

## From hiatus to diphthong: variation and change in the production of te reo Māori opening vowel sequences

Kirsten Culhane<sup>1</sup>, Jennifer Hay<sup>1</sup>, Penny Harris<sup>2</sup>, Kate Maindonald<sup>2</sup> and Allie Osborne<sup>2</sup>

<sup>1</sup>*New Zealand Institute of Language, Brain and Behaviour, University of Canterbury (New Zealand)* <sup>2</sup>*University of Canterbury (New Zealand)*

Te reo Māori (TRM), the indigenous language of Aotearoa New Zealand, attests many different vocalic sequences. We examine the production of the opening sequences /ia/ /ua/, /oa/ and /ea/. These sequences have been described as hiatuses; [1] produced as a sequence of each component vowel, with a syllable boundary in between [2]. In contrast, closing sequences such as /ai/ and /ou/ tend to be described in the literature as diphthongs; two vowel qualities produced with no syllable boundary in between [2]. An important piece of evidence for this distinction is that their phonological behavior differs, with stress attracted to the ‘heavy syllables’ formed by closing sequences, but not to opening sequences [1].

Using longitudinal data from the MAONZE corpus [3], this study investigates if /ia/ /ua/, /oa/ and /ea/ are indeed phonetically produced as sequences of their two component vowels, and whether their production has changed over time. It also examines what variation there is in the production of these sequences, and what phonological, morphological and sociolinguistic factors may underpin this variation.

Cross-linguistically, various acoustic properties are implicated in the phonetic distinction between hiatuses and diphthongs. Hiatuses usually have falling intensity across the sequence, while diphthongs typically have a single peak. Hiatuses also tend to have greater duration and longer formant trajectories than diphthongs, and the formant values of the onset and offset typically overlap with those of corresponding monophthongs [4-6], while for diphthongs this is not the case. However, previous phonetic research on these kinds of vocalic sequences is confirmatory, focussed on languages where there is an established diphthong/hiatus contrast [e.g. 4].

In this study, we do not presume a hiatuses/diphthong binary, but take a bottom-up approach. We quantify formant, intensity, and pitch trajectories using functional principal components analysis (fPCA) [7]. Then, the features identified in fPCA are examined for patterns of co-variation using a ‘uniting functional principal components’ analysis (uPCA). Lastly, we conduct linear mixed-effect regression analyses on the uPCA scores to determine which factors may explain the variation observed, controlling for effects of word and speech rate.

Our analysis reveals that the opening sequences are not hiatus-like in all contexts or for all speakers. Rather, covariation between patterns of formant trajectories, duration, and intensity trajectories form a clear continuum of variation between hiatus and diphthong-like realisations for all 4 sequences. We find that a variety of linguistic and social factors influence this variation. Most notably, historical speakers (born 1871-1916) consistently produce the most hiatus-like variants. For these speakers, both the first and second targets of the sequences overlap with that of their corresponding monophthongs (Fig 1). Contemporary speakers (born 1969-1992) produce most diphthong-like realizations. In addition to this, we find that for young speakers, their monophthongs have shifted (due to contact with NZ English [8]), but the associated vowel sequences have not shifted with them (Fig. 2). This suggests that the sequences are becoming phonologically independent from their putative components.

For the sequence /ia/, there is an additional axis of variation between sequences with a more prominent /i/ and a more prominent /a/. Here we again find variation over time, with /a/-dominant forms becoming more common. For this sequence, we find an effect of morpheme boundaries; with /i/-dominant forms more common when a vowel sequence straddles a boundary, e.g. /i-a/. This finding is striking as the potential for morphology to influence phonetic implementation is a topic of theoretical debate (see. e.g. [9]).

The production of the opening sequences in TRM is increasingly diphthong-like. This raises considerable questions about the phonology of TRM and its relationship with phonetics, its segmental inventory, and if a phonological system can productively support rules (in this case, the distribution of stress) that rely on a distinction that is no longer present in the phonetics.

Figure 1

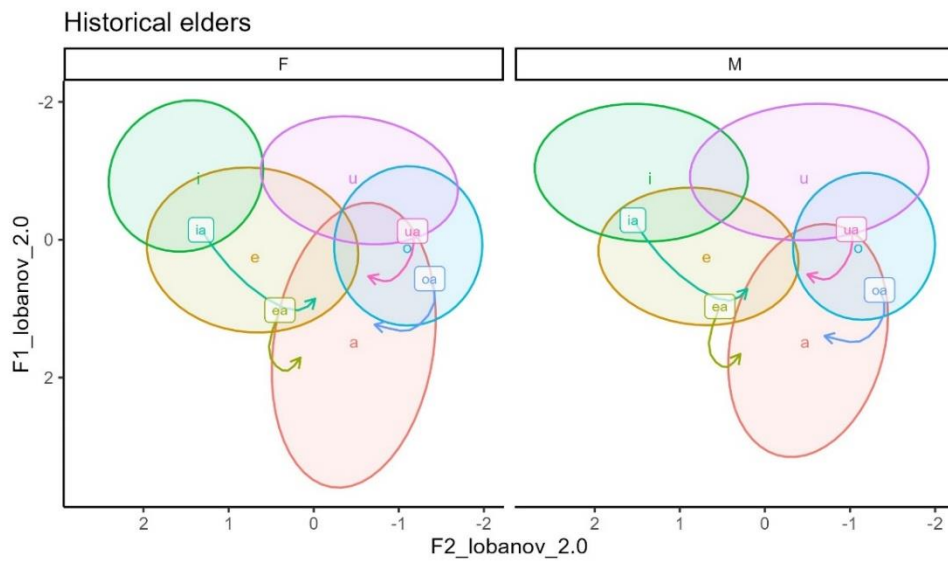
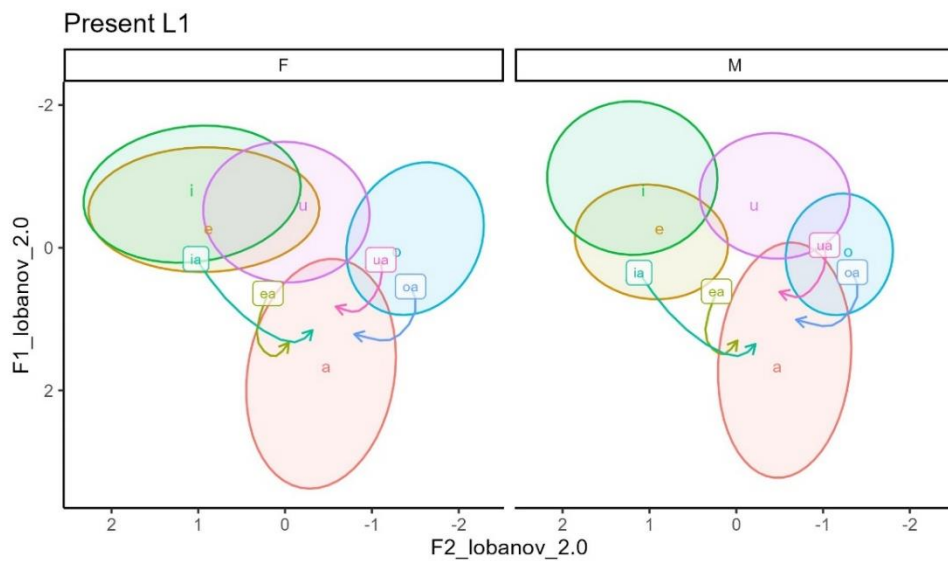


Figure 2



## References

- [1] Harlow, R. (2007). *Maori: A linguistic introduction*. Cambridge: Cambridge University Press.
- [2] Sands, K. L. (2004). Patternings of vocalic sequences in the world's languages. Doctoral Dissertation, University of California, Santa Barbara.
- [3] King, J., M. Maclagan, R. Harlow, P. Keegan, & C. Watson (2011). The MAONZE project: Changing uses of an indigenous language database. *Corpus Linguistics and Linguistic Theory* 7:1, 37–57.
- [4] Chitoran, I. (2003) Inter-gestural timing between vocalic gestures as a function of syllable position: Acoustic evidence from Romanian” in S. Palethorpe and M. Tabain (Eds.) *Proceedings of the 6th International Seminar on Speech Production* (pp. 25–30) Sydney: Macquarie Centre for Cognitive Science.
- [5] Hualde, J. I. & M. Prieto (2002). On the diphthong/hiatus contrast in Spanish: some experimental results. *Linguistics*, 40, 217–234.
- [6] Marin, S. (2014). Romanian diphthongs /ea/ and /oa/: An articulatory comparison with /ja/-/wa/ and with hiatus sequences. *Revista de Filologie Română*, 31, 83–9.
- [7] Gubian, M., F. Torreira, & L.Boves (2015). Using functional data analysis for investigating multidimensional dynamic phonetic contrasts. *Journal of Phonetics*, 49, 16–40.
- [8] Watson, C. I., M. A. Maclagan, J. King, R. Harlow, & P. J. Keegan (2016). *Sound change in Māori and the influence of New Zealand English*. *Journal of the International Phonetic Association*, 46:2, 185–218.
- [9] Stein, S.D. (2022). *The phonetics of derived words in English: Tracing morphology in speech production*. Berlin: Walter de Gruyter GmbH & Co KG.