mandarin to the symbolic form.[30] According to his proposals, not more than five letters are required to indicate a character (the first four deal with syllabic components and the last romanized letter deals with the order of homophonic characters). For example: in Cantonese, Sing Dou Daily 星島日報 can be written as: SIQ1 DOU2 YVT3 BOU3. In Mandarin, The Chinese University of Hong Kong 香港中文大學 can be written as: XIAQ G3AQ J1OQ VEN D4A XYUE.

However in contradistinction to these last proposals, the Modified System used in this study may be considered worthy of further consideration as the average syllable length to be programmed is only 3 letters (see §6.4) and it is easy to learn since it is derived from the Pin-yin System (see §2.3.1).

Finally, I would like to suggest that the extension of this type of study can only emerge from close cooperation between linguists and scientists since it requires the application of techniques from both fields.

For the future, it may be considered of value to carry out a similar research using the compounds as data. This could result in a decrease in the number of homophonic characters needing to be considered during the input of Chinese characters.

Last but not least, I should like to extend my gratitude to Mr. David Newbury, a local air pollution control officer, for going through every word of the manuscript and rendering it into a readable paper, and to Mr. Wong Kar-lung for preparing the programme. Without their help I could not have completed the present survey. I give my best wishes to both of them

[29] *Ibid.*

[30] For Cantonese, refer to "Chinese Telegraphy and Typewriter" 談中文發報打字, *Sing Dou Daily*, Hong Kong, 21st November, 1972. For Mandarin, refer to "A Sequel to Chinese Telegraphy and Typewriter" 再談中文發報打字, *Ming Pao Monthly*, Vol. 111 (March 1975), pp. 98–99.

Appendix I. Secondary Data Used in this Survey: Syllables Involved and Their Frequency of Occurrence (Transcribed in Modified System)

Note: Figure on the left of the stroke in each box indicates number of homophonic characters.
Figure on the right indicates frequency of its occurrence in the sample survey.

1st Tone:

	a	o	e	-i	v	er	ai	ei	ao	ou	an	en	ang	eng	ong	i	ia	iai	iao	ie	io	iou	ian	in	iang	ing	iong	u	ua	uo	uai	uei	uan	uen	uang	ueng	y	ye	yan	yn
b	8/2216	7/372						7/203	5/417		6/761	1/39	3/283	2/22		1/35			2/168				4/1027	6/198		3/470													
p	2/6	2/108					1/124	2/10	2/13		2/33	1/48	2/9	3/19		8/157			2/73	2/6			3/181	1/47		1/4		3/75											
m	1/1043	1/78							1/90			1/6				2/23			1/2	1/35								7/428											
f	2/1743							6/1294			5/137	7/1472	3/1886	12/1210																									
d	3/79						2/48		2/111	2/2383	8/483		3/1037	3/289	5/1711	3/221			5/25	1/279		1/49	3/23			4/146		3/393		1/2159		1/61	1/190	2/95					
t	5/6477						1/15		4/27	1/123	4/85		2/46		1/802	3/71			2/37	2/74			2/3303			3/825		1/8		4/184		1/255	1/1	1/39					
n	1/1																			1/7			1/2																	
l	2/658								1/21							1/13						1/51						1/6		1/6										
z	3/4			9/288			3/135		2/92	3/6	1/1		1/66	3/256	7/269													1/48		1/1			1/17	2/100					
c	1/88			3/19			1/30		2/127		2/549	1/1	5/91		7/109													1/64		2/20		3/22		2/224					
s	2/7			8/1449			3/31		4/40	3/37	2/4007	1/121	2/55	1/11	5/197													4/431		5/82		3/389	1/82	2/127					
zh	2/7				15/3309		2/37	1/35	6/198	6/1489	7/45	11/1014	7/772	10/571	7/4406													11/450	2/81	3/238	1/1	3/106	4/332		5/375					
ch	4/95		1/897		3/953		2/75		3/124	1/65	1/2	1/5	4/129	5/372	5/342													3/2279		1/7		2/121	2/412	1/317	3/125					
sh	5/577		1/3		9/2280		1/1		3/241	1/421	10/1378	7/1104	2/549	9/3965														11/1250	1/102	1/2727	2/36		1/3		3/171					
r														1/44																									
j																25/2280	8/4108		14/856	6/887		2/43	14/1028	7/1757	8/2021	13/2330										5/253	1/1	4/105	5/1198
q																9/1632			4/50	1/36		4/267	13/829	4/804	5/146	8/1271	2/2									7/602	1/80	1/65	
x																24/2648	2/37		13/484	3/1110		4/383	6/946	10/2391	7/1081	6/1083	6/245									6/490	2/18	5/202	5/30
g			8/773				2/444		5/1409	5/125	10/689	2/1016	6/414	5/139	12/3804													9/163	6/137	4/80	1/16	7/440	7/1440		2/756					
k	1/10		11/687				2/1300				5/93		3/251	1/33	2/826													4/136	2/14			3/34	1/49	4/82	2/6					
h	1/329		2/170				2/5	2/383	1/6		3/4			1/19	3/54													4/430	2/690			7/369	1/391	3/81	2/103					
ø	1/243	1/26	1/1				5/129		3/15	3/173	7/728	2/59		1/27		7/15102	5/538		6/237	1/13	1/8	4/188	10/158	6/474	5/277	12/1240	5/31	6/377	5/111	4/90	1/21	5/210	6/595	1/301	1/25	2/74	2/11	2/479	5/41	1/12

2nd Tone:

	a	o	e	-i	v	er	ai	ei	ao	ou	an	en	ang	eng	ong	i	ia	iai	iao	ie	io	iou	ian	in	iang	ing	iong	u	ua	uo	uai	uei	uan	uen	uang	ueng	y	ye	yan	yn
b	2/47	19/635					1/662		2/26					1/1		2/61				1/644																			
p	4/130	2/115					6/260	5/134	2/11		2/121	1/83	5/197	8/489		9/420			2/2				1/23	3/59		8/1176		8/103											
m	6/198	9/312					2/43	11/1640	3/298	3/77	3/43	1/609	5/315	8/202		5/74			3/113				4/267	2/1958		6/2509		1/10											
f	5/100	1/93						2/171			9/330	3/35	5/789	3/63														22/1147											
d	4/878		2/1642													9/324				10/172								3/725		3/142									
t							6/1236		7/339	2/1186	10/467		8/411	5/102	9/2063	7/1252			3/852				6/460			5/515		8/1953		3/61		1/4	1/308	5/34					
n	1/444								3/15		6/1969		1/14	1/1710	5/416	7/409						1/270	3/2835	1/120	1/51	7/234		1/69		2/70									
l							2/4392	6/165	4/232	5/107	10/434		8/151	2/8	8/456	15/578			9/352			8/943	10/1120	11/1082	6/671	14/416		8/149		8/411			4/12	8/585			3/9		1/1	1/1
z	2/107		5/486					1/14	1/38		1/23																	4/410		1/241										
c				7/586			5/1080		4/75		3/233		1/101	2/365	4/1151																			1/103					
s																												1/71				3/241								
zh	5/42		7/106		11/1294		2/11		2/96	1/52																		7/472		11/107										
ch	4/848				6/416		1/106		4/328	6/169	6/33	9/644	7/2327	3/3214	4/462													7/507				5/71	2/734	6/43	3/111					
sh			5/1485		8/9438			1/242	3/11	1/116		1/361		1/47														4/273				1/4								
r									1/25	4/67	3/1323	4/5694	1/1	1/176	10/681													5/1227												
j																24/2791	6/47		1/15	15/1150																	6/293	17/980		
q																22/2196			7/334	2/23		4/1060	7/1478	6/303	6/557	3/784	3/73									4/47		5/1405	3/233
x																10/1236	12/228		1/2	9/322			12/186		4/206	5/2446	2/285									1/80	1/3313	4/135	9/169
g	2/13		8/577																											1/6707									
k			3/76										1/2																		6/52			2/33					
h	1/1		15/3591				3/1613		7/86	3/63	8/397	1/15	4/388	4/241	8/484													12/703	6/1090	1/802	5/156	2/1002	4/241	5/53	13/878					
ø	1/2	1/12	6/190			2/2555	1/1		5/17				1/28			17/847	7/235	1/11	9/265	4/57		9/2207	17/1443	6/149	9/1265	12/462		8/790	1/26			14/2215	4/938	6/1220	2/740		23/1963		14/3036	8/324

3rd Tone:

	a	o	e	-i	v	er	ai	ei	ao	ou	an	en	ang	eng	ong	i	ia	iai	iao	ie	io	iou	ian	in	iang	ing	iong	u	ua	uo	uai	uei	uan	uen	uang	ueng	y	ye	yan	yn
b	1/1692	2/3					2/979	1/1696	4/719		5/443	2/1803	3/89			5/1219			2/912				3/22			7/111		5/295												
p		1/19							1/340	1/12				1/10		5/23			2/37					1/401				5/247												
m	4/711	1/17					1/288	3/2482		1/49	1/372		1/6	3/87		4/286			3/47				5/277	8/91				5/659											
f	2/1566							3/227		1/103	2/428	1/121	6/236															10/751											
d	1/656						2/31	1/90	5/602	3/71	3/42		4/173	1/1234	2/60	4/332							4/1092			2/125		5/47		2/121			1/148	1/5					
t	1/84								1/433		3/99		4/54		3/687	2/993			2/3	3/675			2/5			4/73		2/440		2/15		1/62							
n	2/688						4/187	1/2	3/156		1/4					3/2018			1/255			3/108	5/19					1/208					1/93				1/547			
l	1/26							6/104	3/1278	2/12	4/136		1/43	1/208	3/38	10/4071	1/20		2/141			1/51	1/185	3/6	3/1388	2/430		3/211		1/2			1/36				8/246			
z				4/579			3/118		5/508	1/758		1/889			2/815													3/816		2/274		1/159	2/15						
c				1/530			6/337		2/294		1/47																												
s	3/46			1/416					2/183	2/29	2/31		1/8		3/13															4/1663		1/1		4/83					
zh	1/3		2/452		8/1575		1/4		3/276	2/27	6/293	3/38	4/1180	2/268	4/1512													5/1226	1/4				2/305	2/285	1/1				
ch			1/6		7/330				2/67	2/28	5/616		2/134	2/8	1/5													4/395					1/9	1/4	1/7				
sh	1/17		2/28		6/1578				1/464	3/1237	2/134	4/179	3/71	1/805														9/484	1/16		1/2	1/1681			1/26				
r			1/17						1/27		2/142	1/87	2/90															2/62				1/8	4/74						
j																9/1615	6/349		14/508	3/671		5/1876	12/581	6/368	4/804	7/362	3/11										6/636		1/29	
q																6/1722	1/1		2/100	1/393			3/73	1/8	2/74	2/540											3/507		1/14	
x																4/623			2/2541	2/1110		1/12	5/290		4/1128	2/84											3/519	1/155	1/403	
g			2/58				1/385	1/754	3/56	2/197	6/746		2/349	2/5	3/24													9/845	1/12	4/955	2/9	5/108	3/583	3/59	1/576				
k	1/102		3/2469				4/64		3/392	1/754	4/55	4/174			2/320													1/278	1/3			1/8	1/81	3/19					
h							1/1389		1/2262	1/18	2/127	2/2124			1/2													3/96		3/756		4/183	2/39	1/38	4/24				
ø						5/677	4/57		2/15	4/28						8/4746	3/91		4/56	3/2439		4/7391	9/692	5/245	4/555	2/341	12/440	9/3878	1/87	1/7461		7/487	8/488	3/44	5/445	1/1	11/1427		1/461	1/27

4th Tone:

	a	o	e	-i	v	er	ai	ei	ao	ou	an	en	ang	eng	ong	i	ia	iai	iao	ie	io	iou	ian	in	iang	ing	iong	u	ua	uo	uai	uei	uan	uen	uang	ueng	y	ye	yan	yn
b	6/756	3/224					2/227	11/1429	8/1237		7/996	2/37	5/186	1/15		25/955			1/2	1/1			7/2016	2/8		5/1385		9/9389												
p	2/243	4/309					2/211	4/184	5/136		5/155	1/8	1/37	1/80		5/63			2/363				3/396	1/13				5/45												
m	1/86	14/515					4/337	7/343	6/210		6/337	2/23		2/173		7/468			2/106	2/140			3/1865			1/387		12/1176											
f	2/238							5/690			8/732	6/607	1/580	4/135														18/2073											
d	1/4810						11/1568		8/5571	9/235	11/1498		5/77	7/50	5/1604	9/6370			5/429				10/1329			4/1441		7/1019		6/36		3/1880	5/381	7/219					
t	5/93		1/499				4/1271		1/76	1/86	5/202		2/31		3/152	8/208			2/228									3/49		2/32		1/170		1/3					
n	5/1849		1/29				2/78	1/702	2/98		1/67	1/61			1/81	4/20			1/14	5/17		1/1	3/288		1/17	1/4		1/55		3/69						2/20			
l	6/96		4/450				3/47	3/647	3/14	3/77	3/77		1/88	1/4	1/6	30/3796			2/457	6/610		2/1807	7/516	3/7	4/775	2/446		11/1689		6/351			1/178	1/483			6/511	3/125		
z			1/1	3/2360			3/7465		7/577	3/67	4/98		3/184	2/54	4/63															7/3966		3/1397	2/24	1/3					
c			5/412	3/997			2/331			1/10	1/19																	5/103		5/243		7/84	2/19	2/57					
s	3/76		6/544	12/3409			2/414		1/2	1/10	1/96		1/20		6/511													10/671				7/290	2/359						
zh	6/121		3/4140		20/2248		2/28		7/582	7/70	8/1188	6/460	9/184	6/2261	5/1239													12/1710				2/14	5/77		3/234				
ch	5/79		5/86		7/137					1/24	2/12	2/28	4/426	2/43														5/625		2/5			2/24		2/143				
sh	3/89		7/1533		25/15499		2/54		4/194	7/711	9/243	4/123	2/4290	6/552														13/1516		3/26	3/75	4/302	1/13	3/180					
r			1/436		1/2049				1/97	1/250		6/943	1/247															5/543		3/231		4/91		2/24					
j																23/2188	6/412		7/3076	10/986		9/4203	24/2659	9/1907	4/231	12/1113											17/1166		6/68	8/180
q																12/1865	1/37		5/15	3/247			3/34	1/1	1/1	1/186											4/2498	7/547	2/70	
x																9/886	5/2552		8/2455	10/276		8/200	14/2417	2/451	9/2378	8/859											13/477	3/81	4/9	7/516
g	1/1		4/5008				5/217		2/442	6/551	4/163		1/19	2/486	3/977													7/610	4/127	1/1791	1/169	8/325	7/273	1/19	1/10				
k	1/65		6/2024						1/130	2/57	2/1976		3/273		2/82													3/117	1/24	5/204	6/986	5/44		1/97	7/240				
h			7/106				4/350		8/719	4/3383	13/3999	1/94		1/14	1/1													6/501	6/2050	10/1079	1/200	13/3246	9/214	1/27	1/3				
ø	1/350		14/733			2/4381	6/638		4/178		5/721	1/2	1/1			37/3011	4/500		6/3541	8/1770		9/1603	15/392	3/517	4/1726	3/380	2/2698	12/1751	1/14	5/107	1/1187	17/3301	3/540	3/1030	4/558		30/1821	10/2119	7/874	6/628

5th Tone:

	a	o	e	-i	v	er	ai	ei	ao	ou	an	en	ang	eng	ong	i	ia	...	ua	uo	uai	...	yn
b																							
p																							
m	3/326		1/1998									1/4325											
f																							
d			3/28437																				
t									1/34														
n	1/27		1/599													1/16				1/9			
l			1/7176							1/2													
z				1/2128																			
c																							
s																							
zh			3/2153																				
ch																							
sh					1/1								1/59										
r																							
j																							
q																							
x																							
g																							
k																				1/1			
h																							
o																							

Appendix II. Secondary Data Used in this Survey: Characters Involved and Their Frequency of Occurrence

1. The data listed here was taken from *A Study on the High Frequency Words Used in Chinese Elementary School Reading Materials* prepared by the National Institute for Compilation and Translation, Chung Hwa Book Co. Ltd., Republic of China, 1967.
2. Characters are arranged according to their respective Mandarin Phonetic Letters. Homophones are arranged in descending order of their frequency of occurrence. Variants of the preceding characters are shown in brackets. The number of their occurrences is included in the total given for the preceding character.
3. The figure to the right of each character refers to its frequency of occurrence; they make up a total of 754,994.
4. The romanization to the right of MPL indicates the Pin-yin transcription.

【ㄅㄚ】 ba

ㄅㄚ 八1457 巴 437
吧 296 叭 17
芭 4 笆 2
疤 2 粑 1
ㄅㄚˊ 拔 37 跋 10
ㄅㄚˇ 把1692
ㄅㄚˋ 爸 607 罷 91
霸 42 壩 14
把 1 灞 1

【ㄅㄛ】 bo

ㄅㄛ 波 174 玻 123
撥 51 剝 14
菠 8 缽 2
(鉢 1)
ㄅㄛˊ 伯 148 博 136
(博 3) 柏 102
泊 52 薄 52
渤 46 勃 34
蔔 18 膊 18
脖 12 (頗 1)
鈸 4 帛 3
箔 3 舶 2
鉑 2 駁 2
搏 1
ㄅㄛˇ 跛 2 簸 1
ㄅㄛˋ 播 217 簸 4
亳 3

【ㄅㄞ】 bai

ㄅㄞ 白 662
ㄅㄞˇ 百 910 擺 69
ㄅㄞˋ 敗 160 拜 97

【ㄅㄟ】 bei

ㄅㄟ 杯 112 (盃 2)
悲 43 背 21
(揹 2) 卑 19
碑 8
ㄅㄟˇ 北1696
ㄅㄟˋ 被 754 備 433
背 125 貝 61
倍 32 輩 8
狽 6 焙 4
蓓 3 憊 2
悖 1

【ㄅㄠ】 bao

ㄅㄠ 包 285 胞 123
褒 5 苞 2
剝 2
ㄅㄠˊ 雹 15 薄 11
ㄅㄠˇ 保 403 寶 205
飽 63 堡 48
ㄅㄠˋ 報 891 抱 110
暴 106 爆 94
鉋 19 鮑 12
豹 3 趵 2

【ㄅㄢ】 ban

ㄅㄢ 班 453 般 188
搬 69 斑 26
頒 24 扳 1
ㄅㄢˇ 版 212 板 211
闆 10 阪 9
坂 1
ㄅㄢˋ 辦 495 半 402
伴 62 拌 20
扮 13 瓣 3
絆 1

【ㄅㄣ】 ben

ㄅㄣ 奔 39
ㄅㄢ 本1800 奋 3
ㄅㄣˇ 笨 36 苯 1

【ㄅㄤ】 bang

ㄅㄤ 幫 202 邦 62
傍 19
ㄅㄤˇ 膀 54 榜 23
綁 12
ㄅㄤˋ 棒 138 磅 26
蚌 18 鎊 3
傍 1

【ㄅㄥ】 beng

ㄅㄥ 崩 16 繃 6
ㄅㄥˇ 甭 1
ㄅㄥˋ 蹦 15

【ㄅㄧ】 bi

ㄅㄧ 逼 35
ㄅㄧˊ 鼻 59 荸 2
ㄅㄧˇ 比 778 筆 390
彼 49 泌 1
妣 1
ㄅㄧˋ 必 344 畢 208
避 91 壁 74
臂 54 閉 47
碧 34 幣 27
祕 15 弊 10
俾 8 蔽 7
璧 6 鄙 5
庇 4 斃 4
陛 3 辟 3
斃 2 婢 2
嗶 2 弼 2
比 1 裨 1
愎 1

【ㄅㄧㄝ】 bie

ㄅㄧㄝˊ 別 644
ㄅㄧㄝˋ 鱉 1

【ㄅㄧㄠ】 biao

ㄅㄧㄠ 標 165 彪 3
ㄅㄧㄠˇ 表 896 錶 16
ㄅㄧㄠˋ 鰾 2

【ㄅㄧㄢ】 bian

ㄅㄧㄢ 邊 642 編 355
鞭 29 蝙 1
ㄅㄧㄢˇ 扁 17 貶 4
匾 1
ㄅㄧㄢˋ 便 782 遍 635
變 526 辨 33
辯 24 汴 9
辦 7

【ㄅㄧㄣ】 bin

ㄅㄧㄣ 賓 97 濱 67
彬 21 (斌 7)
瀕 12 檳 1
ㄅㄧㄣˋ 殯 7 鬢 1

【ㄅㄧㄥ】 bing

ㄅㄧㄥ 兵 368 冰 102
(冰 75)
ㄅㄧㄥˇ 丙 40 餅 37
柄 21 秉 7
炳 2 昺 2
稟 2
ㄅㄧㄥˋ 並 799 病 524
幷 31 併 30
摒 1

【ㄅㄨ】 bu

ㄅㄨˇ 補 162 捕 81
埔 33 卜 11
哺 8
ㄅㄨˋ 不6634 部1475
布 558 步 400
薄 130 佈 123
埠 41 怖 27
鈽 1

【ㄆㄚ】 pa

ㄆㄚ 趴 4 啪 2
ㄆㄚˊ 爬 116 琶 11
杷 2 耙 1
ㄆㄚˋ 怕 228 帕 15

【ㄆㄛ】 po

ㄆㄛ 坡 70 潑 38
ㄆㄛˊ 婆 92 鄱 23
ㄆㄛˇ 頗 19
ㄆㄛˋ 破 228 迫 68
皤 7 珀 6

【ㄆㄞ】 pai

ㄆㄞ 拍 124
ㄆㄞˊ 排 198 牌 54
徘 3 蒎 3
簰 1 滭 1
ㄆㄞˋ 派 210 湃 1

【ㄆㄟ】 pei

ㄆㄟ 胚 8 呸 2
ㄆㄟˊ 培 70 陪 33
賠 22 裴 8
坏 1
ㄆㄟˋ 配 104 佩 67
沛 12 珮 1

【ㄆㄠ】 pao

ㄆㄠ 拋 12 泡 1

ㄆㄠ 袍 9 咆 2
ㄆㄠˇ 跑 340
ㄆㄠˋ 皰 78 (砲 20 炮 13) 泡 56 皰 2

【ㄆㄡ】 pou
ㄆㄡˇ 剖 12

【ㄆㄢ】 pan
ㄆㄢ 潘 27 攀 6
ㄆㄢˊ 盤 119 槃 2
ㄆㄢˋ 判 78 叛 54 盼 11 畔 9 拌 3

【ㄆㄣ】 pen
ㄆㄣ 噴 48
ㄆㄣˊ 盆 83
ㄆㄣˋ 噴 8

【ㄆㄤ】 pang
ㄆㄤ 滂 5 乓 4
ㄆㄤˊ 旁 154 螃 15 龐 13 膀 10 傍 5
ㄆㄤˋ 胖 37

【ㄆㄥ】 peng
ㄆㄥ 砰 11 烹 7 抨 1
ㄆㄥˊ 朋 402 澎 30 彭 19 膨 16 蓬 11 鵬 7 棚 2 硼 2
ㄆㄥˇ 捧 10
ㄆㄥˋ 碰 80

【ㄆㄧ】 pi
ㄆㄧ 批 76 匹 31 披 19 劈 12 坯 8 霹 4 噼 4 丕 3
ㄆㄧˊ 皮 346 疲 41 脾 13 琵 11 啤 3 埤 3 毘 2 (毗 1) 枇 1
ㄆㄧˇ 疋 10 匹 8 僻 2 劈 2 癖 1
ㄆㄧˋ 譬 24 闢 21 僻 10 屁 7 媲 1

【ㄆㄧㄝ】 pie
ㄆㄧㄝ 瞥 4 撇 2

【ㄆㄧㄠ】 piao
ㄆㄧㄠ 飄 61 漂 12
ㄆㄧㄠˊ 瓢 1 縹 1
ㄆㄧㄠˇ 漂 36 嘌 1
ㄆㄧㄠˋ 票 340 漂 23

【ㄆㄧㄢ】 pian
ㄆㄧㄢ 篇 123 偏 46 翩 12
ㄆㄧㄢˋ 便 23
ㄆㄧㄢˋ 片 352 騙 28 徧 16

【ㄆㄧㄣ】 pin
ㄆㄧㄣ 拼 47
ㄆㄧㄣˊ 貧 44 蘋 8 頻 7
ㄆㄧㄣˇ 品 401
ㄆㄧㄣˋ 聘 13

【ㄆㄧㄥ】 ping
ㄆㄧㄥ 乒 4 平 964 評 61 屏 46 瓶 44 憑 30 萍 18 蘋 7 坪 6

【ㄆㄨ】 pu
ㄆㄨ 撲 56 鋪 15 仆 4
ㄆㄨˊ 葡 46 蒲 19 樸 19 僕 9 朴 7 莆 1 菩 1 蹼 1
ㄆㄨˇ 普 168 浦 54 譜 14 圃 9 溥 2
ㄆㄨˋ 鋪 30 (舖 24) 曝 7 瀑 4 暴 4

【ㄇㄚ】 ma
ㄇㄚ 媽1043
ㄇㄚˊ 麻 170 嘛 16 蔴 5 麼 3 痳 3 蟆 1
ㄇㄚˇ 馬 598 瑪 40 碼 37 螞 36
ㄇㄚˋ 罵 86
·ㄇㄚ 嗎 321 麼 4 嚒 1

【ㄇㄛ】 mo
ㄇㄛ 摸 78
ㄇㄛˊ 模 118 摩 91 磨 43 魔 35 嚤 12 謨 7 糢 3 摹 2 蘑 1
ㄇㄛˋ 抹 17
ㄇㄛˋ 脈 94 墨 88

莫 77　末 65
膜 48　默 41
漠 34　沒 32
寞 14　陌 12
沫 4　歿 3
抹 2　秣 1

【ㄇㄜ】 me
·ㄇㄜ 麼1998

【ㄇㄞ】 mai
ㄇㄞ 埋 42　霾 1
ㄇㄞ 買 288
ㄇㄞ 麥 162　賣 147
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ㄠˇ 襖 13 拗 2
ㄠˋ 澳 79 奧 71
傲 24 懊 4

【ㄡ】 ou
ㄡ 歐 156 甌 12
毆 5
ㄡˇ 偶 21 藕 5
耦 1 嘔 1

【ㄢ】 an
ㄢ 安 698 鞍 13
菴 11 銨 2
氨 2 庵 1
諳 1
ㄢˇ 案 241 暗 181
岸 178 按 118
黯 3

【ㄣ】 en
ㄣ 恩 53 嗯 6
ㄣˊ 摁 2

【ㄤ】 ang
ㄤ 骯 27
ㄤˊ 昂 28
ㄤˇ 盎 1

【ㄦ】 er
ㄦ 兒1540 而1015
ㄦˇ 爾 544 (尔 7)
耳 123 洱 7
餌 3
ㄦˋ 二4376 貳 5

【ㄧ】 yi
ㄧ 一14147 衣 387
醫 246 依 197
伊 114 壹 9
漪 2
ㄧˊ 遺 375 移 141
宜 136 儀 58
疑 50 夷 27
姨 16 胰 10
貽 8 咦 7
怡 7 詒 3
沂 3 頤 2
彝 2 痍 1
飴 1
ㄧˇ 以3500 已 892
乙 110 尾 90
椅 85 蟻 59
倚 8 矣 2
ㄧˋ 意 840 議 574
義 499 易 280
益 108 異 105

譯 101　藝 95
役 64　亦 53
億 50　疫 39
憶 37　翼 27
羿 24　誼 23
毅 19　逸 14
邑 8　肄 7
翌 6　(翊 2)
抑 6　掖 5
軼 4　驛 4
曳 3　奕 3
蜴 3　溢 3
刈 1　詣 1
懿 1　縊 1
挹 1　鎰 1
腋 1

【ㄧㄚ】 yia
ㄧㄚ 呀 275　壓 134
鴨 77　鴉 43
押 6
ㄧㄚˊ 牙 165　芽 44
衙 13　押 6
蚜 3　涯 2
堐 2
ㄧㄚˇ 雅 78　啞 12
氬 1
ㄧㄚˋ 亞 486　軋 6
訝 5　砑 3

【ㄧㄝ】 yo
ㄧㄝ 唷 8

【ㄧㄝ】 yie
ㄧㄝ 耶 13
ㄧㄝˊ 爺 40　椰 12
琊 3　耶 2
ㄧㄝˇ 也2253　野 173
冶 13

ㄧㄝˋ 業1097　葉 250
夜 225　液 147
頁 44　謁 4
咽 2　燁 1

【ㄧㄞ】 yai
ㄧㄞˊ 崖 11

【ㄧㄠ】 yao
ㄧㄠ 要 113　邀 47
腰 39　妖 31
喲 6　吆 1
ㄧㄠˊ 搖 143　堯 33
窯 33　遙 30
謠 10　姚 9
瑤 3　洮 3
傜 1
ㄧㄠˇ 咬 48　舀 6
窈 1　杳 1
ㄧㄠˋ 要3291　藥 205
(葯 1)　耀 38
鑰 6　鷂 1

【ㄧㄡ】 you
ㄧㄡ 優 124　憂 25
幽 21　悠 18
ㄧㄡˊ 由1156　遊 364
油 342　尤 114
郵 106　游 100
猶 17　鈾 4
猷 4
ㄧㄡˇ 有6894　友 493
莠 2　黝 2
ㄧㄡˋ 又1293　右 168
幼 97　誘 19
佑 10　柚 7
釉 6　叹 2
祐 1

【ㄧㄢ】 yan
ㄧㄢ 煙 97　(烟 32)
淹 17　菸 13
醃 12　咽 6
燕 4　胭 3
奄 3　焉 3
ㄧㄢˊ 研 383　鹽 226
(塩 1)　言 162
嚴 156　沿 145
顏 130　延 96
炎 46　岩 72
(巖 36)　筵 13
簷 5　蜒 3
妍 3　閻 2
癌 1
ㄧㄢˇ 眼 424　演 235
掩 16　鹽 6
郾 5　奄 2
衍 2　偃 1
兗 1
ㄧㄢˋ 驗 195　厭 39
雁 31　宴 30
豔 21　燕 20
焰 13　彥 11
晏 9　堰 8
硯 7　咽 5
(嚥 4)　焱 2
鬣 1

【ㄧㄣ】 yin
ㄧㄣ 因1096　音 532
陰 97　殷 16
姻 2　茵 2
ㄧㄣˊ 銀 130　鄞 8
吟 7　寅 2
垠 1　淫 1
ㄧㄣˇ 引 178　飲 48
隱 13　尹 4

癮 2
ㄧㄣ 印 505 蔭 9
胤 3

【ㄧㄤ】 yang
ㄧㄤ 央 243 秧 26
殃 5 鴦 2
鞅 1
ㄧㄤˊ 陽 556 洋 371
羊 133 揚 96
楊 88 煬 14
佯 3 瘍 2
鍚 2
ㄧㄤˇ 養 396 氧 77
仰 64 癢 18
ㄧㄤˋ 樣1720 養 3
快 2 恙 1

【ㄧㄥ】 ying
ㄧㄥ 英 617 應 513
鷹 47 嬰 17
鶯 13 櫻 10
瑛 7 鸚 5
膺 4 嚶 4
罌 2 媖 1
ㄧㄥˊ 營 180 迎 143
蠅 47 螢 31
楹 22 贏 18
盈 11 瑩 5
縈 2 滎 1
嬴 1 瀛 1
ㄧㄥˇ 影 330 穎 11
ㄧㄥˋ 應 278 硬 61
映 41

【ㄨ】 wu
ㄨ 屋 190 烏 123
汚 45 嗚 8
巫 8 誣 3
ㄨˊ 無 563 吳 137
梧 27 吾 23
蕪 18 唔 11
蜈 10 潕 1
ㄨˇ 五2800 午 570
武 316 舞 125
伍 34 侮 25
鵡 6 嫵 1
憮 1
ㄨˋ 物1134 務 450
誤 46 霧 32
惡 25 晤 16
戊 12 鋈 11
悟 8 塢 7
兀 5 勿 5

【ㄨㄚ】 wa
ㄨㄚ 哇 42 蛙 33
挖 23 凹 7
窪 6
ㄨㄚˊ 娃 26
ㄨㄚˇ 瓦 87
ㄨㄚˋ 襪 14

【ㄨㄛ】 wo
ㄨㄛ 窩 67 倭 20
渦 2 萵 1
ㄨㄛˇ 我7461
ㄨㄛˋ 握 64 臥 23
沃 13 渥 4
斡 3

【ㄨㄞ】 wai
ㄨㄞ 歪 21
ㄨㄞˋ 外1187

【ㄨㄟ】 wei
ㄨㄟ 威 197 崴 9
萎 2 葳 1
偎 1
ㄨㄟˊ 爲1447 維 189
圍 180 微 178
危 108 惟 40
違 33 唯 15
薇 9 韋 6
闈 5 桅 2
巍 2 潍 1
ㄨㄟˇ 委 314 偉 112
尾 44 緯 9
葦 5 諉 2
煒 1
ㄨㄟˋ 爲1409 位 870
衛 373 (衛 220)
未 153 味 149
魏 93 胃 63
謂 38 慰 34
喂 29 餵 28
僞 18 尉 16
渭 12 畏 8
蔚 8

【ㄨㄢ】 wan
ㄨㄢ 灣 520 (湾 14)
彎 65 豌 5
剜 4 蜿 1
ㄨㄢˊ 完 538 玩 370
頑 27 丸 3
ㄨㄢˇ 晚 382 碗 71
婉 14 宛 8
挽 8 莞 2
綰 2 畹 1
ㄨㄢˋ 萬 529 腕 8
惋 3

【ㄨㄣ】 wen
ㄨㄣ 温 301
ㄨㄣˊ 文1048 聞 84
蚊 43 紋 39

玟 4 雯 2
ㄨㄣ 穩 30 吻 10
刎 4
ㄨㄣ 問1025 汶 4
紊 1

【ㄨㄤ】 wang
ㄨㄤ 汪 25
ㄨㄤˇ 王 652 亡 88
ㄨㄤˇ 往 393 網 45
枉 4 罔 2
惘 1
ㄨㄤˋ 望 445 忘 97
妄 9 旺 7

【ㄨㄥ】 weng
ㄨㄥ 翁 60 甕 14
ㄨㄥˋ 蓊 1

【ㄩ】 yu
ㄩ 淤 7 迂 4
ㄩˊ 於1298 魚 253
餘 94 漁 82
愉 49 予 22
余 15 與 36
榆 18 于 16
娛 16 逾 11
瑜 9 竽 8
俞 7 虞 6
輿 6 愚 5
渝 5 隅 3
臾 2 萸 1
畬 1
ㄩˇ 語 485 與 359
(㠯 1) 雨 303
予 61 宇 54
禹 53 羽 52
嶼 44 瑀 12
庾 4
ㄩˋ 育 839 預 216
玉 190 域 174
遇 120 愈 51
獄 35 譽 35
裕 21 籲 19
(籞 1) 欲 18
禦 14 毓 12
寓 11 浴 11
喻 7 鬱 7
豫 6 峪 6
御 5 與 5
煜 5 鈺 4
郁 4 癒 2
彧 1 慾 1
聿 1 堉 1

【ㄩㄝ】 yue
ㄩㄝ 約 470 曰 9
ㄩㄝˋ 月1412 越 284
樂 210 閱 81
粵 50 岳 38
躍 17 嶽 16
悅 10 鉞 1

【ㄩㄢ】 yuan
ㄩㄢ 淵 29 寃 4
宛 3 鳶 3
鴛 2
ㄩㄢˊ 原 830 員 780
元 705 園 228
圓 127 源 115
援 107 緣 49
袁 41 垣 19
沅 14 猿 9
轅 8 媛 4
ㄩㄢˇ 遠 461
ㄩㄢˋ 院 654 願 182
怨 25 苑 7
瑗 3 媛 2
愿 1

【ㄩㄣ】 yun
ㄩㄣ 暈 12
ㄩㄣˊ 雲 293 勻 21
云 3 昀 3
芸 1 耘 1
筠 1 溳 1
ㄩㄣˇ 允 27
ㄩㄣˋ 運 589 韻 21
蘊 8 熨 7
孕 2 醞 1

【ㄩㄥ】 yong
ㄩㄥ 庸 17 傭 8
雍 3 壅 2
邕 1
ㄩㄥˇ 永 185 勇 126
擁 48 湧 25
(涌 2) 泳 24
蛹 13 詠 9
(咏 2) 甬 6
踴 3 恿 1
ㄩㄥˋ 用2695 佣 3

APPENDIX III. COMPUTER PROGRAMME USED IN THIS SURVEY

```
*ALGOL LRN=HKC=180, HO KWOK CHEUNG                                    RUN BY BABS-H MARK 3
                                                                      DATE : 16/01/75 TIME : 18.24.43

*TRACE 1
*TIME 100
STATEMENT NO.
        0       'BEGIN'
        1       'INTEGER' XEL;
        2       'INTEGER' I,J,K,VAR1,RB,RP,RM,RF,RD,RT,RN,RL,RZ,RC,RS,RZH,RCH,RSH,RR,
        2         RJ,RQ,RX,RG,RK,RH,ROO,
        2         RA,RO,RE,RII,RV,RER,RAI,RFI,RAO,ROU,RAN,REN,RANG,RENG,RONG,
        2         R1,RIA,RIAO,RIE,RIOU,RIAN,RIN,RIANG,RING,RIONG,
        2         RU,RUA,RUO,RUAI,RUEI,RUAN,RUEN,RUANG,RUENG,
        2       RY,RYF,RYAN,RYN,   R1,R2,R3,R4,R0,   SP,STAR,XNI,
        2         X1,X2,X3,X4,X0,  XA,XB,XC,XD,XE,XF,XG,XH,XI,XJ,XK,XL,XM,XN,XO,XP,XQ,
        2       XR,XS,XT,XU,XV,XW,XX,XY,XZ,XHI,STOP,INCR;
        3       'ARRAY' A[1:9];
        4       XEL:=CODE('('EL')');
        5       STOP:=CODE('('$')');
        6       STAR:=CODE('(':')');
        7       XHI:=CODE('('-')');
        8       SP:=CODE('('%')');
        9       X0:=CODE('('0')');
       10       X1:=CODE('('1')');
       11       X2:=CODE('('2')');
       12       X3:=CODE('('3')');
       13       X4:=CODE('('4')');
       14       XA:=CODE('('A')');
       15       XB:=CODE('('B')');
       16       XC:=CODE('('C')');
       17       XD:=CODE('('D')');
       18       XE:=CODE('('E')');
       19       XF:=CODE('('F')');
       20       XG:=CODE('('G')');
       21       XH:=CODE('('H')');
       22       XI:=CODE('('I')');
       23       XJ:=CODE('('J')');
       24       XK:=CODE('('K')');
       25       XL:=CODE('('L')');
       26       XM:=CODE('('M')');
       27       XN:=CODE('('N')');
       28       XO:=CODE('('O')');
       29       XP:=CODE('('P')');
       30       XQ:=CODE('('Q')');
       31       XR:=CODE('('R')');
       32       XS:=CODE('('S')');
       33       XT:=CODE('('T')');
       34       XU:=CODE('('U')');
       35       XV:=CODE('('V')');
       36       XW:=CODE('('W')');
       37       XX:=CODE('('X')');
       38       XY:=CODE('('Y')');
       39       XZ:=CODE('('Z')');
       40       RB:=0;RP:=0;RM:=0;RF:=0;RD:=0;RT:=0;RL:=0;RZ:=0;RC:=0;RS:=0;RZH:=0;
       51       RCH:=0;RSH:=0;RR:=0;RJ:=0;RQ:=0;RX:=0;RG:=0;RK:=0;RH:=0;ROO:=0;
       61       RN:=0;  RA:=0;RO:=0;RE:=0;RII:=0;RV:=0;RER:=0;RAI:=0;RFI:=0;RAO:=0;
       71       ROU:=0;RAN:=0;REN:=0;RANG:=0;RENG:=0;RONG:=0;
       77       R1:=0;RIA:=0;RIAO:=0;RIE:=0;RIOU:=0;RIAN:=0;RIN:=0;RING:=0;RIANG:=0;
       86       RIONG:=0;
       87       RU:=0;RUA:=0;RUO:=0;RUAI:=0;RUEI:=0;RUAN:=0;RUEN:=0;RUANG:=0 ;
       95       RUENG:=0;   RY:=0;RYF:=0;RYAN:=0;RYN:=0;  R1:=0;R2:=0;R3:=0;R4:=0;R0:=0;
      105       INCR:=0;
      106       'FOR' K:=1 'STEP' 1 'UNTIL' 1000 'DO'
      106       'BEGIN'
      107       I:=1;
      108       LOOP:
      108       A[1]:=READ CH;
      109       'IF' A[1]=SP 'THEN' 'BEGIN' I:=1; 'GOTO' LOOP 'END';
      112       'IF' A[1]=XEL 'THEN' 'BEGIN' I:=1; 'GOTO' LOOP 'END';
      115       'IF' A[1]=STOP 'THEN' 'GOTO' EOJ;
      116       'IF' A[1]=STAR 'THEN' 'GOTO' EXITI;
      117       I:=I+1;
      118       'IF' I>8 'THEN' 'GOTO' EXITII;
      119       'GOTO' LOOP;
      120       EXITI:
      120       'FOR' J:=I+1 'STEP' 1 'UNTIL' 8 'DO' A[J]:=SP;
      121       A[9]:=READ; 'GOTO' EXAMI;
      123       EXITII:
      123       A[9]:=READ; 'GOTO' EXAMI;
      125       EXAMI:
      125       'IF' A[1]=XA 'THEN' 'BEGIN' ROO:=ROO+A[9]; 'GOTO' EXAMA 'END';
      128       'IF' A[1]=XE 'THEN' 'BEGIN' ROO:=ROO+A[9]; 'GOTO' EXAMA 'END';
      131       'IF' A[1]=XI 'THEN' 'BEGIN' ROO:=ROO+A[9]; 'GOTO' EXAMA 'END';
      134       'IF' A[1]=XO 'THEN' 'BEGIN' ROO:=ROO+A[9]; 'GOTO' EXAMA 'END';
      137       'IF' A[1]=XU 'THEN' 'BEGIN' ROO:=ROO+A[9]; 'GOTO' EXAMA 'END';
      140       'IF' A[1]=XY 'THEN' 'BEGIN' ROO:=ROO+A[9]; 'GOTO' EXAMA 'END';
      143       'IF' A[1]=XB 'THEN' 'BEGIN' RB:=RB+A[9]; 'GOTO' EXAMB 'END';
      146       'IF' A[1]=XP 'THEN' 'BEGIN' RP:=RP+A[9]; 'GOTO' EXAMB 'END';
      149       'IF' A[1]=XM 'THEN' 'BEGIN' RM:=RM+A[9]; 'GOTO' EXAMB 'END';
      152       'IF' A[1]=XF 'THEN' 'BEGIN' RF:=RF+A[9]; 'GOTO' EXAMB 'END';
      155       'IF' A[1]=XD 'THEN' 'BEGIN' RD:=RD+A[9]; 'GOTO' EXAMB 'END';
      158       'IF' A[1]=XT 'THEN' 'BEGIN' RT:=RT+A[9]; 'GOTO' EXAMB 'END';
```

```
161     'IF' A[1]=XN 'THEN' 'BEGIN' RN:=RN+A[9]; 'GOTO' EXAMB 'END';
164     'IF' A[1]=XL 'THEN' 'BEGIN' RL:=RL+A[9]; 'GOTO' EXAMB 'END';
167     'IF' A[1]=XR 'THEN' 'BEGIN' RR:=RR+A[9]; 'GOTO' EXAMB 'END';
170     'IF' A[1]=XJ 'THEN' 'BEGIN' RJ:=RJ+A[9]; 'GOTO' EXAMB 'END';
173     'IF' A[1]=XQ 'THEN' 'BEGIN' RQ:=RQ+A[9]; 'GOTO' EXAMB 'END';
176     'IF' A[1]=XX 'THEN' 'BEGIN' RX:=RX+A[9]; 'GOTO' EXAMB 'END';
179     'IF' A[1]=XG 'THEN' 'BEGIN' RG:=RG+A[9]; 'GOTO' EXAMB 'END';
182     'IF' A[1]=XK 'THEN' 'BEGIN' RK:=RK+A[9]; 'GOTO' EXAMB 'END';
185     'IF' A[1]=XH 'THEN' 'BEGIN' RH:=RH+A[9]; 'GOTO' EXAMB 'END';
188     'IF' A[1]=XZ 'THEN' 'BEGIN' 'IF' A[2]=XH 'THEN' 'BEGIN'
190             RZH:=RZH+A[9]; 'GOTO' EXAMC 'END'
191         'ELSE' 'BEGIN' RZ:=RZ+A[9]; 'GOTO' EXAMB 'END';   'END';
195     'IF' A[1]=XC 'THEN' 'BEGIN' 'IF' A[2]=XH 'THEN' 'BEGIN'
197             RCH:=RCH+A[9]; 'GOTO' EXAMC 'END'
198         'ELSE' 'BEGIN' RC:=RC+A[9]; 'GOTO' EXAMB 'END';   'END';
202     'IF' A[1]=XS 'THEN' 'BEGIN' 'IF' A[2]=XH 'THEN' 'BEGIN'
204             RSH:=RSH+A[9]; 'GOTO' EXAMC 'END'
205         'ELSE' 'BEGIN' RS:=RS+A[9]; 'GOTO' EXAMB 'END';   'END';
209     NEWLINE(10);
210     WRITE TEXT ('('ERROR:%%%')');
211     'FOR' I:=1 'STEP' 1 'UNTIL' 8 'DO' PRINTCH (A[I]);
212     PRINT (A[9],5,0);
213     I:=1;  'GOTO' LOOP;
215     EXAMA:
215     I:=1; 'GOTO' EXAMH;
217     EXAMB:
217     I:=2; 'GOTO' EXAMH;
219     EXAMC:
219     I:=3; 'GOTO' EXAMH;
221     EXAMH:
221     'IF' A[I]=XH 'THEN' 'BEGIN' RII:=RII+A[9]; I:=I+1; 'GOTO' EXHYME 'END';
225     'IF' A[I]=XV 'THEN' 'BEGIN' RV:=RV+A[9]; 'GOTO' EXHYME 'END';
228     'IF' A[I]=XA 'THEN' 'GOTO' EXA;
229     'IF' A[I]=XE 'THEN' 'GOTO' EXE;
230     'IF' A[I]=XI 'THEN' 'GOTO' EXI;
231     'IF' A[I]=XO 'THEN' 'GOTO' EXO;
232     'IF' A[I]=XU 'THEN' 'GOTO' EXU;
233     'IF' A[I]=XY 'THEN' 'GOTO' EXY;
234
234     NEWLINE(10);
235     WRITE TEXT ('('ERROR:%%%')');
236     'FOR' I:=1 'STEP' 1 'UNTIL' 8 'DO' PRINTCH (A[I]);
237     PRINT (A[9],5,0);
238     I:=1;  'GOTO' LOOP;
240
240     EXA:
240     I:=I+2;
241     'IF' A[I]=XG 'THEN' 'BEGIN' RANG:=RANG+A[9]; 'GOTO' EXHYME 'END'
243         'ELSE' 'BEGIN' I:=I-1;
245             'IF' A[I]=XN 'THEN' 'BEGIN' RAN:=RAN+A[9]; 'GOTO' EXHYME 'END';
248             'IF' A[I]=XI 'THEN' 'BEGIN' RAI:=RAI+A[9]; 'GOTO' EXHYME 'END';
251             'IF' A[I]=XO 'THEN' 'BEGIN' RAO:=RAO+A[9]; 'GOTO' EXHYME 'END';
254             RA:=RA+A[9]; I:=I-1; 'GOTO' EXHYME;
257                'END';
258     EXE:
258     I:=I+2;
259     'IF' A[I]=XG 'THEN' 'BEGIN' RENG:=RENG+A[9]; 'GOTO' EXHYME 'END'
261             'ELSE' 'BEGIN' I:=I-1;
263         'IF' A[I]=XN 'THEN' 'BEGIN' REN:=REN+A[9]; 'GOTO' EXHYME 'END';
266         'IF' A[I]=XI 'THEN' 'BEGIN' REI:=REI+A[9]; 'GOTO' EXHYME 'END';
269         'IF' A[I]=XR 'THEN' 'BEGIN' RER:=RER+A[9]; 'GOTO' EXHYME 'END';
272         RE:=RE+A[9]; I:=I-1; 'GOTO' EXHYME;
275                    'END';
276     EXO:
276     I:=I+1;
277     'IF' A[I]=XU 'THEN' 'BEGIN' ROU:=ROU+A[9]; 'GOTO' EXHYME 'END';
280     'IF' A[I]=XN 'THEN' 'BEGIN' RONG:=RONG+A[9];
282                                 I:=I+1; 'GOTO' EXHYME 'END';
284     RO:=RO+A[9]; I:=I-1; 'GOTO' EXHYME;
287     EXY:
287     I:=I+1;
288     'IF' A[I]=XA 'THEN' 'BEGIN' RYAN:=RYAN+A[9]; I:=I+1;
291                                 'GOTO' EXHYME 'END';
292     'IF' A[I]=XE 'THEN' 'BEGIN' RYE:=RYE+A[9]; 'GOTO' EXHYME 'END';
295     'IF' A[I]=XN 'THEN' 'BEGIN' RYN:=RYN+A[9]; 'GOTO' EXHYME 'END';
298     RY:=RY+A[9]; I:=I-1; 'GOTO' EXHYME;
301     EXI:
301     I:=I+1;
302     'IF' A[I]=XE 'THEN' 'BEGIN' RIE:=RIE+A[9];  'GOTO' EXHYME 'END';
305     'IF' A[I]=XN 'THEN' 'BEGIN' I:=I+1;
307     'IF' A[I]=XG 'THEN' 'BEGIN' RING:=RING+A[9]; 'GOTO' EXHYME 'END'
309         'ELSE' 'BEGIN' RIN:=RIN+A[9]; I:=I-1; 'GOTO' EXHYME 'END';
313        'END';
314     'IF' A[I]=XO 'THEN' 'BEGIN' I:=I+1;
316         'IF' A[I]=XU 'THEN' 'BEGIN' RIOU:=RIOU+A[9]; 'GOTO' EXHYME 'END'
318             'ELSE' 'BEGIN' RIONG:=RIONG+A[9]; I:=I+1; 'GOTO' EXHYME 'END';
322        'END';
323     'IF' A[I]=XA 'THEN' 'BEGIN' I:=I+2;
```

```
325             'IF' A[I]=XG 'THEN' 'BEGIN' RIANG:=RIANG+A[9]; 'GOTO' EXHYME 'END'
327               'ELSE' 'BEGIN' I:=I-1;
329         'IF' A[I]=XN 'THEN' 'BEGIN' RIAN:=RIAN+A[9]; 'GOTO' EXHYME 'END';
332         'IF' A[I]=XO 'THEN' 'BEGIN' RIAO:=RIAO+A[9]; 'GOTO' EXHYME 'END';
335         I:=I-1; RIA:=RIA+A[9]; 'GOTO' EXHYME 'END';
338            'END';
339         I:=I-1:   RI:=RI+A[9];   'GOTO' EXHYME;
342         EXU:
342         I:=I+1;
343         'IF' A[I]=XA 'THEN' 'BEGIN' I:=I+2;
345               'IF' A[I]=XG 'THEN' 'BEGIN' RUANG:=RUANG+A[9]; 'GOTO' EXHYME 'END'
347                            'ELSE' 'BEGIN' I:=I-1;
349                                 'IF' A[I]=XN  'THEN' 'BEGIN' RUAN:=RUAN+A[9];
351                                                      'GOTO' EXHYME 'END';
352                                 'IF' A[I]=XI  'THEN' 'BEGIN' RUAI:=RUAI+A[9];
354                                                      'GOTO' EXHYME 'END'
354                                                'ELSE' 'BEGIN' I:=I-1;
356                                       RUA:=RUA+A[9]; 'GOTO' EXHYME 'END';
358                         'END';          'END';
360         'IF' A[I]=XE 'THEN' 'BEGIN' I:=I+2;  'IF' A[I]=XG
362               'THEN' 'BEGIN' RUENG:=RUENG+A[9]; 'GOTO' EXHYME 'END'
364               'ELSE' 'BEGIN' I:=I-1; 'IF' A[I]=XN
366                        'THEN' 'BEGIN' RUEN:=RUEN+A[9]; 'GOTO' EXHYME 'END';
369                                       'IF' A[I]=XI
369                        'THEN' 'BEGIN' RUEI:=RUEI+A[9]; 'GOTO' EXHYME 'END';
372                     'END'
372                     'END';
373         'IF' A[I]=XO 'THEN' 'BEGIN' RUO:=RUO+A[9]; 'GOTO' EXHYME 'END'
375                     'ELSE' 'BEGIN' RU:=RU+A[9]; I:=I-1; 'GOTO' EXHYME 'END';
379         EXHYME:
379         I:=I+1;
380         'IF' A[I]= X1 'THEN' 'BEGIN' R1:=R1+A[9]; 'GOTO' FINISH; 'END';
384         'IF' A[I]= X2 'THEN' 'BEGIN' R2:=R2+A[9]; 'GOTO' FINISH; 'END';
388         'IF' A[I]= X3 'THEN' 'BEGIN' R3:=R3+A[9]; 'GOTO' FINISH; 'END';
392         'IF' A[I]= X4 'THEN' 'BEGIN' R4:=R4+A[9]; 'GOTO' FINISH; 'END';
396         'IF' A[I]= X0 'THEN' 'BEGIN' R0:=R0+A[9]; 'GOTO' FINISH; 'END';
400
400         NEWLINE(10);
401         WRITE TEXT ('('ERROR:XXX')');
402         'FOR' I:=1 'STEP' 1 'UNTIL' 8 'DO' PRINTCH (A[I]);
403         PRINT (A[9],5,0);
404         I:=1;  'GOTO' LOOP;
406
406         FINISH:
406         'FOR' I:=1 'STEP' 1 'UNTIL' 8 'DO' PRINTCH(A[I]);
407         PRINT(A[9],5,0);
408         SPACE(5);
409         INCR:=INCR+1;
410         'IF' INCR=5 'THEN' 'BEGIN' NEWLINE(1); INCR:=0 'END';
413         'END';
414         EOI:
414         'FOR' VARI:=RO,RP,RM,RF,PD,RT,RN,RL,RZ,RC,RS,RZH,RCH,RSH,RR,
414           RJ,RQ,RX,RG,RK,RH,ROO,
414           RA,RO,RE,RII,RV,RER,RAI,RFI,RAO,ROU,RAN,REN,RANG,RENG,RONG
414         'DO' 'BEGIN' NEWLINE(1);
416                   PRINT(VARI,6,0)   'END';
417         'FOR' VARI:=
417           RI,RIA,RIAO,RIE,RIOU,RIAN,RIN,RIANG,RING,RIONG,
417           RU,RUA,RUO,RUAI,RUEI,RUAN,RUEN,RUANG,RUENG,
417           RV,RVE,RVAN,RYN,   R1,R2,R3,R4,R0
417           'DO' 'BEGIN' NEWLINE(1);
419                   PRINT(VARI,6,0)   'END';
420         'END'
```

漢語常用音素之研究

（中文摘要）

何國祥

本研究之主要工作在統計漢語（國語）各音素在七十五萬字資料中所出現之次數，並分析其分配狀態；提供具體數字與圖表，以便讀者閱覽及作進一步分析之根據。這種研究工作不但有利於改進中文速記，而且對拼音化中文打字機的鍵盤設計，和漢字電腦化輸入程式的分析，也有參考價值。

此項研究所根據之次級資料是國立編譯館一九六七年出版之《國民學校常用字彙研究》。該字彙研究由毛子水、何容、齊鐵恨、蔡樂生等十數位語言、文字、教育、統計、心理各方面的專家領導，歷時四年，方克完成。其於資料之選取，範圍甚廣，包括報章、國民學校課本、兒童作品、課外讀物、廣播稿和民衆讀物等六種資料計約七十五萬字。本研究即根據其分析該等漢字之字音及統計每字之出現次數而作者。例如：該書指出出現次數最多的是「的」ㄉㄜ（dė）字，計達26,938次，本研究即在聲母ㄉ(d)、韻母ㄜ（e）及輕聲項下各加26,938次。（至於出現只一次的，則有565字。）

漢語語音有聲母、韻母和聲調三種音素成份，韻母又可再分爲介音、主要元音及韻尾。

爲求減少計算錯誤與節省時間起見，本研究採用電腦進行音素統計之主要工作，即聲母、韻母和聲調的計算。至於介音、主要元音、韻尾、羅馬字母、注音符號和音節等統計則爲電腦計算結果之進一步分析與歸納。茲將本研究所得結果，簡述如次（所用音素以拼音方案和注音符號表示）：

（一）聲母：七十五萬字資料中，沒有聲母的有十一萬，相當於總數的15%。其他有聲母者，/d/ ㄉ之出現次數最多，佔全部資料之10%，其次爲/sh/ ㄕ（7.81%）、/j/ ㄐ（6.38%），較不常用的是/r/ ㄖ（1.94%）、/c/ ㄘ（1.13%）和/p/ ㄆ(1.00%)。

據統計，漢語中的/zh/ㄓ、/ch/ㄔ、/sh/ㄕ、/r/ㄖ；/z/ㄗ、/c/ㄘ、/s/ㄙ和/j/ㄐ、/q/ㄑ、/x/ㄒ三組音之總出現次數，佔全部資料的40％；換言之，若不能善於把握此等聲母，則每說十個音便有四個犯錯或令人誤解的可能。

（二）韻母：最常用的韻母是/e/ㄜ，佔總次數的9.28％，其次是/i/ㄧ（9.25％）、/u/ㄨ（6.59％）、/-v/〔ɹ〕（5.44％）、/uo/ㄨㄛ（4.44％）、/a/ㄚ（4.41％），較不常用的是/io/ㄧㄛ和/iai/ㄧㄞ，各佔總數的0.001％而已。韻母再分爲介音、主要元音及韻尾，分述如下：

（1）介音：據研究所得，絕大多數（72％）漢字沒有介音，其他有〔-i-〕ㄧ介音的出現次數佔總次數的15％，有〔-u-〕ㄨ介音的佔11％，〔-y-〕ㄩ介音最少用，只佔總數的2％。

（2）主要元音：本研究對主要元音統計，分別採用國際音標、漢語拼音和注音符號（單韻母）三個系統分析：

(a)國際音標：最常用的是〔i〕，佔14.39％，其次是〔ɤ〕(13.72％)、〔*a*〕（10.91％）、〔a〕（10.47％），較少用的是〔y〕和〔ɻ̩〕，各佔2.31％和1.69％。

(b)漢語拼音：展唇元音/a/、/e/、/i/之總出現次數佔全部資料的80％，遠較圓唇元音/o/、/u/、/ü/爲常用。其個別百分比爲/a/31％、/e/24％、/i/ 22％、/o/ 14％、/u/ 7％、/ü/ 2％。

(c)注音符號：ㄢ爲最常用的單韻母，出現次數佔總次數的10％，ㄩ及ㄦ爲罕用單韻母，分別佔2％及1％。

（3）韻尾：據統計，沒有韻尾之字音數目佔總次數的45％，其餘52％有韻尾字音中，鼻音韻尾/-n/、/-ŋ/最常用，佔17％和15％，較少用的是/-ɹ/，只佔統計資料的1％。

（三）聲調：漢語五個聲調中（包括輕聲），去聲在全部資料中的出現次數最多，佔總次數的34％，其次是陰平（21％）、陽平（20％）、上聲（18％）和輕聲（6％）。

（四）羅馬字母和注音符號：漢語拼音方案所用的羅馬字母有26個（包括ü），最常用的是 i ，佔全部字母數的14％，其次是 n 、a 、u 、e 。有趣的是，英語常用的e（13％）在漢語（拼音方案）中只位列第五（7％），漢語常用的 i （14％）在英語中亦剛好位居第五（7％）。

至於常用的注音符號則爲ㄧ和ㄨ，佔符號出現總數的13％和9％，出現次數最少的是ㄦ，只佔總數的0.4％。

（五）音節和同音字：本研究所用次級資料共有音節1,153個，不同之漢字4,862字。四聲中（輕聲不計），上聲的音節最多，有 325 個，但其總出現次數及所收漢字數則爲四聲中之最少者。

（六）音節平均長度：漢語拼音音節之長短視所用系統不同而異。據統計，採用注音符號之漢語音節平均長度最短，只有兩個符號；至於採用拼音方案，則每音節平均需要三個羅馬字母表示。