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An Acoustic Phonetic Analysis of Three Tonally Contrastive Grammatical Moods in Anyi: Orthographic Implications - A Festschrift in Honor of Rev. Dr. Gilbert Ansre

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AN ACOUSTIC PHONETIC ANALYSIS OF THREE TONALLY CONTRASTIVE GRAMMATICAL MOODS IN ANYI: ORTHOGRAPHIC IMPLICATIONS

ETTIEN KOFFI

A FESTSCHRIFT IN HONOR OF REV. DR. GILBERT ANSRE[1]

ABSTRACT

It is an honor to write this paper for Dr. Gilbert Ansre's festschrift. He was my mentor when I was doing my Ph.D. in linguistics. In the summers, the United Bible Societies would send me to study under him as a translation-consultant in training. He challenged me and coached me in applying theoretical linguistics concepts to real life language problems. When I received my Ph.D. and joined him in Togo, West Africa, he congratulated me saying, "Now, you are going to do real linguistics." This was an absurd statement at first, but over the years, I keep discovering its wisdom. The mentoring that Dr. Ansre provided helped me to improve on the existing orthographies of the languages under my supervision. The lack of tone marking in these languages made the reading of the Holy Scriptures a herculean task, even for the translators themselves. The quest for solutions led me to pioneer an orthographic approach to tone marking known as ***Tone Optimality Model*** *(Koffi 2012:230-232). It is deeply anchored in acoustic phonetics and influenced by Dr. Ansre's view that orthographies need not be overcrowded with superfluous diacritic marks. The model that I came up with marks tones systematically, yet sparingly. This paper describes and exemplifies how the same model was used to transcribe three tonally contrastive moods in the New Testament of Anyi Morofu, an Akan language spoken in Côte d'Ivoire. This festschrift is a fitting tribute to Dr. Gilbert Ansre whose book, Tonal Structure of Ewe (1961), is highly regarded for its seminal contribution to contemporary understanding of the tonal structure of West African languages*.

Key Words: Gilbert Ansre, Anyi Language, Tone Orthography, Tone Marking, Grammatical Tones, Grammatical Moods, Intentional Mood, Injunctive Mood, Tone Optimality Model.

1.0 Introduction

When it comes to writing tone in the orthography of African languages, a paradox emerges: the more experts know about tone at a theoretical level, the less able practitioners are in transferring this knowledge into designing orthographies that mark tone optimally. In a sense, the contemporary African linguist is no better off than the missionaries who came up with "brilliant" ideas for not writing tones in the orthographies of African languages (Welmers 1973:77). The goal of this paper is to show how the **Tone Optimality Model** (TOM) is changing this situation by

[1] On April 16, 2020, I received a request from Dr. John Ekem of the Bible of Society of Ghana about writing a festschrift to honor Reverend Dr. Gilbert Ansre. I responded enthusiastically and submitted this paper for consideration. Dr. Ekem acknowledged on August 8, 2020 that he had received the festschrift. Since then, I have heard nothing. On December 22, 2020, I wrote him an email making known of my intention to publish the festschrift elsewhere. My email did not receive any response. Because Dr. Ansre played a major role in my professional formation, I decided to proceed with publishing the festschrift in this journal. This is a fitting venue because of the worldwide reach of this publication. Since Dr. Gilbert Ansre is a towering stature in African linguistics, a festschrift in his honor deserves to be broadcasted as widely as possible.

using acoustic phonetic measurements and interpreting them for marking tone in the orthography of African languages. The language used for this demonstration is Anyi, an Akan language spoken in the eastern part of Côte d'Ivoire. The tonal patterns under consideration are those that occur in the conjugation of verbs in the **declarative (indicative)**, the **intentional,** and the **injunctive (subjunctive) moods**. Auditory differentiations between these three grammatical moods are based solely on tonal melodies.

2.0 Background Information

The sources of information on the tone patterns of Anyi are Quaireau (1978, 1987), Burmeister (1983), Koffi (2009), and to a lesser extent Cresseils and Kouadio (1977) for their analysis of Baule tone. Baule is mutually intelligible with the Anyi Morofu dialect being described in this paper. The consensus among these researchers is that the underlying pitch register of monosyllabic verbs in Anyi and Baule is high /CV́/, while that of disyllabic verbs is low on the first tone bearing unit (TBU) and high on the second TBU. This pattern is represented canonically as /CV̀.CV́/ or /CV̀.V́/. According to Cresseils and Kouadio (1977:377), underlying pitch registers are the form of the verb in the **imperative mood** (see Hyman 2010:186 for generalization to other African languages). There is also a consensus among Anyi and Baule researchers that the underlying pitch of the **subject pronoun** is **low** (/Pr̀/). Table 5 in Appendix 1 provides acoustic phonetic measurements which support this view. There are, however, divergences among the above-mentioned researchers regarding the pitch registers of subject pronouns and verbs in the declarative, the intentional, and the injunctive moods (Quaireau 1987:276, 282; Burmeister 1983: 165; Cresseils and Kouadio 1977:191, 376). Because of these differences, an instrumental analysis was needed to clarify the issue in the Anyi New Testament. The steps used to investigate the issue are described in the rest of the paper.

3.0 Participants, Equipment, and Data Collection

Anyi is spoken by more than a million people (1,072,618) in Côte d'Ivoire. The Morofu dialect, which is the focus of this paper, has some 800,000 speakers.[2] The participants are 10 adult males in their 30s, 40s, and 50s from Bongouanou county. They are all fluent speakers of Anyi and French, and are employed as part-time teachers for CATA (Anyi Literacy and Translation Center), a non-profit promoting adult literacy in the region. The data was recorded on an Olympus Digital Voice Recorder WS-710. The participants wore a Panasonic head-mounted, noise cancellation fixed microphone in order to minimize ambient noises. The recordings took place in a quiet room on the premises of CATA. Approval for data collection was obtained from The Institutional Review Board (IRB) of Saint Cloud State University in MN, USA. The software, WavePad Sound Editor, Version 5.17 by NCH, was used to sample of all the files at 44100 Hz, 16-bit rate.

Each participant produced five sentences in the declarative, intentional, and injunctive moods. Tone is grammatically contrastive in these moods, as indicated by the translations:

[2] These figures are projections based on the official data from the 2000 census. It takes into account an overall 3% annual population grown in Côte d'Ivoire.

1. Sentence 1: */ɔ̀ dí àlíɛ̀ /*
   Declarative mood: *He/she loves to eat.*
   Intentional mood: *He/she has made up his/her mind to eat.*
   Injunctive mood: *Let him/her eat.*

2. Sentence 2: */ɔ̀ kɔ́ sùkúlù /*
   Declarative mood: *He/she is a student.*
   Intentional mood: *He/she has made up his/her mind to go to school.*
   Injunctive mood: *Let him/her go to school.*

3. Sentence 3: */ɔ̀ bɔ̀ká Kàsí /*
   Declarative mood: *He/she helps Kasi.*
   Intentional mood: *He/she has decided to help Kasi.*
   Injunctive mood: *Let him/her help Kasi.*

4. Sentence 4: *ɔ̀ sìké ɛ̀wɔ́fɔ̀ɔ́/*
   Declarative mood: *He/she is hospitable.*
   Intentional mood: *He/she has decided to host a visitor.*
   Injunctive mood: *Let him/her host a visitor.*

5. Sentence 5: */ɔ̀ tìé ndɛ̀ɛ́/*
   Declarative mood: *He/she is a good listener.*
   Intentional mood: *He/she has made up his/her mind to listen intently.*
   Injunctive mood: *Let him/her listen carefully.*

The declarative mood is taken to be a mood in which factual statements are made. The intentional mood, as defined by Burmeister (1983:171), Quaireau (1987:305-7), Creisseils and Kouadio (1977:378) is a mood in which speakers express their determination to do something. The injunctive mood allows speakers to express their wishes to be authorized to carry out their desires. Even though all the five sentences have been studied acoustically, because of space limitation, only **Sentence 3** is used to illustrate the methodology and the measurements in this paper. The relevant measurements of the four remaining utterances are found in Appendix 2. The consensus that emerged from the arithmetic means from the measurements obtained from the 10 participants undergird the orthographic representations of tone in Anyi with regard to these three grammatical moods.

4.0 Methodology

Collectively, the participants produced 30 sentences (10 participants x 3 grammatical moods) of Sentence 3. The fact that the analysis is based on speech samples from 10 participants is worth noting. Ladefoged (1968:xi)[3] opines that acoustic phonetic studies should have more than three participants, otherwise the findings are simply a reporting on the participants' speech

[3] Ladefoged thanked Rev. Dr. Gilbert Ansre in the acknowledgments section of this book.

idiosyncrasies. To arrive at results that are generalizable to an entire speech community, Himmelmann and Ladd (2008:265) recommend 8 to 10 participants. This study meets this requirement. It is important to underscore this point because in phonology-based studies, researchers draw strong conclusions from listening to only one or two participants. Worst, some native speakers base their entire findings on their own auditory acuity. However, Houstma (1995:268, 288) makes it abundantly clear that only an infinitesimal number of human beings possess "perfect absolute pitch." He notes that many orchestra musicians do not even possess "acquired" absolute pitch detection skills. In other words, ordinary human beings, linguists included, are not good at perceiving pitch. Ladefoged (2003:75) says so about his own pitch perception abilities! It is, therefore, highly presumptuous for any linguist to rely solely on his/her ears to make categorical statements about tone patterns in African languages. To avoid presumptions of this type, my statements about tone patterns in Anyi are firmly anchored in acoustic phonetic measurements. The procedures used to extract the relevant data are displayed in Figure 1:

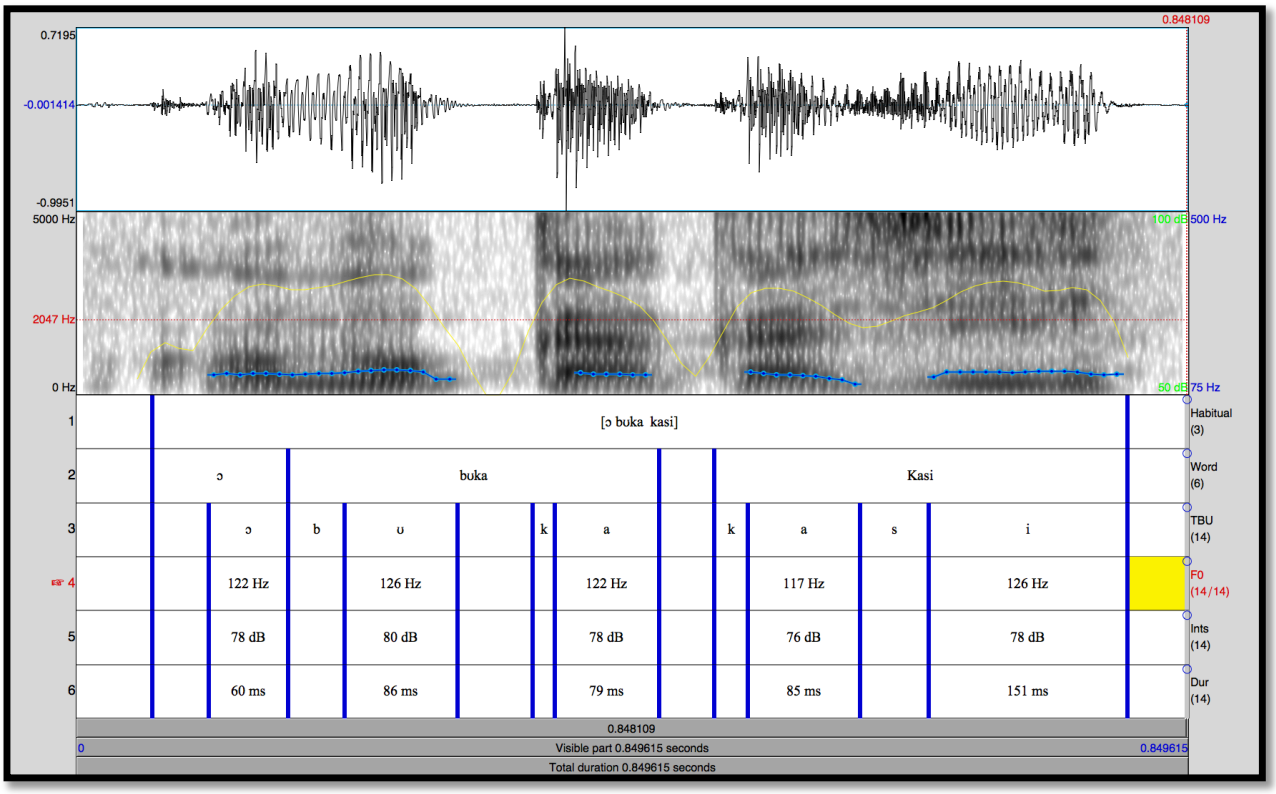


Figure 1: File Annotation Procedures

Utterances are annotated and boundaries are created around TBUs. Thereafter, the relevant data are extracted. For this paper, the extracted correlates are F0/pitch, intensity, and duration. These three correlates are needed because speech is a three-dimensional event in which the three are independent, and yet fully interdependent. Consequently, any informed study of tone must examine all three, not only F0/pitch. It is worth noting that Anyi has four syllabic nasals [m̀, ǹ, ɲ̀, ŋ̀]. When they occur at the beginning of words, they have a low tone, but none occurs in this data.

As noted earlier, in Anyi verb conjugation, the elements whose tonal structures are strongly affected by grammatical mood are **the subject pronoun** and **the verb**. The tone of the elements that follow the verb are not directly affected, even though their presence may affect the pitch register of the verb. For this reason, in analyzing Sentence 3, we do not pay attention to the underlying tone of /kàsí/, a proper noun. Consequently, the findings reported in this paper are based on 270 TBU tokens (1 TBU of the subject pronoun /ɔ̀/ x 2 TBUs of the disyllabic verb /bɔ̀ká/ x 10 participants x 3 moods x 3 correlates).

5.0 The Interpretive Framework

It is one thing to measure speech sounds. It is an entirely different thing to know what the measurements mean when a human being hears speech sounds in free fields (i.e., outside a laboratory). The premier acoustic phonetic theory that replicates how humans hear sound signals with their naked ears is the Critical Band Theory (CBT), which was pioneered by the world-renown physicist, Harvey Fletcher. He is famous for many great breakthroughs, including his work on electrons, the oil drop experiment, and stereophonic sounds. He is the inventor of the modern audiograph machine and the artificial larynx. More than 200 patents are registered under his name. He calculated mathematically the frequency responses to sound in the basilar membrane. Georg von Bekesy, another physicist, spent 20 years demonstrating through various ingenious experiments that Fletcher's theoretical postulates were grounded in anatomical reality. For this, von Bekesy was awarded a Nobel Prize in Medicine and Physiology in 1961. Scharf (1961:215) writes that critical bands, especially their subdivisions into 1/3 fractional octaves, are **the minimal units of auditory perception**. A similar point is made by Zwicker (1961:248). According to Everest and Pohlmann (2015:529), this subdivision "approximates the critical bandwidth accuracy of our hearing." Table 1 displays the 1/3 octave frequency bandwidth system and correlates it with pitch registers for the interpretation of F0 measurements. A fuller explanation is found in Koffi (2017):

	Tone Registers	Lower Band Limits	1/3 Center Frequency	Upper Band Limits
1.	Extra low	71	80	88
2.	Low	89	100	113
3.	Mid	114	125	141
4.	High	142	160	176
5.	Extra high	177	200	225

Table 1: Threshold Measurements for Pitch Registers for Men[4]

The subdivisions in Table 1 have been endorsed by the American National Standards Institute (ANSI), the International Standardization Organization (ISO), and the International Electrotechnical Commission (IEC) for designing and manufacturing of audio products and sound level meters (Pope 1998:1347).

The thresholds in Table 1 are self-explanatory, but it is worth drawing attention to the fact that frequency modulations and variations within the same critical bandwidth are perceived similarly by the naked ear. In other words, 89 Hz is perceived as a low pitch, and so are 90 Hz, 98 Hz, 103 Hz, 108 Hz, and so on and so forth until 113 Hz. A similar process takes place in the intensity domain. The naked ear perceives a sound as being louder (more sonorous) than another

[4] A table for males is used because all the participants are men. A table for females is found in Koffi (2017:157).

if the intensity difference between them is ≥ 3 dB. Anything less than this threshold is not auditorily perceptible. Readers are encouraged to refer to Koffi (2020) for a comprehensive treatment of the perception of intensity. The auditory perception of duration operates similarly. People perceive a speech signal as being longer than another if and only if the durational distance between them is ≥ 10 ms for signals lasting less than 200 ms (Stevens 2000:228-9). Koffi (2021a) has devoted an entire paper to the different auditory and perceptual thresholds in the duration domain. To put it differently, I did not come up with these JNDs. I simply use them to ground my interpretations of acoustic phonetic measurements. Since CBT is an award-winning theory of physics and acoustics, and since it yields results that replicate as faithfully as possible the human auditory system, it can be used confidently to interpret acoustic phonetic measurements.

6.0 F0/Pitch Measurements and Analyses

The F0/pitch measurements in Table 2 are extracted from the pronunciation of the 10 participants who read Sentence 3. The focus in on averages, not on interspeaker variability. Such variations are expected because of slight differences in the physiology and anatomy of the upper respiratory systems. Even so, the standard deviation calculations indicate that the variations fall within expected norms. In each mood, the TBU of the subject pronoun, the first TBU of the verb, and the second TBU of verb are in bold because these are the three elements worth paying attention to.

F0/Pitch	**Declarative Mood**					**Intentional Mood**					**Injunctive Mood**				
	/ɔ/	/bʊ/	/ka/	/Ka/	/si/	/ɔ/	/bʊ/	/ka/	/Ka/	/si/	/ɔ/	/bʊ/	/ka/	/Ka/	/si/
Speaker 1	123	132	140	134	156	152	154	149	125	115	129	170	184	124	119
Speaker 2	114	112	109	110	129	136	147	144	91	102	113	129	123	121	97
Speaker 3	133	135	141	96	105	173	187	190	177	205	99	120	133	95	91
Speaker 4	109	106	106	101	117	153	135	134	105	109	114	135	140	105	107
Speaker 5	138	144	141	136	164	163	179	119	119	135	139	204	226	124	134
Speaker 6	123	130	122	121	126	141	167	161	114	109	114	145	162	119	109
Speaker 7	126	122	132	124	140	153	182	134	125	130	142	187	203	134	136
Speaker 8	108	111	104	99	119	202	247	246	192	185	133	243	243	180	180
Speaker 9	122	126	119	113	120	181	239	224	140	132	146	186	200	122	105
Speaker 10	93	93	93	88	100	108	129	118	81	88	86	121	139	89	87
Mean	**118**	**121**	**120**	112	127	**156**	**176**	**161**	126	131	**121**	**164**	**175**	121	116
St. dev.	13	15	17	16	20	25	40	44	35	37	19	40	41	28	27
F0 Register	M	M	M	L	M	H	H	H	M	M	M	H	H	M	M

Table 2: Pitch Measurements

We recall from the discussions in Section 2.0 that the underlying tone of the TBU of the subject pronoun /ɔ/ is low. However, its mean pitch value in the declarative mood is 118 Hz, which corresponds to a mid-tone register according to the frequency conversion in Table 1. Its mean pitch in the intentional mood is 156 Hz, which is a high pitch register. For the injunctive mood, the mean pitch value of /ɔ/ is 121 Hz, also a mid-pitch register. The underlying tone pattern of /bɔ̀ká/ is also changed. In the declarative mood, the tone of the first TBU rises to mid, while that of the second TBU lowers to mid. In the intentional mood, the pitch of the first TBU of /bɔ̀ká/ raises to high, almost extra high. The second TBU of the verb stays high. A similar change takes place in the injunctive mood. The first TBU of /bɔ̀ká/ also raises to high, and the second TBU goes up higher, almost to extra high.

7.0 Focus on Intensity Measurements

The human ear processes intensity on a logarithmic scale, not on an arithmetic or linear scale. Consequently, if the sonority distance between two speech signals is **< 3 dB**, human beings do not perceive any difference between them. This JND is used to interpret the measurements in Table 3.

Intensity	**Declarative Mood**					**Intentional Mood**					**Injunctive Mood**				
Sentence	/ɔ/	/bʊ/	/ka/	/Ka/	/si/	/ɔ/	/bʊ/	/ka/	/Ka/	/si/	/ɔ/	/bʊ/	/ka/	/Ka/	/si/
Speaker 1	75	80	76	74	71	79	72	76	74	68	79	76	77	74	69
Speaker 2	81	76	78	79	80	81	71	75	78	75	81	79	77	76	74
Speaker 3	82	78	77	76	76	81	73	79	77	75	78	78	78	78	72
Speaker 4	78	77	75	76	77	79	75	76	76	78	77	80	77	75	75
Speaker 5	80	79	76	77	77	78	76	76	75	74	79	77	77	74	74
Speaker 6	76	81	76	77	79	80	76	79	76	78	79	80	79	79	77
Speaker 7	81	75	77	77	77	81	77	77	78	75	81	77	78	78	77
Speaker 8	80	75	77	77	74	80	78	77	77	77	80	80	76	77	78
Speaker 9	80	77	76	79	77	81	77	77	78	77	81	77	76	77	75
Speaker 10	69	68	67	69	59	69	69	57	65	61	67	69	60	67	58
Mean	**78**	**76**	**75**	76	74	**78**	**74**	**74**	75	73	**78**	**77**	**75**	75	72
St. dev.	3	3	3	2	6	3	2	6	3	5	4	3	5	3	5

Table 2: Intensity Measurements

The intensity measurements show the subject pronoun /ɔ/ has the same intensity of 78 dB in all three grammatical moods. Pairwise comparisons between the subject pronoun and the first and second TBUs of the verb show that intensity does not discriminate between the declarative and the injunctive. Their intensity differences are < 3 dB. However, in the intentional mood, the difference between /ɔ/ and the TBUs of the verb is 4 dB, which is auditorily perceptible by the naked ear, albeit faintly. In other words, Anyi speakers rely on the intensity correlate to encode, decode, and discriminate between the intentional mood and the two other moods.

8.0 Focus on Duration Measurements

Experimental studies going as far back as 1920 have shown that the naked ear perceives that a speech signal is longer than another if and only if the durational distance between them is ≥ **10 ms** for signals lasting less than 200 ms. This JND is used to interpret the data in Table 3.

Duration	**Declarative Mood**					**Intentional Mood**					**Injunctive Mood**				
Sentence	/ɔ/	/bʊ/	/ka/	/Ka/	/si/	/ɔ/	/bʊ/	/ka/	/Ka/	/si/	/ɔ/	/bʊ/	/ka/	/Ka/	/si/
Speaker 1	113	31	83	80	93	76	38	81	60	86	61	48	76	65	86
Speaker 2	85	52	82	63	81	106	32	74	88	56	105	61	87	79	111
Speaker 3	78	66	93	81	91	103	57	71	64	93	73	76	65	49	61
Speaker 4	68	78	113	44	72	124	73	96	68	61	103	68	131	77	77
Speaker 5	57	39	97	70	62	65	51	101	79	57	124	54	103	76	64
Speaker 6	61	57	82	71	117	75	62	88	60	89	94	75	67	62	49
Speaker 7	72	31	65	69	77	86	67	147	78	73	80	39	94	76	82
Speaker 8	79	39	59	61	94	90	55	103	72	110	115	61	116	86	113
Speaker 9	56	69	105	69	70	106	67	78	72	77	109	79	104	60	60
Speaker 10	**110**	**83**	**114**	63	89	**140**	**65**	**99**	86	83	**92**	**94**	**111**	82	60

Mean	77	54	89	67	84	97	56	93	72	78	95	65	95	71	76
St. dev.	20	19	18	10	15	23	13	22	10	17	19	16	21	11	21

Table 3: Duration Measurements

The TBU of the subject pronoun /ɔ/ (110 ms) is longer than that of the injunctive mood (92 ms) by 18 ms. The difference is perceptible to the naked ear. The subject pronoun /ɔ/ is short when the verb is conjugated in the injunctive mood. However, it is considerably longer in the intentional mood (140 ms). In fact, it is respectively four and three times longer than the JND in the two other moods. This means that Anyi speakers perceive a clear difference between the intentional mood on the one hand, and the two other moods on the other. The durational difference of 18 ms between the declarative and the injunctive is auditorily perceptible, but this perceptual difference pales in comparison with that of the intentional mood.

9.0 Application to Orthographic Representation

Quaireau (1987:280) and Cresseils and Kouadio (1977:378) consider the tone patterns of the declarative mood to be the default in Anyi and Baule. This means that the tone patterns of the declarative mood need not be represented in the orthography by diacritical pitch marks. If so, then how do we represent tone patterns so that readers can easily discriminate between the declarative, the intentional, and the injunctive moods? A two-pronged solution is proposed. The first focuses on the TBU of the subject pronoun, and the second on the first and second TBUs of the verb.

First, let's consider the TBU of the subject pronoun. The declarative (118 Hz) and the injunctive (121 Hz) resemble each other because they both have a mid-pitch register. Their sonority levels are identical (78 dB). Only duration differentiates between them. The duration of the TBU is 110 ms for the declarative versus 92 ms for the injunctive. This durational difference is auditorily perceptible, but it does not warrant a separate orthographic representation. Now, let's turn our attention to the TBU of the subject pronoun in the intentional and the injunctive moods. The pitch of the subject pronoun in the intentional is high (156 Hz), but it is mid in the injunctive (121 Hz). We see clearly that pitch is a robust correlate that sets the intentional mood completely apart from the declarative and the injunctive moods. For this reason, the TBU of the subject pronoun in the intentional mood is written with an acute accent diacritic [́]. We also saw in Section 8.0 that the TBU of the subject pronoun in the intentional mood is four times longer than the injunctive and three times longer than the declarative. For this reason, the TBU is geminated (doubled) in the orthography as <ɔ́ɔ>.

Now, let's consider the tone pattern of the TBUs of the verb. In the declarative mood, the first (121 Hz) and second (120 Hz) TBUs have mid-pitch registers. Since the declarative is the default mood, its tone patterns are not indicated in the orthography. The intentional and the injunctive resemble each other because the first and second TBUs in each mood have high pitch patterns. They are respectively 176 Hz/161 Hz for the intentional and 164 Hz/175 Hz for the injunctive. The TBUs of the verbs in both moods also resemble each other in sonority. They are respectively 69 dB/57 dB versus 69 dB/60 dB. The intensity difference of 3 dB between the second TBUs of disyllabic verbs is somewhat auditorily perceptible. However, this has no impact on orthographic decisions because no language represents loudness orthographically. Intensity is not phonemic in any human language. The durational difference between the first TBU of the verb in the intentional mood (65 ms) and that of the injunctive mood (94 ms) is perceptually salient. The 29 ms difference between them is almost three times the JND. Duration is also a robust cue for

the second TBUs of the verb. It is 99 ms for the intentional and 111 ms for the injunctive. In other words, the combined duration of TBUs of verbs in the injunctive mood (205 ms) are 41 ms longer than their counterparts in the intentional mood (164 ms). How can the above-mentioned patterns of differences and similarities be exploited orthographically? Table 4 provides an answer:

Declarative Mood	**Intentional Mood**	**Injunctive Mood**
<ɔ bʊka Kasi> He/she helps Kasi	<ɔ́ɔ bʊka Kasi> He/she has decided to help Kasi	<ɔ bʊ́ka Kasi> He/she should help Kasi

Table 4: Orthographic Applications

The use of the high accent diacritic to indicate high pitch register and the doubling of the vowel of the subject pronoun in the intentional mood set it apart from both the declarative and the injunctive moods. In literacy classes, readers are instructed to raise their pitch and lengthen the vowel of the subject pronoun. In so doing, they are applying two phonological rules at once: a high pitch spreading rule and a vowel lengthening rule. The TBU of the subject pronoun in the injunctive mood has a mid-pitch register, which is not written in the orthography. However, the high pitch register of the first TBU of verb is indicated orthographically. This strategy eliminates overcrowding the orthographic with superfluous tonal diacritics. Tone is marked sparingly but systematically so that the three moods are distinguished from each other. Fluency tests show that Anyi readers have no difficulty differentiating between the three grammatical moods.

10.0 Summary

The preceding demonstrations have shown how acoustic phonetic measurements can be used to buttress orthographic decisions. Using all three acoustic correlates to account for tone patterns is better than relying only on F0/pitch. Had I limited myself to the latter, I would not have discovered that Anyi speakers and hearers also rely on intensity and duration to encode and decode differences between the declarative, the intentional, and injunctive moods. The methodology exemplified in this paper was also used to write tones optimally and systematically in the orthographies of Ditammari, Lokpa, and Moba-lok without burdening them with unnecessary tonal diacritics. The Tone Optimality Model that I have pioneered would not have come about without Dr. Gilbert Ansre's mentorship, challenge, and advice. His insights and scholarship on tones in West African languages live on and continue to yield dividends.

ABOUT THE AUTHOR

Ettien Koffi, Ph.D. linguistics, teaches at Saint Cloud State University, MN. He is the author of four books and author/co-author of several dozen articles on acoustic phonetics, phonology, language planning and policy, emergent orthographies, syntax, and translation. His acoustic phonetic research is synergetic, encompassing L2 acoustic phonetics of English (Speech Intelligibility from the perspective of the Critical Band Theory), sociophonetics of Central Minnesota English, general acoustic phonetics of Anyi (a West African language), acoustic phonetic feature extraction for application in Automatic Speech Recognition (ASR) and Text-to-Speech (TTS), and voice biometrics for speaker verification. He can be reached at enkoffi@stcloudstate.edu.

Appendix 1

The measurements of the subject pronouns are based on the pronunciation of Speakers 1, 2, 3, and 4. They pronounced each word three times, for a total of 108 tokens (6 pronouns x 3 repetitions x 3 correlates). The measurements are based on pronouns occurring in citation form (in isolation, not in a sentence).

	Pronouns	**Pitch Register**	**Frequencies**	**Intensity**	**Duration**
1.	[mì]	Low	110 Hz	63 dB	282 ms
2.	[è]	Low	112 Hz	68 dB	209 ms
3.	[ɔ̀]	Low	103 Hz	66 dB	199 ms
4.	[jè]	Low	107 Hz	66 dB	274 ms
5.	[āmɔ̀]	Mid/low	118/92 Hz	68/62 dB	118/161 ms
6.	[bè]	Low	102 Hz	69 dB	111 ms

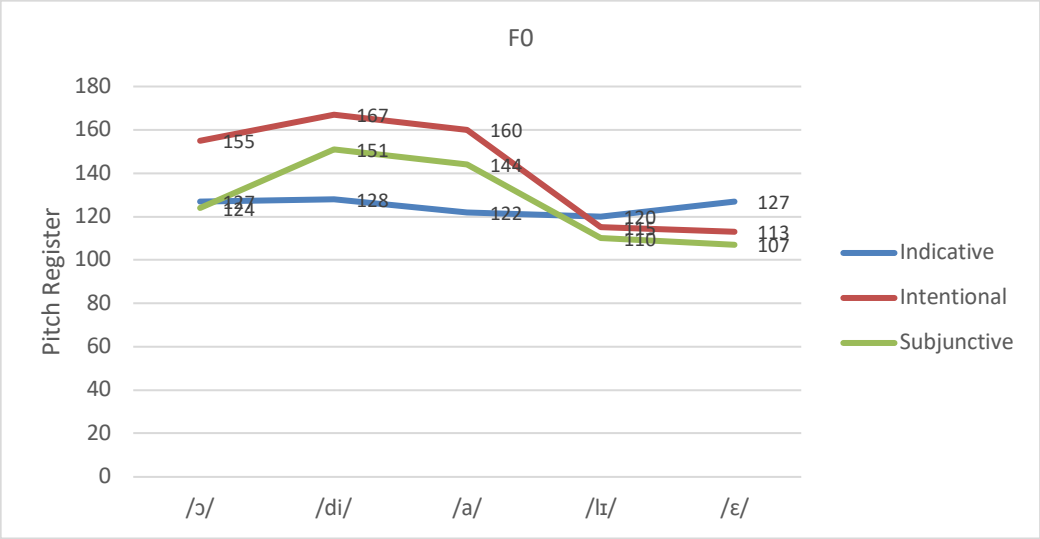
Table 5: Acoustic Correlates of Subject Pronouns

Appendix 2

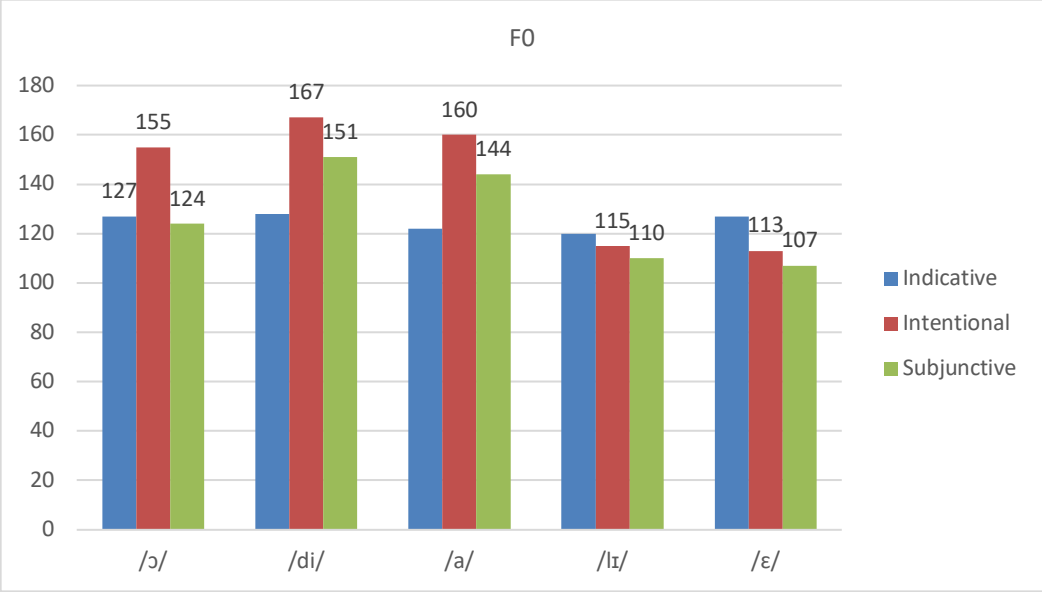
The measurements reported in all the tables below represent the arithmetic means of all the sentences produced by the 10 speakers of Anyi Morofou mentioned in Section 3.0 of the paper.

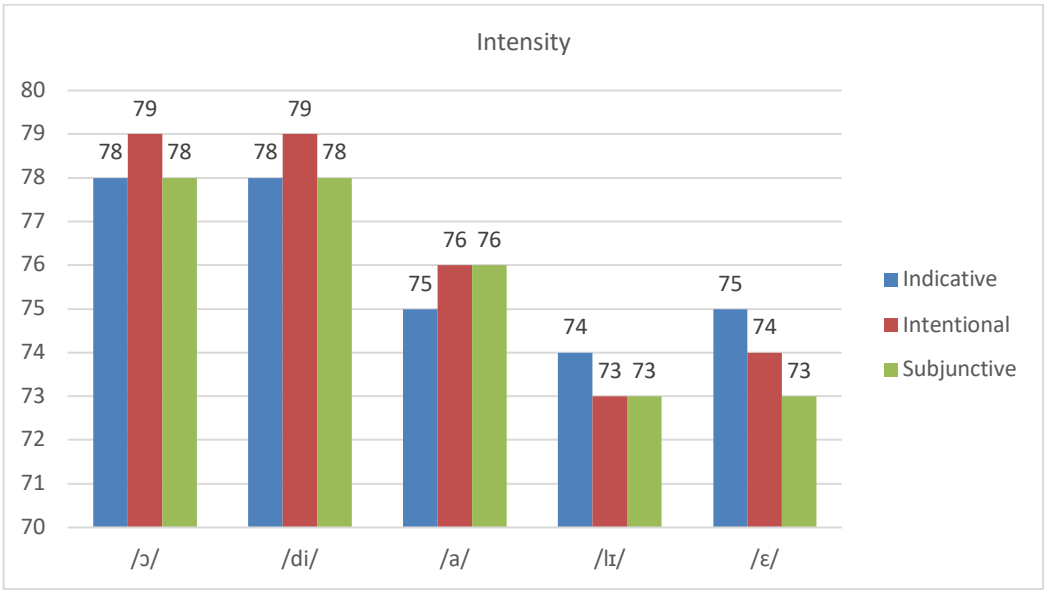
Sentence 1

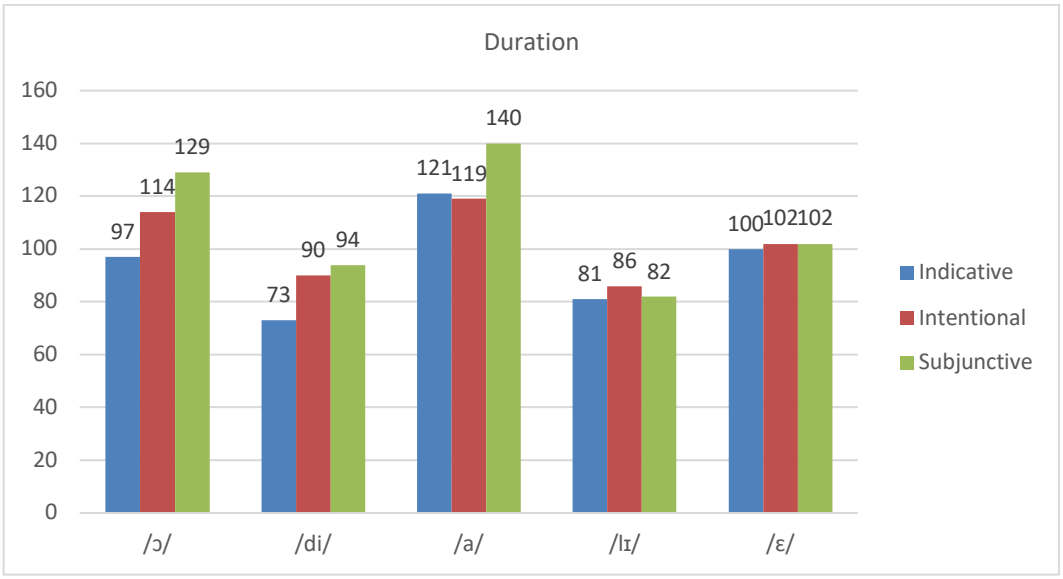
Declarative	*ɔ*	*di*	*a*	*lɪ*	*ɛ*
F0	127	128	122	120	127
Intensity	78	78	75	74	75
Duration	97	73	121	81	100
Pitch Register	M	M	M	M	M
Intentional	*ɔ*	*di*	*a*	*lɪ*	*ɛ*
F0	155	167	160	115	113
Intensity	79	79	76	73	74
Duration	114	90	119	86	102
Pitch Register	H	H	H	M	L
Injunctive	*ɔ*	*li*	*a*	*lɪ*	*ɛ*
F0	124	151	144	110	107
Intensity	78	78	76	73	73
Duration	129	94	140	82	102
Pitch Register	M	H	H	L	L



Note: The **indicative** and the **subjunctive** in the charts are respectively synonymous with the **declarative** and the **injunctive**. Both terms are used interchangeably in Anyi linguistics.

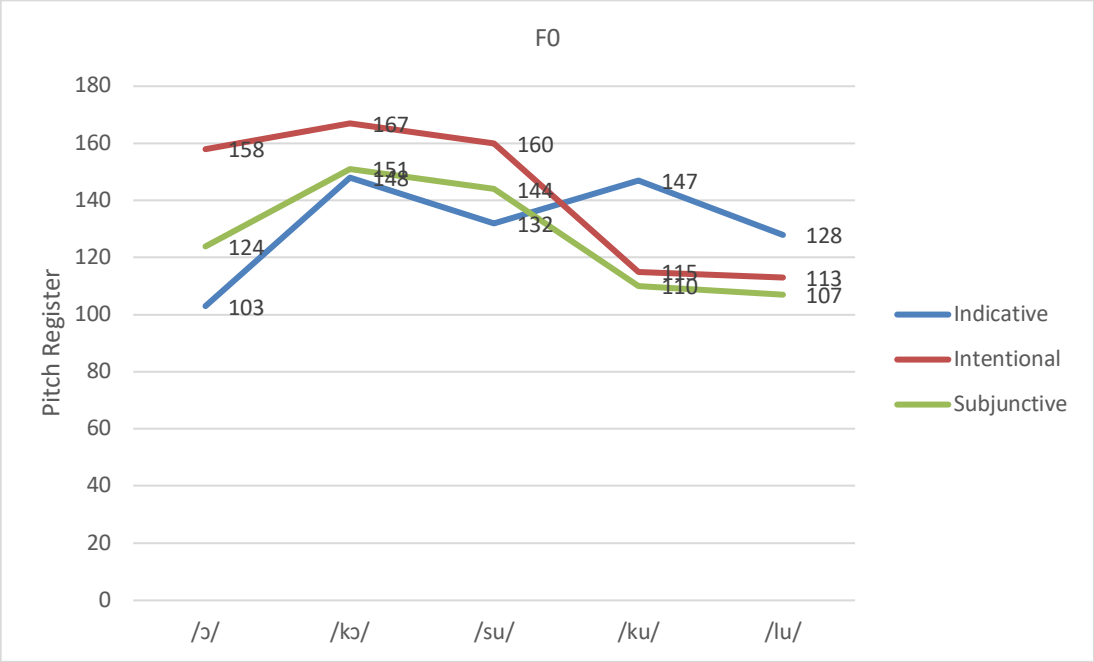


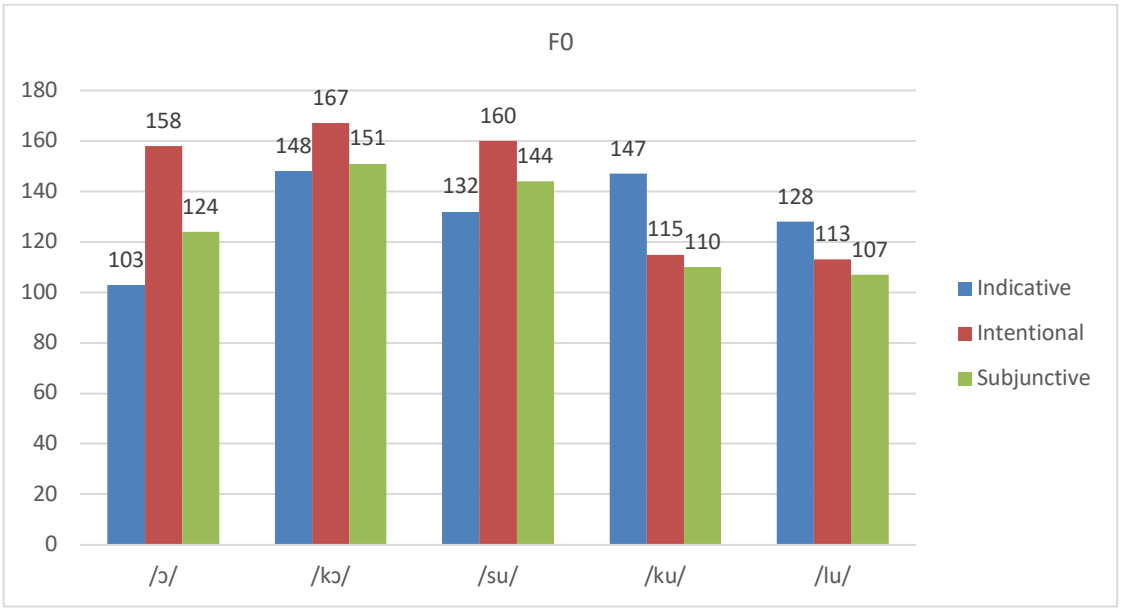

Intensity
80
79
78
77
76
75
74
73
72
71
70
78 79 78
78 79 78
75 76 76
74 73 73
75 74 73
/ɔ/
/di/
/a/
/ɪ/
/ɛ/
Indicative
Intentional
Subjunctive

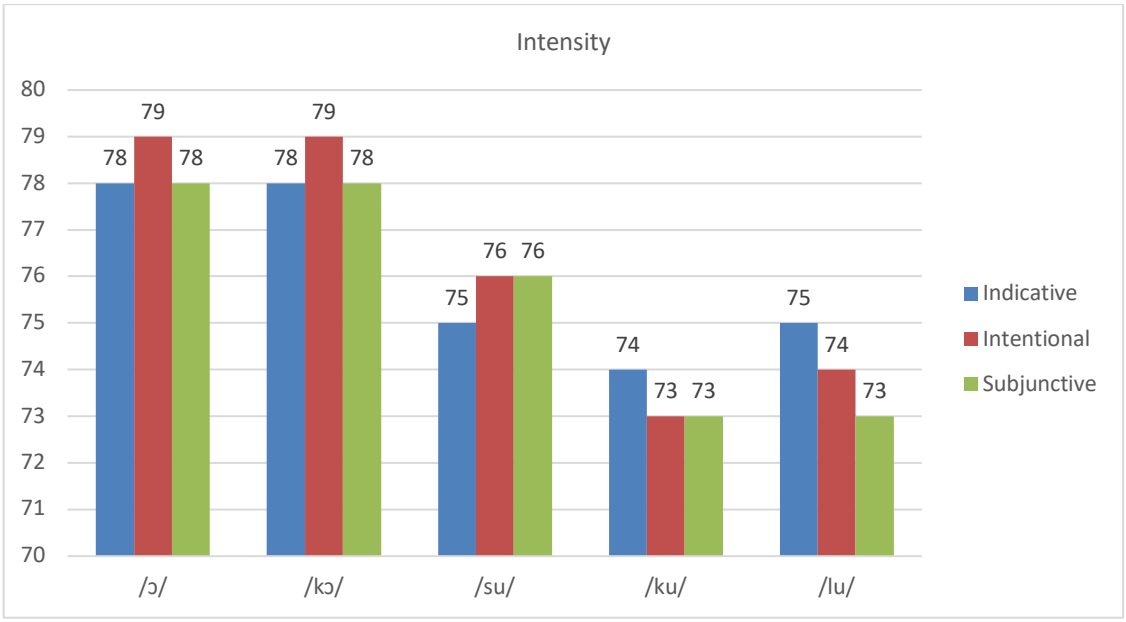

Duration
160
140
120
100
80
60
40
20
0
97 114 129
73 90 94
121 119 140
81 86 82
100 102 102
/ɔ/
/di/
/a/
/ɪ/
/ɛ/
Indicative
Intentional
Subjunctive

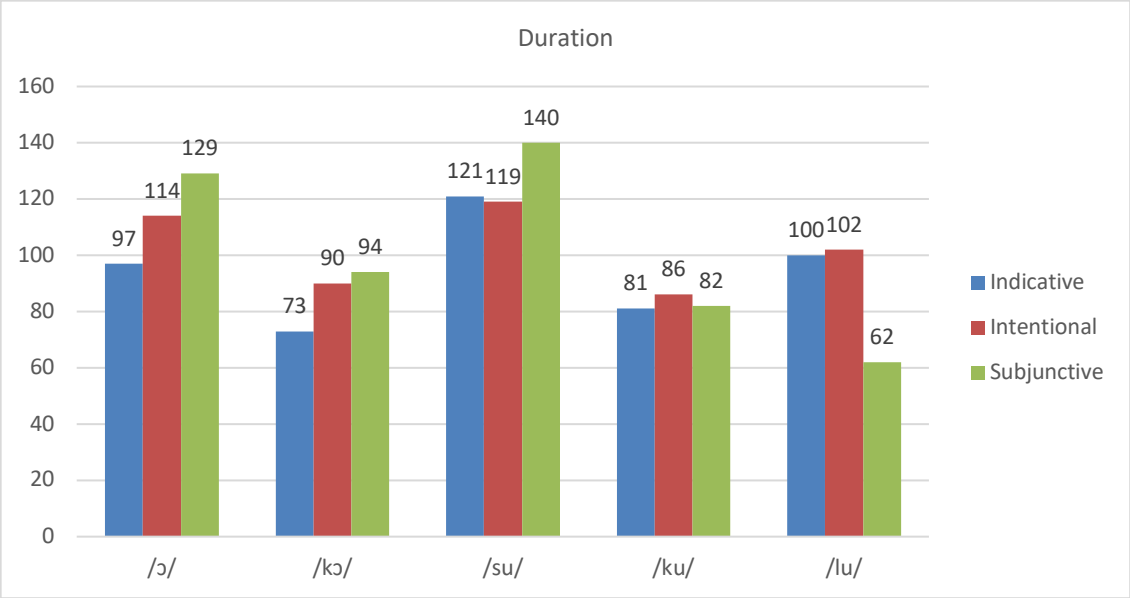
Sentence 2

Declarative	ɔ	*kɔ*	*su*	*ku*	*lu*
F0	131	138	132	147	128
Intensity	76	77	74	78	76
Duration	81	72	75	52	71
Pitch Register	M	M	M	H	M
Intentional	ɔ	*kɔ*	*su*	*ku*	*lu*
F0	160	176	127	125	115
Intensity	78	78	72	77	76
Duration	92	77	59	46	65
Pitch Register	H	H	M	M	M
Injunctive	ɔ	*hɔ*	*su*	*ku*	*lu*
F0	123	166	121	133	109
Intensity	79	78	71	77	75
Duration	94	95	54	51	62
Pitch Register	M	H	M	M	L



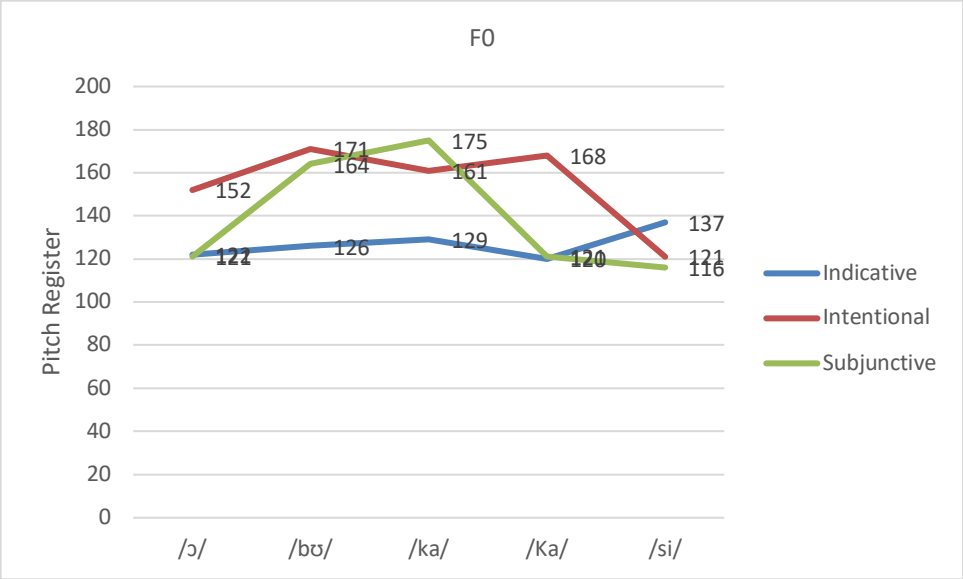

F0
180
160
140
120
100
80
60
40
20
0
103
158
124
148
167
151
132
160
144
147
115
110
128
113
107
/ɔ/
/kɔ/
/su/
/ku/
/lu/
Indicative
Intentional
Subjunctive

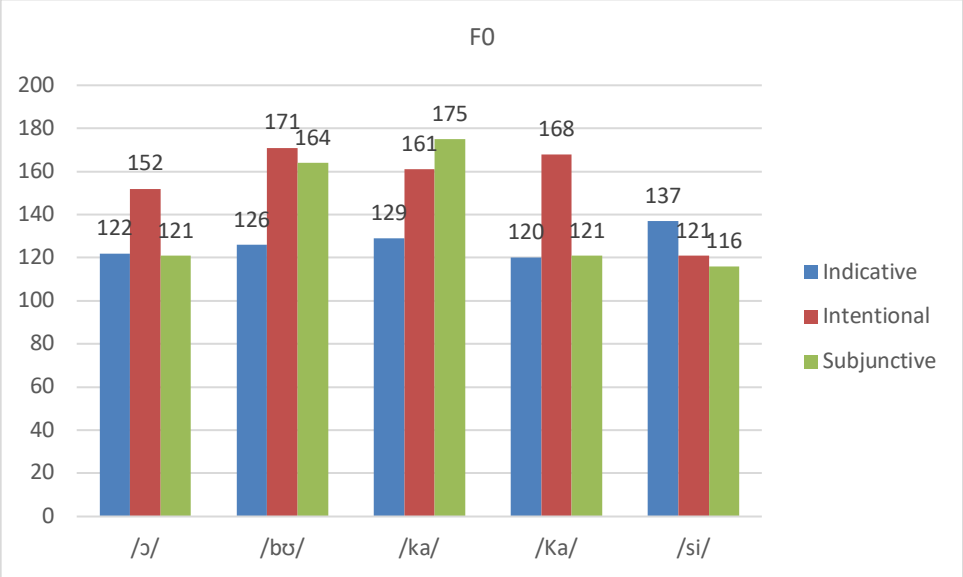

Intensity
80
79
78
77
76
75
74
73
72
71
70
78
79
78
78
79
78
75
76
76
74
73
73
75
74
73
/ɔ/
/kɔ/
/su/
/ku/
/lu/
Indicative
Intentional
Subjunctive

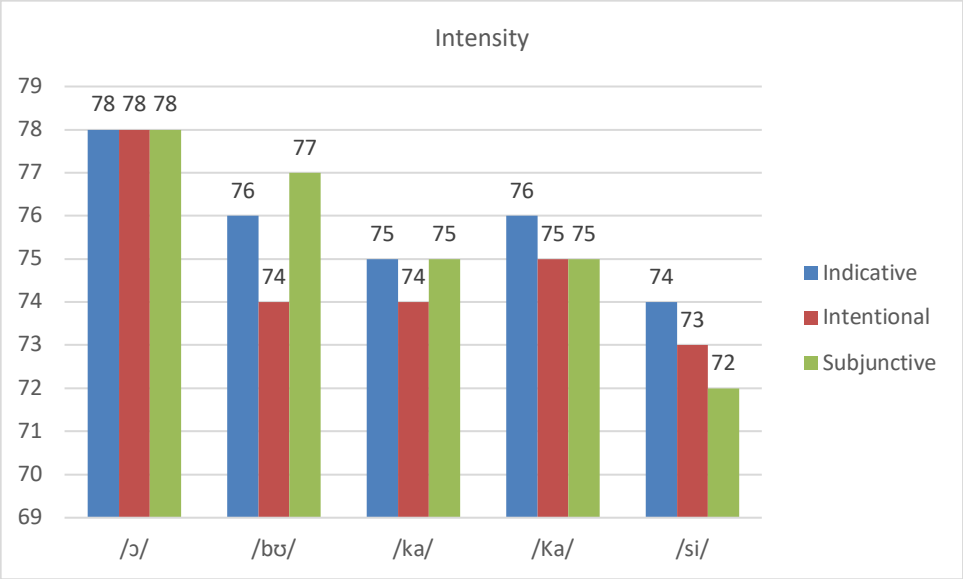


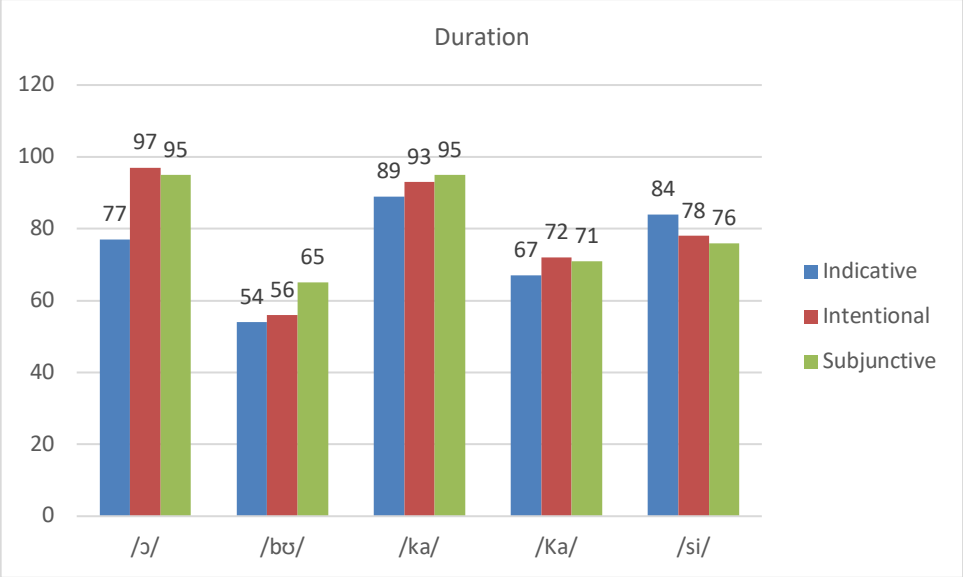
Sentence 3

Declarative	*ɔ*	*bʊ*	*ka*	*Ka*	*si*
F0	122	126	129	120	137
Intensity	78	76	75	76	74
Duration	77	54	89	67	84
Pitch register	M	M	M	M	M
Intentional	*ɔ*	*bʊ*	*ka*	*Ka*	*si*
F0	152	171	161	168	121
Intensity	78	74	74	75	73
Duration	97	56	93	72	78
Pitch register	H	H	H	H	L
Injunctive	*ɔ*	*bʊ*	*ka*	*Ka*	*si*
F0	121	164	175	121	116
Intensity	78	77	75	75	72
Duration	95	65	95	71	76
Pitch register	M	H	H	M	M


F0
Pitch Register
200
180
160
140
120
100
80
60
40
20
0
152
171
164
175
161
168
122
126
129
120
137
121
116
/ɔ/
/bʊ/
/ka/
/Ka/
/si/
Indicative
Intentional
Subjunctive

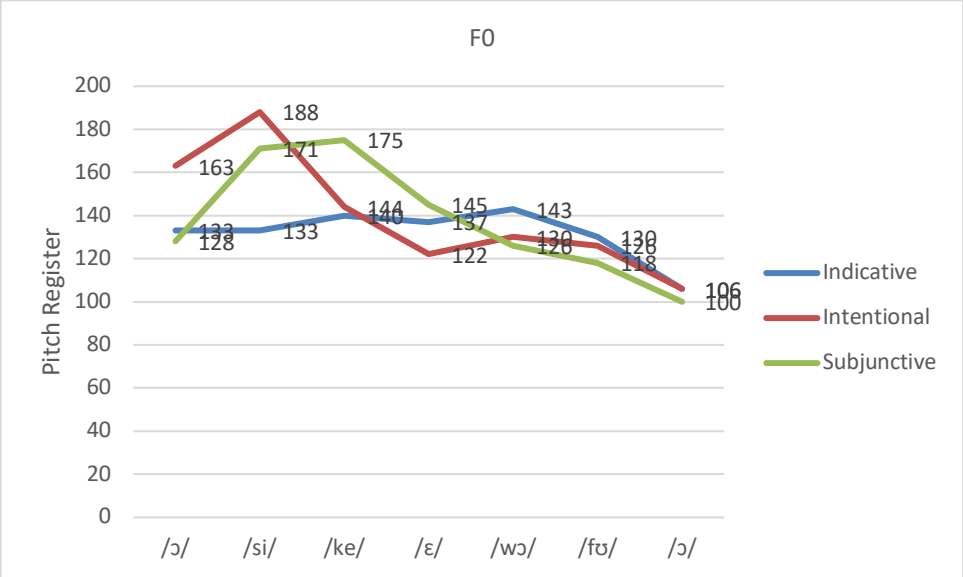

F0
200
180
160
140
120
100
80
60
40
20
0
122
152
121
126
171
164
129
161
175
120
168
121
137
121
116
/ɔ/
/bʊ/
/ka/
/Ka/
/si/
Indicative
Intentional
Subjunctive

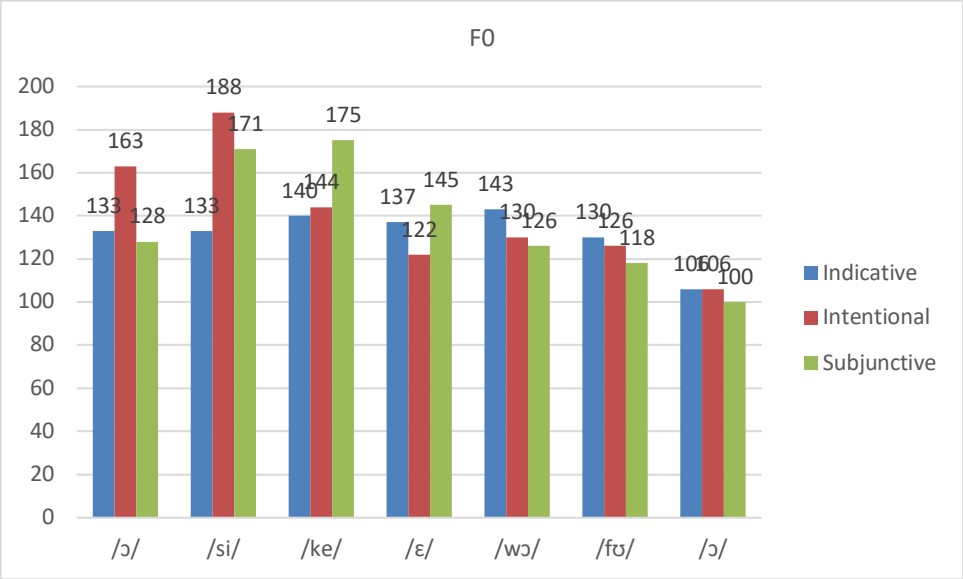

Intensity
79
78
77
76
75
74
73
72
71
70
69
78 78 78
76
74
77
75
74
75
76
75 75
74
73
72
/ɔ/
/bʊ/
/ka/
/Ka/
/si/
Indicative
Intentional
Subjunctive

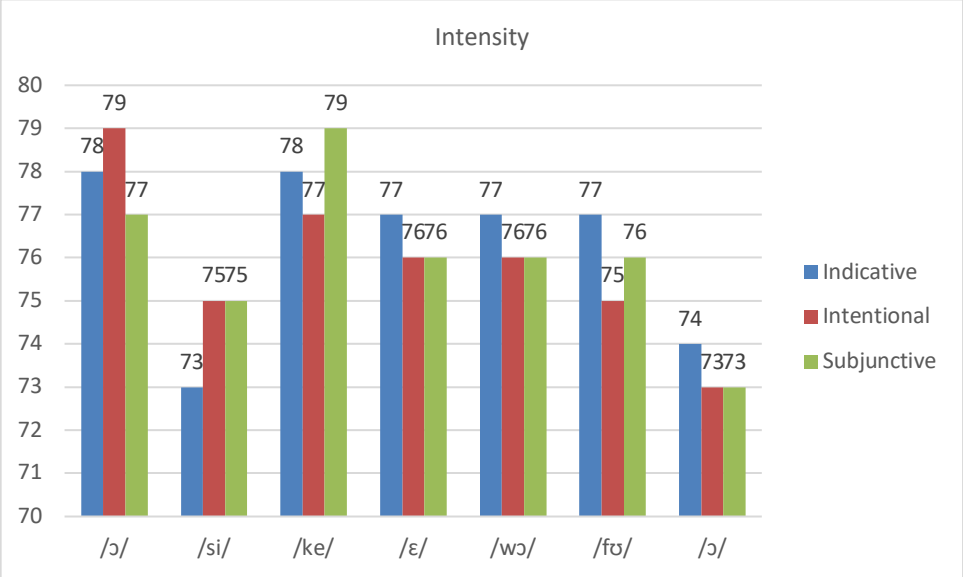

Duration
120
100
80
60
40
20
0
77
97 95
54 56
65
89 93 95
67 72 71
84 78 76
/ɔ/
/bʊ/
/ka/
/Ka/
/si/
Indicative
Intentional
Subjunctive

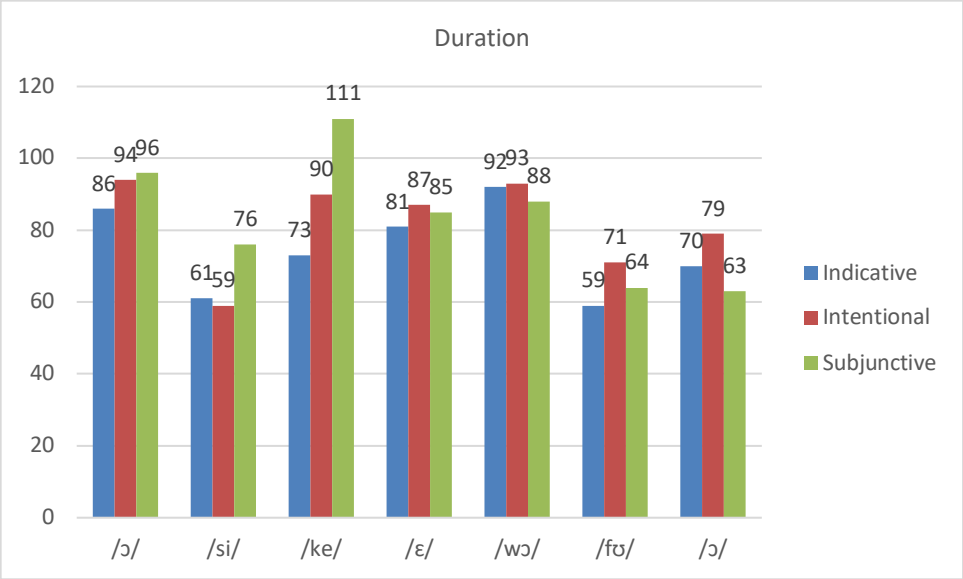
Sentence 4

Declarative	ɔ	*si*	*ke*	ɛ	*wɔ*	*fʊ*	ɔ
F0	133	133	140	137	143	130	106
Intensity	78	73	78	77	77	77	74
Duration	86	61	73	81	92	59	70
Pitch register	M	M	M	M	H	M	L
Intentional	ɔ	*si*	*ke*	ɛ	*wɔ*	*fʊ*	ɔ
F0	163	188	144	122	130	126	106
Intensity	79	75	77	76	76	75	73
Duration	94	59	90	87	93	71	79
Pitch register	H	Extra H	H	M	M	M	L
Injunctive	ɔ	*si*	*ke*	ɛ	*wɔ*	*fʊ*	ɔ
F0	128	171	175	145	126	118	100
Intensity	77	75	79	76	76	76	73
Duration	96	76	111	85	88	64	63
Pitch register	M	H	H	H	M	M	L



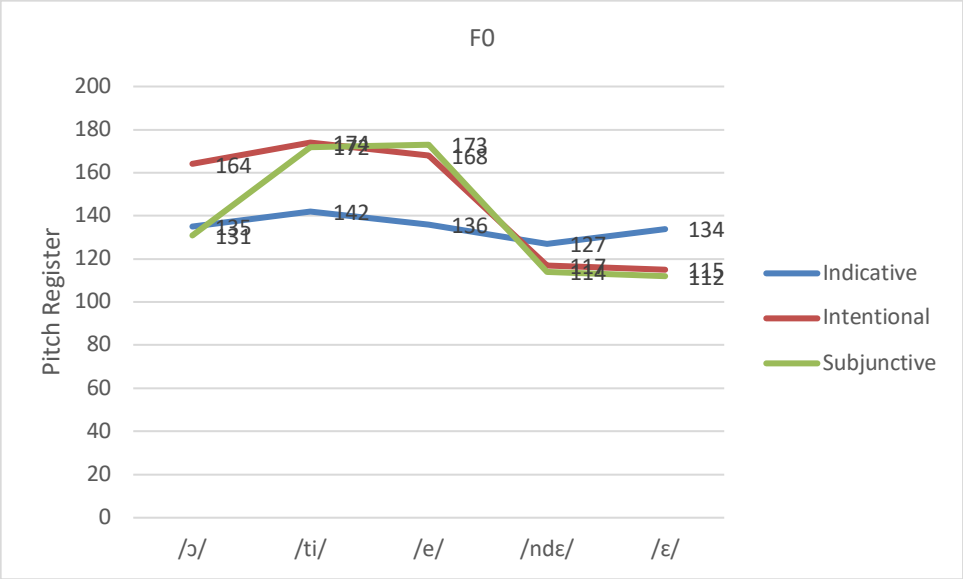

F0
200
180
160
140
120
100
80
60
40
20
0
133
163
128
133
188
171
140
144
175
137
122
145
143
130
126
130
126
118
106
106
100
/ɔ/
/si/
/ke/
/ɛ/
/wɔ/
/fʊ/
/ɔ/
Indicative
Intentional
Subjunctive


Intensity
80
79
78
77
76
75
74
73
72
71
70
78
79
77
73
75
75
78
77
79
77
76
76
77
76
76
77
75
76
74
73
73
/ɔ/
/si/
/ke/
/ɛ/
/wɔ/
/fʊ/
/ɔ/
Indicative
Intentional
Subjunctive

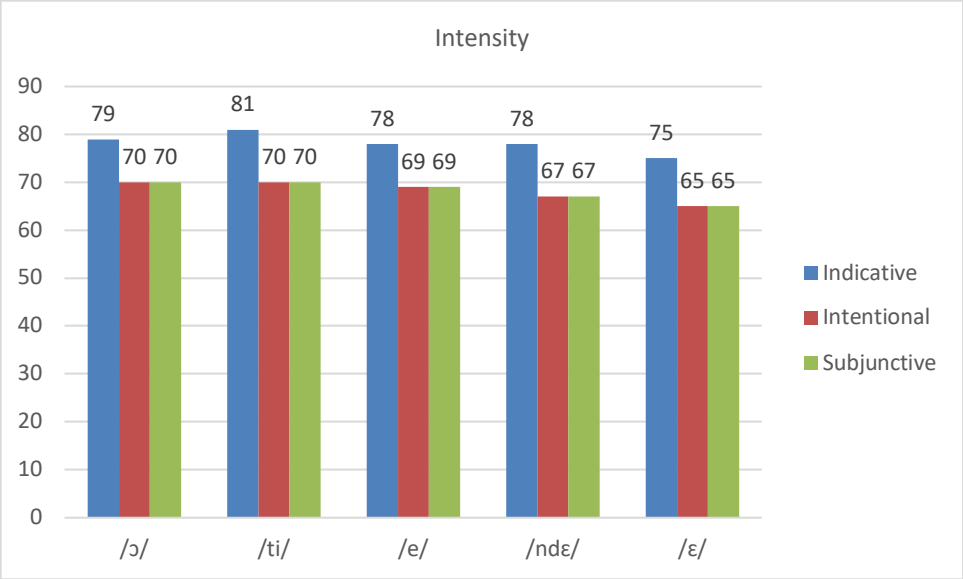


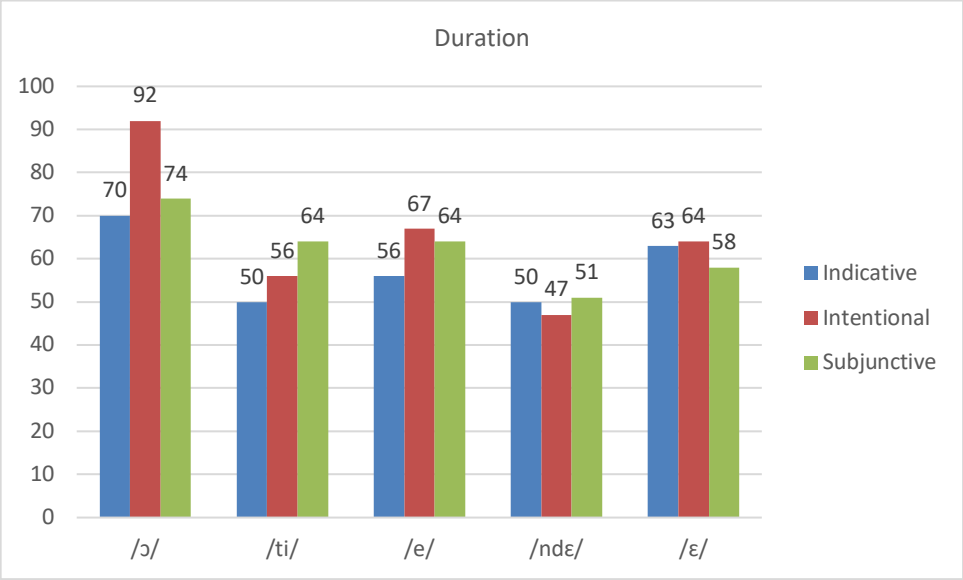
Sentence 5

Declarative	*ɔ*	*ti*	*e*	*ndɛ*	*ɛ*
F0	135	142	136	127	134
Intensity	79	81	78	78	75
Duration	70	50	56	50	63
Pitch register	M	H	M	M	M
Intentional	*ɔ*	*ti*	*e*	*ndɛ*	*ɛ*
F0	164	174	168	117	115
Intensity	70	70	69	67	65
Duration	92	56	67	47	64
Pitch register	H	H	H	M	M
Injunctive	*ɔ*	*ti*	*e*	*ndɛ*	*ɛ*
F0	131	172	173	114	112
Intensity	70	70	69	67	65
Duration	74	64	64	51	58
Pitch register	M	H	H	M	L


F0
Pitch Register
200
180
160
140
120
100
80
60
40
20
0
/ɔ/
/ti/
/e/
/ndɛ/
/ɛ/
Indicative
Intentional
Subjunctive


F0
200
180
160
140
120
100
80
60
40
20
0
/ɔ/
/ti/
/e/
/ndɛ/
/ɛ/
Indicative
Intentional
Subjunctive


Intensity
90
80
70
60
50
40
30
20
10
0
79
70 70
81
70 70
78
69 69
78
67 67
75
65 65
/ɔ/
/ti/
/e/
/ndɛ/
/ɛ/
Indicative
Intentional
Subjunctive


Duration
100
90
80
70
60
50
40
30
20
10
0
70
92
74
50
56
64
56
67
64
50
47
51
63
64
58
/ɔ/
/ti/
/e/
/ndɛ/
/ɛ/
Indicative
Intentional
Subjunctive

References

Burmeister, Jonathan. 1983. L'Agni. *Atlas des Langues Kwa de Côte d'Ivoire*. Tome 1, ed. by G. Herault, pp. 155-172. Abidjan, Côte d'Ivoire: Institut de Linguistique Appliquée, Université d'Abidjan.

Creissels, Denis, and Nguessan Kouadio. 1977. *Description Phonologique et Grammaticale d'un Parler Baoule*. Abidjan, Côte d'Ivoire: Institut de Linguistique Appliquée, Université de Côte d'Ivoire.

Everest, Alton F. and Ken C. Pohlmann. 2015. *Master Handbook of Acoustics*. Sixth Edition. New York: McGraw Hill Education.

Himmelmann, Nikolaus P. and Robert Ladd. 2008. Prosodic Description: An Introduction for Fieldworkers. *Language Documentation and Conservation* 2 (2): 244-274.

Houtsma, A. J. M. 1995. Pitch Perception. *Hearing: Handbook on Perception and Cognition*, ed. by Brian C. J. Moore, pp. 267-295. New York: Academic Press.

Hyman, Larry M. 2010. How to Study a Tone Language, with Exemplification from Oku (Grassfields Bantu, Cameroon). *UC Berkeley Phonology Lab Annual Report*, pp. 179-209.

Koffi, Ettien. 2020. A Comprehensive Review of Intensity and its Linguistic Applications. *Linguistic Portfolios* 9:2-28.

Koffi, Ettien. 2021a. A Comprehensive Review of Duration and its Linguistic Applications. *Linguistic Portfolios* 10:2-27.

Koffi, Ettien. 2017. The New Paradigm in Tone Analysis: The Contribution of the Critical Band Theory. *Linguistic Portfolios* 6:147-165.

Koffi, Ettien. 2012. *Paradigm Shift in Language Planning and Policy: Game-Theoretic Solutions*. Boston, MA: De Gruyter Mouton.

Koffi, Ettien. 2009. *The Interface between Phonology and Morpho(phono)logy in the Standardization of Anyi Orthography*. Revised Ph.D. Dissertation. Indiana University: Bloomington, Indiana, USA. https://bit.ly/3vVzXOT

Ladefoged, Peter. 1968. *A Phonetic Study of West African Languages: An Auditory-Instrumental Survey.* New York: Cambridge University Press.

Ladefoged, Peter. 2003. *Phonetic Data Analysis: An Introduction to Fieldwork and Instrumental Techniques*. Malden, MA: Blackwell Publishing.

Pope, J. 1998. Analyzers. *Handbook of Acoustics*, ed. by Malcom J. Crocker, pp. 1341-1353. A Wiley-Interscience Publication: New York.

Quaireau, Andre. 1978. *Essai d'Interpretation des Faits Phonologiques de l'Agni*. Thèse de Doctorat 3ème Cycle: Universite de Nancy II, France.

Quaireau, Andre. 1987. *Description de l'Agni: des Parlers Moronou, Nednie, et Bona,* Thèse de Doctorat d'Etat: Departement des Sciences du Langage, Universite de Grenoble III: France.

Scharf, Bertram. 1961. Complex Sounds and Critical Bands. *Psychological Bulletin 58* (3):205-217. http://www.auditory.org/mhonarc/2012/pdfEmnQ4un9oz.pdf

Stevens, Kenneth N. 2000. *Acoustic Phonetics*. Cambridge, MA: The MIT Press.

Welmers, William E. 1973. *African Language Structures*. Los Angeles: University of California Press.

Zwicker, E. 1961. Subdivision of the Audible Frequency Range into Critical Bands (Frequenzgruppen). *The Journal of the Acoustical Society of America* 33 (2): 248.