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AN ACOUSTIC PHONETIC ANALYSIS OF THE INTELLIGIBILITY OF NEPALI-ACCENTED ENGLISH VOWELS

ETTIEN KOFFI[1]

ABSTRACT

This research is carried out to gauge the intelligibility of vowels produced by 19 Nepali international students (10 male and 9 female) enrolled at St. Cloud State University (SCSU) in fall 2017. At the time of the study, the average length of residency of students was 2.4 years. The students' data were collected for two interrelated projects. One focused on the social network of Nepali students at SCSU (see companion paper in this volume) and this one investigates the intelligibility of their vowels. Vowels are singled out because they play a greater role in intelligibility than consonants (Prator and Robinett 1985:13). Intelligibility in this study is assessed instrumentally rather than impressionistically. In so doing, F1 and F2 of English vowels produced by Nepali speakers are compared and contrasted with those produced by General American English (GAE) in Peterson and Barney (1952).[2] Masking scores and relative functional load calculations are used to assess which Nepali-accented English vowels are intelligible and which ones are not. Pedagogical implications are drawn. The findings discussed in this paper are based on 1,254 vowel tokens (11 vowels, 19 participants, 3 repetitions, and two correlates, i.e., 11 x 19 x 3 x 2).

1.0 Introduction

St. Cloud State University (SCSU) offers a variety of support services such as the Academic Learning Center, the Math Skills Center, and the Write Place to help students. Additionally, the university has the Intensive English Center (IEC) and the English for Academic Purposes (EAP) through which non-native speakers can receive additional instruction to improve their language skills.[3] Many international students routinely express the need to improve their oral proficiency skills. Oral proficiency, also known here as speech intelligibility, covers a wide range of issues, including but not limited to, speech tempo, intonation, voice quality, lexical stress, and the production of individual speech segments. English vowels are notorious for their deleterious impact on speech intelligibility. Prator and Robinett (1985:13) have famously stated that "If you wish to understand and be understood in English, you must be able to distinguish and make the distinction among the vowel sounds with accuracy." This is the reason why this paper focuses on the pronunciation of English vowels by Nepali students. Concentrating on vowels allows us to gain great insights into how to help Nepali speakers who wish to improve the intelligibility of their speech. Nineteen participants (10 males and 9 females) provided the data for this study. The analysis and diagnosis of their produced vowels are the object of this six-part

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[1] I wish to acknowledge the help of the students who took my sociolinguistics course in fall of 2017. They collected the data which have served as the basis for the analyses in this paper.

[2] Ladefoged and Disner (2012:43) note that GAE is an "old-fashioned" dialect. Yet, the acoustic measurements provided by this dialect are taken to be prototypical phonetic invariant measurements against which other dialects of American English are gauged. If the acoustic measurements of vowels produced by non-native speakers match those in Peterson and Barney, they are deemed to be fully intelligible.

[3] Julie J. Condon is the English for Academic Purposes (EAP) Coordinator at SCSU. She offered insights and editorial assistance on this paper. She also helped with various aspects of this project, including serving as a liaison between me and the Center for International Student and Scholar Services. Her assistance is gratefully valued and graciously acknowledged.

paper. The first installment provides a quick overview of the literature on past studies of vowels carried out on international students at SCSU. The second deals with the participants and the methodology. The third highlights pieces of relevant linguistic information about Nepal. The fourth, which is also the longest, focuses on the acoustic measurements of Nepali-accented English vowels. The fifth discusses the findings, and the sixth makes some pedagogical recommendations.

2.0 A Quick Literature Review

The current study is the fourth in an ongoing research on L2-accented English vowels produced by students enrolled at St. Cloud State University (SCSU). In the first study of its kind, Abat and Koffi (2016:34-47) investigated the intelligibility of vowels produced by Jason, a Mandarin speaker who was enrolled at SCSU. In the second study, Koffi et al. (2017:50-71) examined the vowels and acoustic vowel spaces of five international students: one Argentinian, one Arabic speaker, one Brazilian, and two Salvadorians. In the third study, Koffi and Rebeiro (2018:152-174) analyzed the vowels and acoustic vowel spaces produced by 7 Brazilian Portuguese speakers who were studying at SCSU. These studies highlighted problematic vowels whose pronunciation hampered intelligibility. The present study follows the same methodology in investigating Nepali-accented English vowels.

3.0 Participants and Methodology

Nepalis are the largest international student group at SCSU. In fall of 2017, when the data was collected, there were 387 Nepali students enrolled at SCSU.[4] Nineteen of them (10 males and 9 females) volunteered to be interviewed for this research. The survey/interview sought to elicit data on the students' social network analysis (see companion paper in this volume) and their pronunciation of English vowels. The participants signed an informed consent form that was approved by the Institutional Review Board (IRB). They were compensated for their participation by receiving Cultural and Academic Sharing Scholarship credits that helped to reduce their tuition. Their length of residency (LOR) ranged from 3 months to 3 years, averaging 2.4 years.

The participants were recorded reading the following words: <*heed, hid, hayed, head, had, hod, hawed, hoed, who'd, hud*> which represent the 11 phonemic vowel monophthongs of English. Each word was repeated three times. This is a standard methodology that has been replicated hundreds of times to study vowels in L1 and L2 English, and dialect variations in L1 English, going all the way back to Peterson and Barney's (1952) seminal paper on the acoustic phonetic properties of General American English (GAE) vowels. The files were recorded on laptop computers using the Praat software and sampled at 44100 Hz. Individual vowels were annotated and measured following the model displayed in Figure 1 below:

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[4] Source: https://www.stcloudstate.edu/internationalstudies/_files/documents/enrollment/enorllment_fall_2017.pdf
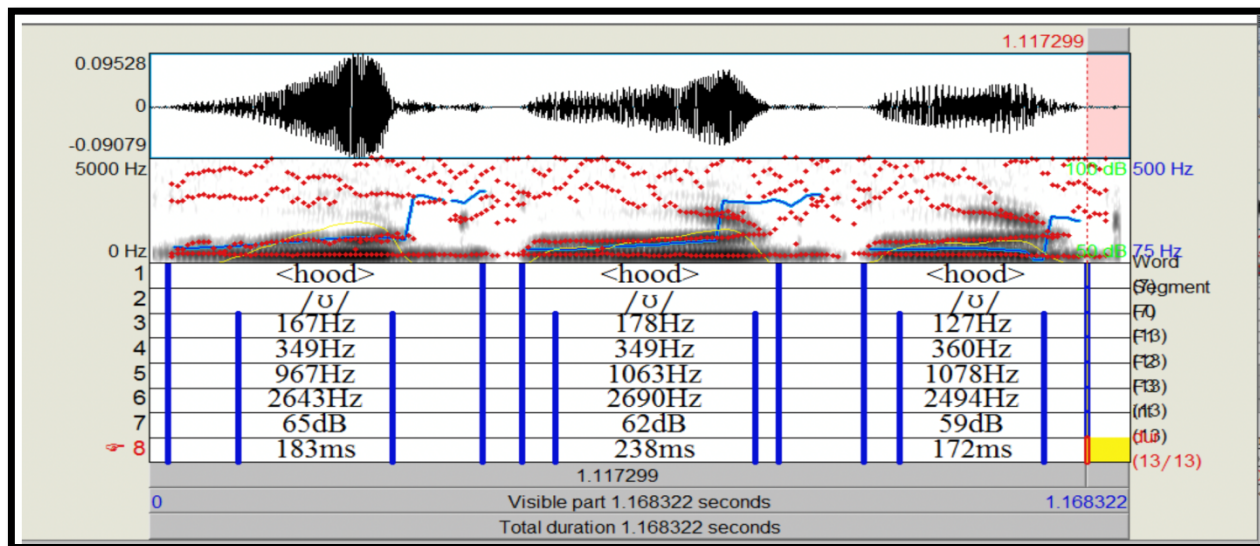
Figure 1: Annotation Procedures

A large amount of acoustic phonetic data was collected and measured, including F0, F1, F2, F3, intensity, and duration. However, for the purposes of this analysis, we focus only on F1 and F2, since they are the two correlates that are most relevant for the intelligibility of vowels. Male and female data are first analyzed separately, and are later normalized for the purposes of generalization (see 5.5).

3.1 Instrumental Assessment of Intelligibility

Before proceeding further, a summary statement needs to be made about how intelligibility of vowels is assessed instrumentally. When vowels are measured acoustically, F1 and F2 are the only two correlates that are deemed important for intelligibility. Furthermore, F1 is deemed the most robust cue for gauging intelligibility because it alone accounts for 80% of the acoustic energy found in vowels (Ladefoged and Johnson 2015:207). Numerous acoustic phonetic experiments have confirmed over and over again that on the F1 frequency bandwidth, two adjacent phonemically contrastive vowels are optimally perceived if the acoustic distance between them is ≥60 Hz. If the acoustic distance between them is ≤20 Hz, they mask each other completely and they become unintelligible. Complete masking means that hearers cannot distinguish which vowel is which. Intelligibility is further degraded if the relative functional load (RFL) of the two vowels is high. Catford (1987:88) provides the following definition of RFL, "the functional load of a phoneme or phonemic contrast is represented by the number of words in which it occurs in the lexicon, or in the case of phonemic contrast, the number of pairs of words in the lexicon that it serves to keep distinct." If the RFL of two vowels is low, it means that the vowels in question are not used to distinguish between many words. Such is the case of the English vowels [u] and [ʊ] whose RFL is only 7%. On the other hand, if the RFL of two vowels is high, it means that the language teams with lexical minimal pairs. A case in point is [i] and [ɪ] whose RFL is 95%. RFL is extremely important in assessing intelligibility. If the RFL of two segments is low, even if they mask each other, intelligibility is not seriously compromised. But if the RFL is high and masking takes place, intelligibility is seriously jeopardized. Masking levels, RFL calculations, the correlations between them and intelligibility are displayed here in Table 1. Additional explanations and illustrations are provided in relevant sections of the paper.

N0	F1 Distance	Masking Levels	RFL	Intelligibility Rating
1.	> 60 Hz	No masking	0-24%	Good intelligibility
2.	41 Hz – 60 Hz	Slight masking	25-49%	Fair intelligibility
3.	21 Hz – 40 Hz	Moderate masking	50–74%	Average intelligibility
4.	0 Hz – 20 Hz	Complete masking	75–100%	Poor intelligibility

Table 1: Correlations between Masking, Acoustic Distance, RFL, and Intelligibility

Ladefoged and Disner (2012:176) quote Diane Kweley-Port as saying that listeners can distinguish formant frequencies differing by as little as 12 Hz. However, they hasten to add that "Of course in the rough and tumble of every day speech, differences as small as this are unlikely to be used for distinguishing words. Even if we only set about to distinguish the subtleties of accent within a language, we probably need differences that are twice or three times as large as the set of "just noticeable differences." Koffi (2014:12-13) has shown that in Central Minnesota English where the "cot/caught" merger has already taken place, speakers cannot perceive any difference between [ɑ] and [ɔ] because the acoustic distance between them is ≤20 Hz. Thomas (2011:56) agrees and states that people cannot perceive frequencies below 20 to 25 Hz. Consequently, the Just Noticeable Difference (JND) threshold of ≤20 Hz can be safely used to assess the intelligibility of L2-accented English vowels.

4.0 The Linguistic Background of Nepal
Nepal is a small country that is rich in linguistic diversity. Estimates of the number of languages spoken in this country of 11 million range from 17 to 113 (Bista 2011:2, Ghimire 2013:55, Sapkota 2013:189). It is unclear how to take these figures because the number of languages fluctuates according to various censuses. Sapkota (2013:189-190) reports that the 1952-1954 census enumerated 44 languages; that of 1961 listed 33 languages; that of 1971 had 17 languages; and in 1981 mentioned 20 languages. The number of languages jumped to 92 after the census of 2001, while the one of 2011 catalogued 113 languages! The confusion is symptomatic of the inability of linguists to rely on foolproof criteria to differentiate languages from dialects. It may also mean that the fluctuating number of languages betrays past attempts to suppress linguistic minorities while the ballooning number of languages reflects the contemporary zeal in acknowledging linguistic diversity. After the fall of the monarchy in 1959 and the rise of democratic institutions, linguistic issues have risen to the forefront in Nepal. Constitutional amendments have taken place to address the issue of linguistic plurality. Prior to the overthrow of the monarchy, hegemonic language planning ruled the day. Every effort was made to foster the unrivaled development of Nepali, which was and still is the language of wider communication (LWC). According to the census data from 2001, 48.61% of the population spoke Nepali as their first language. For the rest, Nepali was/is a dominant second language (Sapkota 2013:195). The forward-looking Constitutions of 1990 and 2007 made room for minority languages. They were recognized as media of instruction in some elementary schools. Prior to these constitutional amendments, Nepali was the main, and indeed, the only language of education in Nepal (Ghimire 2013:58-9, Sah 2013:183).

4.1 English Language Planning in Nepal
Officially, English is not a privileged second language in Nepal. The 15 foreign languages mentioned in Ghimire (2013:58) are in principle on equal footing. However, English has the upper hand over other foreign languages because it has a very high prestige. It has, in

some cases, been recognized as a de facto administrative language on par with Nepali. Sapkota (2013:190) notes that the 1964 Nepali Company Act requires that companies keep their records in English or Nepali. No other foreign language has been recognized at such a high level. Tin (2014:399) retraces the history of English in Nepal. It made forays into the country in 1851 after a king of Nepal went on a royal visit to England. From that day onward, English received an elevated status in the kingdom. Since then until the fall of the monarchy, the offspring of the ruling elite have been educated either exclusively or predominantly in English. In many localities, English is taught as a school subject from the first grade. The higher the students go up in grade, the more exposure they receive in English. On average English is taught from 5 to 6 hours a week in middle school, and 6 to 10 hours a week in college (Bista 2011:2). Bista also notes that English is the medium of instruction in many private schools, colleges, and universities. It is also reported that 28.3% of all secondary schools, and 83.1% of all colleges and universities in Nepal are privately owned and managed. It goes without saying that even though English is not officially a second language in Nepal, it is widely known, taught, and viewed as such. Questionnaires distributed by Tin (2014:403) for her ethnographic study reveal the following about the status of English in Nepal:

> Concerning their reasons for studying English, the view of English as a **language of social mobility** is a recurrent theme reflected in students' responses given in the background questionnaire (e.g. 'to improve knowledge, skill and personal status', **'to get opportunity'**, 'to be ensured for getting good job', 'having good knowledge in English is high status in society of Nepal', **'English has become a popular language nowadays in business, at college, in hospital, in organization everywhere'** [Emphasis added].

Even so, Tin (2014:403) adds that "Students at the higher education level are considered to be proficient in English. However, there is a division in English proficiency between students who have studied at the English-medium private schools and those who have studied at Nepali-medium public schools." This statement is important and explains the wide range of English proficiency that we observe when dealing with Nepali students at SCSU. The standard deviations in our data (see Tables 3 and 5 below) attest to this discrepancy in proficiency levels.

4.2 Overview of Nepali Vowel Phonology
       Before delving into the English vowels produced by Nepali students, it is important to take a look at Nepali vowels. According to the publications consulted for this portion of the paper, Nepali has 6 oral vowels and 5 nasal vowels. Nasality is phonemic. Khatiwada (2009:377) reports that all six vowels except /o/ have nasal counterparts. Nasalization is a robust phonological process. An oral vowel in the vicinity of nasal consonants is also nasalized, except /o/. Table 2 displays some important articulatory characteristics of Nepali oral vowels:

	Front	Central	Back
High	i		u
Mid high	e		o
Low-mid		ʌ	
Low		a	

Table 2: Nepali Vowel Phonemes

By all accounts, /ʌ/ is a phoneme with two allophones: [ɔ] and [ɘ]. The IPA transcription of the Nepali text in Khatiwada (2009:379) shows mostly /ʌ/ except in one instance where [ɘ] occurs immediately after [p]. General American English (GAE) has 11 phonemic vowel monophthongs: /i, ɪ, e, ɛ, æ, ɑ, ɔ, o, ʊ, u, ʌ/ whereas Nepali has only 6 phonemic oral vowels /i, e, a, o, u, ʌ/. The English vowels /ɪ, ɛ, æ, ɔ, ʊ/ do not have any counterparts in Nepali. The discrepancies in vowel inventories beg the following questions:

1. Can Nepali speakers of English whose native language lacks one or more of English vowels manage to produce it/them intelligibly?
2. If they cannot, which vowels do they use to substitute for it/them?
3. Do the compensatory strategies used interfere with segmental intelligibility?

An important tool for comparing and contrasting vowels is acoustic vowel spaces. Unfortunately, I was not able to find an acoustic vowel space of Nepali. However, Gautan (2013:52) provides the following vowel diagram of Balami, a language of Nepal that is spoken by a little over one million people. Since more than 84% of Nepalis are bilingual in Nepali and other languages in the country, one could tentatively refer to the information in Figure 1 as being possibly similar to the vowels of Nepali.
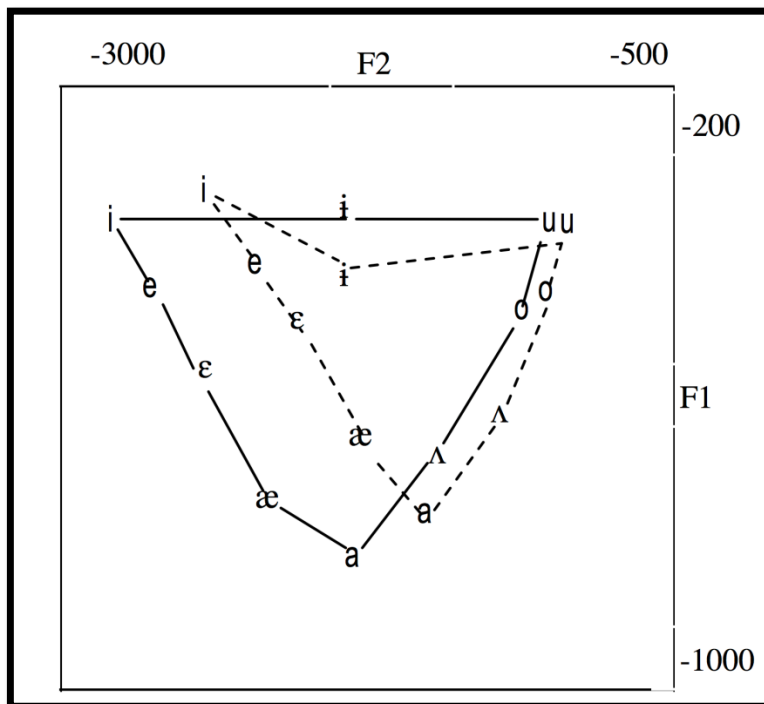
Figure 1: Comparative Vowel Spaces

In fact, as we will see in section 5.6, the acoustic vowel spaces produced by the 10 male and 9 female speakers are very similar to the data in Figure 1. Consequently, opining that the acoustic vowel space of Nepali may be similar to this one is not an egregious departure from linguistic reality.

5.0 The Acoustics of Nepali-accented English Vowels

It has become customary since Peterson and Barney (1952) to provide separate acoustic phonetic measurements for male and female speakers of the same language or dialect. The reason for doing so is physiological. Males and females have slightly different laryngeal anatomies. The dimensions of their glottises and laryngeal ligaments are different. These differences affect the aerodynamic and acoustic qualities of the vowels produced by both genders. In keeping with tradition, I will discuss vowel measurements separately. Males' data will be discussed first, followed by females' data. However, in 5.6, male and female vowels will be normalized for the purposes of generalization in consideration for putative pedagogical implications.

5.1 Nepali-accented English Vowels Produced by Male Speakers

Tables 3 and 4 contain F1 and F2 information produced by each participant. A lot can be written about various facets of the data presented here. However, our goal is the big picture. I will not dwell on individual speaker's idiosyncrasies. I will focus instead on the mean measurements for all speakers. Suffice it to say that the tables contain enough information to write whole dissertations on inter-speaker variability. GAE vowel measurements are displayed in each table for the purposes of direct comparisons. All GAE measurements, except for the vowel

sounds in "face"[5] and "goat", are from Peterson and Barney (1952). The measurements of the "face" and "goat" vowels are from Hillenbrand et al. (1995) because Peterson and Barney did not measure these two vowels.

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F1	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 1M	283	298	356	381	575	644	478	411	359	338	545
Nepali 3M	275	410	372	525	628	412	628	444	572	284	813
Nepali 4M	348	377	399	478	635	590	580	451	452	412	605
Nepali 5M	296	381	312	472	587	567	546	385	340	341	555
Nepali 7M	332	335	415	439	623	536	561	445	398	440	521
Nepali 9M	335	355	390	448	667	602	565	383	369	337	583
Nepali 12M	343	377	341	520	654	655	449	514	550	455	656
Nepali 14M	252	279	430	516	722	761	665	431	408	337	728
Nepali 15M	359	502	397	590	787	858	818	441	435	441	688
Nepali 17M	326	323	502	406	570	420	422	407	352	349	360
Nepali Mean	**321**	**373**	**387**	**473**	**636**	**587**	**560**	**431**	**425**	**377**	**591**
St. Dev.	23.33	126.5	74.24	130.1	153	309.7	280	24	58.6	65	231
GAE Mean	**270**	**390**	**476**	**530**	**660**	**730**	**570**	**497**	**440**	**300**	**640**

Table 3: F1 Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F2	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 1M	2365	2306	2173	2170	1829	1224	1588	1710	1178	1086	1159
Nepali 3M	2314	1948	2227	1896	1723	893	1115	1307	1490	790	1475
Nepali 4M	2014	2072	2182	1951	1855	1227	1522	1603	1757	1559	1816
Nepali 5M	2316	1966	2217	1856	1721	1110	1391	984	1325	1251	1258
Nepali 7M	1942	1907	1906	1854	1790	1254	1203	1174	1206	1152	1329
Nepali 9M	2369	2249	2218	2085	1896	932	1007	930	1144	1032	1077
Nepali 12M	2335	2487	2285	1903	1809	1838	2249	908	1510	1252	1494
Nepali 14M	2370	2335	2322	2003	1955	1181	1086	955	1240	1051	1301
Nepali 15M	2435	1933	2413	1828	1771	1398	1344	1116	1515	1507	1920
Nepali 17M	2227	2088	2116	1924	1778	1219	1392	1203	1351	1186	1401
Nepali Mean	**2257**	**2106**	**2193**	**1940**	**1796**	**1232**	**1423**	**1215**	**1386**	**1201**	**1436**
St. Dev.	147	109	210	67	4.94	126.5	33.94	61.51	115.9	226.9	366.9
GAE Mean	**2290**	**1990**	**2089**	**1840**	**1720**	**1090**	**840**	**910**	**1020**	**870**	**1190**

Table 4: F2 Measurements

5.2 Acoustic Vowel Spaces of Male Speakers

F1 and F2 data are used together to create acoustic vowel spaces. Diagrams such as the one in Figure 1 above make it possible to visualize vowel contrasts and gauge intelligibility at a glance. Ladefoged and Johnson (2015:234) cannot say enough about the pedagogical importance of acoustic vowel spaces. They express it as follows:

> … When teaching English as a second language, one might use the vowels of the first language of the students as reference points for comparison with the dialect of English

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[5] In keeping with contemporary practices, Well's lexical approach for naming English vowels is used in all tables and diagrams instead of the words used in the actual recordings. The full lexical set is found in Ladefoged and Johnson (2015:103)

that one is trying to teach. If a chart of the vowels of this language is not available, then the instructor's first step should be to make one.

Figure 2 contains Nepali-accented English vowels and GAE vowels side by side.[6]
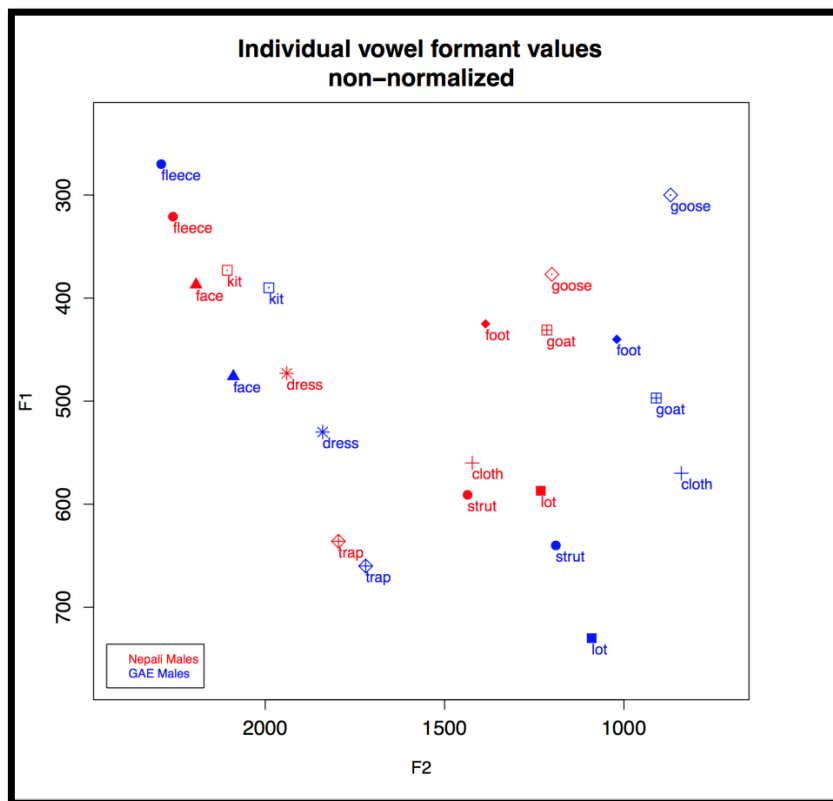

Figure 2: Male Acoustic Vowel Space

The information in Figure 2 allows us to make two types of masking assessments. The first has to do with **internal masking**. It shows which of the 11 phonemic monophthong English vowels Nepali speakers have a hard time producing distinctly. The second is **external masking**. It highlights which vowels produced by Nepali speakers overlap with GAE vowels in the vowel space.[7] The overall impact of the two types of masking on intelligibility is evaluated in accordance with the discussions in 3.1 and the thresholds in Table 1. We limit our discussions of intelligibility only to cases where the acoustic distance between two adjacent phonemically contrastive vowels on the F1 frequency band is ≤20 Hz.

5.3 Masking, RFL, and Intelligibility of Male Speakers
    Four pairs of vowels mask each other internally, meaning that the participants do not distinguish these vowels clearly in pronunciation. The vowels in question are [ɪ] vs.[e], [ɑ] vs.

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[6] All the acoustic vowel spaces in this study are generated through Norm, a free vowel normalization suite available at http://lingtools.uoregon.edu/norm/norm1.php.
[7] It is always a good idea to also investigate external masking because, as Ladefoged and Disner (2012:103) note, in making vowel intelligibility judgments, "listeners are strongly influenced by their own language." This also applies when GAE hearers are listening to L2-accented Englishes.

[ʌ], [ɑ] vs. [ɔ], and [ʊ] vs. [ɔ]. This is not surprising since we know that the vowels [ɪ], [ɑ], [ʊ], and [ɔ] do not exist in Nepali. The acoustic distance between their [ɪ] (373 Hz) vs. [e] (387 Hz) is 14 Hz. The one between [ɑ] (590 Hz) vs. [ɔ] (580 Hz) is 27 Hz, and the one between [ɑ] (587 Hz) vs. [ʌ] (591 Hz) is 4 Hz.   Also, the distance between [o] (431 Hz) vs. [ʊ] (425 Hz) is only 6 Hz. The masking of [ɑ] and [ɔ] has no negative consequence on intelligibility because these two vowels mask each other in many dialects of American English. The intelligibility impact of [o] and [ʊ] is moderate because their RFL is 51%, and so is the intelligibility between [ɑ] vs. [ʌ] since their RFL is 65%. However, the failure to differentiate clearly between [ɪ] and [e] affects intelligibility strongly because their RFL is 80%.

Some Nepali-accented vowels externally mask vowels produced by GAE speakers. When Nepali speakers produce [e] (399 Hz), GAE hearers may misperceive it as [ɪ] (390 Hz) because the acoustic distance between them is only 9 Hz. If the discourse context is not clear, if a Nepali speaker says <hate>, a GAE hearer may perceive it as <hit>. Similarly, if a Nepali speaker says <met>, his GAE interlocuters may misperceive it as <mate> because the distance between a Nepali-accented [ɛ] is 478 Hz, while [e] in GAE is 476 Hz. There is only 2 Hz difference between them. With an RFL of 53%, this confusion can lead to mild or moderate unintelligibility. Furthermore, when Nepali male speakers produce [o] (451 Hz), its F1 masks [ʊ] (440 Hz) in GAE by 11 Hz. Since their RFL is 51%, this can also lead to mild or moderate unintelligibility.

5.4 Nepali-accented English Vowels Produced by Female Speakers
Table 5 displays F1 measurements, while Table 6 deals with F2. These measurements are used together to create the comparative acoustic vowel space in Figure 3. They also help us assess the intelligibility of vowels produced by Nepali female speakers.

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F1	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 2F	452	418	484	530	849	683	663	544	440	462	667
Nepali 6F	315	409	463	608	907	792	760	496	342	391	818
Nepali 8F	310	430	536	610	860	850	590	555	470	370	760
Nepali 10F	471	477	543	484	927	698	749	476	445	449	754
Nepali 11F	309	386	378	685	1016	447	587	557	404	392	633
Nepali 13F	326	511	453	572	865	783	677	545	531	401	831
Nepali 16F	384	366	555	468	891	479	639	570	360	407	685
Nepali 18F	293	356	438	634	845	469	600	445	325	262	797
Nepali 19F	377	400	454	418	727	456	519	449	359	393	526
Nepali Mean	**359**	**417**	**471**	**556**	**876**	**628**	**642**	**515**	**408**	**391**	**719**
St. Dev.	65.59	50.30	67.21	87.49	77.17	165	78.79	49.07	68.31	56.83	99.89
GAE Mean	**310**	**430**	**536**	**610**	**860**	**850**	**590**	**555**	**470**	**370**	**760**

Table 5: F1 Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F2	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 2F	2482	2623	2453	2264	1967	1401	1455	1261	1202	1225	1525
Nepali 6F	2584	2186	2248	2110	1926	1181	1339	1065	1169	1083	1572
Nepali 8F	2447	2316	1831	1741	1640	1108	1283	1373	1225	987	1186
Nepali 10F	2072	2137	2433	2063	2017	1260	1309	1171	1177	1207	1306
Nepali 11F	2780	2390	2662	2369	2322	1603	1046	1098	1440	1165	1174
Nepali 13F	2827	2341	2542	2170	2060	1110	991	956	1534	1027	1661
Nepali 16F	2380	2287	2204	2151	1964	1193	1199	1276	1190	1122	1378
Nepali 18F	2056	2073	2098	1889	1778	946	1037	1566	910	1197	1651
Nepali 19F	2612	2711	2714	2516	2242	1202	1264	1928	1200	1232	1474
Nepali Mean	**2471**	**2340**	**2353**	**2141**	**1990**	**1222**	**1213**	**1299**	**1227**	**1138**	**1436**
St. Dev.	272.7	212	284.7	234.3	209.7	188.1	157.9	296.5	176.3	89.2	185.7
GAE Mean	**2790**	**2480**	**2530**	**2330**	**2050**	**1220**	**920**	**1035**	**1160**	**950**	**1640**

Table 6: F2 Measurements
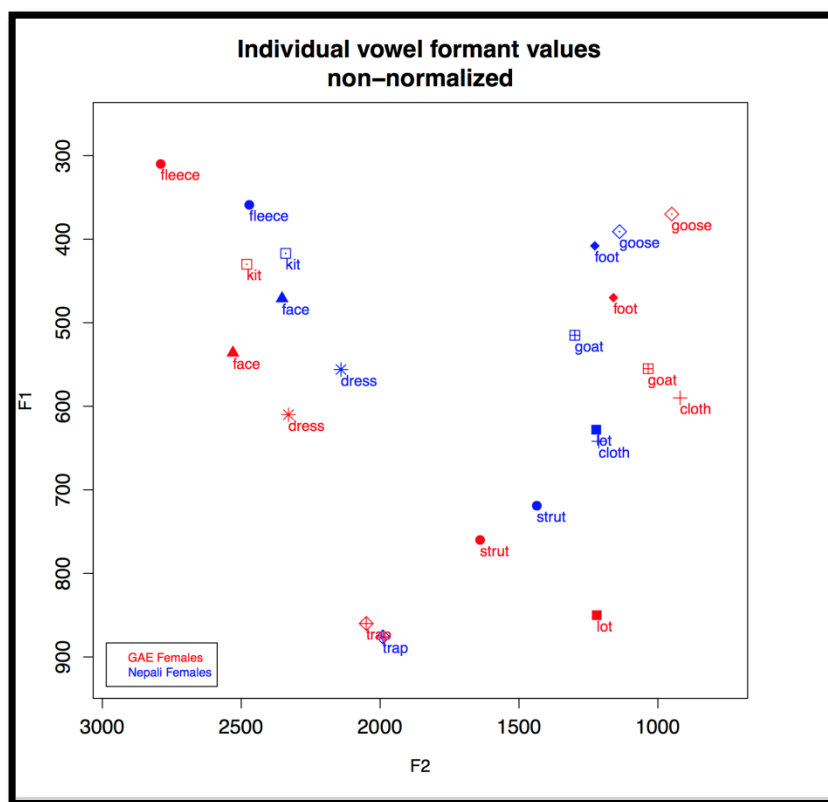

Figure 3: Female Acoustic Vowel Space

5.5 Masking, RFL, and Intelligibility of Female Speakers

Two pairs of vowels mask each other internally in female speech. The vowels [ɑ] (628 Hz) vs. [ɔ] (642 Hz) mask each other completely because the acoustic distance between them is only 14 Hz. However, intelligibility is not an issue here because these two vowels have merged

in many dialects of GAE. The vowels [u] (408 Hz) vs. [ʊ] (391 Hz) also mask each other because they are separated by just 17 Hz. Confusing these two vowels does not impede intelligibility because their RFL is only 7%. In other words, there are virtually no minimal pairs in English where the [u] and [ʊ] contrast phonemically. In fact, many speakers of GAE produce words such as <cookies> with either [u] or [ʊ]. Words such as <fool> vs. <full>, <pool> vs. <pull> are produced identically by some speakers in Texas (Bailey and Tillery 2006:40), and in Pittsburg, Pennsylvania (Johnstone and Kiesling 2006:80), to mention only these. For external masking, we note that when Nepali female speakers produce their [ɛ] (556 Hz), some GAE hearers may misperceive it as [e] (536 Hz) while others may perceive correctly. The reason is because the acoustic distance between them is just at the 20 Hz threshold. Their RFL is 53%. Consequently, confusing these two vowels can lead to mild or moderate unintelligibility.

5.6 Normalized Nepali Vowels

In Figure 4, we normalize the vowel data produced by male and female Nepali speakers of English and place them in the same acoustic vowel space. Normalization is necessary whenever male and female vowels are compared directly with each other. It is an algorithm that is used to smooth out the difference between male and female speakers due to vocal track differences. We prefer the TELESUR G normalization algorithm because it is the same one that Labov et al. (2006) used in averaging the data from their telephone survey of American speakers and in their influential book *Atlas of North American English*. The point of the normalization and the acoustic vowel space in Figure 4 is to highlight some important similarities and differences between how Nepali males and females produce their English vowels.
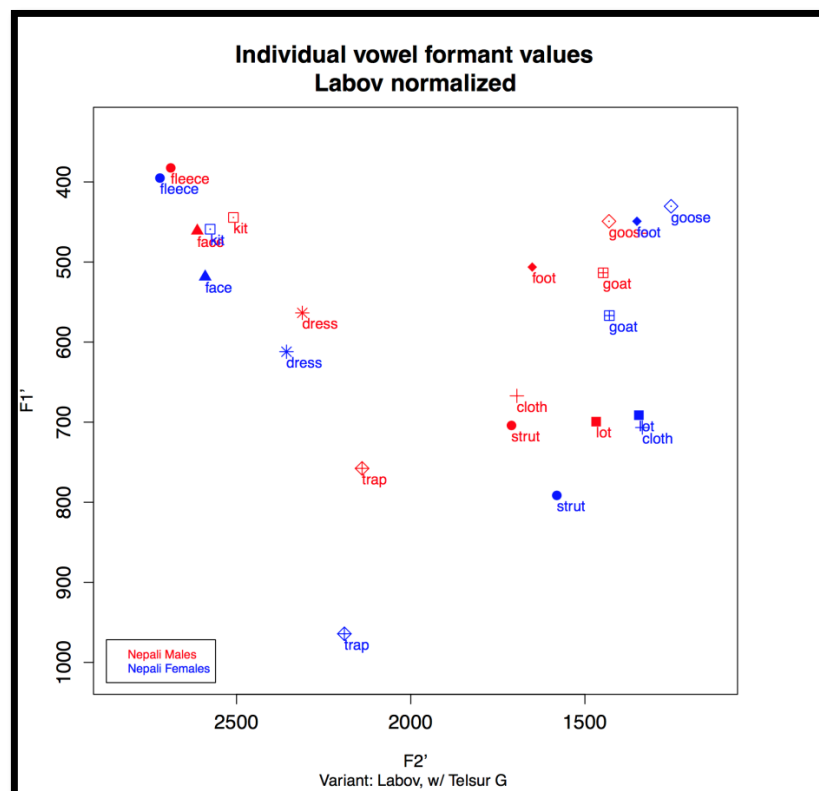

Figure 4: Normalized Vowel Spaces

A casual but important observation that may have consequences for intelligibility is that the Nepali female speakers in this study use all the important regions of their mouths to produce English vowels. Their vowels are spread nicely. In other words, Nepali female speakers' pronunciation of English vowels conforms to the principle of Sufficient Perceptual Separation (SPS), "whereby the sounds of a language are kept acoustically distinct to make it easier for the listener to distinguish one from the other," (Ladefoged 2006:222-3, 263). The only two vowels that they do not separate are [ɑ] and [ɔ]. Again, speakers of many dialects of American English do not separate these two vowels. Male speakers do not conform to SPS very well. Many of their back vowels mask each other, as is the case of [ʊ] and [o], along with [ʌ] and [ɔ]. In other words, the female Nepali speakers in the data speak more intelligibly than their male counterparts. Whereas four vowel pairs produced by male speakers mask each other, only two vowel pairs mask each other in female speech.

5.7 Transfer of Vowel Pronunciation Patterns

There are striking similarities between when Nepali male and female speakers produce the vowels of their native languages and when they speak English. The diagram in Figure 1 provided by Gautan (2013:52) supports this contention. It is fascinating to see how female speakers utilize a wider area of the acoustic vowel space than males when speaking in Balami. We see exactly the same pattern in Figure 4. This is a clear indication that the male and female participants in our study carry their Nepali speech patterns over into their English. If Figures 1 and 4 were to be juxtaposed on top of each other, we would see some interesting patterns that point to transfer of L1 Nepali vowel features into their L2 English. For example, the F1 of high vowels [i] and [u] in Nepali are between 350 to 400 Hz. The participants produce English high vowels similarly. Nepali female speakers open their mouths very wide when producing [a] in Nepali. They do the same when speaking English.

6.0 Pedagogical Implications

This research was motivated by the desire to enhance the academic support services offered to international students, and in this case, Nepali students. They are meant to help university officials understand how Nepali students interact with international and domestic students at SCSU (see companion paper in this volume) in order to better meet their academic needs. In the past, some Nepali students have had to enroll in a listening/speaking class when they arrive at SCSU. Instructors in this class address to the best of their abilities pronunciation issues that arise. Even though this paper does not address the myriad of issues in pronunciation, it offers some clues as to which English vowels Nepali students need to pay special attention to in order to be optimally intelligible.

7.0 Summary

The vowels produced by female students are more intelligible than those produced by their male counterparts. Whereas only [ɛ] vs. [e] is problematic for females, [ɪ] vs. [e], [ɑ] vs. [ʌ], and [ʊ] vs. [ɔ] compromise intelligibility in male speech. It is unclear why such an intelligibility chasm exists between the genders. One explanation is that this study focused on the big picture and did not zero in on individuals. If it did, it would have uncovered other discrepancies which could be attributed directly to the kind of English instruction that the participants received in high school. Because, according to Tin (2014:403), proficiency in English varies widely between Nepalis who attended private schools versus those who attended public schools. It did not occur

to us before the data collection to investigate this point. It may be that many of the female participants in our study attended private schools whereas many of the males did not. Regardless of the school that the participants attended prior to coming to SCSU, this study has shown us which vowels are more likely to cause intelligibility problems for Nepali talkers and for their American hearers. This information can now be used in tutoring Nepali students who wish to improve their pronunciation, i.e., the intelligibility of their English.

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Ettien Koffi, Ph.D. in linguistics from Indiana University, teaches linguistics at Saint Cloud State University, MN. Author of many peer-reviewed articles on various topics in linguistics and of four books: *Language and Society in Biblical Times* (1996), *Paradigm Shift in Language Planning and Policy: Game Theoretic Solutions* (2012), *Applied English Syntax* (2010, 2015), and the *New Testament in Anyi Morofu* (2017), a task which took over 25 years. Specializing in acoustic phonetics, dialect variation, and emergent orthographies, his current research centers on speech acoustics of L2 English (within the Speech Intelligibility Framework), Central Minnesota English, and Anyi. He can be reached at enkoffi@stcloudstate.edu.

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Appendices

As noted in the body of the paper, the amount of information collected for this paper is enormous. The total amount of tokens is 3,762, that is, (11 vowels, 19 participants, 3 repetitions, and six correlates, i.e., 11 x 19 x 3 x 6). The correlates used in the paper are F1 and F2.   F0, F3, intensity, and duration measurements, though important for the overall assessment of vowel quality, were not included in the body of the paper because they are not directly relevant for intelligibility. They are provided here for anyone who is interested in researching these aspects of Nepali accented-English vowels.

F0 Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F0	**[i]**	**[ɪ]**	**[e]**	**[ɛ]**	**[æ]**	**[ɑ]**	**[ɔ]**	**[o]**	**[ʊ]**	**[u]**	**[ʌ]**
Nepali 1M	145	147	144	142	142	142	142	145	144	147	138
Nepali 3M	91	102	97	91	91	93	92	112	108	111	94
Nepali 4M	107	109	107	135	187	116	109	112	120	117	106
Nepali 5M	128	124	132	135	132	127	128	127	126	131	127
Nepali 7M	143	137	125	121	116	133	138	123	153	139	162
Nepali 9M	140	131	125	137	121	131	123	135	137	142	142
Nepali 12M	102	101	97	101	98	99	98	101	99	100	94
Nepali 14M	110	105	112	109	104	100	112	112	113	117	107
Nepali 15M	194	182	194	172	182	201	210	199	211	211	201
Nepali 17M	181	183	136	136	137	133	148	133	157	160	164
Nepali Mean	**136**	**135**	**128**	**130**	**134**	**130**	**132**	**131**	**139**	**139**	**136**
St. Dev.	9	0.7	41	25	31	48	43	46	38	36	26
GAE Mean	136	135	129	130	127	124	129	129	137	141	130

Table 7A: Male F0 Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F0	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 2F	251	259	266	243	236	213	245	244	253	266	250
Nepali 6F	223	254	243	242	219	223	224	245	273	268	237
Nepali 8F	267	267	234	239	233	241	232	246	268	268	271
Nepali 10F	218	216	204	210	203	190	204	213	222	226	206
Nepali 11F	223	214	207	209	201	204	197	193	210	208	200
Nepali 13F	193	169	197	174	171	160	180	207	186	209	198
Nepali 16F	173	265	247	252	233	238	227	240	264	262	260
Nepali 18F	244	250	241	242	237	244	230	230	259	258	222
Nepali 19F	219	215	213	198	177	199	199	200	200	205	196
Nepali Mean	**223**	**234**	**228**	**223**	**212**	**212**	**215**	**224**	**237**	**241**	**226**
St. Dev.	28	32	23	26	25	27	21	21	32	28	28
GAE Mean	235	232	219	223	210	212	216	217	232	231	221

Table 7B: Female F0 Measurements

F3 Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F3	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 1M	3030	3007	2553	2623	2568	2680	2438	2605	2913	3081	2585
Nepali 3M	2886	2615	2788	2604	2381	2899	2907	2952	2912	2955	2516
Nepali 4M	2913	2792	2867	2788	2820	2530	2739	2859	2990	2899	3103
Nepali 5M	2979	2611	2815	2617	2582	2623	3031	2786	2696	2626	2732
Nepali 7M	2665	2536	2619	2510	2756	2293	2469	2269	2207	2295	2160
Nepali 9M	2867	2699	2691	2647	2656	2585	2650	2577	2470	2432	2533
Nepali 12M	2957	3164	3021	2730	2781	2709	2903	2601	3016	2752	2850
Nepali 14M	3124	2983	2980	2799	2788	2895	2824	2788	2731	2706	2684
Nepali 15M	2766	2745	2809	2698	2868	2894	2818	2840	2641	2636	2694
Nepali 17M	2563	2277	2176	2094	2012	2465	2326	2469	2609	2219	2260
Nepali Mean	**2847**	**2716**	**2704**	**2590**	**2602**	**2630**	**2697**	**2662**	**2717**	**2655**	**2603**
St. Dev.	143	330	447	427	605	303	347	262	22	294	306
GAE Mean	3010	2550	2691	2480	2410	2440	2410	2459	2240	2240	2390

Table 8A: Male F3 Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
F3	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 2F	3263	3234	3141	3043	3104	2866	3087	2881	2790	3015	2835
Nepali 6F	2903	2867	2829	2735	2896	2967	3065	2885	2610	2859	2835
Nepali 8F	2845	2821	2802	2792	2813	2723	2896	2680	2666	2768	2663
Nepali 10F	2833	2843	2865	2856	2802	2706	2813	2983	2816	2924	2768
Nepali 11F	3479	2930	3058	3001	3015	2991	2909	2962	2970	3027	2928
Nepali 13F	3575	3078	3153	2986	3016	3136	3192	3325	2738	2891	3078
Nepali 16F	2898	2871	2295	2696	2233	1174	1351	2357	2831	3108	2134
Nepali 18F	3206	3004	2907	2754	2317	2391	2489	2617	2354	2658	2829
Nepali 19F	3142	3342	3360	3283	3166	2639	2686	2865	2644	2677	2740
Nepali Mean	**3127**	**2998**	**2934**	**2905**	**2818**	**2621**	**2720**	**2839**	**2713**	**2880**	**2756**
St. Dev.	277	184	302	189	331	585	556	270	174	157	261
GAE Mean	3310	3070	3047	2990	2850	2810	2710	2828	2680	2670	2780

Table 8B: Female F3 Measurements

Duration Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Duration	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 1M	290	237	214	240	262	260	200	261	261	255	174
Nepali 3M	164	90	250	142	200	234	271	272	158	235	132
Nepali 4M	185	280	298	227	247	265	319	222	208	267	236
Nepali 5M	263	135	300	148	180	153	203	254	194	209	116
Nepali 7M	186	122	202	164	183	178	189	171	151	142	157
Nepali 9M	285	205	353	203	312	194	301	310	204	187	150
Nepali 12M	118	106	678	129	178	179	226	117	146	188	140
Nepali 14M	190	113	272	146	181	210	216	221	156	222	143
Nepali 15M	333	225	356	300	432	302	365	270	161	214	121
Nepali 17M	223	161	256	248	291	279	249	231	197	207	166
Nepali Mean	**227**	**173**	**323**	**200**	**253**	**227**	**258**	**234**	**186**	**211**	**154**
St. Dev.	77	45	70	36	99	16	82	27	25	4	31
GAE Mean	243	192	267	189	278	267	283	265	192	237	188

Table 9A: Male Duration Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Duration	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 2F	353	195	377	275	305	220	269	281	306	395	246
Nepali 6F	282	117	313	180	291	236	320	210	157	232	140
Nepali 8F	141	88	165	134	142	123	159	225	83	202	81
Nepali 10F	184	206	197	245	301	238	264	292	266	255	262
Nepali 11F	266	158	255	184	253	234	208	310	179	198	180
Nepali 13F	193	79	130	85	144	122	120	115	105	112	92
Nepali 16F	161	108	116	83	114	98	138	111	131	139	138
Nepali 18F	416	225	406	245	371	372	397	469	436	418	266
Nepali 19F	210	165	212	229	225	183	232	222	192	208	179
Nepali Mean	**245**	**149**	**241**	**184**	**238**	**202**	**234**	**248**	**206**	**239**	**176**
St. Dev.	92	53	104	70	88	84	89	108	112	104	70
GAE Mean	306	237	320	254	332	323	353	326	249	303	226

Table 9B: Female Duration Measurements

Intensity Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Intensity[8]	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 1M	69	70	74	69	66	68	69	71	72	72	66
Nepali 3M	54	54	51	47	53	49	56	44	47	55	51
Nepali 4M	90	85	87	86	85	83	83	77	76	76	71
Nepali 7M	65	65	66	66	69	69	70	68	69	69	68
Nepali 9M	75	75	74	76	76	78	77	76	78	78	77
Nepali 12M	36	34	35	41	44	42	38	41	39	40	76
Nepali 14M	43	43	41	40	39	38	39	48	49	49	42
Nepali 15M	75	76	78	76	76	80	79	82	82	80	79
Nepali 17M	60	62	57	61	55	57	63	59	62	63	66
Nepali Mean	**65**	**65**	**65**	**65**	**65**	**65**	**66**	**64**	**65**	**66**	**69**
St. Dev.	10	9	14	10	14	16	11	16	14	12	9

Table 10A: Male Intensity Measurements

Words	fleece	kit	face	dress	trap	lot	cloth	goat	foot	goose	strut
Intensity	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
Nepali 2F	67	65	65	66	64	67	65	67	66	65	66
Nepali 6F	71	70	66	66	64	66	65	67	69	67	68
Nepali 8F	65	64	62	64	67	63	61	64	65	63	65
Nepali 10F	64	65	61	64	60	60	62	66	65	69	60
Nepali 11F	57	52	54	51	53	53	51	51	53	53	51
Nepali 13F	46	48	52	50	49	53	52	52	51	50	51
Nepali 16F	52	57	54	58	58	58	60	61	60	59	58
Nepali 18F	75	74	76	76	76	77	77	76	75	76	76
Nepali 19F	74	76	74	73	71	72	71	72	73	74	75
Nepali Mean	**63**	**63**	**62**	**63**	**62**	**63**	**62**	**64**	**64**	**64**	**63**
St. Dev.	9	8	8	8	8	8	8	8	8	8	9

Table 10B: Female Intensity Measurements

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[8] Intensity data was inadvertently not reported for Nepali 5M.
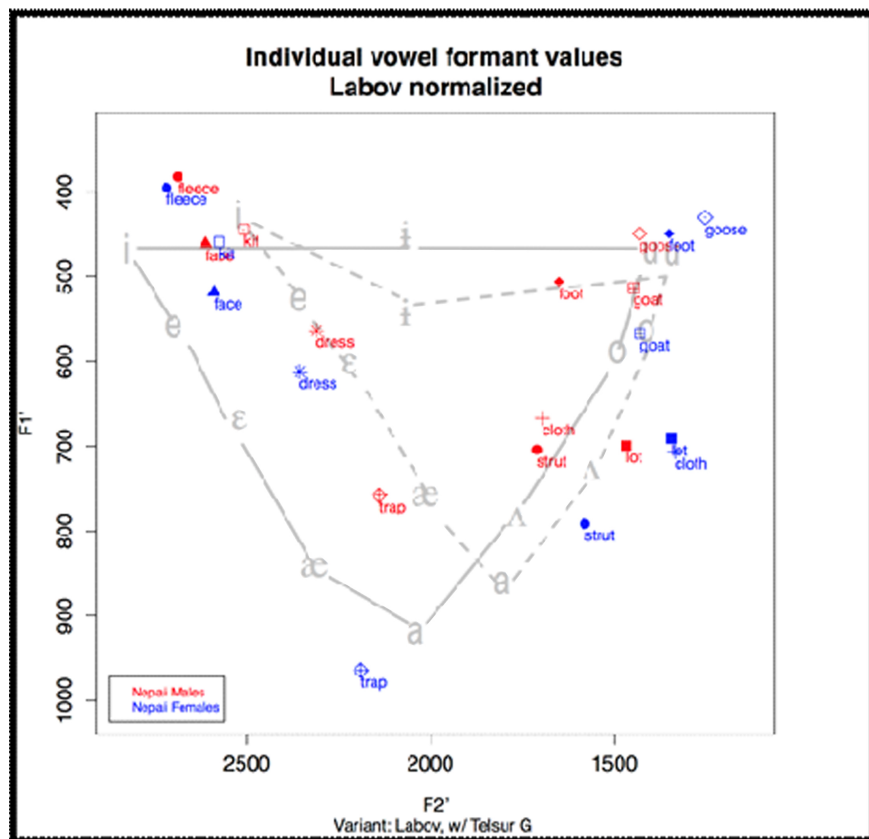
Figure 5: Juxtaposed Vowels[9]

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[9] The vowels of Balami are juxtaposed with the English vowels produced by Nepali males and females. My sincere thanks to Michel Backstrom-Lopez for creating this juxtaposition.