Durational Variability and Stress-Timing in Hawaiian

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Abstract

The PVI is a phonetic measure, which has been associated with the impressionistic categories of stress-timed and syllable-timed languages. This paper reports on some preliminary PVI values for Hawaiian, a rhythmically unclassified Eastern Polynesian language. The meaning of the Hawaiian PVI values are considered against an invented measure, called the ‘slope PVI’. This measure is a linear discriminant classifier, which defines what it means for a PVI value to be ‘high’ or ‘low’.

1. Introduction

The Pairwise Variability Index (PVI) is a phonetic measure of variability between vocalic or intervocalic speech durations. Low, Grabe, and Nolan (2001, p. 383) calculate a normalized PVI with the equation in (1),

$$nPVI = 100 \times \left[\sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{(d_k + d_{k+1})/2} \right| / (m-1) \right] \quad (1)$$

where m is the number of vocalic or intervocalic speech durations, and d is the kth duration's value.

Grabe and Low (2002, p. 519) calculate a raw PVI with the equation in (2),

$$rPVI = \left[\sum_{k=1}^{m-1} \left| d_k - d_{k+1} \right| / (m-1) \right] \quad (2)$$

and apply (1) to vocalic durations and (2) to intervocalic durations (see Grabe and Low 2002, §2.4).

Grabe and Low hypothesize that (1) and (2) are correlated with the typological, impressionistic categories of stress-timed and syllable-timed languages. That is, they hypothesize that the stress-timed languages should return similar PVI values with each other, but substantially different PVI values from the syllable-timed languages. Likewise, the syllable-timed languages should also return similar PVI values with each other, but substantially different PVI values from the stress-timed languages.

In order to test this hypothesis, Grabe and Low applied the PVI to some relatively uncontroversial stress-timed and syllable-timed languages; see Figure 1. These results support the hypothesis, given three conditions: (i) that the stress-timed languages (i.e. the white circles) group together; (ii) that the syllable-timed languages (i.e. the black circles) group together; and (iii) that no member of one rhythm class groups with a member of the other. Informally, these conditions would appear to be met. For the sake of argument, let us assume that they are.

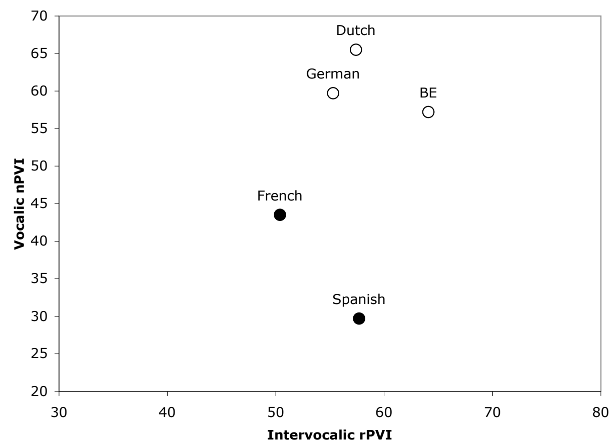

Figure 1: PVI profiles for data from five languages (cf. Grabe and Low 2002, Figure 1, p. 528).

Grabe and Low have also applied the PVI to a variety of other languages; see Figure 2. The mixed or unclassified languages (i.e. the white squares) fill out more of the PVI space, suggesting that, if we want the rhythm classes to capture these other languages, then the categories will have to be re-conceived as gradient. It might not be surprising that Japanese, a mora-timed language (i.e. the black square), appears to be within the domain of the syllable-timed languages. Moreover, given Grabe and Low's (2002, p. 527) prediction that stress-timed languages should have high PVI values, and syllable-timed languages low ones, it might not be a strain to eyeball Mandarin as a strong candidate for classification as a syllable-timed language. Informally, we might be able to convince ourselves that Mandarin should pattern with the syllable-timed langauges, and, say, Thai should pattern with the stress-timed languages. It would be good to have an explicit way of determining this. In addition, a number of the other data points challenge all intuitive classifications. For example, to which category does Welsh belong? What about Greek? How about Polish? Therefore, we should like an explicit way of answering these more difficult questions, and of confirming the ‘apparent’ classification of easier cases like Thai and Mandarin. One goal of this paper is to propose a method for answering these questions.

The other primary goal of this paper is to report on a preliminary case-study of Hawaiian, which Grabe and Low

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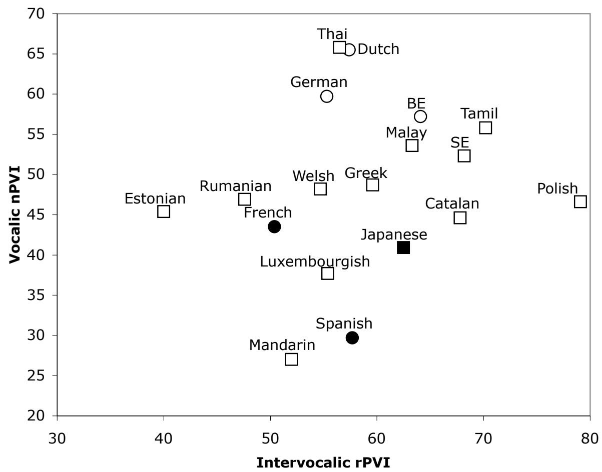

Figure 2: PVI profiles for data from eighteen languages (cf. Grabe and Low 2002, Figure 2, p. 530).

did not include in their analysis. Indeed, Hawaiian exhibits some of the hallmarks of a stress-timed language, like vowel reduction, and, although I treat Hawaiian here as unclassified, we might predict it to have high PVI values, as Grabe and Low (2002, p. 527) predict of all stress-timed languages. In other words, it would be surprising if Hawaiian had very low PVI values.

Finally, please note that this paper represents work in progress, rather than a final analysis.

2. Durational variability in Hawaiian

To my knowledge, Hawaiian has not been previously been classed as stress-timed or syllable-timed. Hawaiian Creole English, however, has been described as syllable-timed (Vanderslice and Pierson 1967). But Hawaiian rather exhibits many of the hallmarks of a stress-timed language. For example, it allows reduced vowels, and a study of its stress system suggests no one-to-one match between syllables and stresses (Schütz 1978, 1981). Following Grabe and Low (2002, p. 527), I might therefore predict Hawaiian to have relatively high PVI values.

Note, however, that language like 'relatively high' is not terribly explicit. In the second half of this paper, I shall attempt to formalize this idea by suggesting a way to classify previously unclassified languages as stress-timed or syllable-timed, based on their PVI values. Jumping ahead then, the explicit prediction about Hawaiian is that it should return PVI values within the range of the stress-timed category.

Let us begin, however, by considering how I determined a working set of PVI values for Hawaiian. More work on this should be done.

2.1. Methodology

Three native speakers of Hawaiian were recruited for the production task, which consisted of reading a Hawaiian translation of *The North Wind and the Sun*. I recorded the recitals on a Mac PowerBook G4, using its internal microphone and a sampling rate of 44,100 Hz. For this preliminary study, one speaker's recording was analyzed in Praat (Boersma and Weenink 2005). Paralinguistic pauses were flagged and ignored. Vocalic and intervocalic durations were then segmented, measured, and typed into an Excel spreadsheet (http://www.phon.ox.ac.uk/∼esther/), which automatically calculated both the vocalic and intervocalic PVI.

2.2. Results

The results suggest that Hawaiian has a vocalic PVI of 55.9 and an intervocalic PVI of 56.1. These are only slightly lower than the reported vocalic PVIs of the exemplar stress-timed languages, BE (+1.3), German (+3.8), and Dutch (+9.6); see Table 1. Hawaiian even has a higher intervocalic PVI than one of the assumed stress-timed languages, German (−0.8).

Table 1: PVI values for nineteen languages, including Hawaiian (in bold). The table is sorted in descending order by vocalic nPVI values. Cf. Grabe and Low 2002, Table 1, p. 544.

Languages	Vocalic nPVI	Intervocalic rPVI
Thai	65.8	56.5
Dutch	65.5	57.4
German	59.7	55.3
BE	57.2	64.1
Hawaiian	**55.9**	**56.1**
Tamil	55.8	70.2
Malay	53.6	63.3
SE	52.3	68.2
Greek	48.7	59.6
Welsh	48.2	54.7
Rumanian	46.9	47.6
Polish	46.6	79.1
Estonian	45.4	40.0
Catalan	44.6	67.8
French	43.5	50.4
Japanese	40.9	62.5
Luxembourg	37.7	55.4
Spanish	29.7	57.7
Mandarin	27.0	52.0

The assumed syllable-timed languages are French and Spanish, which have lower vocalic PVIs than Hawaiian, i.e. French (−12.4) and Spanish (−26.2). Hawaiian, however, has a lower intervocalic PVI than one of these languages, Spanish (+1.6). But Spanish also has a higher intervocalic PVI than German and Dutch, contra Grabe and Low's prediction.

In sum, these results more or less place Hawaiian somewhere between the exemplars of stress-timed and syllable-timed languages, but arguably closer to the stress-timed languages, although we should still like an explicit way of measuring 'closeness'. Figure 3 plots Hawaiian amongst the other values listed in Table 1, and amongst the points given in Figure 2.

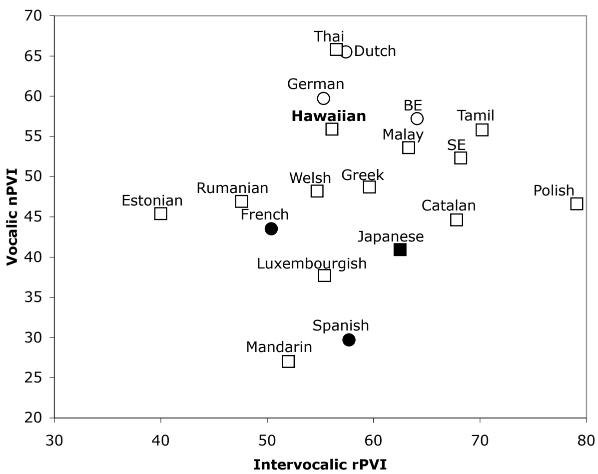

Figure 3: PVI profiles for data from nineteen languages, including Hawaiian (in bold).

3. Stress-timing in Hawaiian

One complication of using the PVI is that it actually provides *two* measures, a vocalic one and an intervocalic one, where the value of one might disagree with the value of the other. For example, in Table 1 and Figures 2 and 3, Thai has the highest vocalic PVI but not the highest intervocalic PVI—that belongs to Polish. What if the PVI was a tool for determining the rhythm class of these languages, how could we use it? Here is one proposal.

Let us take the average values of the three assumed stress-timed languages, as well as the averages from the two assumed syllable-timed languages. Let us also find the midpoint between the two averages. We can plot these points, and then fit a slope through them. Let us call this the PVI slope. Now, for any point in PVI space, we can plot a line through it that is perpendicular to the PVI slope. If we solve for the intersection of the two lines, we derive a point on the PVI slope. Then, with the Pythagorean theorem, we can calculate an absolute PVI value for this point, which we can use to compare it against other points. In effect, we collapse the two dimensions of PVI space into one. Values on one side of the midpoint could be classed as stress-timed, and values on the other side as syllable-timed. As for the midpoint itself, values on it could be left undefined, arbitrarily categorized in each instance as stress-timed or syllable-timed, or set to a single default, say, stress-timed.

I have done this for Hawaiian, using the averages of the three stress-timed languages and two syllable-timed languages from Grabe and Low; see Figure 4.

Finally, using the Pythagorean theorem, Hawaiian returns what I will call a 'slope PVI' value of about 58.25, whereas the midpoint has a slope PVI value of about 56.49 (cf. Table 2). Hawaiian's higher slope PVI can be taken to classify it as stress-timed, as we can see in Figure 4 that the intersection of the line through the Hawaiian point and the PVI slope is closer to the average stress-timed point than to the average syllable-timed point. What is the significance of these results? Since we predicted Hawaiian to have high PVI values in section 2., this could be taken to confirm that

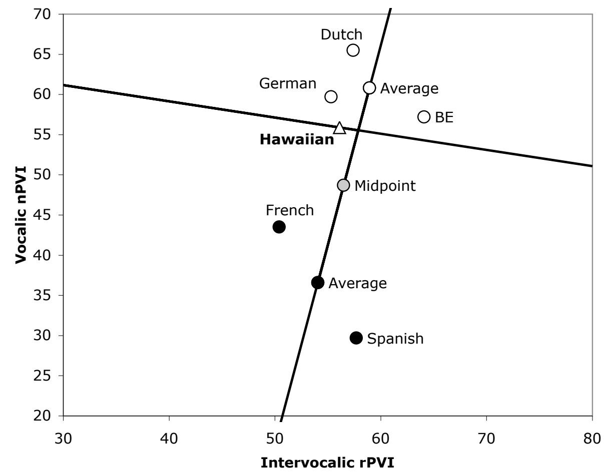

Figure 4: The average stress-timed and syllable-timed points, the PVI slope plotted between them, and the perpendicular intersect that categorizes Hawaiian on the stress-timed half of the continuum, as divided by the midpoint between the averages.

prediction by virtue of making explicit what counts as a 'high value'.

4. Extending the slope PVI to other languages

In addition to Hawaiian, we can also use this approach to classify the other mixed, unclassified, or mora-timed languages above, as in Figure 5, where I have removed the assumed stress-timed and syllable-timed languages in order to make it less incomprehensible.

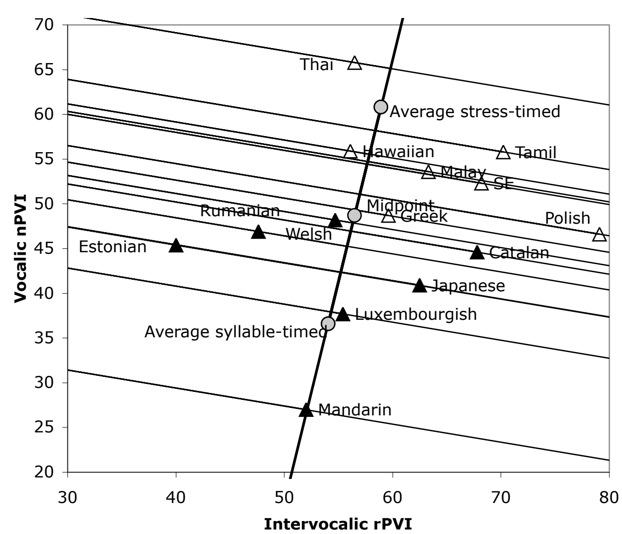

Figure 5: The perpendicular intersects for the fourteen languages that were not already classified as stress-timed or syllable-timed. Under this scheme, the white triangles are now classified as stress-timed, and the black triangles are classified as syllable-timed.

The slope PVI values should further clarify these results, as in Table 2. For example, returning to the hard ques-

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tions posed back in section 1, this approach classifies Welsh as syllable-timed but Greek and Polish as stress-timed. Incidentally, these categorizations are still meant to be fuzzy, so that the membership of any language to a category can be better or worse. But we can decide now which category something belongs to.

Table 2: The slope PVI values for nineteen languages, listed in descending order. The categorization of Mandarin (in italics) is probably a bug in my calculation (cf. its position here and in Figure 5). Values above the MID-VALUE (underlined) are stress-timed. Values below the MID-VALUE are syllable-timed.

Languages	Slope PVI
Thai	61.96928191
Tamil	59.13614452
Hawaiian	58.2514422
Malay	58.00093434
SE	57.91161677
Polish	57.00992448
Greek	56.6146613
Mandarin	*56.53490734*
MID-VALUE	56.49204887
Welsh	56.3341381
Catalan	56.17317043
Rumanian	55.91476577
Japanese	55.60006242
Estonian	55.59687063
Luxembourg	55.41659766

Finally, in addition to the incompleteness of this work in progress, there are some interesting problems with this approach, which we might already be able to see. For example, look at the slope PVI values for Japanese and Estonian. Whereas the two have extremely different intervocalic rPVI values, they have near identical slope PVI values. This highlights the fact that, for an approach like this to be well founded, it would need to explain why the two dimensions should be conflated into one. More work could be done on this, the theoretical foundation of the approach.

5. Conclusions

In this paper, we considered durational variability and stress-timing in Hawaiian. Following Grabe and Low (2002), we first predicted for Hawaiian to have 'high' PVI values, before actually looking at some working PVI values of Hawaiian. We then considered a way to be more explicit about what exactly counts as a 'high' PVI value, introducing the 'slope PVI'. This measure was also applied to the unclassified languages from Grabe and Low's (2002) work, providing an explicit answer to some intuitive and some not-so intuitive categorizations of their data. The 'slope PVI' could be applied straightforwardly to data from other languages, too. However, at least one bug remains in my formulation of this approach, and the theoretical foundation of it remains to be defended or attacked.

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References

Boersma, P. and D. Weenink (2005). Praat: Doing phonetics by computer, version 4.3.28. (Available online: http://www.praat.org/).

Grabe, E. and E. L. Low (2002). Durational variability in speech and the rhythm class hypothesis. In C. Gussenhoven and N. Warner (Eds.), *Papers in Laboratory Phonology*, Volume 7, pp. 377–401. Berlin: Mouton de Gruyter. (Available on-line: http://www.phon.ox.ac.uk/∼esther/).

Low, E. L., E. Grabe, and F. Nolan (2001). Quantitative characterisations of speech rhythm: Syllable-timing in Singapore English. *Language and Speech 43*(4), 377–401. (Available on-line: http://www.phon.ox.ac.uk/∼esther/).

Schütz, A. J. (1978). Accent in two Oceanic languages. *Anthropological Linguistics 20*(4), 141–149.

Schütz, A. J. (1981). A reanalysis of the Hawaiian vowel system. *Oceanic Linguistics 20*(1), 1–44.

Vanderslice, R. and L. S. Pierson (1967). Prosodic features of Hawaiian English. *The Quarterly Journal of Speech 53*(2), 156–166.

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