Working Papers of the Cornell Phonetics Laboratory
2002, vol. 14, pp.1-15

Vowel Laxing in Ngaju Dayak*

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Ngaju Dayak, an Austronesian language of Borneo, exhibits a process of vowel laxing, realized as centralization, which is sensitive to morphological structure. A phonetic study with a native speaker reveals that a vowel in a final syllable closed by a consonantal suffix (CV+C) is more centralized than a vowel in a syllable closed by a consonant in the same morpheme (CVC). This process appears stronger at the beginning of the vowel than at its end. We further conclude that this centralization is less evident at the end of the vowel due to the strong influence of the final consonant on the vowel's formant structure.

1. Introduction

The present study investigates the effect of morphology on the process of vowel laxing in Ngaju Dayak. Ngaju Dayak, an Austronesian language spoken in Central Kalimantan in Indonesia, exhibits a process of vowel laxing whereby vowels in closed syllables are more lax than vowels in open syllables. The purpose of this project is to see if vowels in syllables closed by a consonant of the same morpheme (monomorphemic syllables) exhibit the same degree of laxing as vowels in syllables closed by a consonant across a morpheme boundary (bimorphemic syllables). Results of the study reveal that there is a phonetic difference between the two different morphological classes. Section 2 of the paper includes information on the language and our correlates of laxing. Section 3 describes our methodology; Section 4 contains our results, and the conclusions are summarized in Section 5.

2. Ngaju Dayak and Vowel Laxing

Ngaju Dayak has five simple vowel phonemes /i, u, e, o, a/, all of which are impressionistically tense in open syllables and lax in closed syllables. (The three

* We would like to thank Ben Abel for his generous commitment to this project as a native speaker consultant. We would also like to thank Amanda Miller-Ockhuizen, Abigail Cohn, John Wolff and audiences at Cornell University and at the Ninth International Conference on Austronesian Linguistics, where previous versions of this paper were presented, for their valuable comments. Additionally, we would like to thank Eric Evans for technical support.

diphthongs in the language will not be considered). In the following pair, for example, the tense /u/ in *asu* is in an open syllable and the lax /ʊ/ in *kasut* is in a closed syllable:

1. [asu] 'dog'
2. [kasʊt] 'shoe'

While such a contrast is not surprising, we found that pairs like the following which differ only in their morphological structure reveal a more complicated set of facts:

3. [tosɔn] 'red squirrel'
4. [tosɔ + n] 'the breast of _____'

We undertook a phonetic study to address the issue of whether or not the degree of laxing is affected by the presence of the morpheme boundary. We chose to concentrate on the contrast between monomorphemic and bimorphemic syllables closed by /m/ and /n/ because Ngaju Dayak has two possessive suffixes which consist of a single consonant, /-m/ 'second person singular possessive marker' and /-n/ 'third person genitive marker'.

We focused on the first and second formants (F1 and F2) as the main correlates of laxing. Lax vowels were expected to centralize in the vowel space, with the centralization indicated by a rise of F1 for high vowels and a lowering for low vowels with a lowering of F2 for front vowels and a rise for back vowels. We also considered the duration of each segment, but as there was no significant correlation between length and centralization, we will not discuss this data.

3. Methodology

We designed a wordlist containing the following types of tokens whereby all words were disyllabic nouns and the target vowels were in the final syllable[1]:

-each of the five vowels closed by a glottal stop

-each of the five vowels closed by /-n/ in the same morpheme

-each of the five vowels closed by /-m/ in the same morpheme

-each of the five vowels closed by /-n/ across a morpheme boundary

-each of the five vowels closed by /-m/ across a morpheme boundary

In every category we listed two different words with six repetitions each, bringing us to a total of 300 tokens. Due to some segmentation difficulties in words where the preceding consonant was a sonorant, we excluded 62 tokens, leaving us with 238 tokens all of which had an obstruent as the preceding segment, most of which were dentals. The words were included in the following frame sentence:

5. Aku manyewut ________ intu pander-ku male.
I think this feeling-my good
"I have a good feeling about the word __________."[2]

We recorded a male speaker of Ngaju Dayak, in his forties, reading the list in four sessions during the fall of 2001 in the sound-proof booth at the Cornell Phonetics Laboratory. We digitized the tapes in Xwaves, labeled the beginning and endpoints of the vowels and ran the ESPS utility *Formant* to measure the first four formants of each vowel. We then used a Perl script to locate F1 and F2 values at five equidistant points. Finally, we checked the measurements by hand, relabeled suspicious cases and then re-ran *Formant*. We excluded cases that were at least two standard deviations away from the average (5.13% of the total tokens).

[1] The only word which was not disyllabic was one trisyllabic token of monomorphemic /im/.

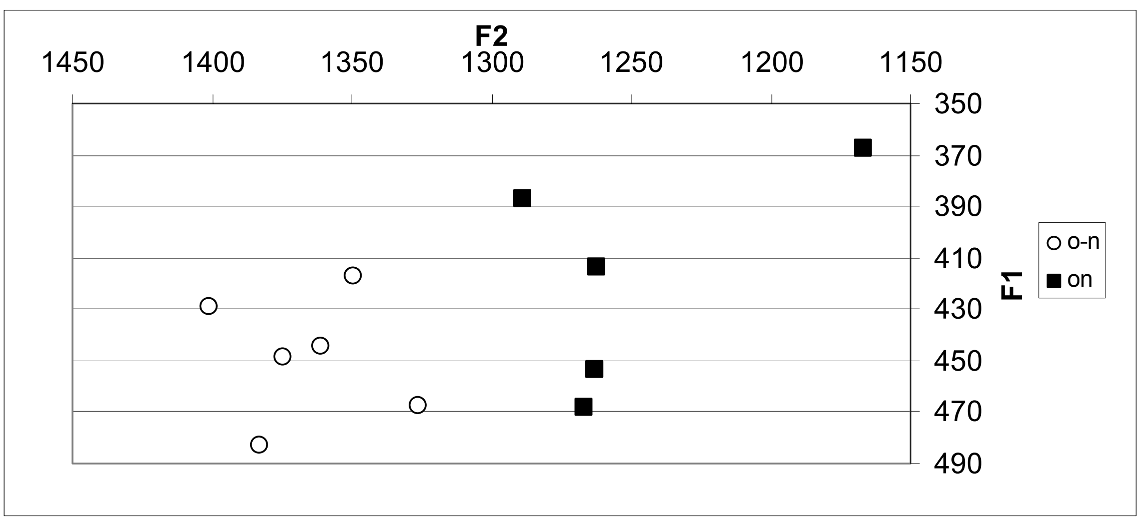
[2] The third person possessive marker /-n/ is followed by the proper noun *Utuy* in the frame sentence, resulting in a different phrasal context for these tokens. However, in terms of laxing, these tokens do not behave differently than the words inflected with the second person possessive marker /-m/, which is not followed by the proper noun. We therefore conclude that this difference in phrasal context is not relevant to the laxing process.

4. Results

4.1 Vowel Laxing

Most significantly, we found that the vowel in a closed final syllable of a bimorphemic word is consistently more centralized than a similar vowel in a monomorphemic word. This is well illustrated by the quasi-minimal pair *toso-n* / *toson*. (By quasi-minimal pair, we mean that the mid-back vowel of the second syllable is slightly different in the two words, as will be shown below.) This pair illustrates the difference between the two groups quite clearly, because the two words consist of the same underlying segmental string but have different morphological structures. *Toson* 'red squirrel' is monomorphemic while *toso+n X* 'the breast of X' is composed of two morphemes.

Chart 1: Monomorphemic and bimorphemic tokens of *toson* – point 2



The formant values of the last vowel of the two words are shown in Chart 1. In this chart and in the following charts, we have chosen to illustrate the formant values as measured at the second fifth of the vowels in order to minimize the effect of coarticulation with the preceding consonant and the substantial effect of the following consonant. We can see in the chart that the F2 of the second /o/ is higher for *toso+n* than for *toson*, a clear sign of centralization in a mid-back vowel. Since the two words are a minimal pair, this is a very conclusive example of vowel laxing before a morphological boundary. Centralization is also found for the other vowels, as shown in Charts 2-11 below.

Chart 2*:* Monomorphemic and bimorphemic tokens ending in *im* – point 2

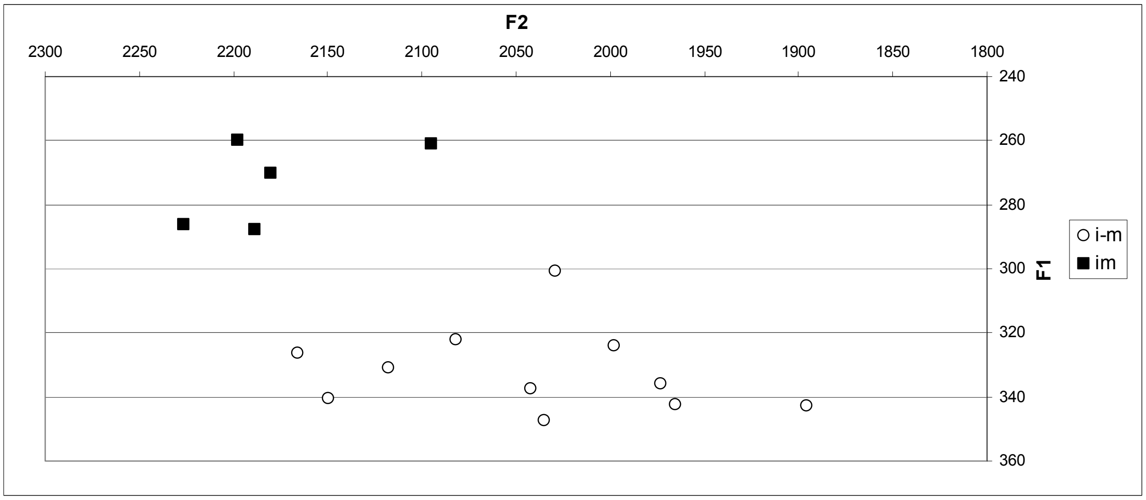


Chart 3: Monomorphemic and bimorphemic tokens ending in *in* – point 2

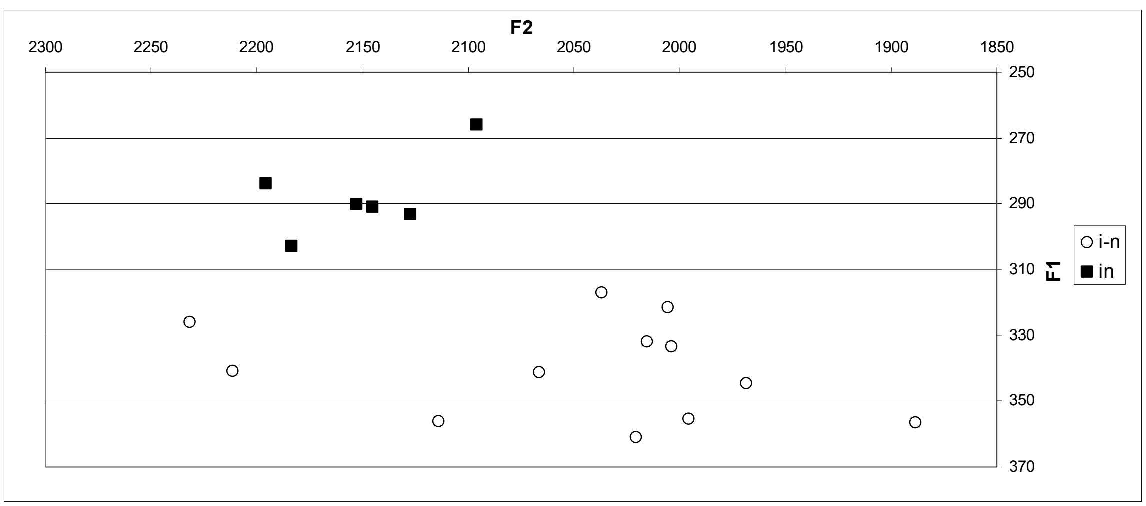


Chart 2 shows monomorphemic /i/'s and bimorphemic /i/'s followed by /m/ while Chart 3 shows the same vowels followed by /n/. Words ending in /m/ and /n/ are treated separately because the place of articulation affects the formants of the vowels differently. In Chart 2, we see that the /i/ in /im/ is less centralized than the /i/ in /i+m/. The two populations cluster very distinctly, and the F2 of the monomorphemic tokens is higher while the F1 is lower, which is what we expect from a non-centralized high front vowel. A t-test has shown that the difference between the averages of the two groups is statistically significant for both F1 and F2 ($p<0.05$). (All of the results presented in the following pages will also be statistically significant unless stated otherwise.) The results plotted in Chart 3 are similar. The F1 of the /i/ in /i+n/ is higher than the F1 of the /i/ in /in/. Although the role of F2 is less decisive than in Chart 2, we see once again that the two population samples are clearly distinct and that /i/ is more centralized when followed by a morpheme boundary.

The behavior of the second high vowel, /u/, is illustrated in Charts 4 and 5. In Chart 4, the /u/ in /u+m/ has a lower F1 than the /u/ in /um/, which means that it is more centralized. The difference in F2 between the two populations is not as clear nor is it statistically significant. However, in Chart 5, the /u/ in /un/ has both a lower F1 and a lower F2 than the /u/ in /u+n/: the two variables indicate that the bimorphemic tokens are more centralized than the monomorphemic tokens. We can therefore conclude that, just like mid vowels, high vowels are more centralized before a morpheme boundary than within the closed syllable of a monomorphemic word.

Chart 4 : Monomorphemic and bimorphemic tokens ending in *um* – point 2

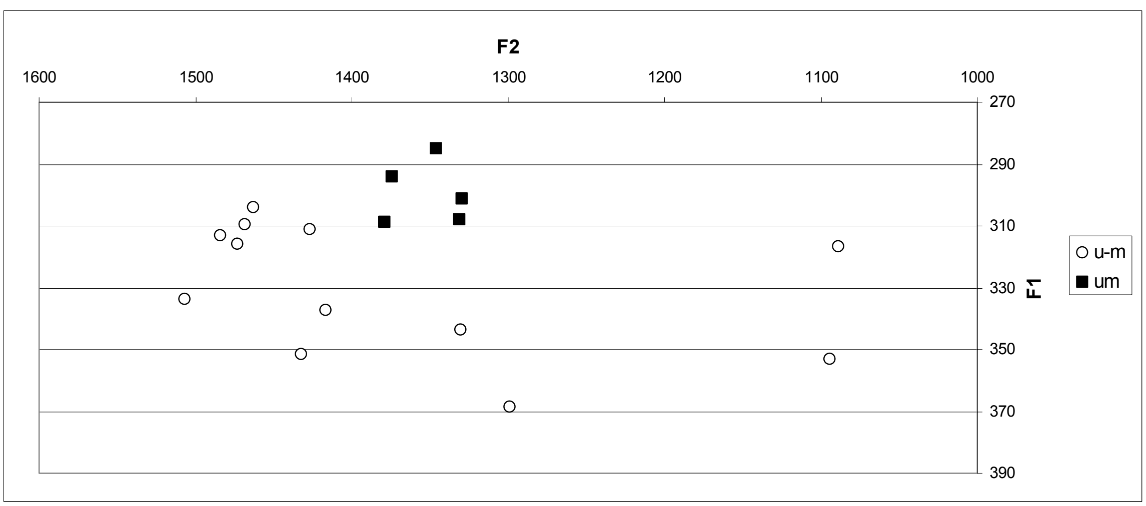
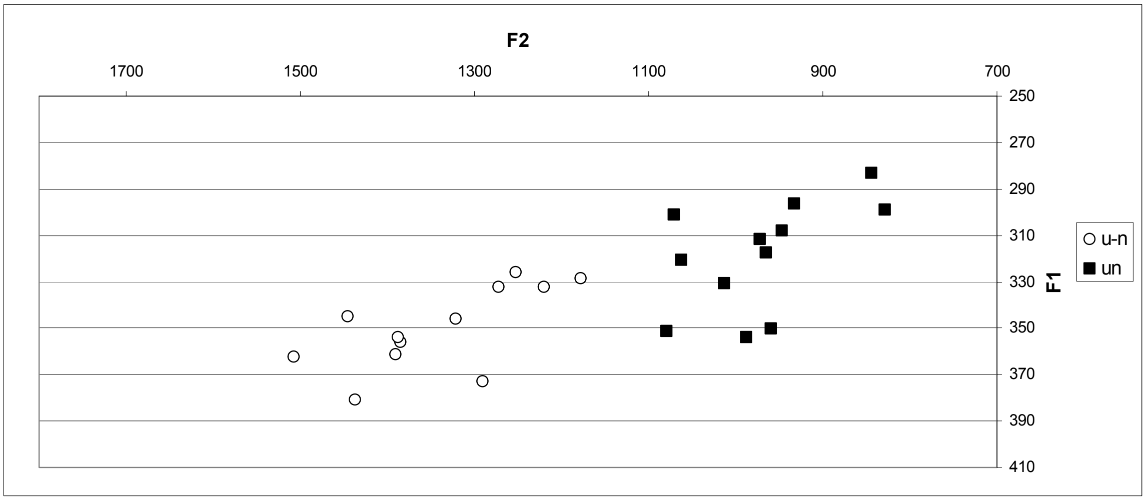


Chart 5: Monomorphemic and bimorphemic tokens ending in *un* – point 2



Mid vowel centralization is obviously realized differently from high vowel centralization since mid vowels are already at the center point of the height axis. While the front mid vowel /e/ should have a lower F2 when it is centralized, the behavior of its F1 is more difficult to predict. Since a mid vowel is not located in a corner of the vowel space, its F1 could, in theory, be either increased or decreased. As expected, we find in our data that /e+m/ has a lower F2 than /em/, while its F1 is not significantly different from the F1 of /em/ (Chart 6). However, no statistical difference is found between /e+n/ and /en/, for either F1 or F2 (Chart 7).

Chart 6 : Monomorphemic and bimorphemic tokens ending in *em* – point 2

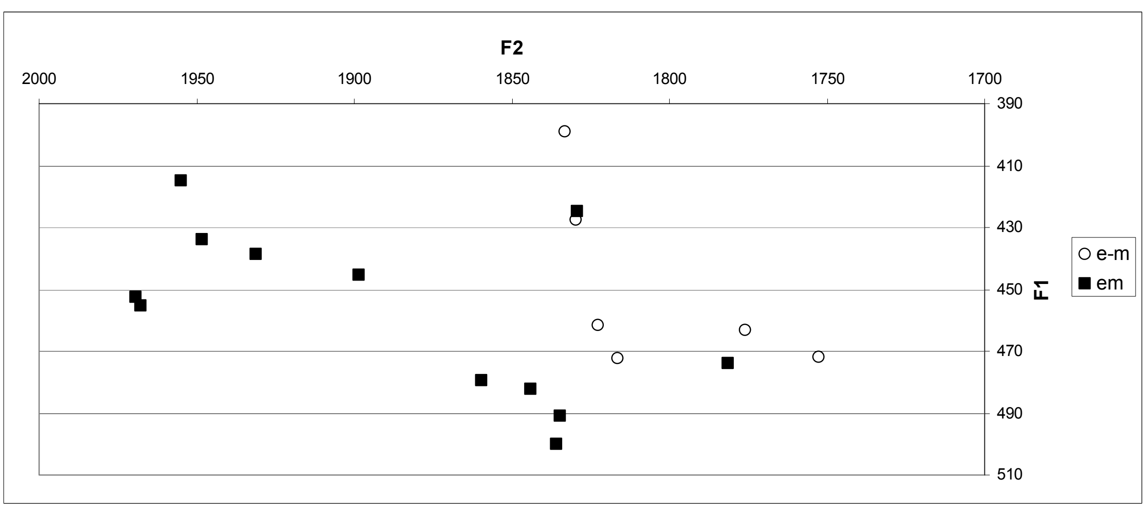
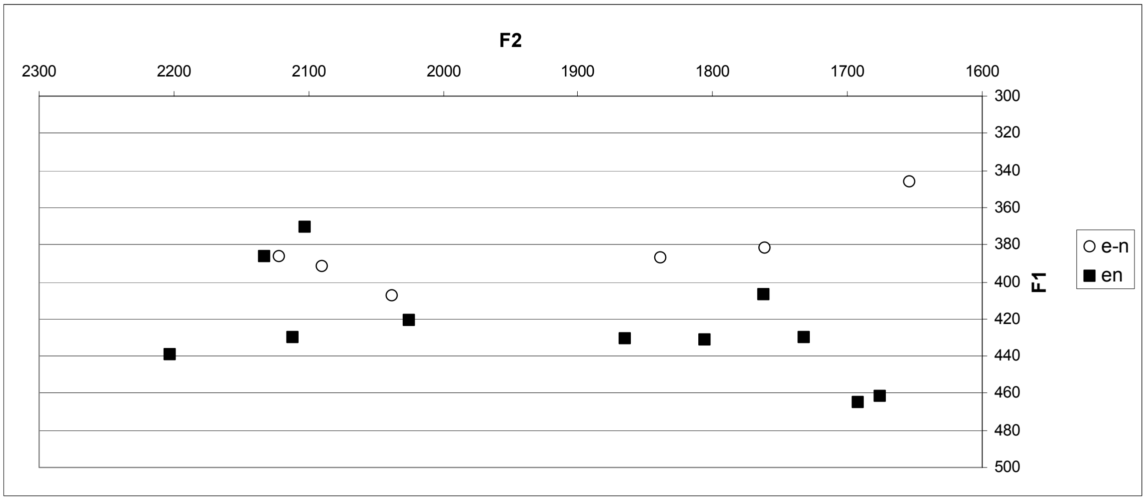


Chart 7: Monomorphemic and bimorphemic tokens ending in *en* – point 2



The mid vowel /o/ conforms to our expectations better. Since it is a mid-back vowel, the F2 of its centralized tokens should be higher than the F2 of its non-centralized tokens. The behavior of F1 is again difficult to predict for a mid vowel. In Charts 8 and 9, we see that the vowels of the bimorphemic words have a higher F2 than the vowels of the monomorphemic words. In both charts, F1 is also significantly lower for monomorphemic words. Overall, the laxing process seems to operate on mid vowels just like it does on high vowels, to the possible exception of /e-n/ - /en/.

Chart 8 *:* Monomorphemic and bimorphemic tokens ending in *om* – point 2

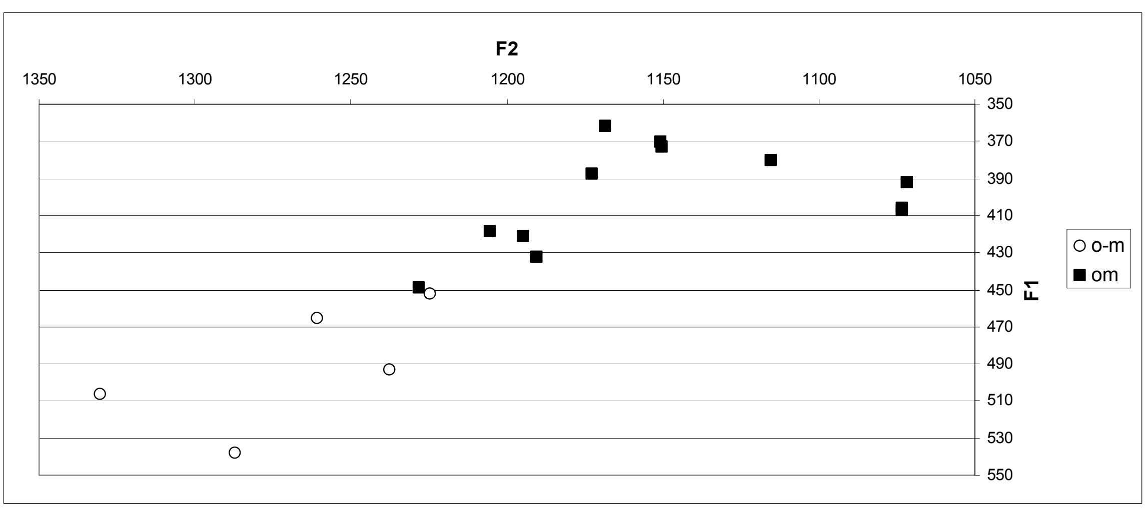
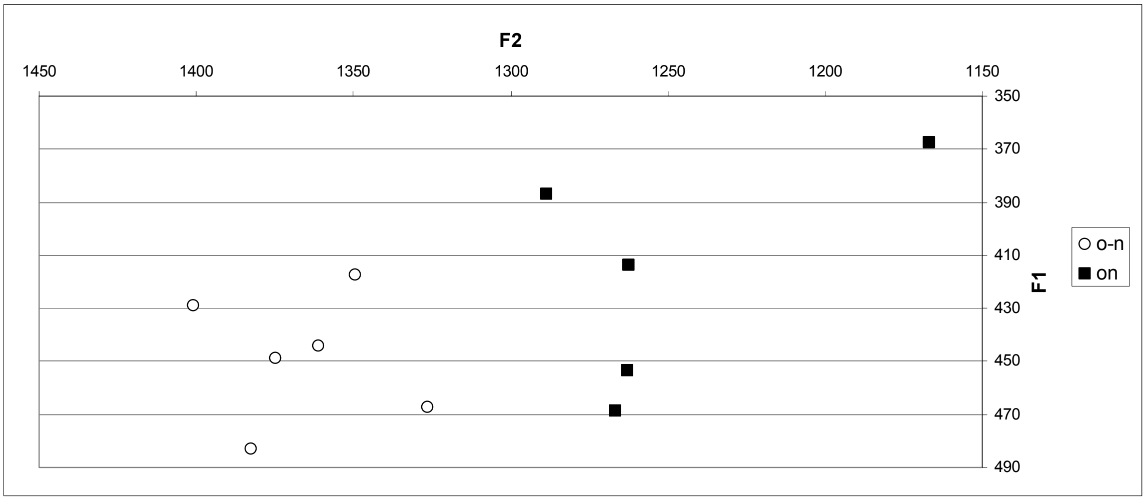


Chart 9: (= Chart 1) Monomorphemic and bimorphemic tokens ending in *on* – point 2



What do we expect from the low vowel /a/? It is difficult to make predictions about how /a/ would centralize. Its F1 would probably be lower than the F1 of its non-centralized counterpart, but its F2 could be either lowered or raised, depending on the default position of /a/ in the vowel space. In fact, we find that the low vowel in Ngaju Dayak does not consistently centralize in bimorphemic syllables. Perhaps this is not surprising considering that a tense/lax contrast in low vowels is cross-linguistically much less common than a similar contrast at the mid or even high levels (Maddieson 1984). However, Maddieson's survey focuses on phonemic inventories rather than phonetic realizations. Therefore, this data does not necessarily inform the Ngaju Dayak case. Furthermore, many of these cases of contrast are likely to be based on advanced and retracted tongue root values, and we have no reason to believe that tongue root movement is a significant factor in Ngaju Dayak vowel laxing.

We found that in Ngaju Dayak, the low vowel /a/ does not seem to be centralized in bimorphemic words. In Chart 10, which shows tokens of bimorphemic /a+m/ and monomorphemic /am/, F1 and F2 are not significantly different for the two population samples, whereas in Chart 11, which shows /a+n/ and /an/, only F2 shows a significant difference between the two populations. These results are difficult to interpret. We thus cannot conclude that /a/ is affected by the laxing process at this stage.

Chart 10: Monomorphemic and bimorphemic tokens ending in *am* – point 2

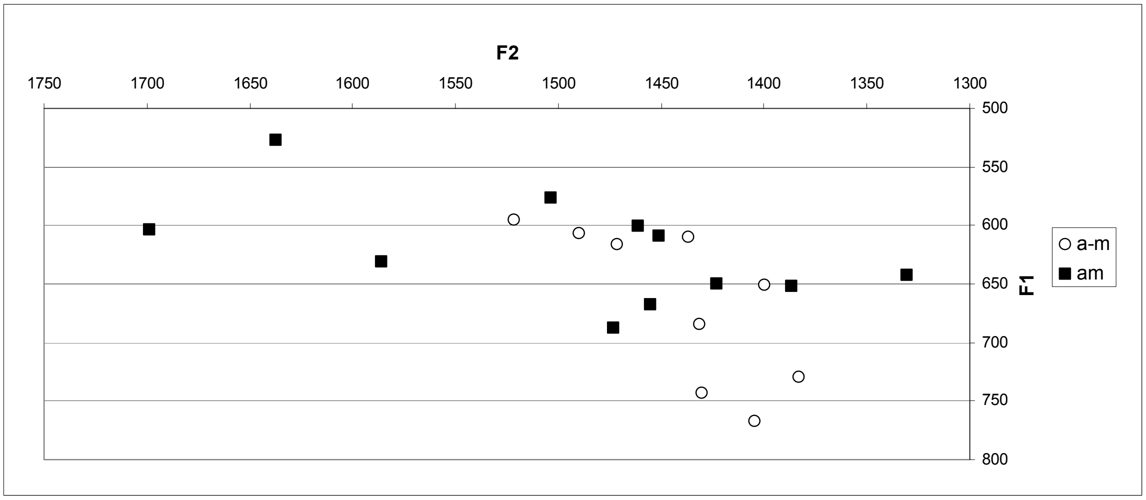
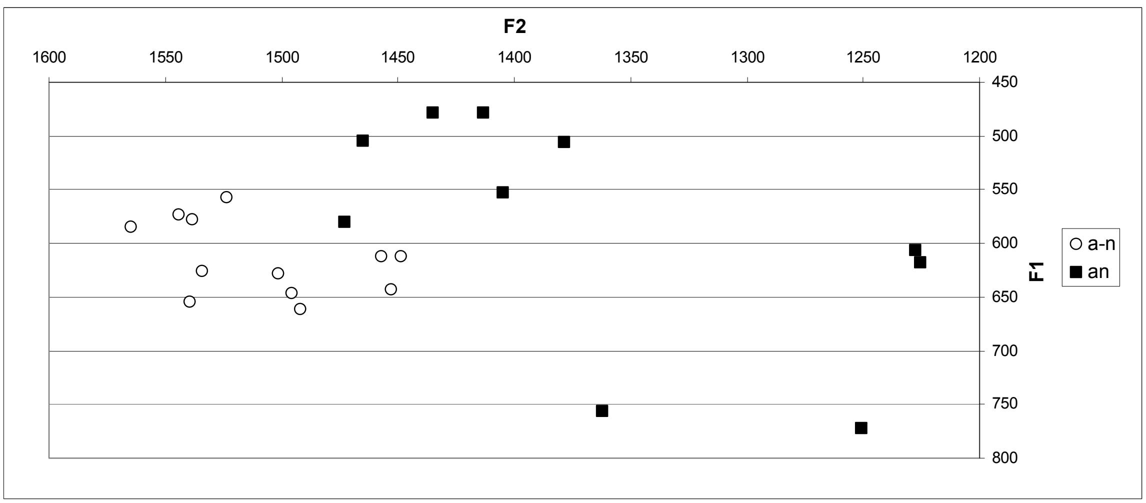


Chart 11: Monomorphemic and bimorphemic tokens ending in *an* – point 2



To summarize thus far, the centralization of high vowels before a morpheme boundary is reflected primarily by a change in F1 and also to some extent by a change in F2. The centralization of mid vowels in the same environment is reflected mostly by a change in F2, and perhaps by a change in F1 in the case of /o/. At this point, there is not enough evidence to make any claims about the centralization of the low vowel /a/.

4.2 Interaction of morphology and final consonants

While the effect of morphology on the laxing process is quite clear at the beginning of the vowel, as the previous charts illustrate, the effect is less clear at the end of the vowel, as can be seen in Charts 12a, b and c in which the formant values of the /u/ in /u+n/ and /un/ are plotted at points 1, 3 and 5, respectively.

Chart 12a: Monomorphemic and bimorphemic tokens ending in *un* – point 1

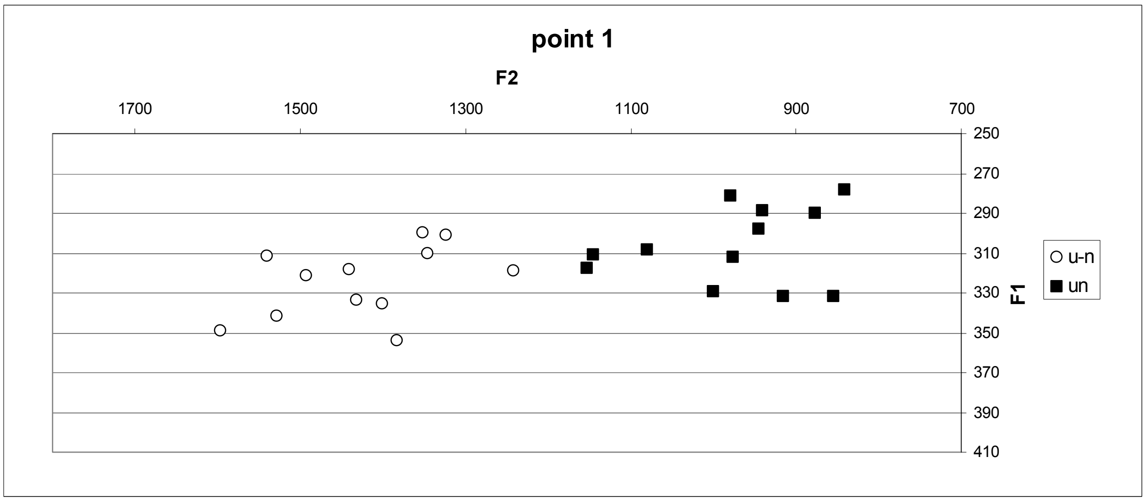


Chart 12b: Monomorphemic and bimorphemic tokens ending in *un* – points3

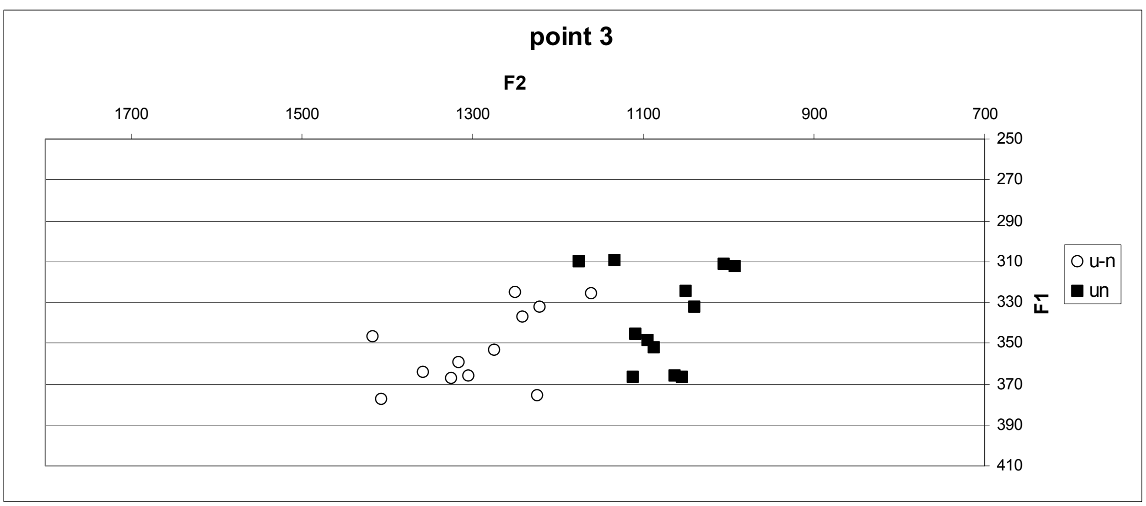
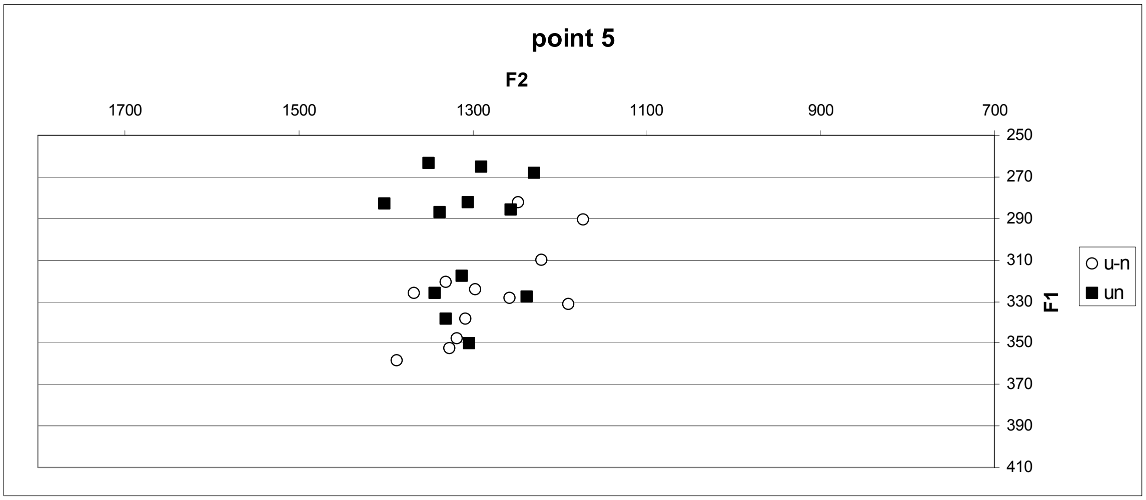


Chart 12c: Monomorphemic and bimorphemic tokens ending in *un* – point 5



At point 1, the two groups are very distinctly clustered according to their morphological structure, with the bimorphemic tokens being more centralized than the monomorphemic tokens; at point 3 the clustering is less distinct, and at point 5 the two groups have almost completely merged. It seems that the phonological laxing process is being masked by the influence of the final consonants on the formants of the preceding vowels. More evidence for the effect of the final consonants on formant structure is presented in the following subsection.

4.3 Effect of final consonant

As has been well-described in the phonetic literature since Lieberman et al. (1956), the place of articulation of a consonant has an effect on the formant transitions of the preceding vowel. In particular, a bilabial nasal, such as the /m/ in Ngaju Dayak, lowers F2 while a dental nasal, such as the /n/ in Ngaju Dayak, raises it. Charts 13a-c illustrate the effect of the final consonant on the preceding vowel in all of the disyllabic tokens, regardless of morphological structure. At point 2, the effect of the final consonants is hardly visible, with the tokens overlapping without regard to the consonants' place of the articulation. At point 4, the effect of the final consonants is beginning to be visible as the tokens begin to cluster together based upon the consonants' place of articulation. Finally, at point 5, a clear pattern emerges: F2 tends to lower before /m/ while it raises before /n/. The contrast is more pronounced for /m/ than /n/ and is more noticeable for back than front vowels. Most importantly, the differential effect of the consonants is not sensitive to morphological structure.

Chart 13a : Effect of final consonant on preceding vowel (all tokens) – point 2

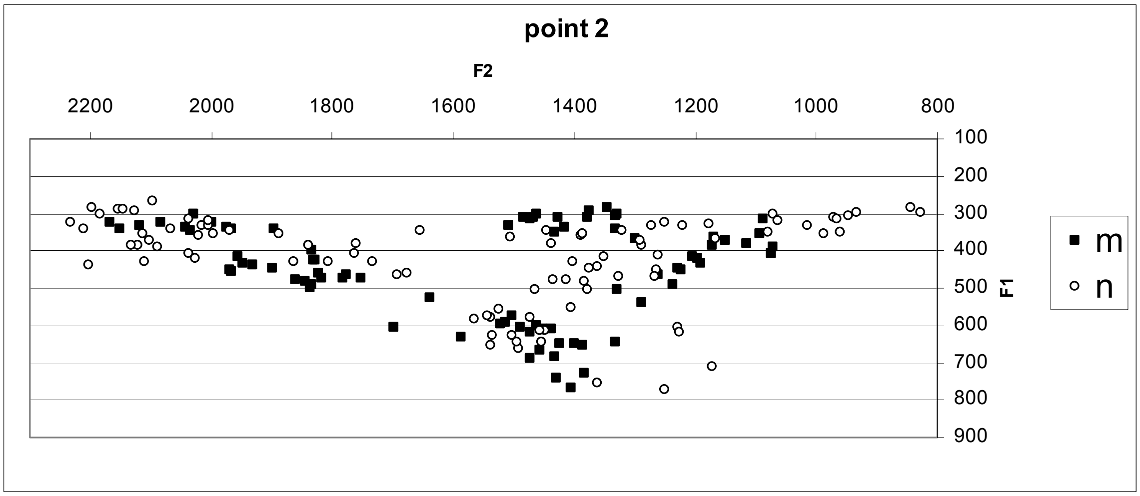


Chart 13b : Effect of final consonant on preceding vowel (all tokens) – point 4

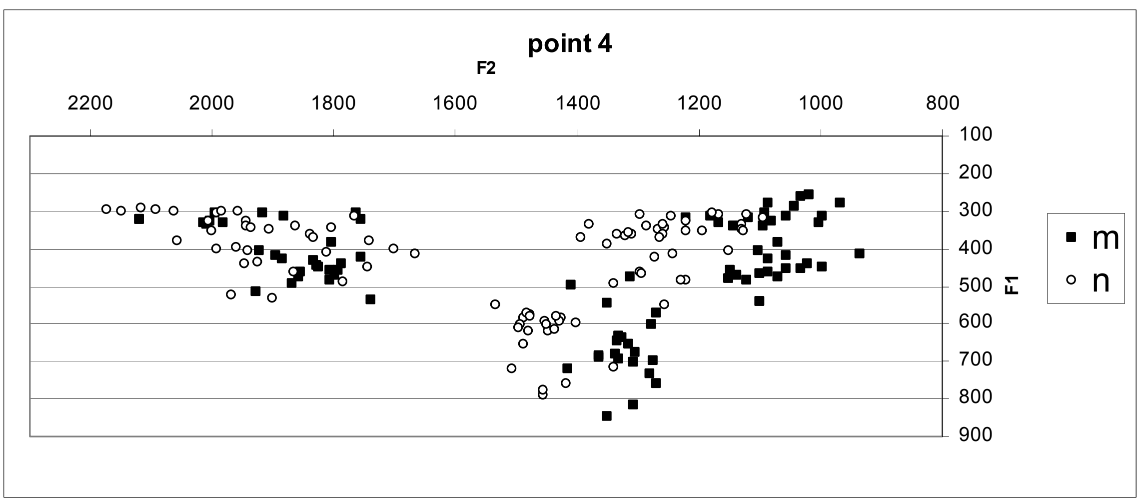
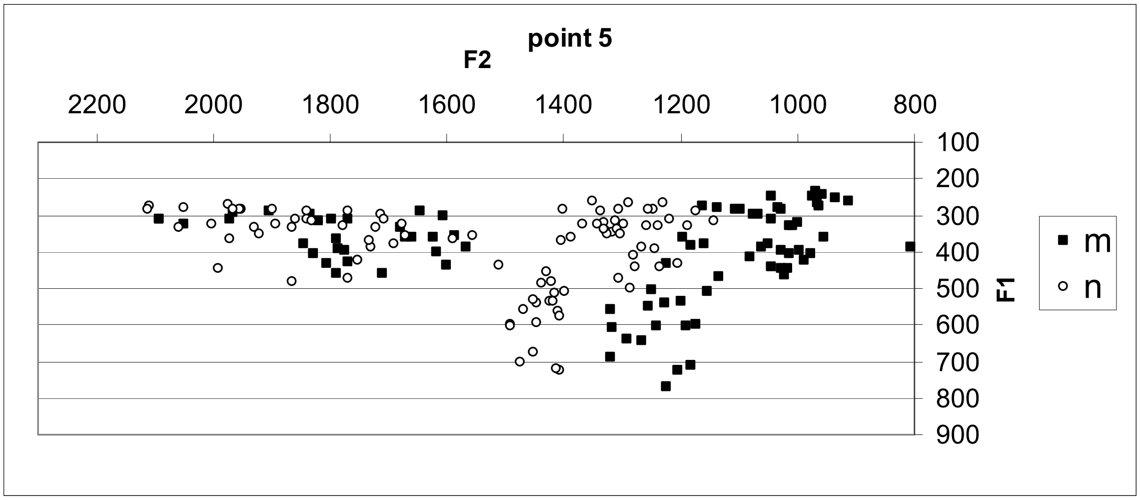


Chart 13c : Effect of final consonant on preceding vowel (all tokens) – point 5



5. Conclusion

Two processes of laxing appear to operate in Ngaju Dayak. The first process (which we will term *morphological centralization*) laxes a vowel in a syllable closed across a morpheme boundary. The second process (which we will term *consonantal effect*) modifies the formant structures of the final portion of the vowel. Since the first process is sensitive to morphological structure, it is more likely to be a phonological rule than a phonetic one. The second process is gradient (its effect being much stronger at the endpoint of a vowel) and therefore likely to be phonetic.

The fact that the morphological centralization process appears stronger at the beginning of the vowel could be explained through its interaction with the phonetic consonantal effect. Though the morphological process may categorically apply to the entire vowel, its effect is obscured by the phonetic process towards the end of the vowel.

Why there would be a morphological centralization process in Ngaju Dayak remains a question for further investigation. One obvious hypothesis is that it serves to disambiguate morphological structure. However, this hypothesis still needs to be tested by a perceptual study.

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