Linguistic Portfolios

Volume 13 Article 12

2024

AN IDIOLECTAL “VOICE REPORT” ANALYSIS OF SINGLE AND DOUBLE CODA DEVOICING IN MINNESOTA ENGLISH

Ettien Koffi
St. Cloud State University

NICOLAS WOLLINSKI

AN IDIOLECTAL "VOICE REPORT" ANALYSIS OF SINGLE AND DOUBLE CODA DEVOICING IN MINNESOTA ENGLISH

ETTIEN KOFFI AND NICOLAS WOLLINSKI[1]

ABSTRACT

The Voice Report function in Praat makes it possible to calculate the amount of voicing that occurs dynamically within a segment. This function is used here to investigate how Author 2 produces voiced consonants that occur in the codas of 15 words in an elicitation paragraph read at a normal tempo. Some words end with a singleton coda, while others have double codas. When the measurements are interpreted in accordance with F0 and the 40/60 Just Noticeable Difference (JND) thresholds, we see that coda devoicing is pervasive in Author 2's speech. When the evidence presented here is added to the findings of Koffi and Lundy (2017:109-24), Koffi and Simmonds (2018:175-84), it becomes clear that coda devoicing is pervasive in Minnesota English. This paper makes a significant contribution because it provides acoustic phonetic measurements on double coda devoicing, a phenomenon that has not been widely studied.

Keywords: Single Coda Devoicing, Double Coda Devoicing, Fricative Devoicing, the 46/60 Threshold, Voice Report

1.0 Introduction

Coda devoicing is an articulatory phenomenon whereby even though a voiced consonant ends a syllable, it is devoiced in naturally produced speech. Ordinarily, this phenomenon is associated with Russian or German. Over the past several years, Author 1 has been collecting data on coda devoicing in Minnesota English. Koffi and Lundy (2017:109-24), Koffi and Simmonds (2018:175-84) have provided preliminary data on it. This paper expands on earlier efforts by appealing to the Voice Report function in Praat and the 40/60 threshold for additional insights. These two metrics are applied to the pronunciation of Author 2, a native speaker of American English who grew up in Minnesota. The investigation is carried out in four installments. The first provides some background information about the speakers, the elicitation paragraph, and the lexical items selected for the analyses. The second is devoted to spectrographic annotations and correlate extraction procedures. The third examines the acoustic measurements. The fourth brings everything together in the "Discussion" section.

1.1 Biographical Sketch

Author 2 was a 28-year-old male native speaker of American English when he recorded himself for an assignment in Author 1's acoustic phonetics course. His dialect of Minnesota English belongs to a conglomerate of dialects that are referred to as "Inland North." Since he is from Minnesota, we simply state that he has a "Minnesotan Accent." This accent is mostly

[1]**Authorship responsibilities:** This paper originated from an acoustic phonetics course that Author 2 took from Author 1. Author 2 did not contribute to the writing of this paper, but he is recognized as such for the measurements that he provided. To the extent that the measurements provided by Author 2 are accurate, Author 1 bears full responsibility for any analytical or interpretive errors in this publication. Both authors share equally in the rights and privileges associated with this publication.

characterized by vowel pronunciation that diverges from other General American English (GAE) vowels and by some lexical items that are indigenous to this region.

1.2 The Elicitation Paragraph and Recording Instructions

The students who enroll in Author 1's course record themselves reading an expanded version of the Speech Accent Archive (SAA). Author 1 has augmented the original SAA text because some segments are not represented in the original text or under-represented. With this augmented version, all English speech segments occur at least three times in many phonological environments. The words singled out for analysis are in red ink [red, online].

> *Please call Stella. Ask her to bring these things with her from the store: Six good spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a footlong sandwich as a snack for her brother Bob. We also need a small plastic snake, the little yellow book, a rubber duck, and a paper I-pad. She should not forget the dog video game and the big toy frog for the kids. She must leave the faked gun at home but she may bring the ten sea turtles, the mat that my mom bought, and the black rug. She can scoop these things into three red bags and two old backpacks. We will go meet her, Sue, Jake, and Jenny Wednesday at the very last train station. The station is between the bus stop and the cookie store on Flag Street. We must meet there at 12 o'clock, for sure. The entrance is at the edge of the zoo in Zone 4 under the zebra sign. York's Treasure Bank is the tall building in the left corner. She cannot miss it.*

Students are encouraged to practice reading the elicitation paragraph two or three times so that they arrive at a reading fluency that approximates their normal talking tempo. The recording takes place in the first two weeks of the course. Even though the students know that the recording has to do with the course, they do not know what exactly it is for. They have no clue about the kinds of analyses that they will perform on their own speech. Consequently, we consider the measurements obtained from such recordings to be a fairly good representation of how the individuals speak in real life.

1.3 Definitions and Spectrographic Annotations

Devoicing is the process whereby a voiced consonant at the end of a word is devoiced or produced as voiceless. Johnson (2012:156) provides aerodynamic and articulatory reasons why codas are often devoiced. His explanation focuses on fricatives, but some of it applies to some voiced stops in general. It applies to our study because the segments under consideration are either fricatives or contain fricatives. His explanation goes as follows:

> Voiced fricatives are relatively unusual in the languages of the world, undergo a variety of phonetically motivated alternations, and are surprisingly difficult to produce. The difficulty, which may underlie the cross-linguistic and phonological patterns, arises because high volume velocity is needed to produce the turbulent noise characteristic of fricatives, and the vibrating vocal folds impede the flow of air through the vocal tract.

In examining Author 2's pronunciation of <*please, good, five, cheese, Bob, big, leave, bags things, spoons, peas, slabs, kids, things, bags*>, we pay close attention to how he produces the final /z, b, d, g, v/. If he devoices them, they will sound like [z̥, b̥, d̥, g̊, v̥]. If he produces them as voiceless, they will sound like [s, p, t, k, f]. In reality, most people cannot tell a difference between devoiced and voiceless segments when they listen to them with their naked ears. However, since we are carrying out an instrumental acoustic phonetic analysis, we can know with certainty if he is devoicing them as [z̥, b̥, d̥, g̊, v̥] or if he is producing them as voiceless [s, p, t, k, f]. The procedures used to extract the relevant voicing information from the 15 test words are best described by the annotated spectrograph in Figure 1:

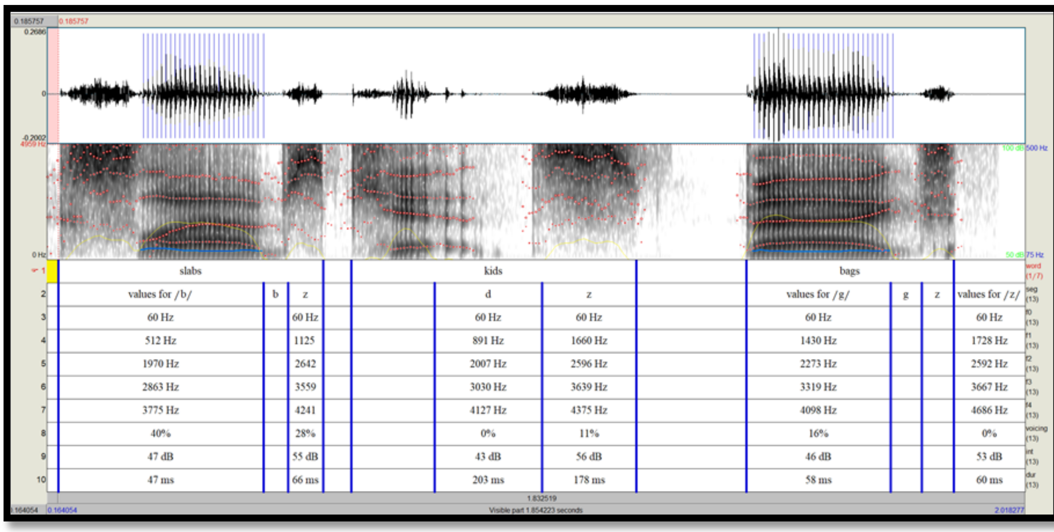

Figure 1: Annotation Procedures

First and foremost, the test words were singled out from the rest of the words in the elicitation paragraph. Secondly, the segment(s) in the coda is/are isolated for additional scrutiny. The end of the word is visualized and listened to in order to determine the coda consonant(s) as accurately as possible. Once a correct determination is made, boundaries are drawn around the coda segment(s), as illustrated in Figure 1. Thereafter, eight correlates (F0/pitch, F1, F2, F3, F4, intensity, duration, and Voice Report, abbreviated as VR) are extracted. For the coda devoicing project, 120 tokens are extracted. Praat (Boersma and Weenink 2022) is the software package used to extract all the relevant correlates. However, for this paper, we focus only on F0 and VR at the expense of the other correlates.

2.0 The Interpretive Framework

The interpretation of the acoustic phonetic measurements is done in accordance with psychoacoustic principles. According to Fastl and Zwicker (2007), as explained in the preface to the first edition, psychoacoustics seeks to establish correlations between "acoustical stimuli and hearing sensation." The specific psychoacoustic theory that we appeal to in finding these correlations is the Critical Band Theory (CBT), as explained in many of Author 1's publications. Nearly 100 years of acoustic phonetic experiments have allowed researchers to identify various thresholds at which the naked ear responds to certain acoustic stimuli. These thresholds are known as Just Noticeable Differences or JNDs, for short. A determination that voicing or lack thereof occurs is based on if one or both of the two JNDs below pertain. The first is based on minimum pitch detection algorithm and the second is based on VR.

Minimum Pitch Detection Algorithm (MPDA)

> Whenever Praat returns a result of "pitch undefined," then the segment in question is most likely voiceless or devoiced because the vocal folds vibrate below 75 Hz.

Praat and nearly all the acoustic phonetic software packages set their MPDA at ≤ 75 Hz. Whenever it fails to detect pitch, it renders a judgment of "pitch undefined." Ordinarily, this is taken to mean that the segment under consideration is voiceless or devoiced because vocal fold vibration is < 74 Hz. "Pitch undefined" does not mean that the vocal folds did not vibrate at all. All it shows is that the vibrations occur at less than 75 Hz. Fry (1979:68) notes that humans cannot cause their vocal folds to vibrate less than 60 Hz. The vocal folds may vibrate from 60 to 74 Hz. However, if they do, the vibrations are so microscopic that the naked ear cannot detect any pitch at all. For this reason, Author 1 advises his students to enter 60 Hz or 74 Hz whenever Praat renders a "pitch undefined" measurements.[2] In the remainder of the paper, 60 Hz is taken as the default value for a "pitch undefined" result in Praat. We will see in 2.3 that F0 does not give an accurate reading of vocal fold vibration. Consequently, it is an unreliable metric for studying coda devoicing. For this reason, we turn to the 40/60 threshold proposed by Gradoville (2011).[3]

The 40/60 Threshold

> If 40% or more of a segment is voiced, then the whole segment is perceived auditorily as voiced.

As stated here, this JND tells us only one thing, namely a sound is either voiced or unvoiced. However, we know that there is a three-way distinction in voicing: fully voiced, devoiced, and voiceless. The combination of the 40/60 JND and insights from Smith (1977:482), has allowed Koffi and Simmonds (2018:177)[4] to provide a three-way differentiation voicing, as follows:

1. If 10% or less of a segment is voiced, it is perceived auditorily as voiceless.
2. If 11% to 39% of a segment is voiced, it is perceived auditorily as devoiced.
3. If 40% or more of a segment is voiced, it is perceived auditorily as voiced.

These benchmarks are extremely useful because the VR function in Praat renders voicing results in percentages.[5] However, before using VR, one must carefully heed the instructions in Praat. When VR is queried, Praat displays the following message: "WARNING: some of the following measurements may be imprecise. For more precision, go to "Pitch settings" and choose "Optimize for voice analysis." Also, it is important to remember that Praat renders VR results in terms of "fraction of locally unvoiced frames." So, if a hypothetical segment has a "fraction of locally unvoiced frames: 12.50% (1/8)," it means that only one eighth of the segment is **not** voiced. Conversely, it means that 87.5% or (7/8) of that segment is voiced. It is important to note that Praat provides pitch information both in fraction and in percentages. Since the degrees of voicing

[2] If not instructed this way, unsuspecting students will enter 0 Hz. This would imply that a human being can produce 0 pitch, which is anatomically impossible.
[3] Originally, Gradoville's statement concerns only fricatives. Abramson and Whalen (2017:81) propose the rule of 50% for stops. However, Gradoville's 40/60 rule works for all segments, including stops.
[4] The wording of the thresholds is clearer here than in Koffi and Simmonds (2019).
[5] To access the "Voice Report" function, first go to <Pulses>, select <show pulses>. Once it has been selected, click on "Voice Report." Scroll down and read the information under "Voicing."

are reported in percentages, it is better to report the degree of voicing in percentages also. It is important to keep in mind while reading this paper that the VR percentages reported in all the tables are voicing percentages.

2.1 A Closer Look at the Codas

The 15 words selected for coda analyses can be divided into four groups:

1. Those that end with voiced fricatives/affricates.
2. Those that end with voiced stops.
3. Those what end with an alveolar nasal and <-s>.
4. Those that end with a velar fricative and <-s>.

The analyses in the remaining section will be carried out according to this subcategorization of codas.

2.2 Devoicing of Voiced Fricatives in the Coda

The words in the list that end with voiced fricatives are <*please, peas, cheese, five, leave*>. The word <*edge*> ends in an affricate, but it is included among fricative codas because it has /dʒ/ has frication noise. Four words, <*please, peas, cheese, edge*> end with sibilant fricatives, while < *five, leave*> have labiodental fricatives. Table 1 provides F0 and VR measurements about their codas:

	please	**peas**	**cheese**	**five**	**leave**	**edge**	**Mean**
IPA	/pli:z/	/pi:z/	/tʃi:z/	/faɪv/	/li:v/	/ɛʤ/	NA
Segment	/z/	/z/	[z]	/v/	/v/	/ʤ/	NA
F0	173 Hz	60 Hz	60 Hz	173 Hz	110 Hz	135 Hz	118 Hz
VR of Voicing	16%	0%	0%	8%	12%	28%	10.33%

Table 1: Singleton Voiced Fricatives in the Coda

Right away, we notice a conflict between F0 and VR measurements. Except for <peas> and <cheese>, F0 data show that, on average, Author 2's vocal folds vibrated 118 Hz when the codas of <*please, five, leave, edge*> were produced. Normally, since this average is greater than 75 Hz, we would conclude that the final consonants in these words are voiced. However, the average measurement for VR is 10.33%, which indicates that the consonants are devoiced. Why do we have these conflicting results?

2.3 Static vs. Dynamic Measurements

In order to understand the source of the contradiction, a distinction must be made between **static** and **dynamic** measurements. The algorithm scans the duration of the segment. As soon as it sees a pitch measurement, it stops and reports the result. An unsuspecting analyst can be fooled into believing that the result applies to the whole segment. VR, on the other hand, reports dynamic measurements. It scans the entire segment and reports values at every 10 msecs or 20 msecs. Because VR does that, it paints a more realistic picture of what is going on in the segment with regard to vocal fold vibration. So, for <*please, five, leave, edge*>, we see that 10.33% of the coda is voiced, while 89.67% is unvoiced. In every case, the voicing of the portion of the vowel bleeds into the abutting coda. However, the remaining portion of the consonant is produced without any vocal fold vibration. For this reason, VR gives a more accurate description of voicing than F0 alone. For instance, when Author 2 produced <peas>, only 16% of the coda was voiced. The rest of the segment, 84%, was produced as voiceless. This explains why to the naked ear, his [pʰi:z] <peas> sounds like [pʰi:s] <peace>. According to the 40/60 JND discussed in 2.0, the codas of <*please, leave, edge*> were devoiced to [z̥, v̥, d͡ʒ̥]. The naked ear perceives these voiced codas as voiceless codas, namely as [s, f, t͡ʃ].

When voiced codas are devoiced in this manner, confusion can arise, and intelligibility can be threatened if the relative functional load (RFL) of the voiced segment and its voiceless counterpart is high. In these examples, the severity of unintelligibility is greatly diminished because in codas, the RFL of /z/ and /s/ is only 6% (Koffi 2021:49-50). The RFL of [d͡ʒ̥] and [t͡ʃ] is only 8%. Finally, the RFL of [f] and [v] is also only 9%. In other words, English can afford coda devoicing because it does not erode intelligibility seriously. In many instances, the discourse context facilitates phonetic recoverability (Johnson 2012:106). Even though Author 2 produced the <-s> of <peas> in <*fresh snow peas*> as [pʰis] (*peace*), the syntactic context eliminates <*peace*> as a viable candidate because native or proficient hearers know from English grammar that <*peace*> is not a countable noun. Moreover, the collocation <fresh snow …> clues the hearer in that the next word is most likely a vegetable. Consequently, even though the /z/ in <*peas*> is devoiced to [z̥] or [s], the syntactic and/or discourse context prevents it from being activated.

2.4 Devoicing of Voiced Stops in the Coda

Four of the words, <*good, Bob, big*>, have singleton voiced consonants in the coda. The spectrographic behavior of these words is displayed in Figure 2.

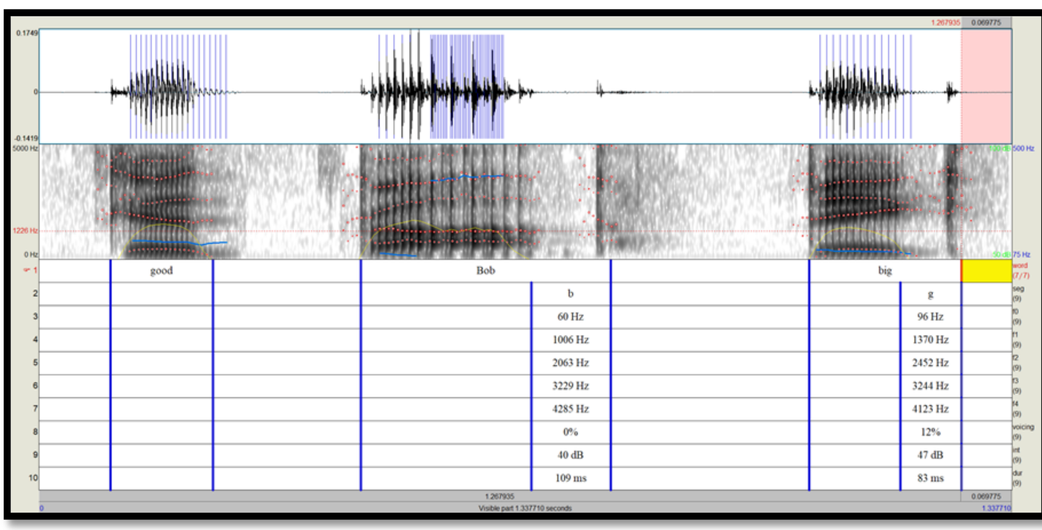

Figure 2: Devoicing of Voiced Stops

	good	Bob	big	Mean
IPA	/gu/	/bɑb/	/bɪg/	NA
Segment	deleted	/b/	/g/	NA
F0	NA	60 Hz	96 Hz	78 Hz
VR of Voicing	NA	0%	12%	6%

Table 2: Singleton Voiced Stops in the Coda

Author 2 completely deleted the /d/ of <good>. This explains why no measurements were entered under <good>. He wrote the following regarding his pronunciation, or rather lack of pronunciation of /d/:

> The spectrograph in Figure 2 shows that I do not pronounce the /d/ in the coda of <good>. This is perhaps just further evidence to support my devoicing habit. In the pronunciation of <good>, I go one step further and omit the coda entirely. This is particularly interesting, however, when one considers that omitting may result in greater intelligibility challenges than simply devoicing. I was not able to locate research examining any relative functional load percentages between a given segment and complete omission of said segment, though that could be an interesting study if more widespread coda omission were to be identified in adult speakers.

The /b/ in the coda of <Bob>, was simply produced as voiceless. There is no hint of voicing anywhere in the spectrograph. The VR of 0% supports this conclusion. We note in passing that Author 2 has a creaky voice, as shown clearly in the spectrographs of vowel /ɑ/ that precedes the final /b/ in <Bob>. Creaks contribute to irregular phonation. In fact, the /ɑ/ of <Bob> was only one-third voiced. The lack of voicing continued all the way through the pronunciation of [b] in the coda. The velar stop /g/ in <big> is auditorily perceived as devoiced because only 12% of it is voiced. The devoicing of stop consonants in the coda affects intelligibility marginally or not at all. The RFL of /g/ and /k/ in the coda is 29%. Thus, <big> can potentially be misunderstood as [bɪk]. However, no such lexical minimal pair exists in English. Furthermore, the phrase < … toy frog> will most likely cause the hearer to retrieve the final consonant as [g] rather than [k] even though the talker actually produced a devoiced [g̥].

3.0 Double Coda Devoicing

The penultimate installment examines Author 2's pronunciation of the complex codas in six words: *<things, spoons, slabs, kids, things, bags>*. These words fall into two categories. In *<slabs, kids, bags>*, the inflectional suffix <-s> is preceded by a voiced oral stop, whereas in *<things, spoons, things>*, the segment preceding is a voiced nasal stop. The former will be addressed in 3.1 and the latter in 3.2.

3.1 Double Coda with Oral Consonants

Figure 3 is a repetition of Figure 1 which was used to illustrate the annotation procedures. Boundaries are drawn around each of the consonants in the codas of the three words. The common denominator in all these words is that the voiced stop is followed by the plural suffix <-s>, which is /z/ in the underlying phonemic representation.

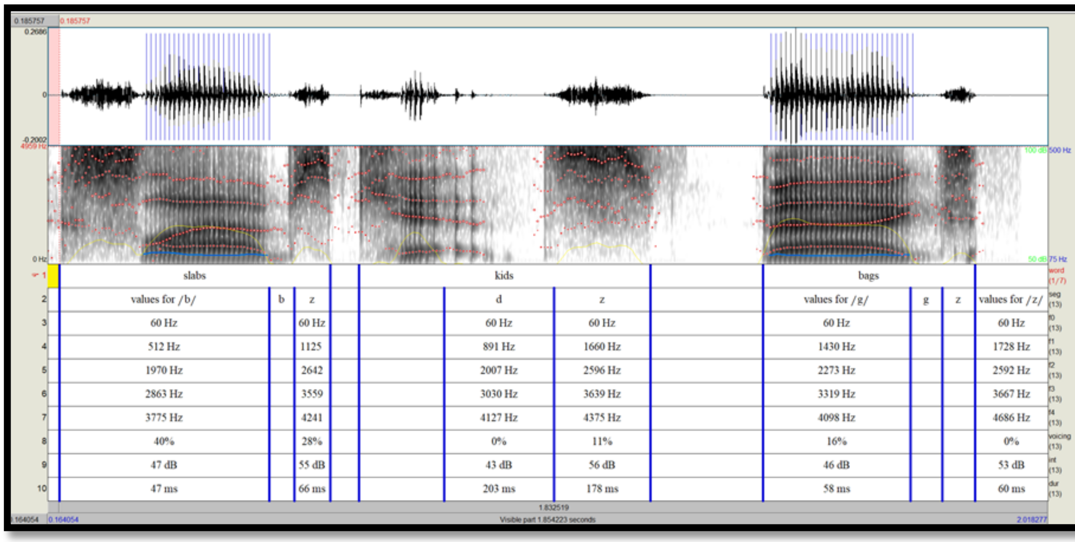

Figure 3: Devoicing in Complex Codas with Oral Stops

	slabs		kids		bags		**Mean**	
IPA	/slæbz/		/kɪdz/		/bægz/			
Segments	/b/	/z/	/d/	/z/	/g/	/z/	stops	[z]
F0	60	60	60	60	60	60	60	60
VR of Voicing	40%	28%	0%	11%	16%	0%	19%	13%

Table 3: Devoicing in Complex Codas with Oral Stops

In the spectrograph, the measurements of /b/ in <slabs> are reported under "values for /b/" because the space inside the boundaries of /b/ is too small. The VR of /b/ is 40%, so that it is perceived as fully voiced. However, the VR of /z/ is 28%. So, we conclude that /z/ is devoiced as [z̥]. Auditorily, <slabs> is perceived as [slæbz̥]. The pronunciation of <kids> is similar, but also different in some ways. We see that the VR of [d] is 0%, which indicates that it was produced as [t]. The VR of /z/ is 16%, hence devoiced. So, <kids> is perceived as [kɪtz̥]. In the case of <bags>, <g> is devoiced as [g̊], while /z/ is produced as [s]. Hence, <bags> is produced and perceived as [bæg̊s]. We see that when /b, d, g/ occur in the coda, /b/ is fully voiced, /d/ is made voiceless, and /g/ is devoiced.

3.2 Double Codas with Nasal Consonant

The last group of words that have double codas are *<things, spoons, things>*. The segments to which the plural morpheme /z/ is attached are the nasal /n/ and /ŋ/. Phonetically, the former is an alveolar nasal, while the latter is a velar nasal. Their spectrographic and acoustic behaviors are illustrated by Figure 4:

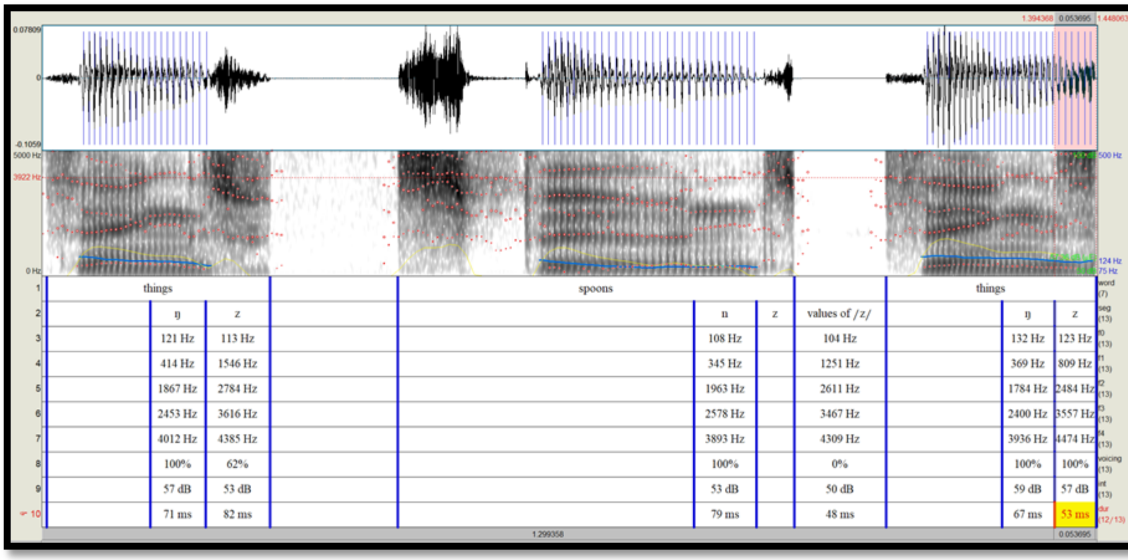

Figure 4: Devoicing in Complex Codas with Nasal Stops

	things$_1$		spoons		things$_2$		**Mean**	
IPA	/θɪŋz/		/spunz/		/θɪŋz/			
Segments	[ŋ]	[z]	[n]	[z]	[ŋ]	[z]	stops	[z]
F0	121	113	108	104	132	123	120	113
VR of Voicing	100%	62%	100%	0%	100%	100%	19%	13%

Table 4: Devoicing in Complex Codas with Nasal Stops

When the inflectional suffix /z/ follows the alveolar nasal as in <spoons>, [n] is fully voiced, but /z/ is produced as a voiceless fricative. Yet, when the same suffix follows <things>, in both instances, both /ŋ/ and /z/ are fully voiced. In <things>, the nasal /ŋ/ is voiced 100%. The [z]s that follow are also voiced, 62% in one case, and 100% in another. In other words, when /ŋ/ occurs in the coda, the plural morpheme /z/ is automatically voiced.

4.0 Discussions

Single coda devoicing includes the devoicing of the stops /b, d, g/ which appeared at the end of the words <*good, Bob, big*> and the fricatives /z, v, dʒ/ in the codas of <*please, peas, cheese, leave, edge*>. For stops, the tendency runs from deletion, as in the case of /d/ in <good> to voiceless in the case of the second /b/ in <Bob>, to devoicing, as in the /g/ of <big>. For the voiced fricatives in the coda, devoicing and voicelessness is the norm. There is no case of segment deletion.

For the double codas /dz/ and /gz/ where /z/ is a plural suffix <-s>, we see that /z/ is devoiced to [z̥] and /d/ and /g/ are also devoiced to [d̥] and [g̥]. So, the two segments in the coda are both devoiced to [d̥z̥] and [g̥z̥] in Author 2's pronunciation. However, for the coda cluster /bz/, only /z/ is devoiced while /b/ remained voiced. The cluster *[b̥z̥] does not appear in his pronunciation. It is as though /b/ blocks double coda devoicing. Another oddity is the nasal clusters /nz/ or /ŋz/. For /nz/, we see that the nasal segment [n] which is an alveolar is 100% voiced, but the fricative [z] is voiceless. So, we end up with the cluster [ns]. Here, it seems like the Obligatory Contour Principle applies to keep the two segments auditorily apart because both [n] and [s] have the feature [+alveolar]. Yet, for the [ŋz] cluster, both the velar nasal /ŋ/ and the plural suffix /z/ are fully voiced. Why is /z/ not devoiced to [z̥] after [ŋ]? Why doesn't /z/ devoice when it follows a velar nasal? Is devoicing of /z/ blocked because of the amount of nasalance in [n] and [ŋ]? Auditorily, /ŋ/ appears to have a greater nasalance than /n/. A nasometer can help answer some of these questions because it helps measure the quantity of airflow through the nostrils. Unfortunately, the acoustic phonetic lab did not have this equipment at the time of the study.

5.0 Summary

This paper adds to the list of growing data about the pervasiveness of coda devoicing in Minnesota English. Koffi and Lundy (2017:109-24) and Koffi and Simmonds (2018:175-84) have provided data in this regard. The present paper complements what is found in Fromkin et al. (2014:278). Yet, the paper raises issues that have not yet been discussed in the acoustic literature with respect to double coda devoicing in American English. Author 2 devoices [d̥z̥] and [g̊z̥] but fails to do so for *[b̥z̥]. Furthermore, he produces [ns] but does not produce *[ŋz̥] or *[ŋs̥]. The lack of *[b̥z̥], *[ŋz̥]/*[ŋs] in his pronunciation is for the moment a mystery. We do not know if this is a speech idiosyncrasy or if the unattested pronunciations are regulated by some phonetic properties that elude Author 1. For now, we are content to take Johnson's (2012:162) word about fricatives for it. He writes that "there may be a substantial range of inter-speaker variability in the frequencies and spectral peaks in fricatives." Since the unexplainable cases involve fricatives, it is a convenient explanation for now.

ABOUT THE AUTHORS

Ettien Koffi, Ph.D. linguistics (Indiana University, Bloomington, IN) teaches at Saint Cloud State University, MN. He is the author of five 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), Text-to-Speech (TTS), voice biometrics for speaker verification, and infant cry bioacoustics. Since 2012, his high impact acoustic phonetic publications have been downloaded **68,201** times (**47,355** as per Digital Commons analytics), (**20,846** as per Researchgate.net analytics), and several thousand downloads from Academia.edu, as of **February 2024**. He can be reached at enkoffi@stcloudstate.edu.

Nicholas Wolinski or Nik, (he/they) is an undergraduate student at Saint Cloud State University, majoring in Film Studies with additional focuses in creative writing, linguistics, and philosophy. As a nontraditional learner, Nik can be found working his day job as a project manager or on campus for evening classes. He can be reached at woni1401@go.stcloudstate.edu and n.d.wolinski@gmail.com.

References

Abramson, Arthur and D.H. Whalen. 2017. Voice Onset (VOT) at 50: Theoretical and Practical Issues in Measuring Voicing Distinctions. *Journal of Phonetics* 63:75-86.

Boersma, Paul and David Weenink. 2016. Praat: doing phonetics by computer [Computer program]. Version 6.2.12, retrieved 7 April 2022 from https://www.fon.hum.uva.nl/praat/.

Fastl, Hugo and Eberhard Zwicker. 2007. *Psychoacoustics: Facts and Models*. 3rd edition. Munich, Germany: Springer.

Fromkin, Victoria, Robert Rodman, and Nina Hyams. 2014. *An Introduction to Language*. 10th Edition. Boston, MA: Cengage Learning.

Gradoville, Michael. 2011. Validity in Measurements of Fricative Voicing: Evidence from Argentine Spanish. *Selected Proceedings of the 5th Conference on Laboratory Approaches to Romance Phonology*, ed by. Scott M. Alvord, pp. 59-74. Somerville, MA: Cascadilla Proceedings Project.

Johnson, Keith. 2012. *Acoustic and Auditory Phonetics*. 3rd Edition. Malden, MA: Wiley-Blackwell.

Koffi, Ettien. 2021. Relevant Acoustic Phonetics of L2 English: Focus on Intelligibility. Course Manuscript: St. Cloud, MN.

Koffi, Ettien and Andrea Simmonds. 2018. Gradience in Coda Cluster Devoicing in a Central Minnesota English Idiolect. *Linguistic Portfolios* 7: 175-184.

Koffi, Ettien and Cassy Lundy. 2017. An Acoustic Phonetic Account of the Production of Word-Final /z/s in Central Minnesota English. *Linguistic Portfolios* 6: 109-124.

Smith, Caroline L. 1997. The Devoicing of /z/ in American English: Effects of Local and Prosodic Context. *Journal of Phonetics* 25: 471-500.