Acoustic Analysis of Māori: Historical Data

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1. Introduction

Māori has been spoken in New Zealand since Māori settled the country some 800 to 1000 years ago (see papers in Sutton 1994). There has been interaction between Māori and English speakers since the late 18th century when, following Cook's voyages, sealers and whalers visited the country as part of their hunting expeditions. From the 1820s, the Christian missions particularly, but also the establishment of British rule in the 1840s, greatly increased the contact between the two languages, and this interaction intensified during the second half of the 19th century when many Māori received schooling in English. Well into the first half of the 20th century, virtually all Māori still spoke the language, with many being bilingual in English and Māori. Between the 1950s and 1980s, an urban drift by Māori led to a dramatic shift to English so that most young Māori spoke only English. Good summaries of the situation of Māori in recent decades can be found in Fishman's chapter on the language in *Reversing Language Shift* (1991: 230-51) and the Bentons' chapter in the sequel to this volume (Benton & Benton 2001).

During the 1970s, surveys found that the number of fluent speakers of Māori had declined dramatically. There were some 60,000 native speakers at that stage, though the great majority were older people (Benton 1991: 17). This discovery was an important trigger for the major revitalization effort which has been taking place since the 1980s. As a result of this, many younger Māori are now fluent L2 speakers, having learnt English as their first language. More recent studies including the 1996 and 2001 censuses, which for the first time included a language question, confirm that the older generation of speakers has indeed declined in number, while total numbers of speakers (including L2 speakers) has risen (Te Puni Kokiri 2003: 25). It is hoped and anticipated that these young speakers will raise children for whom Māori is their first language. This will potentially lead to changes in the pronunciation of Māori, because of the influence of English.

There is very little historical information about the pronunciation of Māori (see Bauer 1993; Biggs 1961; Harlow 2001 for descriptions of modern Māori pronunciation) and changes that have occurred because of the influence of English have not been documented at all systematically. While lexical borrowing is well documented, there is at best only the occasional anecdotal remark on the influence of English on Māori pronunciation (see for instance Benton 1991: 15; Harlow 1991:33-4). This paper seeks to provide a first step in documenting changes in the pronunciation of Māori since its contact with English by

providing an acoustic analysis of the vowel sounds of a speaker, Raureti Te Huia (RTH), born in 1885 who grew up as a fluent L1 speaker of the language. This analysis will serve as a reference point with which analyses of later Māori pronunciation can be compared. It is the first output from a project that seeks to trace changes in the pronunciation of Māori over time by comparing the pronunciation of three groups of speakers. The first group is born in the late 19th century, the second in the 1920s and the third in the 1980s[1].

2. Māori phonology

The Māori language has ten consonants /p, t, k, m, n, ŋ, f, w, r, h/ and five vowels /a, e, i, o, u/. Other aspects of the phonology of Māori, such as timing and to a lesser extent stress, await accurate study. It does appear however that the timing unit in Māori is the mora, a unit consisting of a short vowel plus any preceding consonant (see Bauer 1981:35).[2] There is little that is remarkable about the phonetics of the consonant phonemes: the stops in modern Māori are variably aspirated, though never until recently as strongly as is usual in English. For example, RTH (a member of our first group of speakers, details of whose pronunciations form the central core of this paper) only aspirates 6% of his stops when he is speaking Māori compared with 65% when he is speaking English. In addition, his voice onset time (VOT) for aspirated stops is significantly shorter in Māori (23 ms) than in English (36 ms) (King & Maclagan 2001). /r/ is almost always articulated as a flap. /f/ (spelt <wh>) shows the most variation both historically and regionally, having realizations as a labio-dental or bilabial fricative, a voiceless [w], even a labialized [h]. RTH uses all four of these pronunciations of <wh>, sometimes using several different pronunciations for the same word. For example, *whare* 'house' is pronounced with [h], [f] and [ɸ] (for details of RTH's pronunciation of <wh>, see Maclagan & King 2002).

Māori has simple phonotactics, with a syllable structure of (C)V(V(V)) (Bauer 1993; Biggs 1961; Harlow 2001). Vowel length is phonemic, with contrasting pairs such as *kaka* 'garment', and *kaakaa* 'parrot'. There are numerous diphthongs, with all combinations of a vowel followed by a higher vowel being pronounced as a single peak, at least within morphemes. For instance, /pou/ 'stick' contrasts with /pau/ 'be used up' and with /pao/ 'strike', /tai/ 'tide' with /tae/ 'arrive', /koe/ 'you (singular)' with /koi/ 'sharp'. In addition, six long diphthongs /aai, aae, aau, aao, eei, oou/ occur, so that /taaua/ 'we two incl.' contrasts with /taua/ 'war party'. The extent to which eligible combinations of vowels form diphthongs across morpheme boundaries is dependent on a number of factors, including speed of speech, identity of the vowels, and the nature of the boundary. Diphthongs formed across such boundaries are perceptually identical to diphthongs within morphemes. Where diphthongization does not occur, the unlike vowels in this position are separate articulations.

[1] We wish to thank the Marsden Fund of the Royal Society of New Zealand for funding that has enabled this research to be carried out. The results presented in this paper represent the first output from this project. Some of the values may change slightly when further analysis is carried out.

[2] As will be seen, syllabic peaks may consist of any of the five short vowels, phonemically long versions of the five vowels, and a range of diphthongs. Both the long vowels, and the diphthongs are usually analysed as sequences of like and unlike short vowels respectively. See Bauer 1993:534-542.

3. Speaker

The speaker analyzed in this paper, Raureti Te Huia (RTH), was born in Te Awamutu in the North Island of New Zealand in 1885, of Ngāti Maniapoto and Tūwharetoa descent. He was recorded by the Mobile Recording Unit of the New Zealand Broadcasting Service in 1947. Copies of the recordings were obtained from Radio New Zealand Sound Archives and are held in the Department of Linguistics and the Macmillan Brown Library at the University of Canterbury (for details of the Mobile Unit recordings at the University of Canterbury see Gordon et al. 2004). In the recordings, RTH speaks in Māori and then repeats the material in English. Much of his presentation is *whakapapa* (genealogy), so the English material has sections that are almost pure Māori as well as isolated Māori words. As one listens to the recordings, the pronunciation of both the *whakapapa* and the isolated Māori words sounds very different from RTH's pronunciation of English. RTH grew up speaking Māori as his first language, and his English shows marks of being learnt later in life. His dental fricatives /θ/ and /ð/, for example, are often stopped and his syntax varies from standard English, with affixed /s/ often being added where it does not belong (see the Discussion section below for further examples). There are no indications that the variety of Māori spoken by RTH has any particular dialectal features in its vowel systems.[3] An analysis of his speech should therefore give a general indication of the pronunciation of Māori vowels in the earlier part of the twentieth century.

RTH was familiar with Pākehā culture as well as Māori.[4] He had a life-long interest in historical matters and both he and his father were informants for historians, including James Cowan. He was secretary for an important *hui* (meeting) in 1912 that was convened to record important historical information from his tribal area and was one of the seventeen founding members of the Te Awamutu Historical Society, in February 1935. He stands out among the Māori recorded by the Mobile Unit in that the interviewer does not feel it necessary to interrupt him when he is speaking English to ask for clarification of terms or details.

4. Data and analysis

In this paper, we focus on the short and long monophthongs of Māori, /a, e, i, o, u/ and /a:, e:, i:, o:, u:/ and five of the diphthongs /ai, ae, au, ao, ou/. We compare the values obtained when RTH is speaking in Māori with those obtained for Māori words when he is speaking in English (referred to as *Māori-in-English*). We then compare both sets of Māori formant values with the values obtained for the English monophthongs /i, ɪ, ɛ, æ, a, ʌ, ɒ, ɔ, u, ʊ, ɜ/.

The material available consists of 48 minutes 30 seconds for English and 90 minutes for Māori. Where possible, 30 tokens were analyzed per vowel. For English, only tokens carrying prosodic sentence stress were selected. Because RTH spoke very slowly in English, grammatical words were often sufficiently stressed to have clear vowels. In this case they were included in the analysis. Because this is an initial acoustic analysis for

[3] Regional variation in Māori consists primarily in lexical variation and in the pronunciation of some individual words (e.g. Eastern *taina* vs. Western *teina* 'younger sibling same sex'). Detailed investigation of any phonetic variation which correlates with region is in fact part of our project, but at this stage we have no reason to expect that much will be identified.

[4] *Pākehā* is a term used for non-Māori in New Zealand.

Māori, the first 30 appropriately stressed tokens were selected for each vowel. For Māori, this meant that many particles and grammatical words were included, especially for /e:/ which occurs mainly in grammatical words such as *tēnei* (this). For some English vowels (such as FOOT) and for some vowels for Māori-in-English (/i:/ and /e:/) it was not possible to obtain 30 tokens from the recordings. Table 1 presents the number of tokens analyzed for each vowel. The Māori analysis was carried out by the second author and the Māori-in-English and English analyses by the first author.

The material was originally recorded for broadcast and is therefore of reasonably good quality. However because it was recorded on acetate disks in 1947, there is no information recorded above 5,000 Hz. The recordings were digitized at 16000 Hz (16 bit) and formants were calculated in PRAAT using the default settings (25 ms analysis frame, gaussian window, 10 pole LPC filter) (Boersma and Weenink, http://www.fon.hum.uva.nl/praat/). Formant measurements were taken during the steady state portion of the vowel. If there was no steady state, formant readings were taken at the F2 maximum (and F1 minimum) for front vowels, the F1 maximum (and F2 minimum) for central vowels and the F2 minimum (and F1 minimum) for back vowels. For length measurements, consonant transitions were included within vowel measurements as long as vowel formants could be seen (i.e. as long as there was voicing). Māori does not have syllable final consonants and, with the exception of /r/, anticipatory transitions were not common. Any anticipatory transitions that did occur were included in the vowel length if there was no break before the initial consonant of the following word. Because of the phonotactics of Māori, many vowels follow each other (without forming phonological diphthongs). Where a vowel was adjacent to another vowel, length was measured to the middle of the transition between the two vowels. Graphs were drawn in Emu/R (http://emu.sourceforge.net) and Akustyk (http://bartus.org/akustyk/. T-tests were used to test for the significance of the parameters analysed. All figures are in the appendix at the end of this paper.

Table 1: Number of tokens analyzed for each vowel.

English monophthongs

Vowel	/i/	/ɪ/	/e/	/æ/	/a/	/ʌ/	/ɒ/	/ɔ/	/u/	/ʊ/	/ɜ/	**Total**
#	30	30	30	30	30	30	30	30	30	14	30	314

Māori monophthongs

Vowel	/a/	/e/	/i/	/o/	/u/	/a:/	/e:/	/i:/	/o:/	/u:/	**Total**
#	40	32	27	31	28	30	33	34	30	31	319

Māori diphthongs

Vowel	/ai/	/ae/	/au/	/ao/	/ou/	**Total**
#	32	32	30	30	27	151

Māori-in-English monophthongs

Vowel	/a/	/e/	/i/	/o/	/u/	/a:/	/e:/	/i:/	/o:/	/u:/	**Total**
#	31	30	30	30	30	30	3	5	31	29	249

Māori-in-English diphthongs

Vowel	/ai/	/ae/	/au/	/ao/	/ou/	**Total**	**Grand Total**
#	30	9	30	27	4	100	1133

5. Results

5.1 Māori

Formant frequency values (means and standard deviations) in Hz for the first 3 formants for long and short monophthongs are presented in figure 1 (in the appendix) and table 2. The ellipses in figure 1 and elsewhere contain 95% of the tokens and give an indication of the spread of the data. Except for /o:/, the long vowel ellipses are smaller than the short vowel ellipses, indicating that the long vowels form more compact clusters in acoustic space than the short vowels. For RTH the long vowels with the possible exception of /u:/, are more peripheral than the short vowels. The significance of these differences was tested with t-tests. For /a:/, F1 is higher ($t = 5.92$, $p < 0.01$) and F2 lower ($t = -4.71$, $p < 0.01$) than /a/. F2 for /e:/ is higher than /e/ ($t = 3.97$, $p < 0.01$). For /i:/, F1 is lower ($t = -4.33$, $p < 0.01$) and F2 is higher ($t = 5.00$, $p < 0.01$) than /i/. F2 for /o:/ is lower than /o/ ($t = -4.10$, $p < 0.01$). The most obvious characteristic for /u/ and /u:/ is the spread of F2 for /u/ as indicated by its ellipse. The difference between the means for /u:/ and /u/ is less marked than for the other vowels with F2 for /u:/ being lower than for /u/, ($t = -2.24$, $p < 0.05$).

Table 2: Formant frequencies for Māori vowels for RTH in Hz.

Short vowels	/a/		/e/		/i/		/o/		/u/	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
F1	548	80	448	44	367	48	441	34	355	32
F2	1268	132	1899	194	2086	73	1009	130	1370	313
F3	2519	395	2985	583	3215	449	2659	394	2556	368
Long vowels	/a:/		/e:/		/i:/		/o:/		/u:/	
F1	666	70	448	38	326	26	451	45	345	21
F2	1156	49	2048	95	2178	74	860	152	1213	223
F3	2287	266	2946	449	2971	272	2402	362	2330	165

In articulatory terms, this indicates that /a:/ is more open and farther back than /a/, /e:/ is more front than /e/, /i:/ is closer and more front than /i/, and /o:/ is farther back than /o/. /u:/ is farther back than /u/, and in that a more back pronunciation requires more articulatory effort than a central one, /u:/ could be considered more peripheral than /u/.[5] However there is a strong indication that /u/ and /u:/ are fronted following /t/ (see discussion below), and since a higher proportion of /u/ (16/28) than /u:/ (13/31) followed /t/, the apparent peripherality of /u:/ may be an effect of the phonetic context.

Table 3 presents length measurements for long and short vowels in Māori for RTH. The long vowels are all considerably longer than the short ones, with the differences being significant for each vowel pair and also when the long vowels as a group are compared

[5] We thank the anonymous reviewer for pointing out that retracted /u/ may be accompanied by greater lip rounding which would also lower F2. Unfortunately there is no objective way in which to assess the lip rounding in this historical material.

with the short vowels as a group (all $p < 0.01$).[6] Although there is variation in vowel length, with some short vowels being longer than some long vowels, overall, the long vowels are twice as long as the short vowels. The length data thus support the formant data in indicating that RTH makes considerable and significant differences between the sets of long and short vowels.

Table 3: Length of Māori vowels for RTH in ms. All length differences are significant ($p < 0.01$).

Short vowels	/a/		/e/		/i/		/o/		/u/		Mean	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Length	71	23	68	22	70	15	77	33	61	20	70	5
Long vowels	/a:/		/e:/		/i:/		/o:/		/u:/		Mean	
Length	145	32	122	32	159	51	124	28	150	39	140	16

5.2 English

Figure 2 and table 4 present formant values in Hz for English monophthongs for RTH. Figure 3 plots RTH's vowels against average values for five non-Māori New Zealand born male speakers born in the late 19th century (non-Māori speaker values are based on Gordon et al. 2004). RTH's FLEECE[7] vowel is less fronted than the non-Māori speakers and his FLEECE and KIT are closer together than for most of the non-Māori New Zealanders we have analyzed. This may be an effect of RTH's Māori /i:/ and /i/ on his English FLEECE and KIT, or it may reflect changes that occurred in New Zealand English soon after he was born whereby KIT was fronted for men in some contexts (see Langstrof 2003). RTH's STRUT and START vowels are closer together and farther back than those of the reference speakers, so that he sounds somewhat more upper class than many of the more working

Table 4: Formant frequencies for English vowels for RTH in Hz.

Vowel	**Mean**			**sd**		
	F1	F2	F3	F1	F2	F3
/i/	328	2208	2885	27	80	575
/ɪ/	365	2108	2826	41	158	655
/e/	477	1975	2874	96	128	450
/æ/	627	1914	2850	73	101	406
/a/	735	1236	2489	84	119	294
/ʌ/	676	1266	2438	65	176	458
/ɒ/	650	1027	2445	72	84	387
/ɔ/	504	868	2654	62	108	299

[6] For /a:/ vs /a/, $t = 10.17$, for /e:/ vs /e/, $t = 7.88$, for /i:/ vs /i/, $t = 9.49$, for /o:/ vs /o/, $t = 5.99$ and for /u:/ vs /u/, $t = 11.03$. $p < 0.01$ for each vowel pair. When all the long vowels are compared with the short vowels, $t = 6.91$ and $p < 0.01$.

[7] We use KEY WORDS to represent both phonemes and the lexical sets to which they belong (see Wells, 1982).

/ʊ/	435	1317	2799	41	86	374
/u/	361	1381	2499	32	331	334
/ɜ/	516	1558	2890	55	143	387

class Mobile Unit non-Māori speakers (see Wells 1982: 234 for back qualities of START being associated with greater prestige in RP (Received Pronunciation), and Gordon et al 2004: 125-133 for START fronting and ibid: 136-139 for STRUT fronting in early New Zealand speakers). Apart from this, his vowels are very similar to those of non-Māori New Zealanders born around the same time. When one listens to the recordings, it is clear that RTH is a second-language speaker of English. Non-standard grammatical features (such as the addition of /s/ to many words where it is not appropriate) and pronunciations (/t/ for /θ/ and /d/ for /ð/) contribute strongly to this assessment. However, figure 3 shows that the F1 and F2 values of his vowel sounds, with the possible exception of FLEECE, do not contribute to the impression that English is not his first language.

5.3 Māori-in-English

Figure 4 and table 5 present formant values in Hz for Māori vowels when RTH is speaking English (Māori-in-English). Figure 5 compares RTH's vowel formant frequencies when he is speaking Māori-in-English with his frequencies when he is speaking Māori. From figures 4 and 5 it can be seen that the formant differences between the long/short vowel pairs for Māori-in-English are considerably less than for Māori. The only significant formant difference between the long and short vowels is that /a/ is closer than /a:/ ($t = 3.77$, $p < 0.01$). This means that the centralization of the short vowels and hence the contrast between the long and short vowels that is apparent in RTH's Māori is greatly reduced when he uses Māori words while he is speaking English. The vowel lengths for Māori-in-English vowels are given in table 6. RTH's long vowels are similar in length whether he is speaking in Māori (mean = 140 ms, sd = 16 ms) or English (mean = 142 ms, sd = 46 ms) but his short vowels are considerably longer when he is speaking in English (mean = 112 ms, sd = 56 ms) than in Māori (mean = 70 ms, sd = 5 ms). Subjectively RTH's speech is considerably slower when he is speaking in English than in Māori, but this slower rate affects the long and short vowels differently. Overall the long vowels are still significantly longer than the short vowels for Māori words when RTH is speaking English ($t = 4.75$, $p < 0.01$). Because of the small number of available tokens for /e:/ and /i:/ these two long vowels were not compared with their corresponding short vowels. For the three other vowel pairs, only /a:/ and /a/ were significantly different in length ($t = 3.42$, $p < 0.01$), indicating that the length difference between the long and short Māori vowels does not hold up clearly when RTH is speaking in English.

Table 5: Formant frequencies for Māori-in-English vowels for RTH in Hz. Note that there are very few tokens for /e:/ (3 tokens) and /i:/ (5 tokens).

Short vowels	/a/		/e/		/i/		/o/		/u/	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
F1	665	92	463	34	331	32	478	40	346	29
F2	1232	154	2001	101	2201	147	968	155	1194	256
F3	2370	263	2872	424	3124	311	2589	320	2611	363

Long vowels	/a:/		/e:/		/i:/		/o:/		/u:/	
F1	736	49	448	21	317	13	460	32	342	26
F2	1177	70	2009	98	2286	141	955	115	1341	314
F3	2256	139	2793	684	3437	104	2698	525	2707	423

Table 6: Length of Māori-in-English vowels for RTH in ms.

Short vowels	/a/		/e/		/i/		/o/		/u/		Mean	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Length	121	58	99	48	103	68	118	54	117	49	112	56
Long vowels	/a:/		/e:/		/i:/		/o:/		/u:/		Mean	
Length	167*	46	131	19	125	18	145	67	143	80	142*	46

* the difference between the relevant long and short vowel pairs is significant, $p < 0.01$. The difference between /e/ and /e:/ and between /i/ and /i:/ was not tested because there were very few tokens for /e:/ (3 tokens) and /i:/ (5 tokens).

5.4 Diphthongs

Tables 7 and 8 and figures 6 and 7 show RTH's diphthongs when he is speaking in Māori and Māori-in-English respectively. From figure 6 it can be seen that, for RTH's Māori, the front closing diphthongs /ai/ and /ae/ both start and finish in clearly distinct areas of acoustic space. The same is true for the back closing diphthongs, /ao/ and /au/. The diphthongs /au/ and /ou/, which are often difficult to distinguish in the speech of younger Māori speakers and may well have merged in the speech of many (see Bauer 1993: 540-541), start at clearly distinct positions.[8] Figure 7 shows that, when RTH is speaking in English, these distinctions in his Māori start to break down. Although the finishing points of /ai/ and /ae/ and of /au/ and /ao/ are different, the starting points are falling together. The starting points of /au/ and /ou/, however, remain clearly distinct. Figure 8 compare RTH's Māori and Māori-in-English diphthongs. It shows that the back diphthongs, /au/, /ao/ and /ou/ change more when RTH uses Māori words in his English than do the front diphthongs /ai/ and /ae/.

Table 7: Formant frequencies for the first and second targets of RTH's Māori diphthongs in Hz.

	/ai/		/ae/		/au/		/ao/		/ou/	
T1	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
F1	546	63	653	76	584	45	626	47	416	29
F2	1247	170	1222	167	1315	163	1117	195	1317	340
F3	2555	338	2566	363	2370	443	2426	310	2232	219
T2										
F1	372	38	553	57	359	54	530	64	342	34

[8] The loss of distinction between original /ou/ and /au/ can readily be perceived auditorily by anyone conversant with Maori, and such analysis as has been carried out so far within the context of our project shows this collapse of starting point for the younger speakers in our sample.

F2	2118	142	1878	173	1058	185	984	97	1096	162
F3	3426	397	2986	440	2419	374	2427	291	2253	223

Table 8: Formant frequencies for the first and second targets of RTH's Māori-in-English diphthongs in Hz. Note that there are very few tokens for /ou/ (4 tokens) and /ae/ (9 tokens).

	/ai/		/ae/		/au/		/ao/		/ou/	
T1	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
F1	628	66	664	44	670	48	702	87	472	20
F2	1219	147	1229	143	1265	240	1201	86	1098	134
F3	2495	353	2544	370	2457	351	2510	248	2741	269
T2										
F1	405	100	535	49	422	40	513	57	379	52
F2	2097	461	1930	143	1041	100	1062	134	1046	220
F3	3125	27	3159	459	2638	319	2614	272	2767	444

Table 9: Length of RTH's Māori and Māori-in-English diphthongs in ms. Note that there are very few tokens for /ou/ (4 tokens) and /ae/ (9 tokens).

	/ai/		/ae/		/au/		/ao/		/ou/		Mean	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Māori	148	40	170	42	162	43	162	35	155	37	160	40
Māori-in-English	163	40	206	53	161	55	205	80	158	31	177	61

Length measurements for RTH's diphthongs for both Māori and Māori-in-English are shown in table 9. RTH's Māori diphthongs (mean = 160 ms, sd = 40 ms) are significantly longer than his Māori long vowels (mean = 140 ms, sd = 16 ms) ($t = 4.18$, $p < 0.01$). The Māori-in-English diphthongs are just significantly longer than the Māori diphthongs ($t = 2.48$, $p < 0.05$). A slightly higher proportion of the Māori-in-English diphthongs than the Māori diphthongs preceded syllables starting with voiceless consonants. We have not yet investigated the effect of following consonants on vowel length in Māori. However, if a voiceless consonant at the start of the following syllable should shorten the preceding vowel (see Peterson and Lehiste 1960 for this effect in English), the observed length difference between the two sets of diphthongs may actually underestimate any real difference between them. The observed length difference between the sets of diphthongs is mainly accounted for by the greater length and variability of Māori-in-English /ao/. If /ao/ is removed from the analysis, the length of the remaining Māori-in-English diphthongs is 167 ms (sd 49 ms) which is not significantly different from the length of the Māori diphthongs ($t = 1.06$, $p = 0.29$). It is difficult to see why /ao/ is so much longer than the other diphthongs. The two longest tokens occurred when RTH was chanting a *haka* (dance with an accompanying chant), and was therefore speaking more slowly, but long tokens also occurred in names like *Ao-Nui* and in *taonga* (treasure) with no apparent explanation. It seems possible that RTH lengthens /ao/ so that his Pākehā listeners will clearly hear the difference between /ao/ and /au/, but we have no way of proving this possibility.

6. Discussion

The analysis of RTH's Māori shows that the traditional vowels /a, e, i, o, u/, both long and short, are clearly distinct in his speech. The long vowels (mean = 140 ms, sd = 16 ms) are twice as long as the short vowels (mean = 70ms, sd = 5 ms). This finding is consistent with the usual analysis of the phonetically long vowels of Māori as underlyingly sequences of two like short vowels, (see for instance Bauer 1993:534 or Harlow 2001:8-9 for discussion). However as figure 1 shows, the short vowels are significantly more central than the long vowels and this difference is audible, most clearly for /a/ and /a:/. The greater peripherality of the long vowels probably occurs because their greater length provides more time for the tongue to reach more extreme articulatory positions. Although the differences are statistically significant and can be perceived, they may not be linguistically meaningful, with the short vowels being merely automatic articulatory undershoot.

The five diphthongs /ai, ae, au, ao, ou/ all start and finish in clearly distinct areas of acoustic space. The diphthongs /au/ and /ou/, which are not always distinct for modern speakers of Māori, are auditorily and acoustically clearly different. The diphthongs average 160 ms in length (sd = 40 ms), and are significantly longer than a sequence of two short vowels. This is most likely due in part to the circumstance that diphthongs are always at least half-stressed, whereas the short vowels measured in this research include a number of less stressed tokens. The exact relationship between stress and other properties of vowels and diphthongs is still awaiting study. Diphthongs in Māori are usually analyzed as underlying sequences of short vowels for reasons very similar to the related analysis of long vowels (see above for relevant references).

When we turn to English, RTH clearly sounds like a second language speaker in that he does not always use appropriate English syntax. The first English section of the recording starts with 'The commencing of the tradition of the Māori people' and includes sections such as 'And Tū-matauenga had so many childrens and their lines commencing at Aitu' or 'After these that I remembers of the same year King Tawhiao died in Parawera'. What he means is always clear, but he does not sound like a first language speaker. Similarly, his consonant articulation is not always standard English, with substitutions of /t/ and /d/ for /θ/and /ð/, and lack of aspiration in his stops being particularly noticeable. However figure 3 shows that his vowel pronunciation is not dissimilar to the pronunciation of non-Māori New Zealanders born about the same time. His vowel pronunciation (as measured by the values of the first and second formants) therefore does not contribute to the impression that he is a second language speaker of English.

Figure 9 compares RTH's vowels for English and Māori. The relevant vowels occupy very similar positions in acoustic space. If RTH's English vowels were not so similar to the vowels of other non-Māori speakers (see figure 3), it would be tempting to assume that he was adopting the closest Māori vowel when speaking English. The similarity of his English vowels to the vowels of non-Māori English speakers makes this simple assumption unlikely. When RTH is speaking English, he uses Māori words and includes long stretches of *whakapapa* (genealogy). These sections sound very Māori, and we did not expect to find that they differed from the Māori sections of the recordings. However the formant frequencies and length of his Māori vowels are different when he is speaking English, indicating that, contrary to what we had anticipated, English has affected his Māori pronunciation, but only when he is speaking in English and including a few isolated Māori

words (such as place names, and family names) or longer sections of *whakapapa* (genealogy). The major influence from English on his Māori words is the lessening of the difference between the long and short monophthongs. The long/short vowel pairs occupy much more similar areas of acoustic space when RTH is speaking English than when he is speaking Māori and the clear length differences between them break down. The breakdown of the length differences for Māori-in-English vowels occurs partly because of the different rhythms of English and Māori and partly because of the different hesitation phenomena that occur for RTH in the two languages. As already noted, considerable work remains to be done on Māori stress. The same is true of rhythm. As noted above, Māori is usually regarded as mora timed (Bauer 1981: 35) whereas English is stress-timed. The stress-timing of English, with its alternation of strong and weak syllables and the lack of phonemically contrastive vowel length, would make it difficult to maintain the more precise vowel length contrasts seen in Māori. Hesitation phenomena could also add to the lack of contrast. When RTH is speaking Māori, hesitations are signaled by throat clearing, or repetition of words or phrases (such as repeating particles *ki te… ki te whare* 'to the… to the house'). When he speaks English, both English and Māori words are often lengthened when he is planning what to say next. Such lengthening does not seem to occur when he is speaking Māori. Because short vowels as well as long vowels are lengthened for planning pauses, this could well contribute to the lessening of the length difference between long and short vowels in Māori-in-English.

We have started to analyze another Mobile Unit speaker and two young speakers for whom Māori is their second language. Like RTH, the second Mobile unit speaker's long vowels are more peripheral than his short vowels and twice as long. However, for the two young L2 speakers, the long vowels are not more peripheral than the short vowels and nor are they twice as long, mirroring the effects that we see for RTH's Māori-in-English vowels (Harlow et al. 2004; Maclagan et al. 2004; Maclagan et al forthcoming). It would therefore seem that the effects we are seeing in RTH's Māori in English do represent genuine influences from English on his Māori vowels, influences that continue to affect young speakers of Māori in the 21st century.

We turn finally to a discussion of /u/. In figure 1, /u:/ is significantly farther back than /u/, which seems to indicate that the long vowel is being pronounced more peripherally than the short vowel. However the ellipses for /u:/ and /u/ stretch right across the top of the vowel quadrilateral, with a much greater spread for F2 than shown by the other vowels. When we examined the tokens, we found that both /u/ and /u:/ were much fronter following /t/ than following other consonants. Fronting of /u/ after alveolars was noted by Stevens and House for American English. They found that dentals, alveolars and palato-alveolars before /u/ produced greater raising of F2 than any other consonant-vowel combination (Stevens & House 1963: 119, 120). The fronted variants of /u/ and /u:/ after /t/ in Māori are presumably following similar coarticulatory effects. /u:/ is fronter in Māori-in-English than in Māori, and appears to be approximating RTH's English GOOSE vowel. However more tokens in Māori-in-English (17/29) than in Māori (13/31) follow /t/, and the fronting in Māori-in-English may therefore be an effect of phonetic context. However RTH's F2 for GOOSE in English is more front than his Māori or Māori-in-English /u:/, even though relatively fewer English tokens follow alveolar consonants (12/30). /u/ fronting is well established in modern NZE (Maclagan 1982) and was occurring for non-Māori speakers born about the same time as RTH (Gordon et al. 2004: 144). It is possible that the /u:/ fronting seen in RTH's Māori-in-English does represent an influence from

English, and constitutes the start of the /u:/ and /u/ fronting we have noted in modern Māori (see Maclagan et al. 2004).

7. Conclusions

In this paper we have presented an acoustic analysis of the Māori and English vowels for Raureti Te Huia, a first language speaker of Māori born in 1885. RTH is the oldest speaker of Māori analyzed to date. His variety of Māori is not known to have any particular vocalic dialectal features, so his vowel system can provide a reference point against which the speech of later Māori speakers can be compared. RTH's English vowels are very similar to the vowels of non-Māori speakers born about the same time (see Gordon et al. 2004). His Māori vowels all occupy clearly distinct positions in acoustic space, with little overlap between tokens of adjacent long vowels or tokens of adjacent short vowels. His long vowels /a:, e:, i:, o:, u:/ are more peripheral than his short vowels /a, e, i, o, u/, and twice as long. His front diphthongs, /ai/ and /ae/ have distinct starting and finishing points, as do his back diphthongs /au/ and /ao/. His diphthong pair /au/ and /ou/ are clearly distinct, which is not always the case for younger speakers of Māori. When we compare his pronunciation of Māori vowels when he is speaking Māori with his pronunciation of Māori words when he is speaking English, we find that the long and short vowels are not as distinct acoustically and the length difference is not as clear. In particular the Māori short vowels are considerably longer and more peripheral when RTH is speaking in English. The starting points of the diphthongs are no longer distinct, though their ending points are still well separated. We find a similar lack of contrast between long and short vowels in young second language speakers of Māori, and for some young speakers, the ending points of the front and back diphthongs are no longer well separated, so that, for example, it can be difficult to distinguish /ai/ and /ae/. This suggests that the changes seen in RTH's Māori vowels when he is using Māori words in English are indeed effects from English, effects that continue to operate for younger speakers today.

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Appendix

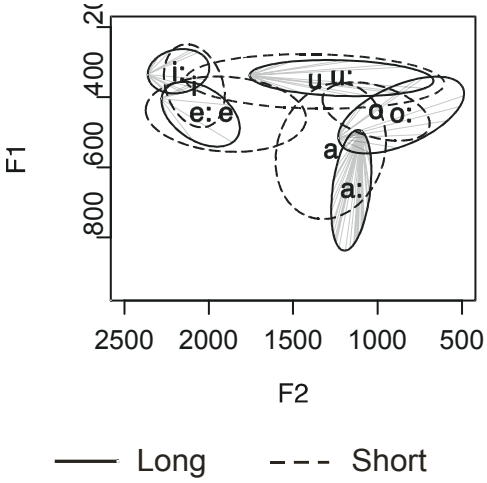

Figure 1: Ellipse formant plot for Maori vowels for RTH in Hz.

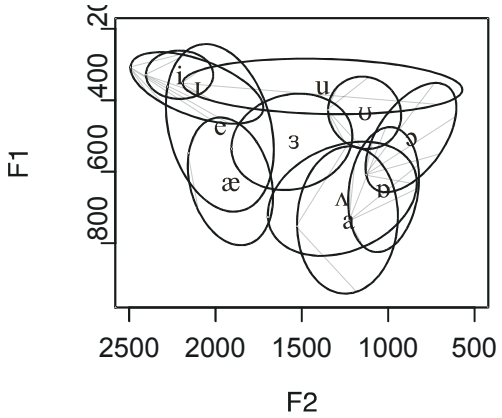

Figure 2: Ellipse formant plot for English vowels for RTH in Hz.

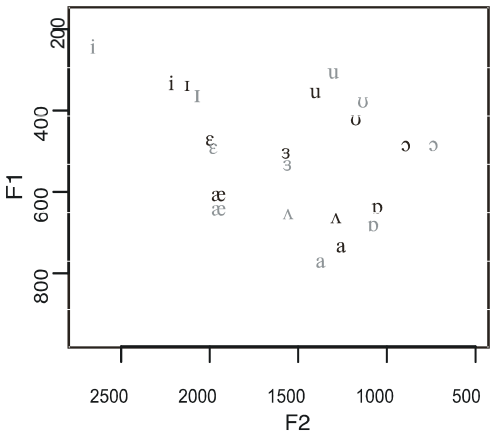

Figure 3: Formant plot comparing English vowels for RTH with average formants for five non-Maori New Zealand male speakers born in the late 19th century (non-Maori values based on Gordon et al 2004). The black symbols represent vowel positions for RTH the grey symbols for non-Maori speakers.

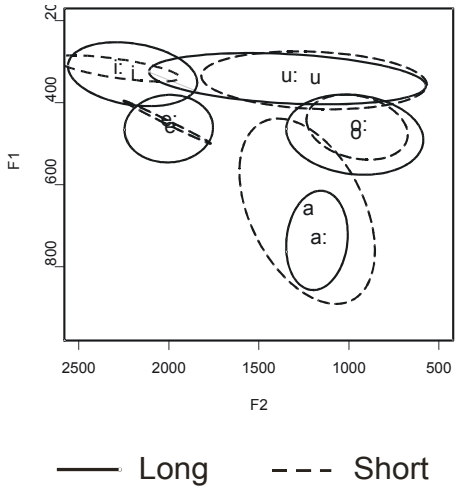

Figure 4: Ellipse formant plot for Maori vowels when RTH is speaking in English (Maori-in-English) in Hz.

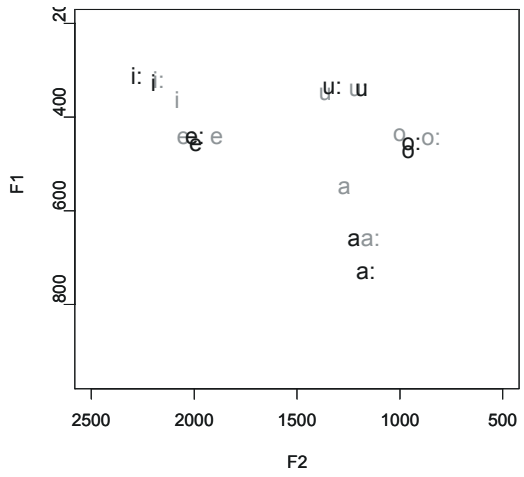

Figure 5: Comparison of formant frequencies (in Hz) for Maori vowels and Maori-in-English vowels. Maori vowels are grey and Maori-in-English vowels are black

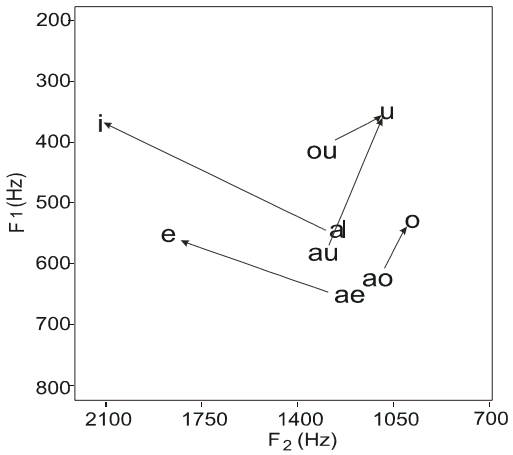

Figure 6: Formant frequency plots in Hz for Maori diphthongs for RTH.

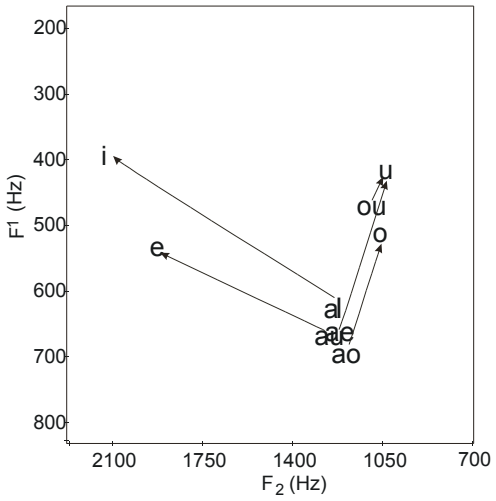

Figure 7: Formant frequency plots in Hz for Maori-in-English diphthongs for RTH.

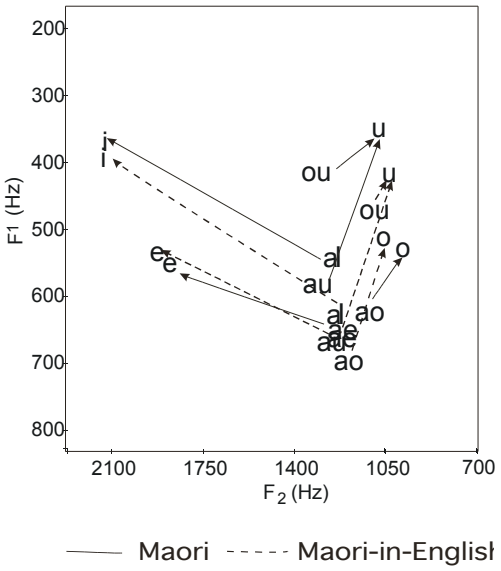

Figure 8: Formant frequency plots in Hz for Maori diphthongs (solid lines) and Maori-in-English diphthongs (dashed lines) for RTH.

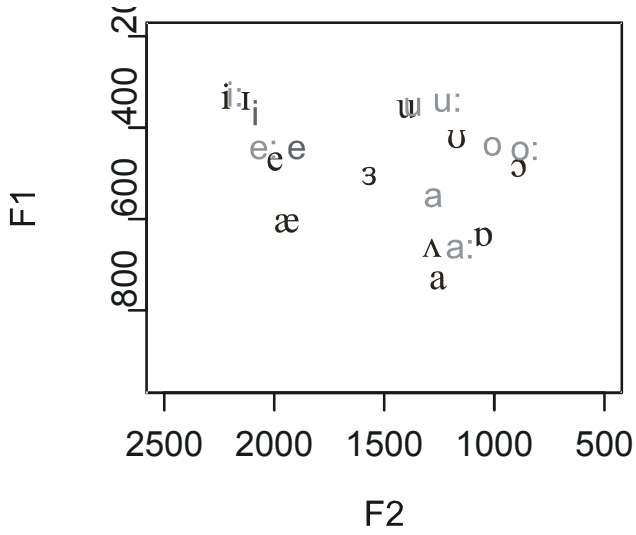

Figure 9: Formant frequency plot in Hz comparing RTH's Maori and English vowels. English vowels are black and Maori vowels are grey.