An acoustic analysis of Kaytetye vowel variability

Kaytetye [ˈkeɪ̯dɪtʃ] is an Arandic language spoken by approximately 150 people in central Australia. Many aspects of Kaytetye phonology remain unclear, including the exact constituency of the vocalic inventory. We present data which shed more light on vowel contrasts in Kaytetye, and discuss broader implications for Arandic phonological structures.

Kaytetye has been analysed as a 2-vowel system (Turpin & Ross, 2012), contrasting a low /ɐ/ with a higher vowel /ə/, whose phonetic quality partly depends on the phonological environment in which it appears. For example, word-initial /ə/ is realised as a high front vowel when followed by palatal or a peripheral consonant (*ipmarre-nke* [ɪˈmɐrənkə] 'scold-PRS'), and lower before interdentals or apical alveolars. Analyses of Kaytetye vocalic phonology, however, have largely been impressionistic, and there is yet to be a systematic acoustic study of the vowel system which can account for the rich allophony of the non-low vowel: [ʊ, ɔ, ɪ, i, ə, ɐ]. Breen and Dobson (2005) describe the closely-related neighbouring language Arrernte as having four vowels: /i-a-ə-u/, but also observe allophony between /u/ and /ə/ following rounded consonants. In an acoustic study of Arrernte vowels, Tabain and Breen (2011) propose a 3-vowel system, /i-a-ə/, for the language.

To establish the phonetic properties of Kaytetye vowels, we first described their distribution in the speech of a 41-year-old female L1 speaker. Elicited studio recordings made for a multimedia Kaytetye-to-English dictionary were analysed; the informant producing two repetitions of each headword in the dictionary. A sample of 200 lexical headwords (x 2 repetitions = 400 tokens) were selected from the dictionary corpus, each predicted to contain at least two medial vowels, e.g. [#(V)ˈCV_1CV_2C(V)#], as in Kaytetye initial and final vowels in the orthography are prone to deletion. Audio files were independently transcribed (double-blind) and segmented in Praat by two annotators. The annotation workflow included measuring 4 formant frequencies for each vowel using Praat formant tracks, correcting values where necessary. Vowel formants were additionally estimated in MATLAB using two different methods, FormantMeasurer (Morrison & Nearey, 2001) and a custom LPC-based algorithm. Mean vowel formants were computed from the 4 estimates.

Transcribed vowel qualities were located on an F1-F2 plane, using mean formant frequency estimates to determine the distribution of perceived vowel qualities (Fig. 1). Stressed vowels were found to form more distinct groupings, clustering in the F1-F2 space. In unstressed medial lexical positions, vowels were generally produced as more acoustically central, as is evident by the relatively higher realisations of the [ɐ] vowels. Surprisingly, unstressed high front vowels [i, ɪ] were realised with significantly higher mean F2 values than stressed [i] and [ɪ]. This may be indicative of a higher degree of coarticulation from the peripheral consonants in the unstressed position.

Few back vowel qualities (3/304 tokens) were perceived for vowels produced in unstressed positions by either transcriber, and Figure 1 reveals considerably more [ɔ, ʊ, u] labels associated with stressed vowels in the F1-F2 distribution. To further validate these categories, *z*-normalised F1, F2, F3 and vowel durations were classified into groups using a *k*-means clustering algorithm. The shapes (triangle, square, circle) next to the vowel labels in Figure 1 indicate the computed groupings. Interestingly, the optimal clusters for both unstressed and stressed vowels were 3 groups ([ɪ], [ə], [ɐ]). That is, stressed back vowels [ɔ, ʊ, u], as transcribed by the annotators, were determined not to be significantly different from the stressed central vowel [ə]. Of course, the relative frequency of occurrence of unstressed back vowels may be due to the sampling of the words.

In order to determine the extent of vocalic variation and the rules governing it in Kaytetye, it will be necessary to analyse the acoustic properties of vowels in the full range of phonological environments. Ongoing transcription and segmentation of the dictionary recordings will provide additional data and allow for further refinement of the method.

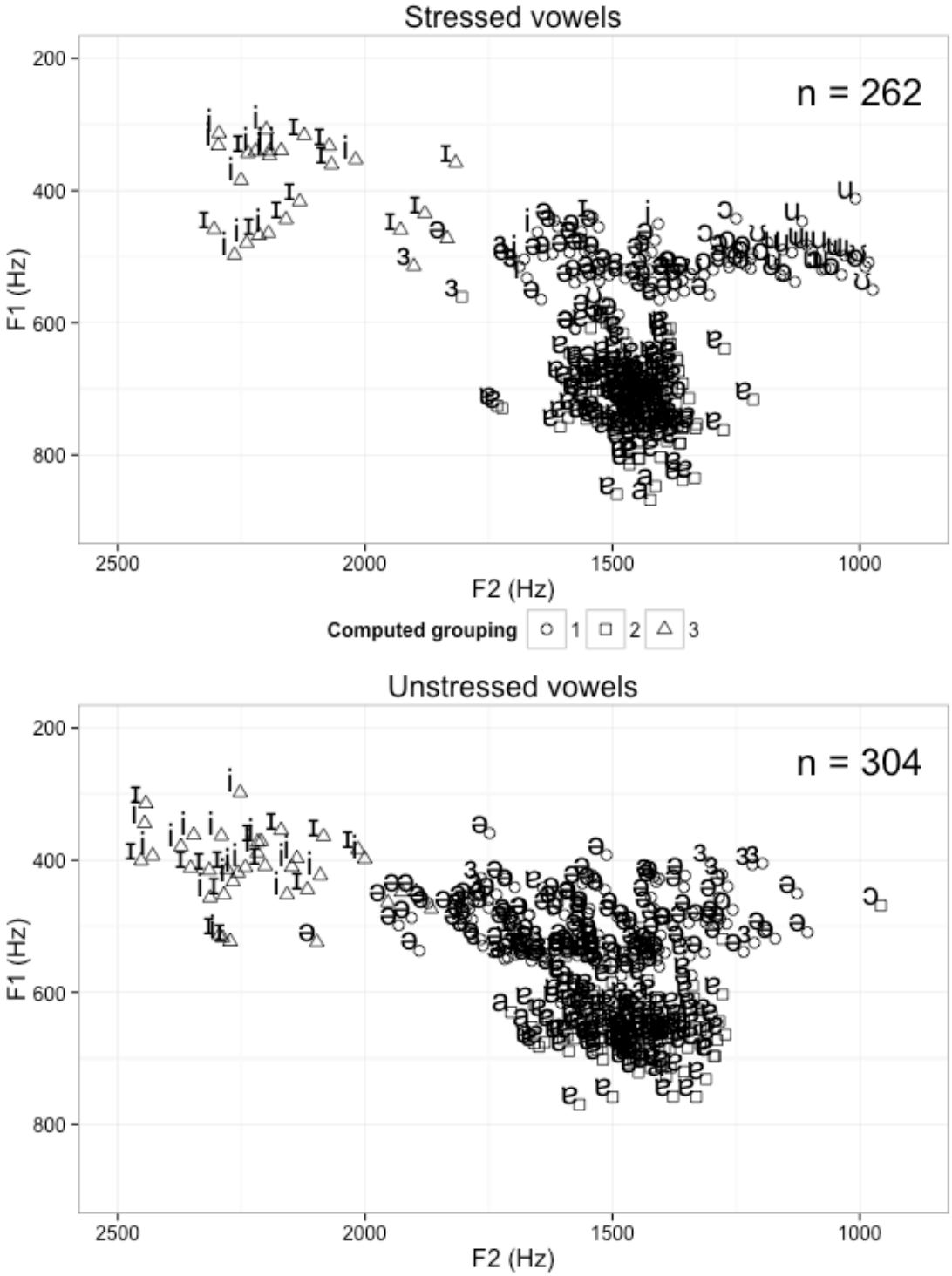

Figure 1. F1-F2 plots of stressed and unstressed medial vowels from Kaytetye (V)ˈCVCVC(V) words. Labels are phonetic transcriptions assigned by annotators and point shapes (e.g. circle, square) are groupings derived from a *k*-means clustering classification ($k = 3$).

References

Breen, G., & Dobson, V. (2005). Central Arrernte. *Journal of the International Phonetic Association*, *35*(02), 249-254.

Morrison, G. S., & Nearey, T. M. (2011). FormantMeasurer: Software for efficient human-supervised measurement of formant trajectories. *Retrieved from http://geoff-morrison.net/#FrmMes.*

Tabain, M., & Breen, G. (2011). Central vowels in Central Arrernte: A spectrographic study of a small vowel system. *Journal of Phonetics*, *39*(1), 68-84.

Turpin, M., & Ross, A. (2012). *Kaytetye to English dictionary*. IAD Press.