University of Pennsylvania Working Papers in Linguistics

Volume 22
Issue 1 *Proceedings of the 39th Annual Penn Linguistics Conference*
Article 24

2016

Prevoicing and Aspiration in Southern American English

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Abstract

This paper reports on an investigation of voicing and aspiration of stops in Southern American English (SAE) and discusses theoretical implications of the findings for the features of contrast in SAE.

Languages that have a two-way stop contrast generally fall into two categories: voicing languages (Russian, Dutch, Spanish) and aspirating languages (German, English, Mandarin). Many phonologists have suggested that aspirating languages have a [spread glottis] ([sg]) contrast and true voice languages a [voice] contrast (Beckman, Jessen, & Ringen 2013, Iverson & Salmons 1995). Surface phonetic cues are intrinsically connected to these phonological features; prevoicing or aspiration in certain environments implicates the phonological feature [voice] or [sg] (Beckman et al. 2013).

In utterance-initial position, voicing languages have negative VOT lenis and short-lag VOT fortis stops, while aspirating languages have short-lag lenis and long-lag fortis stops. However, Helgason and Ringen (2008) show that the two-way contrast in Swedish has phonetic cues of both [sg] and [voice]; they propose that the phonological contrast in Swedish stops is between [voice] and [sg]. Rate effects support this proposal (Beckman, Helgason, McMurray, & Ringen 2011).

This study analyzed utterance-initial lenis and fortis stops across all places of articulation from 13 speakers of Southern American English (SAE). Overall, 77.8% of the 951 lenis stop tokens for SAE speakers were prevoiced in utterance-initial position, with a mean VOT of -92.0 ms for lenis stops; this far exceeds data found in Lisker and Abramson (1964) and is comparable to that found for Dutch, a [voice] contrast language. Additionally, the SAE speakers had fortis VOT values comparable to aspirating languages such as NAE (Northern American English). If prevoicing implicates phonological [voice] and aspiration implicates [spread glottis], then SAE appears to have both, as is argued for Swedish in Helgason and Ringen (2008).

Prevoicing and Aspiration in Southern American English

Leigh Hunnicutt and Paul A. Morris*

1 Introduction

In 1964, Lisker and Abramson conducted systematic research of Voice Onset Time (VOT) contrasts in languages. They found four different kinds of laryngeal contrasts in language. In addition to three-way and four-way laryngeal contrasts, Lisker and Abramson (1964) discuss two types of two-way laryngeal contrasts: languages that contrast voicing lead with short voicing lag in utterance-initial position (hereafter, 'true voice' languages) and languages that contrast short voicing lag with long voicing lag in utterance-initial position (hereafter, 'aspirating' languages).

Keating (1984) distinguishes phonetic categorization from phonological features; she suggests that in both true voice languages and aspirating languages, the feature of laryngeal contrast is [voice], regardless of whether the language is true voice or aspirating. According to Keating, an aspirating language like English has a phonological category [+voice] that is phonetically realized with short-lag VOT and a phonological category [-voice] that is phonetically realized with long-lag VOT. More recently, it has been suggested that in true voice languages, the phonological feature of contrast is indeed [voice], but in aspirating languages the feature of contrast is [spread glottis] ([sg]) (Iverson and Salmons 1995, Beckman et al. 2013).

Some researchers have argued that English is an aspirating language which has a privative feature [sg] as the phonological feature of contrast. Yet a recent study conducted by Jacewicz et al. (2009) found evidence of consistent phonetic voicing during closure in utterance-medial, word-initial contexts in lenis stops in English as spoken in the American South. They did not find the same consistent phonetic voicing in English spoken in the American Midwest. This leads to two questions: if we assume that the feature of contrast in aspirating languages is [sg], then what should be made of the Jacewicz et al. (2009) results? Furthermore, might this indicate that not all varieties of American English use [sg] as the sole feature of contrast in initial position?

This paper reports on a study conducted on Southern American English (SAE) in order to answer these questions. Specifically, this study investigates SAE as spoken in Mississippi and Alabama to determine whether these dialects have a different voicing pattern than other regional Englishes. Based on the results, this study also seeks to reconcile these data with the claim that the feature of contrast in American English is [sg].

2 Background

2.1 [voice] and [sg] Contrasts

It is not controversial that in true voice languages, the feature of laryngeal contrast is [voice]. These languages realize lenis stops with lead VOT and fortis stops with short-lag VOT. Spanish is one such language (see Table 1); it contrasts lead and short-lag VOTs in utterance-initial position (Lisker and Abramson 1964, Zampini and Green 2001, Magloire and Green 1999). In the lenis series of stops, the mean lead VOT is robust and continues uninterrupted until the release of the stop.

	Bilabial	Dental	Velar
Lenis	-138 ms	-110 ms	-108 ms
Fortis	4 ms	9 ms	29 ms

Table 1: Mean VOT (milliseconds) for utterance-initial Spanish stops (Lisker and Abramson 1964).

	Bilabial	Dental	Velar
Lenis	-70 ms	-75 ms	-78 ms
Fortis	18 ms	20 ms	38 ms

Table 2: Mean VOT for utterance-initial Russian stops (Ringen and Kulikov 2012).

*We are grateful to Catherine Ringen, Jill Beckman, Bob McMurray, and Christine Shea for their suggestions and comments throughout this project. Any errors are our own.

Russian also contrasts lead and short-lag VOTs in utterance-initial position (Ringen and Kulikov 2012). In Russian, the lenis series of stops does not have as much lead VOT as in Spanish, but the voicing is still robust and uninterrupted until the release of the stop (see Table 2).

According to some accounts, the feature of laryngeal contrast in aspirating languages is [sg]. These languages realize lenis stops with short-lag VOT, while fortis stops are realized with long-lag VOT. Cantonese is an example of an aspirating language (see Table 3); it contrasts short-lag and long-lag VOTs in utterance-initial position.

	Bilabial	Alveolar	Velar
Lenis	11 ms	15 ms	34 ms
Fortis	58 ms	62 ms	68 ms

Table 3: Mean VOT for utterance-initial Cantonese stops (Lisker and Abramson 1964).

	Bilabial	Alveolar	Velar
Lenis	7 ms	18 ms	29 ms
Fortis	75 ms	77 ms	87 ms

Table 4: Mean VOT for utterance-initial stops in German (Jessen 1998).

German has also been reported as an aspirating language (see Table 4. The average duration of the long-lag VOT is greater in German than in Cantonese, although the short-lag average is roughly the same.

One difference that has been found to distinguish true voice languages and aspirating languages is the percentage of the closure that is voiced in intervocalic stops (Beckman et al. 2013). In Russian, a true voice language, it was found that 97% of intervocalic stops were voiced throughout the entire closure (Ringen and Kulikov 2012). In German, however, an aspirating language, only 62.5% of intervocalic lenis stops were voiced throughout at least 90% of the closure (Beckman et al. 2013).

2.2 Dutch

Recent literature seems to suggest that languages either have voicing lead or aspiration, but not both. In a two-way contrast between a lead VOT category and a short-lag VOT category, as in Spanish, it is presumed that the vast majority of lenis stops will be realized with robust lead VOT and the vast majority of fortis stops will be realized with short-lag VOT. In a two-way contrast between a short-lag VOT category and a long-lag VOT category, as in Cantonese, it is presumed that the vast majority of lenis stops will be realized with short-lag VOT, and the vast majority of fortis stops will be realized with long-lag VOT. However, Van Alphen and Smits (2004) found that Dutch has robust lead VOT in initial lenis tokens, but overall, only 75% of lenis tokens were realized with lead VOT (see Table 5).

	% Prevoiced tokens	VOT
Labial	78.9	-112.9 ms
Alveolar	71.8	-104.1 ms

Table 5: Percentage and VOT of voiced lenis tokens in Dutch (Van Alphen and Smits 2004).

Despite this, Van Alphen and Smits (2004) still classify Dutch as a true voice language. These data do contrast with data from other true voice languages, however; in Russian, for example, more than 97% of initial lenis tokens were realized with lead VOT (Ringen and Kulikov 2012).

2.3 English

English is a language which has a short-lag/long-lag contrast in utterance-initial position (Lisker and Abramson 1964, Flege 1982, Smith 1978, Westbury 1979). According to Lisker and Abramson (1964), English lenis stops are realized with either short-lag VOT or lead VOT (see Table 6); however, 96% of the lead VOT tokens in their sample came from a single speaker.

	Bilabial	Alveolar	Velar
Lenis	1/-101 ms	5/-102 ms	21/-88 ms
Fortis	58 ms	70 ms	80 ms

Table 6: Mean VOT for utterance-initial stops in English (Lisker and Abramson 1964).

Since the time of that research, there has been a variety of results reported for the laryngeal contrast in English. While all of the research seems to agree that English fortis stops are realized with long-lag VOT, the description of the lenis stop series is less consistent. Some studies have reported English lenis VOTs similar to Lisker and Abramson (1964), with the vast majority of lenis stops being realized as short-lag: Suomi (1980), Zue (1976), Kewley-Port (1982), and Klatt (1975) all report exclusively short-lag VOT data for lenis stops.

However, other researchers have reported more variation in the realization of English lenis stops. Westbury (1979), for example, reports that across all places of articulation, 57% of utterance-initial lenis stops were produced with lead VOT. Flege (1982) only measured utterance-initial bilabial stops but reports that 59% of those bilabial lenis stops were produced with lead VOT. Lorge (1967), as cited in Docherty (1992), states that in alveolar lenis stops, 41% of stops in utterance-initial position were produced with lead VOT; Lorge also looked at bilabial lenis stops, but none of the bilabial lenis stops examined for the study were produced with lead VOT. More recently, Dmitrieva et al. (2015) found that 31% of utterance-initial bilabial lenis stops were produced with robust lead VOT.

Research has also been conducted on voicing in intervocalic stop closures and stop closures in utterance-medial positions. Jacewicz et al. (2009) found considerable differences in the voicing for speakers of American English from Wisconsin and North Carolina. They used an utterance-medial, word-initial environment for their data collection, where the target segment followed a voiced consonant. They found that North Carolina speakers had considerably more voicing than the Wisconsin speakers. In bilabial lenis tokens from Wisconsin speakers, only 24% of the tokens were voiced through the entire closure; in the North Carolina speakers, 73% of the tokens were voiced throughout the entire closure.

The average percentage of the closure that was voiced was also smaller for Wisconsin speakers: on average, only 67% of the closure was voiced, all in an utterance-medial, word-initial environment following a liquid. For North Carolina speakers, in the same environment, an average of 92% of the closure was voiced.

3 Methods

We recorded 13 speakers of English from Alabama and Mississippi. The subjects were monolingual speakers of English, 8 males and 5 females. 4 of the subjects were born and raised in Alabama, 2 males and 2 females; 9 of the subjects were born and raised in Mississippi, 6 males and 3 females. None of the speakers had training in phonetics. Their ages ranged from 22 to 45.

The speakers read a list of words twice; the words were presented in the same order for both readings. The list contained 120 target words and 40 fillers presented in randomized order. The list contained 30 utterance-initial fortis stops (bilabial = 10, alveolar = 10, velar = 10), 30 utterance-initial lenis stops (bilabial = 10, alveolar = 10, velar = 10), 30 word-medial, morpheme-initial fortis and lenis stops (for each: bilabial = 10, alveolar = 10, velar = 10). The word-medial, morpheme-initial tokens were all preceded by consonants, either a stop, a fricative, or a nasal. There was not an even distribution of tokens produced following fortis and lenis consonants. 955 out of 1247 tokens were produced following a fortis consonant; 292 out of 1247 tokens were produced following a lenis consonant.

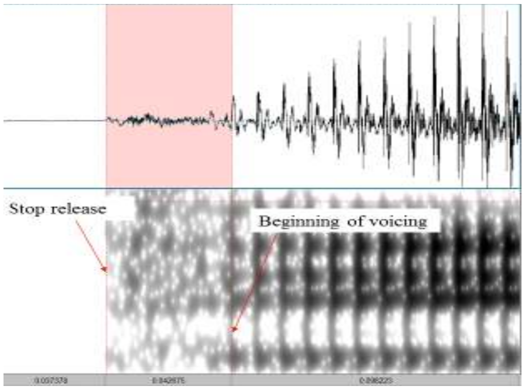

Figure 1: Long-lag VOT (spkr 1): *pig* (42.3 ms).

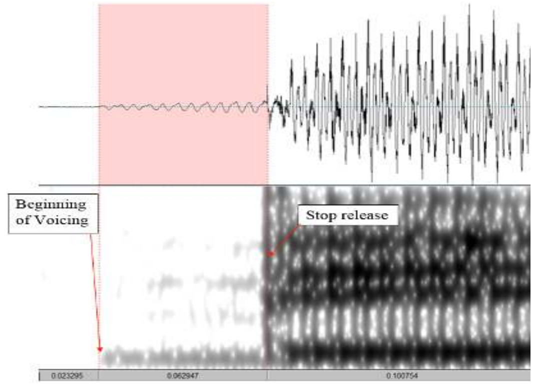

Figure 2: Lead VOT (spkr 1): big (-62.9 ms).

Data were recorded using a Marantz PMD661 handheld solid state recorder with a head-mounted unidirectional microphone (Shure WH30XLR) and sampled at 44100 Hz. The microphone was positioned to the side approximately 3 cm from the subject's mouth. The recordings took place in the quietest location possible.

Data was analyzed using Praat software. Positive VOT was measured from the stop release to the onset of voicing, as identified by the onset of the second formant (see Figure 1). Aspirated stops have a longer VOT (long-lag), while unaspirated tokens produced with positive VOT have a shorter VOT (short-lag). When the onset of voicing occurs before the stop release (lead VOT), the VOT is negative (prevoicing) (See Figure 2). The percentage of closure that is voiced was measured by comparing the duration of voicing during closure to the duration of the closure (see Figure 3). For tokens following stops, we measured the onset of closure after the preceding stop release. VOT measurements were taken from a waveform with a spectrogram for reference.

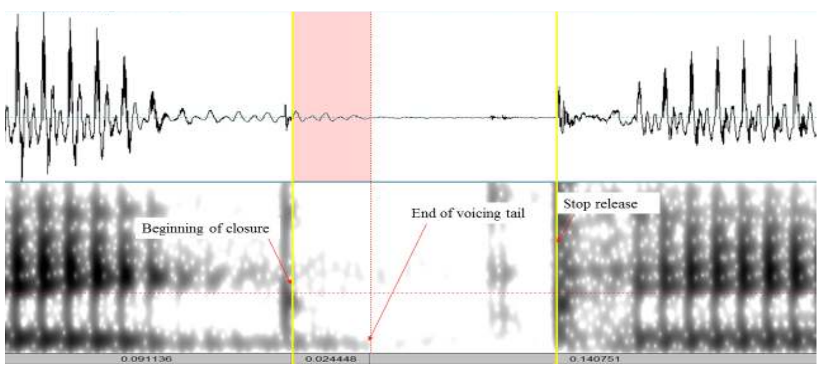

Figure 3: Fortis token with voicing tail (Spkr 2): pigpen (cl duration: 82.9 ms; voicing duration 24.4 ms; 29.4% of closure voiced.

4 Results

4.1 Word-Initial Stops

For the lenis tokens, 740 out of 951 were prevoiced (77.8%, see Figure 4). Across places of articulation, 76.1% of bilabial, 77.5% of alveolar, and 81.2% of velar lenis stops were prevoiced. The mean VOTs and standard deviations for initial fortis and lenis stops are shown in Table 7 below. There was a large difference between the VOTs of fortis stops (M = 73.1 ms), lenis stops produced with prevoicing (M = -92 ms), and lenis stops produced with short-lag (M = 13.2 ms). The distribution and mean voicing duration for utterance-initial stops are given in Figure 5.

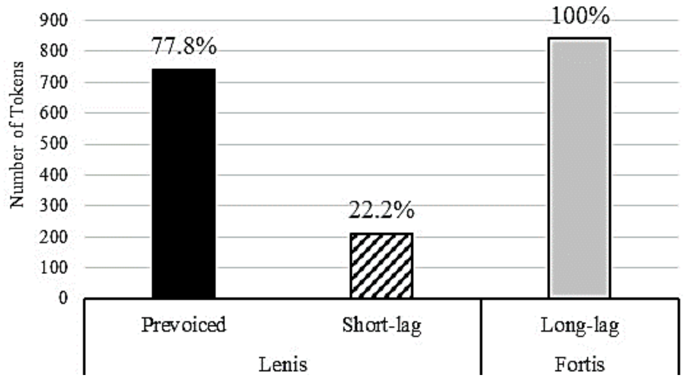

Figure 4: Count of prevoiced, short-lag, and long-lag tokens.

Lenis:	Bilabial (ms)	Alveolar (ms)	Velar (ms)
- Prevoiced	-92.6 ms (23.7)	-96.9 ms (26.4)	-85.7 ms (25.6)
-Short-lag	11.7 ms (2.9)	15.7 ms (5.5)	22.6 ms (7.6)
Fortis:	69.2 ms (26.6)	81.4 ms (25.9)	77.3 ms (23.8)

Table 7: Mean VOT and SD for initial lenis and fortis stops.

We collapsed lead- and lag-VOT productions for lenis stops and conducted a one-way t-test comparing the VOT of lenis stops against 0 ms. The mean collapsed value for lenis tokens for all speakers was negative (-66.73 ms). The t-test confirmed that there was a significant difference between the VOT of lenis tokens and 0 ms ($t(12) = -8.697$, $p < .001$*). A comparison of the VOT for fortis stops against 0 ms using a one-way t-test also revealed a significant difference ($t(12) = 11.012$, $p < .001$*).

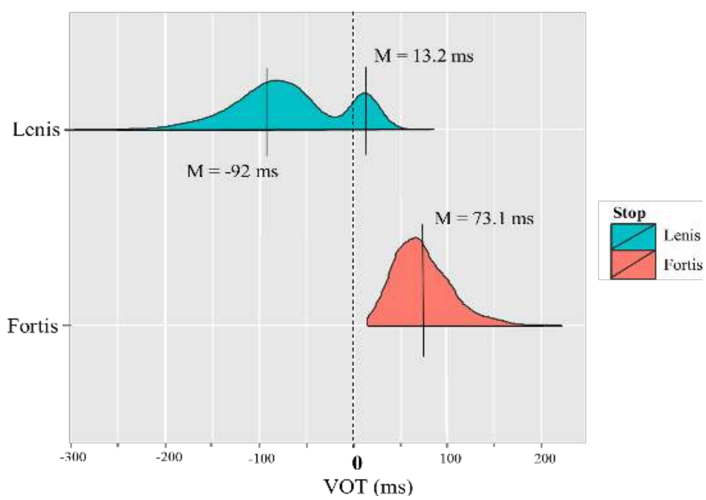

Figure 5: Mean voicing duration in word-initial stops.

A series of one-way ANOVAs examined various factors that could have influenced the VOT of lenis stops. First, we looked at whether place of articulation or number of syllables could have confounded the VOT results. There was no significant difference in VOTs for lenis stops at different places of articulation (bilabial, alveolar, velar) or for lenis stops in words containing different numbers of syllables (mono-, di- and tri-syllabic words) (see Table 8). Additionally, while the majority of tokens were produced preceding a vowel, some tokens preceded a liquid. Thus, we conducted analyses to determine whether the following phoneme, vowel or liquid, could have influenced the VOT of lenis stops. For lenis stops preceding vowels, we also analyzed whether vowel height (low, mid, high) and backness (back, central, front) could have influenced the results. A series of one-way ANOVAs did not reveal any significant differences between the VOTs of lenis stops based on these factors (Table 8). The robust prevoicing of utterance-initial lenis stops was not affected by the confounding factors tested. Fortis tokens were also analyzed based on these same factors but no significant differences in VOT were found (Table 8).

		Lenis		Fortis	
Analysis	Effect *(df)*	F	*p*	F	*p*
× Place of Articulation	VOT *(2,36)*	< 1		< 1	
× Syllables	VOT *(2,36)*	2.26	.119	1.674	.202
× Following Phoneme	VOT *(1,24)*	< 1		1.316	.263
× Vowel Backness	VOT *(2,36)*	<1		< 1	
× Vowel Height	VOT *(2,36)*	1.87	.169	< 1	

Table 8: Analysis of VOT in initial stops (one-way ANOVAs).

The percentages of lenis tokens with lead VOT (77.8%) in this study on Southern American English far exceed what has previously been found in other studies of English, such as the 20% found in Lisker and Abramson (1964), 48% in Smith (1978), and 57% in Westbury (1979).

4.2 Word-Medial Lenis Stops

Across all places of articulation, an average of 68.8% of the closure was voiced in word-medial lenis stops and 27.2 % of the closure was voiced in word-medial fortis stops (see Figure 6). We found that 61.4% of lenis tokens were voiced through more than 90% of the closure in contexts following both voiced and voiceless consonants. This percentage is due to the imbalance between the number of targets that followed fortis consonants and those that followed lenis consonants (See Table 9). When following lenis consonants, 90.5% of lenis tokens were voiced through more than 90% of the closure. Even when following a fortis consonant, 52.8% of word-medial lenis tokens were voiced through more than 90% of the closure.

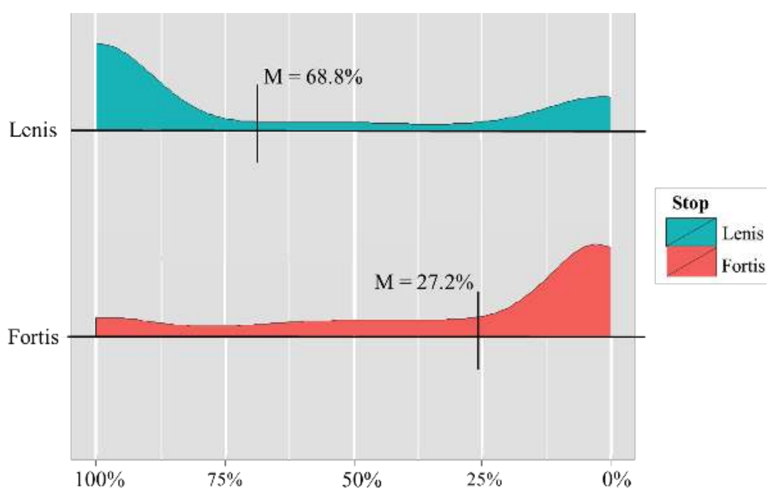

Figure 6: Distribution of % of closure that is voiced.

For the following analyses, due to the finite range of percentage of closure that is voiced, the data were transformed to rationalized arcsine units (Studebaker 1985). There was a significant difference in the percentage of closure that is voiced for lenis stops (M=68.8%, SD = 17.9) and fortis stops (M = 27.2%, SD = 18.5); $t(12) = 12.888$, $p < .001$*.

	Environment	>90%	Tokens >90%
Lenis	After lenis	90.5%	133/147
	After fortis	53%	262/496
Fortis	After lenis	26.6%	38/145
	After fortis	6%	28/459

Table 9**:** Percentage and count of tokens voiced through more than 90% of the closure.

We once again conducted a series of two-way analyses to determine if any factors could have influenced the percentage of closure that is voiced. We examined the same factors as before (place of articulation, number of syllables, following phoneme (vowel or liquid), vowel height and vowel backness), as well as whether the preceding consonant, fortis or lenis, could have influenced the percentage of closure that is voiced. Additionally, we examined whether primary stress falling on the syllable containing the target stop affected the percentage of the closure that is voiced.

A series of one-way ANOVAs revealed that the percentage of the closure that is voiced for both lenis and fortis tokens was not influenced by vowel height, number of syllables in the word, or vowel backness (see Table 10). There was a significant difference between the percentage of the closure that is voiced based on the preceding consonant (fortis or lenis) for both lenis stops ($F(1,24) = 19.775$, $p < .001$*) and fortis stops ($F(1,24) = 12.032$, $p = .002$*). Lenis stops following fortis consonants had a percentage of the closure that is voiced of 61%, compared to 94.9% for lenis stops following lenis consonants. Similarly, fortis stops following fortis consonants had a percentage of the closure that is voiced of 19.4%, compared to 51.9% for fortis stops following lenis consonants.

While there was not a significant difference between the percentage of the closure that is voiced for lenis stops with different following phonemes (vowel or liquid), there was a significant difference for fortis stops ($F(1,24) = 5.678$, $p = .025$*). 46.6% of the closure was voiced for fortis stops preceding liquids, while 24.8% was voiced when preceding vowels. It should be noted that the unequal numbers of preceding lenis/fortis consonants influenced these results.

A significant difference was found between the percentage of the closure that is voiced for place of articulation (bilabial, alveolar, velars) for both lenis ($F(2,36) = 9.682$, $p < .001$*) and fortis stops ($F(2,36) = 8.151$, $p = .001$*). The percentage of the closure that is voiced for lenis tokens is 88% for bilabials, 68.2% for alveolars, and 49.6% for velars. The percentage of closure that is voiced for fortis tokens is 46.2% for bilabials, 19.5% for alveolars, and 14% for velars. No lenis or fortis velar tokens preceded lenis consonants, and only 21 out of 229 alveolar lenis stops and 18 out of 173 alveolar fortis stops were preceded by lenis consonants, thereby influencing the results. There was also a significant difference between percentage of the closure that is voiced for lenis stops in stressed and unstressed syllables ($F(1,24) = 5.65$, $p = .026$*). The percentage of the closure that is voiced for lenis tokens in stressed syllables is 49.5%, compared to 72.2% in unstressed syllables. There were no lenis tokens in stressed syllables produced following a lenis consonant.

		Lenis		Fortis	
Analysis	*(df)*	F	*p*	F	*p*
× Vowel Height	*(2,36)*	< 1		< 1	
× Syllables	*(1,24)*	< 1		2.735	.111
× Following Phoneme	*(1,24)*	< 1		5.678	.025*
× Vowel Backness	*(2,36)*	1.045	.362	< 1	
× Place of Articulation	*(2,36)*	9.682	<.001*	8.151	.001*
× Preceding Phoneme	*(1,24)*	19.775	<.001*	12.032	.002*
× Stress	*(1,24)*	5.65	.026*	1.939	.177

Table 10: Analysis of % of closure that is voiced in medial stops (one-way ANOVAs).

5 Discussion

If surface phonetic cues are intrinsically connected to phonological features, then phonetic lead VOT in certain environments implicates phonological [voice] and phonetic long-lag VOT in certain environments implicates phonological [sg] (Beckman et al. 2013). Under this assumption, the results for utterance-initial stops suggest that [voice] might be a feature of SAE lenis stops.

In this study, consistent, robust lead VOT was found in utterance-initial contexts, where passive voicing is unlikely to occur. As well, consistently high percentages of word-medial stops were found to be voiced throughout the entire stop closure, even in contexts that would be unfavorable to passive voicing. These consistent lead VOT values in utterance-initial position pattern with other languages that have [voice], such as Spanish or Russian.

The percentage of lenis tokens produced with lead VOT in this experiment also far exceeds what has previously been found for English (see Table 11). The highest percentages previously reported for English were given by Flege (1982), though he measured only bilabial stops; it should also be noted that Flege conducted his research at the University of Alabama at Birmingham, where at least some of his subjects were probably speakers of SAE. While the percentage of lead VOT lenis stops found in this study is not as high as some true voice languages, such as the 97% that Ringen and Kulikov (2012) found for Russian, the 77.8% of initial lead VOT lenis stops in this study is comparable to the 75% found by Van Alphen and Smits (2004) in Dutch, which is still considered to be a [voice] language. The values found in this study, then, taking Dutch as an example, suggest that [voice] could be a feature of SAE lenis stops.

Variability in voicing in medial contexts can be the result of passive voicing (Keating 1996). Passive voicing occurs when a target stop is in a voiced environment and voicing the stop does not have to involve any active voicing gestures. For example, Beckman et al. (2013) attribute their 62.5% of intervocalic stops that were voiced through 90% of the closure to passive voicing. However, many of the target stops in word-medial contexts in our study were preceded by a fortis consonant, which would not produce an environment favorable to passive voicing.

This study found similar results in utterance-initial aspirated stops to what was found in previous research for American English. There was consistent, robust aspiration in initial position, with values comparable to those in Lisker and Abramson (1964), in the vast majority of fortis initial stops. This patterns with other aspirating languages. As these results were consistent with previous research, it can also be argued that SAE has [sg] as a feature of fortis stops, as with other varieties of American English.

	% with lead VOT Overall
Lisker and Abramson (1964)	20%
Smith (1978)	48%
Westbury (1979)	57%
Flege (1982)	59% (bilabial only)
Dmietrieva et al. (2015)	38% (bilabial only)
Present Study	**77.8%**

Table 11: Comparison of the overall reported percentage of lenis stops with lead VOT.

6 Conclusion

This study found that there is evidence supporting both phonetic lead VOT lenis stops and long-lag VOT fortis stops in SAE; the environments in which these phonetic categories were found could be used to argue for the presence of phonological [voice] and [sg] as features of SAE. Although Lisker and Abramson (1964) presented two-way contrast languages as definitely belonging to one group or the other—either contrasting a lead VOT category with a short-lag VOT category or contrasting short-lag VOT and long-lag VOT—the data in this study do not support such a contrast in SAE.

Instead, SAE appears to have the same kind of contrast argued by Helgason and Ringen (2008) to exist in Swedish: a lenis series of stops produced with lead VOT and a fortis series of stops produced with long-lag VOT. Helgason and Ringen (2008) argue that in Swedish, both [voice] and [sg] are active features; this would mean that there is not an unmarked stop series.

	Bilabial	Dental	Velar
Lenis	-96 ms	-90 ms	-61 ms
Fortis	49 ms	65 ms	78 ms

Table 12: Mean VOT values for Swedish stops (Helgason and Ringen 2008).

As the preliminary data in this study show the same kind of spread between robust lead VOT lenis stops and robust long-lag VOT fortis stops, this study suggests that [voice] and [sg] could be active in Southern American English as well.

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