Speech Analysis of the Vowels for Penang Hokkien Language

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Abstract

Speech is the preferred communication channel among people. It is an intuitive and most natural means of communication. Speech analysis of language is an important aspect to understand how a language is built up and compared to IPA. In this paper, the monophthong vowel will be analyzed to determine the physic and acoustic feature of the speech. Formants, pitch, and duration are measured using Praat software, and the average F1 and F2 are plots together with IPA formant vowel average frequency.

Keywords: IPA, Praat, Vowel

1. Introduction

Speech is the preferred communication channel among people. It is an intuitive and most natural means of communication. Humans are born with the ability to recognize a spoken language effortlessly. [1] Human listeners recognize different phonemes based on acoustic features such as voice onset time, formant frequencies, and formant transitions. [2]. We can segment a continuous stream of speech into distinct parts and recognize the parts in other words and segment sentences into words and words into sounds. [3] Acoustic phonetics which focuses on the physical properties of the sounds of language makes use of various computerized tools to analyze the speech waveform of the spoken language and segment them into separated acoustic words and they are represented by consonants and vowels. In this paper, I will focus on vowels within the Penang Hokkien language and discuss the acoustic feature using Praat software.

2. Background/Related Literature

There was not much-related literature/journal on the same topic as Penang Hokkien is a dialect that is used by the local peoples of Penang, Malaysia. But there are websites created by Penang Hokkien enthusiasts.

Penang Hokkien is a spoken language and rarely written in Chinese characters and there is no official standard romanization. The standard romanization systems commonly used are based on Tâi-lô and Pe̍h-ōe-jī (POJ), with varying modifications to suit Penang Hokkien phonology. There are seven simple vowels and four nasal vowels, there are twenty-one initials consonants with three final nasal consonants, four finals stop consonants and two syllabic consonants in Penang Hokkien. Originally there are eight tones in the Hokkien language. In recent years, tone six has merged with tone seven. Most of the native speakers of Penang Hokkien are only aware of four tones in unchecked syllables (high, low, rising, high falling). [4]

Young generation speakers of Penang Hokkien had reduced the Southern Min chain shift tone sandhi rules to a binary H vs. L contrast in sandhi position. Close relation with Malay and Baba-Nyonyas Hokkien might be the cause of the change in the high falling tone. [5]

A Study Of Penang Peranakan Hokkien conduct a study of borrowed Malay words in Penang Hokkien through interviews and observation in the Peranakan community and family and conclude that the lack of identity within the Peranakan community is being exacerbated by continuing pressure of resinization and westernization. These Malay words are being sidelined by Hokkien and English equivalents. [6]

3. The Language

Hokkien, a Southern Min language which originated from the Minnan region in the south-eastern part of Fujian Province in Southern China, is known as Quanzhang or Tsuan-Tsiang in linguistic. It is spoken widely in Taiwan, Malaysia, Singapore, Indonesia, the Philippines, and other parts of Southeast Asia. Hokkien is widely spoken by Chinese in the Northern part of Malaysia, especially in Penang where they have their local variant of dialect call Penang Hokkien. [4]

3.1. About the Language

Penang Hokkien is unique for its assimilation of the Malay language, such as the frequent use of Malay particles such as lah, pun, and nya, as well as the use of Malay loan words, such as

nouns (senduk, balai) and verbs (tarik). It is similar, yet different, to other variations of Hokkien in Malaysia. In the early day, Peranakan Chinese in Penang who is also known as Baba-Nyonyas, who were the descendants of intermarriage between Chinese migrants and local groups had their version of the Malay language, however, Hokkien lexicon gradually absorbed into Baba Malay as Peranakan Chinese blended into mainstream Chinese culture. [7]

3.2. The Writing System

Hokkien can be written in Chinese characters or Roman characters, but written Hokkien was inconsistent due to lack of official recognition. Mandarin is the national language of China in 1920, all other written Chinese languages remain unstandardized. Samuel Dyer from England came to Penang in 1827 and published the first-ever Penang Tsiang-tsiu Hokkien dictionary at Anglo-Chinese College, Melaka. The system continued to evolve and later became known as Peh-oe-ji. The Taiwanese government improvised and standardized it in 2006 to cover major accental differences and renamed it as Tâi-lô. [8] There is no official writing system for Penang Hokkien, Timothy Tye of Penang-Travel created his version of a writing system called TJ System for a native speaker of Penang Hokkien. Many of the words in the TJ system look the same as in the Missionary and Tâi-lô systems. [9] This paper will refer to TJ system to represent the writing word.

3.3. From Grapheme-to-Phoneme

3.3.1. Consonants

Unlike other dialects of Hokkien, coronal affricates and fricatives remain the same and do not become alveolo-palatal before /i/, e.g. 時 [si]. The consonants ⟨f⟩, ⟨d⟩, ⟨r⟩, and ⟨sh⟩ are only used in loanwords. [4]

Table 1, Consonants table

Initials										
		Bilabial		Labiodental	Alveolar		Postaveolar	Velar		Glottal
		Voiceless	Voiced	Voiceless	Voiceless	Voiced	Voiceless	Voiceless	Voiced	Voiceless
Nasal			m /m/ 名 (miâ)			n /n/ 爛 (nuā)			ng /ŋ/ 硬 (ngēe)	
Stop	Unaspirated	p /p/ 比 (pí)	b /b/ 米 (bí)		t /t/ 大 (tuā)	d /d/ 煎薟 (tsian-doi)		k /k/ 教 (kàu)	g /g/ 牛 (gû)	
	Aspirated	ph /pʰ/ 脾 (phî)			th /tʰ/ 拖 (thua)			kh /kʰ/ 扣 (khàu)		
Affricate	Unaspirated				ts /ts/ 姊 (tsí)	j /dz/ 字 (jī)				
	Aspirated				tsh /tsʰ/					

					飼 (tshī)					
Fricative				f [f]	s /s/ 時 (sî)		sh [ʃ]			h /h/ 喜 (hí)
Lateral						l /l/ 賴 (luā)				
Approximant						r /ɹ/ 4ing-gĭt				

Table 2, Consonants finals and syllabic

Finals					Syllabic consonant		
	Bilabial	Alveolar	Velar	Glottal		Bolabial	Velar
Nasal consonant	-m /m/ 暗 (àm)	-n /n/ 安 (an)	-ng /ŋ/ 紅 (âng)		Nasal	m /m/ 毋 (m̄)	ng [ŋ̍] 霜 (sng)
Stop consonant	-p /p̚/ 答 (tap)	-t /t̚/ 殺 (sat)	-k /k̚/ 角 (kak)	-h /ʔ/ 鴨 (ah)			

3.3.2. Vowels

Table 3, Monophthongs Vowels

Monophthongs				
	Front		Back	
	Simple	Nasal	Simple	Nasal
Close	i /i/ /iː/ 伊 (i)	inn /ĩ/ 圓 (înn)	u /u/ /uː/ 有 (ū)	
Close-Mid	e /e/ /eː/ 會(ē)		o /o/ /oː/ 蠔 (ô)	
Open-Mid	ee /ɛ/ /ɛː/ 下 (ēe)	enn /ɛ̃/ 嬰 (enn)	oo /ɔ/ /ɔː/ 烏 (oo)	onn [ɔ̃] 嗚 (onn)
Open	a / a / /aː/ 亞 (a)	ann /ã/ 餡 (ānn)		

- In the Tâi-lô system for Penang Hokkien, nasal vowels are indicated using final ⟨-nn⟩, while POJ uses superscript ⟨◌ⁿ⟩. Vowel also occurs in words that have nasal initials (⟨m-⟩, ⟨n-⟩, ⟨ng-⟩), however, this is not indicated, e.g. 卵 nūi (/nuĩ/). For most speakers who are not aware of POJ or Tâi-lô, is commonly indicated by putting an ⟨n⟩ after the initial consonant of a word. This is commonly seen for the popular Penang delicacy Tau Sar Pneah (豆沙餅 Tāu-sa-piánn). In other instances, may not be indicated at all, such as in Popiah (薄餅 poh-piánn), or as in the common last name Ooi (黃 Uînn). [4]

- When ⟨i⟩ is followed by final ⟨-k⟩ or ⟨-ng⟩, it is pronounced as /ek̚/ and /eŋ/ respectively

rather than other dialects which will be pronounced as [iɪk̚] and [iɪŋ] respectively. E.g. 色 sik /sek̚/. [4]

3.3.3. Diphthongs

Table 4, Diphthongs Vowels

Diphthong					**Triphthong**
ai /ai/ 愛 (ài)	ia /ia/ 椰 (iâ)	io /io/ 腰 (io)	iu /iu/ 油 (iû)	ua /ua/ 話 (uā)	iau /iau/ 枵 (iau)
au /au/ 後 (āu)	ia /iɛ/ 燕 (iàn)*	ioo /iɔ/ 娘 (niôo)*	ui /ui/ 為 (uī)	ue /ue/ 鍋 (ue)	uai /uai/ 歪 (uai)

- The rime ⟨ionn⟩ is a variant pronunciation of ⟨iaunn⟩. The two may be used interchangeably in Penang Hokkien, e.g. 張 tiaunn/tionn, 羊 iâunn/iônn. [4]
- When ⟨ia⟩ is followed by final ⟨-n⟩ or ⟨-t⟩, it is pronounced [iɛ], with ⟨ian⟩ and ⟨iat⟩ being pronounced as [iɛn] and [iɛt̚] respectively. In the speech, these sounds are often reduced to [ɛn] and [ɛt̚], e.g. 免 mián/mén. [4]
- ⟨ioo⟩ is a variant of ⟨io⟩ which is only found with the initial ⟨n-⟩, e.g. **娘** niôo. [4]
- Diphthongs <ua> and <au> often romanised as <wa> and <aw> respectively. e.g. **我** wá/uá /ua̍/, **够** kàw/kàu /kaʊ/.[4]
- Loanwords with diphthongs <ia> often romanised as <ya>. e.g. **挵央** sa-yang /sa-iaŋ/. [4]

3.3.4. Other possible phonemes

Table 5, Non-native vowels

Non-native vowels (used in loanwords)			
Tâi-lô	IPA	Example	Note
er	/ə/	ber-lian	Occurs in Quanzhou accented varieties of Hokkien such as those spoken in Southern Malaysia and Singapore. Used in Malay and English loanwords.
y	/y/	豬腸粉 tsý-tshiông-fân	Used in Cantonese loanwords, may be pronounced as ⟨i⟩.
ei	/ei/	無釐頭 môu-lêi-thāu	Used in Cantonese loanwords.
eoi	/ey/	濕濕碎 sa˝p--sa˝p--sêoi	An alternate pronunciation of ⟨ue⟩ due to Cantonese influence. Used in Cantonese loanwords, may be pronounced as ⟨ue⟩.
oi	/ɔi/	煎蕊 tsian-doi	Used in Malay, Cantonese and Teochew loanwords. Replaces ⟨ol⟩ in Malay loanwords, e.g. botol (瓶瓠 bo̍t-toi), cendol (煎蕊 tsian-doi).
ou	/ou/	大佬 tāi-lôu	Used in Cantonese and Teochew loanwords.

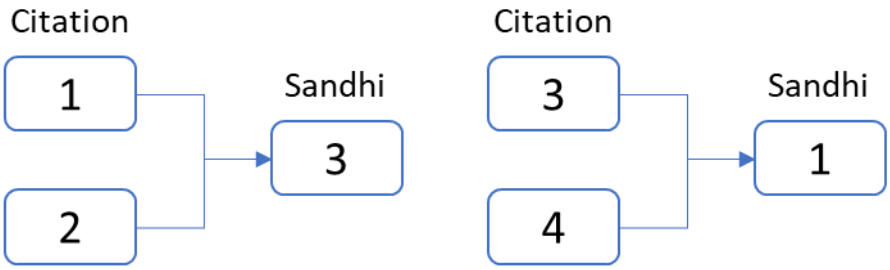
Penang Hokkien has four tones as shown below.

Penang Hokkien tones		
	TJ system number	Contour
Level	1	
High Rising	2	˥˧
Low Falling	3	˨˩
Falling	4	˥˩

The syllables change their tone based on their location within a sentence. It is known as tone sandhi. The rules of tone sandhi as below: [10]

morphemes of tones 1 and 2 change to tone 3
morphemes of tones 3 and 4 change to tone 1

Fig 1, Morphemes of tones



By this rule, the morpheme kiam2 (salty) becomes kiam3 when placed in front of pneah4 (biscuit) to form kiam3pneah4 (salty biscuit). [10]

Morphemes are grammatical unit that carries a meaning. They can function independently as words (e.g. bird, break) or appear as parts of words (un-, -ing, -tion). In English, we can form words by putting the morphemes together (bird+cage, friend+ly, un+break+able). [10]

In Penang Hokkien, a syllable that carries meaning is a morpheme. For example, ang2 (red) is both a morpheme and a word; ang3mor2 (Westerner) are two morphemes (ang2 = red and mor2 = hair) but are placed together to form a single word (a compound noun). [10]

4. The Analysis of Vowel of the Language

In this section, vowels listed in section 3.3.2 will be analyzed in detail and the speech analysis results will be explained in this section.

4.1. Recording Words

Seven simple monophthongs vowels which are listed in section 3.3.2 are selected for the recording. Five words related to each vowel will be recorded using Audacity software, after noise reduction, Praat software is used to further analyze the waveform. The recording has been saved in five different files as the list in the below table.

Table 6, Praat filename

File Name	Vowels reference
praat.Collection_i	/i:/
praat.Collection_e	/e:/
praat.Collection_ee	/ɛ:/
praat.Collection_a	/a:/
praat.Collection_u	/u:/
praat.Collection_o	/o:/
praat.Collection_oo	/ɔ:/

4.2. Vowel Analysis

Table 7 shows the phoneme of each vowel, script in Chinese character, the word in TJ system, transcription, and translation. Table 8, 9, and 10 show the average pitch, average F1 and F2, and average duration of each Simple Monophthongs vowels in Penang Hokkien language.

Table 7, List of phoneme, word, transcription, and translation of vowels

Phoneme	Script	Word	Transcription	Translation
/i:/	喜	hi1	/hi:/	joy
	疑	gi2	/gi:/	suspect
	痒	ge3 li4	/gə-li:/	ticklish
	护士	mi3 si1	/mi-si:/	nurse
	麻痺	bah3 pi3	/ba-pi:/	Numb
/e:/	不	be33	/be:/	no
	小	se3	/se:/	small
	鞋帶	eh3 tua3	/e-tua:/	shoe lace
	坐	che3	/che:/	sit
	好勢	ho1 seh3	/ho-se:/	succeeded

/ɛ:/	加	kae1	/kɛ:/	add
	烟	en1	/ɛn/	smoke
	牙	geh3	/gɛ:/	tooth
	茶	teh1	/tɛ:/	tea
	爬	pae2	/pɛ:/	crawl
/a:/	切	ka1	/ka/	cut
	早	ca1	/ca/	morning
	饱肚子	pa1	/pa/	stomach full
	松	sang1	/saŋ/	loose
	焦	ta1	/ta:/	Dry
/u:/	乌龟	ku1	/ku:/	tortoise
	你	lu4	/lu:/	you
	输	su1	/su:/	loss
	猪	tu1	/tu:/	pig
	杜库	du3 ku1	/duku:/	duku
/o:/	做	co3	/co:/	doing
	划	ko3	/ko:/	To row
	島	toh4	/to:/	island
	不好	boh3 ho1	/bo-ho:/	bad
	阿哥	ah3 ko1	/a-ko:/	brother
/ɔ:/	蘑菇	kor1	/kɔ:/	mushroom
	五	gor33	/gɔ:/	five
	尪公	ang3 kong1	/aŋ-kɔŋ/	Taoist deity
	墓	bong33	/bɔŋ/	grave
	朦朦	bong3 bong2	/bɔŋ-bɔŋ/	unclear

Table 8, Average pitch of each word

Vowel	Average Pitch from 5 words	Word 1	Word 2	Word 3	Word 4	Word 5
		Average Pitch	Average Pitch	Average Pitch	Average Pitch	Average Pitch
/i:/	125	131	128	126	139	102.89
/e:/	95	103	98	91	93	92
/ɛ:/	95	112	109	93	83	82
/a:/	106	104	111	108	109	100
/u/	140	117	147	148	145	146
/o/	104	101	100	108	107	104
/ɔ/	102	129	89.7	111	91	94

Table 9, Average F1 and F2 of each word

Vowel	Average Pitch from 5 words		Word 1		Word 2		Word 3		Word 4		Word 5	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
/i:/	270	2568	289	2582	265	2571	282	2547	273	2605	245	2537
/e:/	382	2106	401	2072	390	2087	371	2121	371	2183	379	2068
/ɛ:/	540	1880	504	1898	528	1901	555	1977	552	1740	564	1884
/a:/	822	1369	795	1401	793	1356	863	1355	781	1362	880	1373
/u:/	294	830	277	761	297	788	302	913	307	904	288	785
/o:/	417	918	413	934	436	894	424	966	411	884	404	915
/ɔ:/	551	980	595	1081	512	980	562	994	569	934	517	913

Table 10, Average duration of each word

Vowel	Average duration from 5 words	Word 1	Word 2	Word 3	Word 4	Word 5
		Duration	Duration	Duration	Duration	Duration
/i:/	0.308	0.315	0.349	0.284	0.303	0.292
/e:/	0.322	0.346	0.360	0.260	0.314	0.333
/ɛ:/	0.348	0.371	0.296	0.369	0.374	0.330
/a:/	0.363	0.444	0.371	0.423	0.234	0.345
/u:/	0.451	0.493	0.506	0.398	0.481	0.377
/o:/	0.438	0.348	0.491	0.348	0.479	0.525
/ɔ:/	0.237	0.301	0.343	0.197	0.233	0.112

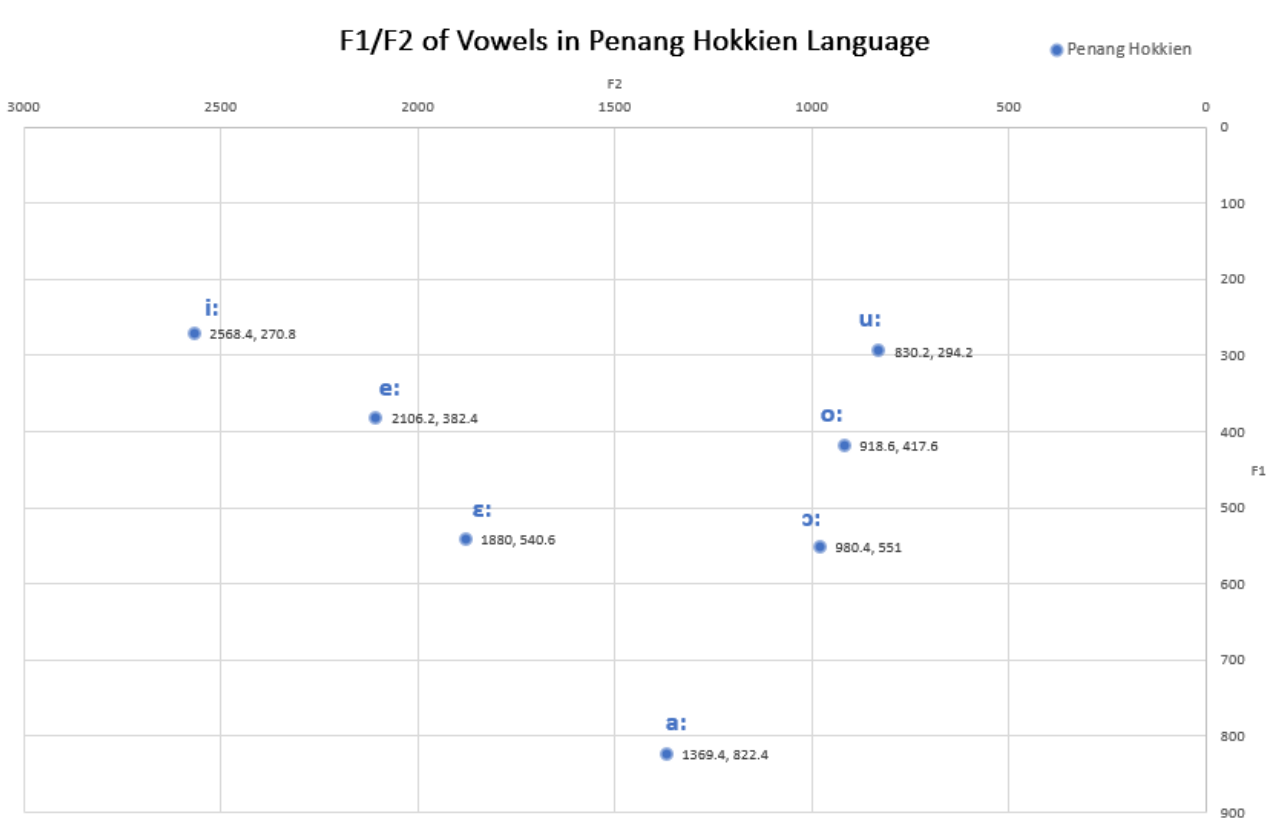
There is a mix in the words recording to illustrate when will long and short vowels happen in which location of words or sentences (Marking in red is a short vowel). When there is a

consonant after a vowel, the vowel will become a short vowel, when it is a single word or end of sentences that end with a vowel, the vowel will become a long vowel.

4.3. Mapping the Graph

To map the frequency response to the graph, the overall average F1 and F2 values listed above in Table 8 have been plotted into a graph. F1 and F2 are known as formants and can be used to distinguish the position of the tongue and the openness of lips.

Fig 2, Average vowel formants of Penang Hokkien language



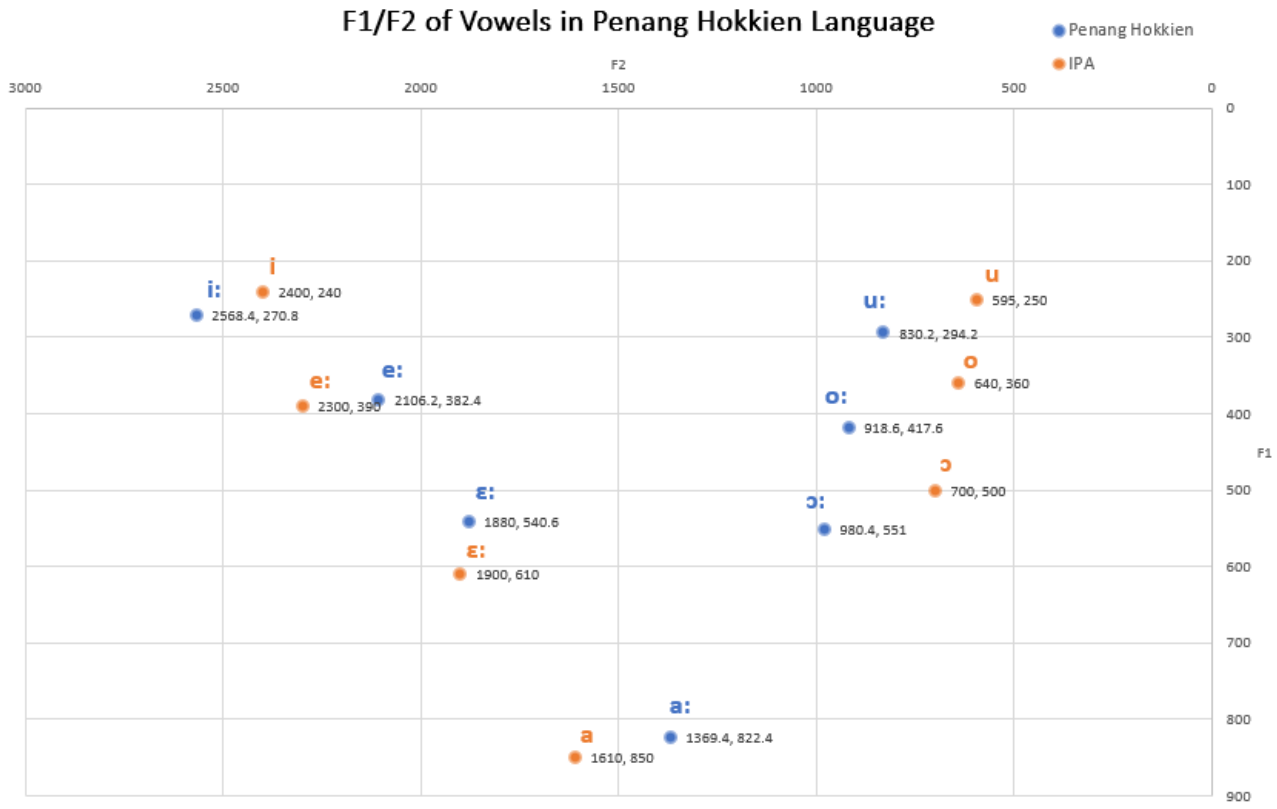
5. Conclusion and Discussion

The graph plotted for F1 and F2 chart in Fig 2 has been compared with the standard International Phonetic Acoustic (IPA) vowel chart using average vowel formats for a male voice from A Practical Introduction to Phonetics, Oxford University Press [11] [12]. They are mapped in the Formants chart format shown in Fig 3. Table 11, shows a summary of the average of F1, F2, Pitch, and Duration. Table 12, shows the summary of the acoustic feature of vowels.

Table 11, Summary of average F1, F2, Pitch and Duration

Phoneme	Average Pitch	Average F1	Average F2	Average Duration
/i:/	125	270	2568	0.308
/e:/	95	382	2106	0.322
/ɛ:/	95	540	1880	0.348
/a:/	106	822	1369	0.363
/u:/	140	294	830	0.451
/o:/	104	417	918	0.438
/ɔ:/	102	551	980	0.237

Fig 2. Formant plot Penang Hokkien vs IPA



Penang Hokkien vowels formants frequency match closely with IPA vowels, observe that vowels produce /e:/, /a:/, /u:/, /o:/, /ɔ:/ with tongue closer to the central, /i:/ have higher F2 frequency compared to IPA /i/. Also observed are that formants produce more with open-mid and close-mid of the lips.

Table 12, Summary of acoustic feature of vowels

Phoneme	Open/Close	Front/Central/Back	Rounded/Unrounded
/iː/	Close	Front	Unrounded
/eː/	Close-mid	Front	Unrounded
/ɛː/	Open-mid	Front	Unrounded
/aː/	Open	Front-Central	Unrounded
/uː/	Close	Central-Back	Rounded
/oː/	Close-mid	Central-Back	Rounded
/ɔː/	Open-mid	Central-Back	Rounded

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