PHONETIC VARIATION ACROSS AUSTRALIAN LANGUAGES

Sarah Babinski and Claire Bowern

Yale University
sarah.babinski@yale.edu

ABSTRACT

Acoustic cues to stress across Australian languages have not been widely studied. This paper looks at the variation in cues (duration, intensity, and F0) across some languages of Australia. Most of these languages have consistent initial stress systems, but the variation seen in their acoustic cues to stress belies a more diverse linguistic landscape than this might suggest. Within-language variation is either not significant or varies in predictable ways based on speaker sex. Between-language variation, on the other hand, is shown to be statistically significant in the vast majority of language comparisons. This work opens up many avenues of research in the subfields of phonetic variation and sound change.

Keywords: Phonetics of Sound Change; Phonetics of Lesser Documented and Endangered Languages.

1. INTRODUCTION

1.1. Background to topic

It has become a common observation of Australian prosodic systems that the languages of the continent overwhelmingly exhibit initial stress [9, 10, 14]. Goedemans [14] finds that 80% of the languages of Australia have initial stress, while most of the remainder have a quantity-sensitive system, most frequently described as stress realization on long vowels. However, no one (to our knowledge) has compared the realization of lexical stress across Australia, to study the ways in which phonetic and phonological systems might differ, and how variable are the instantiations of phonological representations within and between languages. This paper presents a proof of concept study using the realization of lexical stress in a small number of languages.

Increasingly, work on phonetics in Australian languages is uncovering cross-linguistic variation, even where segmental inventories are similar or identical. For example, Fletcher and Butcher [12] show that Iwaidja, Warlpiri, and Bininj Gun-wok differ in their utilization of the vowel space in stressed and unstressed syllables, despite having superficially similar inventories.

Most of the work on the prosodic structure of Australian languages is impressionistic, as Fletcher and Butcher [12] note, and systematic comparative studies for multiple languages on any aspect of acoustic phonetics are rare. The studies that exist to date [19, 12, 6, 18] show that Australian languages vary in a number of respects, reinforcing the notion that the 'relative uniformity' [4] of Australian languages is at best a superficial statement about surface inventory.

Here we utilize data from three languages from different parts of the country to study another aspect of language variation: the realization of lexical stress. We investigate the between-language and within-language variation in four parameters of stress variation: F0, duration, intensity, and vowel space. Results show that the languages in the sample have different cues for the realization of stress, but speakers are consistent within languages except for features which we would expect to be conditioned by gender (such as F0 realizations).

1.2. Languages

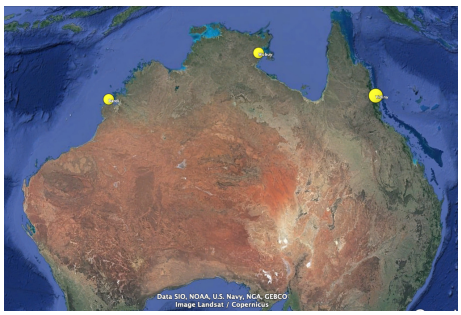
Data for this project comes from three languages: Bardi, Wubuy, and Yidiny. Bardi and Wubuy are non-Pama-Nyungan languages, while Yidiny is Pama-Nyungan. Bardi is the northernmost member of the Nyulnyulan family, while Wubuy is a Gunwinyguan language from Central Arnhem Land. The place of Yidiny in the Pama-Nyungan family is not agreed on; some place it as a member of the Paman family [2] while others [10] treat it as a primary subgroup (along with Djaabugay) of Pama-Nyungan or a higher-order family.

Bardi has uncontroversial consistent initial stress [3]. Initial syllables are longer than those later in the word and have higher average F0. Analysts have noted a secondary stress on the first syllable of inflecting verb roots. Wubuy stress is initial by default, but attracted to the penult when that syllable is heavy (Brett Baker, p.c.). Yidiny stress is described by Dixon [7] as being initial in words containing short vowels, attracted to long vowels in certain positions in the word, and triggering deletion in certain contexts beyond the scope of this paper (see further

Dixon [7, 8]). Dixon [7] mentions that Yidiny stress is frequently attracted to initial syllables in larger prosodic units (see also Nash [16]). Bowern et al. [5] show that Yidiny stress is better analyzed as a consistently initial system and that analysis is followed here.

A map of the languages included in the sample is given in Fig 1 below:

Figure 1: Map of the languages used in the sample.



2. METHOD AND MATERIALS

2.1. Speakers

The Wubuy recordings were made by Brett Baker and Rikke Bundgaard-Nielsen from 3 speakers in 2018. Bardi recordings were made from three fluent speakers recorded over the period 1990–2008. Jessie Sampi, Bessie Ejai, and Nancy Isaac contributed material. Early recordings were made on analog cassette tapes and digitized with an Edirol R-09 solid state recorder, at 16 bit 44KHz. We also used 45 minutes of speech from Yidiny speakers Tilly Fuller and Dick Moses, recorded by R. M. W. Dixon in the early 1970s, which were digitized by The Australian Institute of Aboriginal and Torres Strait Islander Studies at archival standards. The Bardi and Yidiny data are narratives that were forced aligned using the p2fa algorithm [11] and manually corrected. Wubuy data consist of 36 trisyllabic words in a frame sentence with 5 repetitions each per speaker, aligned by hand.

The data used are a sample of convenience and were not created for the purposes of this study, but they provide a useful and fairly reliable source of data for a preliminary exploration. While factors such as speaker age, language contact, and other sociolinguistic factors may have some effect on the measurements extracted from these data, the authors do not anticipate these issues compromising the comparability of the results in any way

2.2. Analytical Methods

The following acoustic measures were extracted from Praat: consonant and vowel duration, maximum intensity, maximum pitch and pitch range, and vowel formants. All of these are potentially correlated with stress [13, 20], but not every measure taken is a correlate of stress in every language tested.

Plots were made with `ggplot2` [21] and `ggridges` [22], and vowel plots with the `phonR` [15] package in R [17]. Pairwise Wilcoxon tests were run with the `stats` [17] package to compare distribution means. When multiple variables are involved, as in comparing vowel means, linear regressions were run in `lme4` [1] with language, speaker, and segment as fixed effects.

3. RESULTS

There is considerable (significant) variation across these languages. Within-language variation between speakers exists in some cases, usually related to known differences in speech production which are conditioned by gender.

Duration varied among languages both in terms of overall distributions and whether there was an effect of vowel length or stress on duration. Figure 2 shows these distributions by language and vowel type. Mean durations were compared with pairwise Wilcoxon tests, and were found to be significantly different ($p < 0.001$) between languages. Within-language speaker differences were found for Bardi across all speakers ($p < 0.001$), but not for speakers in Yidiny or Wubuy ($p > 0.05$). These distributions demonstrate how much variation exists between these languages. Yidiny and Wubuy exhibit noticeable variation based on phonemic vowel length and stress, while Bardi does not seem to have such variation. Bardi, on the other hand, shows considerable between-speaker variation here.

Distributions of maximum vowel intensity are shown in Figure 3. Only Wubuy is significantly different from the other two languages in the sample ($p < 0.001$). Bardi and Yidiny are statistically indistinguishable from one another on this measure ($p > 0.05$). These results seem to show clear stress-related variation, as only Wubuy shows some differences in vowel intensity based on stress, and neither Bardi nor Yidiny have such a difference.

Mean values of maximum pitch (distributions in Figure 4) are significantly different between languages ($p < 0.001$). Within-language speaker variation was also significant between all speakers in each language ($p < 0.001$). These results are consistent in both pairwise Wilcox tests and linear regression. It

Figure 2: Distribution of vowel duration measurements across languages in the sample. All pairwise means significantly different ($p < 0.001$).

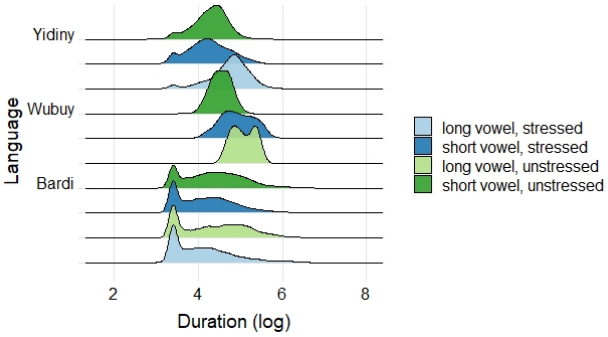
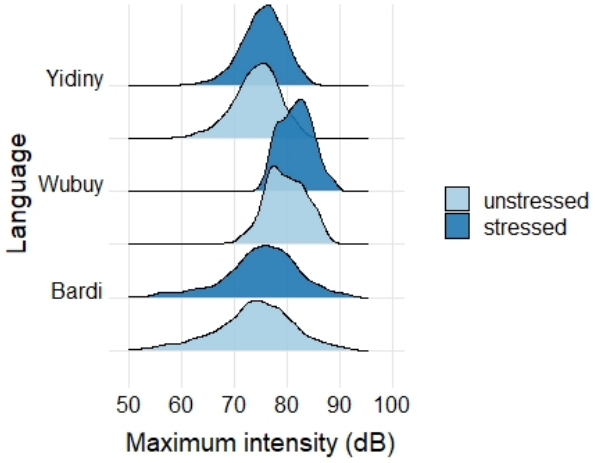


Figure 3: Distribution of maximum vowel intensity between all languages. Bardi and Yidiny means are not significantly different ($p > 0.05$), while the Wubuy mean is different from both Bardi and Yidiny ($p < 0.001$).



may be, given these results, that the language differences observed for pitch maximum are simply reflecting speaker differences. The same results were found for measures of pitch range over the vowel.

Figure 5 shows mean vowel measurements for each vowel in all three languages, collapsed across speakers. Both between and within language differences were found for vowel space. Linear regression models show that Yidiny's vowels are significantly different than Wubuy and Bardi vowels ($p < 0.001$), while Wubuy and Bardi have statistically similar F1 values ($p > 0.05$) and different F2 values ($p < 0.001$). Within each language, speaker

Figure 4: Distribution of maximum pitch values between all languages. All languages significantly different ($p < 0.001$).

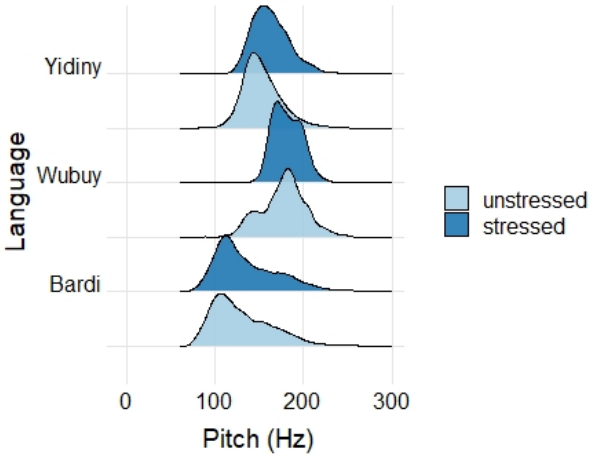
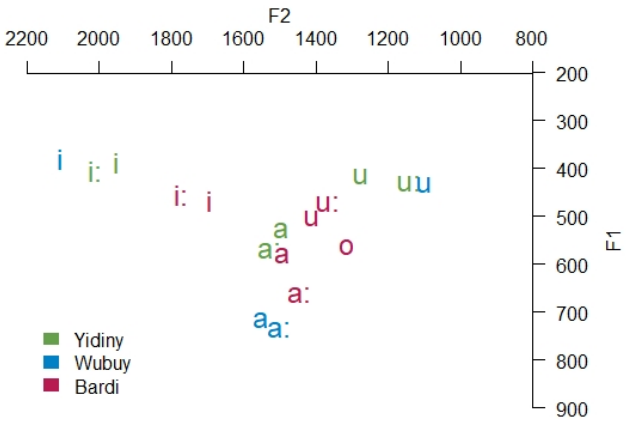


Figure 5: Mean vowel measurements across all languages in the sample. Means significantly different on at least one dimension (F1 or F2) for all languages.



variation was generally found to be significant. In some cases, these differences can be attributed to speaker gender, but same-gender speaker differences were also found.

Upon further investigation, it was also found that for all languages, F1 is significantly different ($p < 0.001$) between stressed and unstressed vowels, controlling for segment and speaker. For Yidiny and Bardi, the trend is that stressed vowels are more central (approximated by higher F1), while in Wubuy stressed vowels are generally more peripheral (lower

F1).

4. DISCUSSION AND CONCLUSIONS

This paper has shown the results of a preliminary exploration of some aspects of acoustic variation across three unrelated Australian languages, namely: duration, F0, intensity, and vowel space. All three languages in this study differ from one another on at least a few of the measures considered, suggesting that phonetic variation in these languages is wide-ranging.

Next steps in this work include adding more Australian languages to this sample, and determining what (if any) acoustic measures can be explained by a language's stress system and/or its history. Some points for further investigation came out of the results just presented. Duration measures show variation based on whether vowels are generally longer when stressed than not. Wubuy also shows a stress difference in intensity measures, while Yidiny and Bardi do not. All languages also show a difference in F1 values based on stress, but Wubuy trends towards more peripheral stressed vowels, while Yidiny and Bardi have more central ones. One can imagine that similar sorts of variation exist for other potential correlates of stress as well, such as spectral tilt, pitch peak anchoring, and post-stress consonant lengthening.

5. ACKNOWLEDGEMENTS

This work was funded by NSF grant BCS-1423711 and ARC Discover Grant GA2582. Thanks to Jason Shaw, Brett Baker, and Janet Fletcher. We gratefully acknowledge the PARADISEC and AIATSIS Archives for access to data.

6. REFERENCES

[1] Bates, D., Mächler, M., Bolker, B., Walker, S. 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software* 67(1), 1–48.

[2] Bouckaert, R. R., Bowern, C., Atkinson, Q. D. 2018. The origin and expansion of Pama–Nyungan languages across Australia. *Nature ecology & evolution* 2, 741–749.

[3] Bowern, C. 2012. *A Grammar of Bardi*. Mouton Grammar Library. Berlin: Mouton.

[4] Bowern, C. 2017. Standard average australian? *ALT, Canberra*.

[5] Bowern, C., Alpher, B., Round, E. 2013. Yidiny stress, length and truncation reconsidered. *Poster presented at the 44th North East Linguistic Society*.

[6] Butcher, A., Tabain, M. 2004. On the back of the tongue: Dorsal sounds in australian languages. *Phonetica* 61(1), 22–52.

[7] Dixon, R. 1977. *A grammar of Yidiny*. Cambridge: Cambridge University Press.

[8] Dixon, R. 1977. Some phonological rules in yidinˆ\rmy. *Linguistic Inquiry* 8(1), 1–34.

[9] Dixon, R. 1980. *The Languages of Australia*. Cambridge: Cambridge University Press.

[10] Dixon, R. 2002. *Australian languages: their nature and development*. Cambridge: Cambridge University Press.

[11] Evanini, K. 2009. The permeability of dialect boundaries: A case study of the region surrounding erie, pennsylvania. *Publicly accessible Penn Dissertations* 86.

[12] Fletcher, J., Butcher, A. 2014. Sound patterns of australian languages. In: Nordlinger, R., Koch, H., (eds), *The Languages and Linguistics of Australia: A Comprehensive Guide*. Berlin: Walter de Gruyter.

[13] Fry, D. B. 1955. Duration and intensity as physical correlates of linguistic stress. *The Journal of the Acoustical Society of America* 27(4), 765–768.

[14] Goedemans, R. 2010. An overview of word stress in Australian Aboriginal languages. In: van der Hulst, H., Goedemans, R., van Zanten, E., (eds), *A survey of word accentual patterns in the languages of the world*. Berlin/New York: Walter de Gruyter 55–86. 00004.

[15] McCloy, D. R. 2016. *phonR: tools for phoneticians and phonologists*. R package version 1.0-7.

[16] Nash, D., others, 1979. Yidiny stress: a metrical account.

[17] R Core Team, 2013. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing Vienna, Austria. ISBN 3-900051-07-0.

[18] Tabain, M., Butcher, A. 1999. Stop consonants in yanyuwa and yindjibarndi: locus equation data. *Journal of Phonetics* 27(4), 333–357.

[19] Tabain, M., Fletcher, J., Butcher, A. 2014. Lexical stress in pitjatjantjara. *Journal of Phonetics* 42, 52–66.

[20] Van Bergem, D. R. 1993. Acoustic vowel reduction as a function of sentence accent, word stress, and word class. *Speech communication* 12(1), 1–23.

[21] Wickham, H. 2016. *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York.

[22] Wilke, C. O. 2018. *ggridges: Ridgeline Plots in 'ggplot2'*. R package version 0.5.1.