IN SEARCH OF COWBOY B: BILABIAL IMPLOSIVES IN AMERICAN ENGLISH

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ABSTRACT: This article presents acoustic evidence for the existence of a bilabial implosive, [ɓ], in one variety of U.S. English. One articulatory observation is that vocal chord vibration of the English bilabial stop, /b/, can only be maintained for a maximum of about 82 ms. Increasing the vibration beyond this threshold is only possible by increasing the size of the vocal cavity, which in turn is often enabled by lowering the glottis, a gesture characteristic of implosive stops. The authors compare the voiced bilabial stops of five white males from the Western United States, three of whom impressionistically appear to have implosive stops and two who do not. For each stop, a normalized stop duration was calculated based on speech tempo, the actual stop duration, and the percentage of the stop that displayed vocal fold vibration. As far as normalized stop duration is concerned, there are no significant differences between the five speakers. However, the vocal fold vibration patterns for the two nonimplosive-sounding speakers and the three implosive-sounding speakers differ a great deal. In addition to evidence for biliabial implosives, there are large differences in the percentage of stop closure that displays vocal fold vibration. Both of these factors merit further study in terms of their social distribution in English, which is not known for implosion.

KEYWORDS: Western US dialect, implosive, phonetics, stop voicing

THE BULK OF THE RESEARCH on English dialects focuses on vowels, which is not surprising since a great deal of the variation in English resides in vowels. There are, of course, thoroughly researched variations in English consonants, such as rhotic deletion and *t*-tapping (e.g., Wells 1982). Another variation in consonants, which has been reported only anecdotally, is the class of implosive voiced stops. For example, Ladefoged and Johnson (2015, 148) note that Carl Sagan seems to use a voiced bilabial implosive to emphasize the phrase "billions and billions." In like manner, Stewart (1971, 48) observed the existence of voiced implosives in African American Vernacular English, while Stahlke (n.d.) reports implosives in Nebraska, Oklahoma, North Carolina, and Mississippi. We have observed these consonants in the

American Speech, Vol. 92, No. 1, February 2017 DOI 10.1215/00031283-4153197

speech of rural, blue-collar Westerners, which is why we have dubbed this phenomenon "the cowboy B."

Surprisingly, there are not more references to implosives in the phonetic or variationist literature given their apparently wide distribution in the world's languages. The lack of evidence in the literature may exist because researchers have not been seeking them out, or because they have not yet been associated with sociolinguistic variables, or because clear acoustic characteristics of implosives are difficult to register spectrographically; that is, incipient implosion in stops may be hard to identify. The implosive quality of a stop is best documented by measuring intraoral pressure. However, to test intraoral pressure for [ɓ], the speaker must be in the speech laboratory, wear a mask, and speak with a tube placed between the lips. There are practical problems when seeking to observe implosives that appear in conversations. We tested one speaker in the lab under these circumstances. Outside the lab, the speaker appeared to use the bilabial implosive [ɓ] in casual speech, but once inside of the lab, he became [ɓ] self-conscious and consequently did not produce a single implosive. This laboratory atmosphere and necessary recording apparatus likely inhibit natural speech, the kind needed to determine the social and linguistic factors that may govern the use of implosives.

Stahlke (n.d.) provides some other anecdotal evidence regarding the social and pragmatic aspects of voiced implosives in American English—namely, its prevalence among men, among the working class, and in emphatic contexts. This suggests that implosives (with measureable durations of vocal fold vibration) may constitute an unanalyzed sociolinguistic dimension of American English. What holds this research back, however, is the lack of a method outside of the laboratory to identify implosives in recordings of spontaneous speech.

The present article is an initial foray into this question, how to identify potential implosives in acoustic data. We begin by examining the acoustic properties of voiced implosive stops visible on a spectrogram. We then describe our method for eliciting instances of bilabial stops from the speech of five speakers. Our goal is two-fold: first, to document the existence of voiced bilabial implosives in American English, and second, to examine other salient characteristics of voiced bilabial stops that correlate with the auditory impression of stop implosion with the hopes that future sociolinguistic studies of American English will include those characteristics.

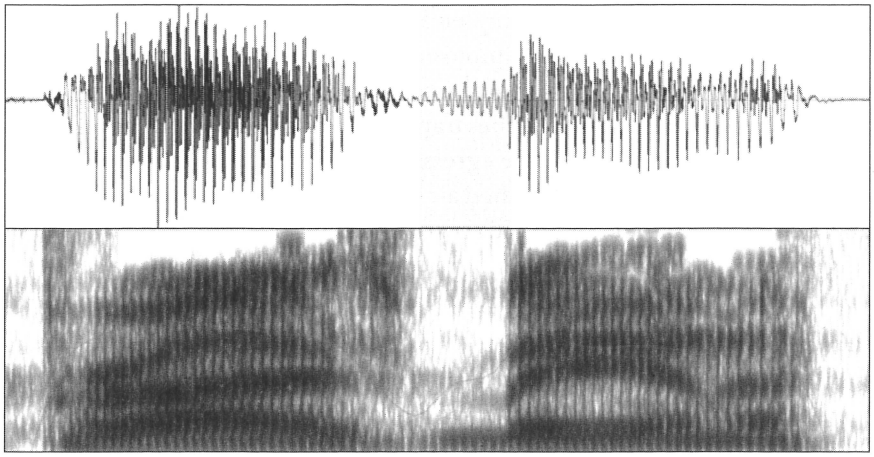
CHARACTERISTICS OF IMPLOSIVES

Oral stops in English result from a pulmonic egressive gesture with closed oral and nasal cavities and by completely blocking the egressive airflow during this closure phase. Bilabial implosives are a class of stops produced by simultaneously closing off the vocal tract at the glottis and at the lips. The glottis is then lowered, which rarifies trapped interoral air. When the anterior closure at the lips is released, the egressive airflow from the lungs meets the ingressive flow caused by the rarified air trapped between the lips and glottis. These two opposing flows can either cancel each other out, resulting in no outgoing airflow or create a slight ingressive airflow. Phoneticians have noted a number of clues to voiced implosives. One indication has to do with vocal fold vibration. In general, the vocal fold vibration of a voiced stop tends not to last throughout the entire duration of the stop in English, as opposed to that in Thai and French. For English speakers, no effort is made to sustain vocal fold vibration for a voiced plosive. In implosives, on the other hand, the lowering of the larnyx creates a larger oral cavity, which allows vocal fold vibration to be maintained during the entire closure. Another clue to implosion is often amplitude, since it will often increase toward the end of an implosive stop or at least remain constant (Lindau 1984).

A number of researchers have observed that the initial pitch of a vowel following an implosive is higher at the onset of that vowel than it is in the rest of the vowel (Ohala 1976; Chavez-Peon 2005). This elevated pitch, or increased rate of vocal fold vibration, may result because, during the production of an implosive, the lowered larynx causes more air to flow through the glottis, hence increasing the vocal fold vibration rate and producing a noticeably higher pitch. However, Hombert (1978, 91) believes that this would change the pitch of the stop only, not the following vowel. In the SiSwati language, a raised pitch following voiced implosives was not observed (Wright and Shryock 1993). In short, this characteristic is debated and not a necessary part of the set of functions we employ for determining implosion in the set of recordings reported here.

Ohala and Riordan (1979) measured how long a speaker can maintain vocal fold vibration in a stop. In their study, the vibration in bilabial stops could be maintained for only about 82 ms. However, when the larnyx is lowered, as occurs in implosives, vocal fold vibration can be extended. Therefore, a stop with vocal fold vibration lasting 83 ms or longer is a good candidate for an implosive because some articulatory compensation must have been made by the speaker. To maintain vocal fold pulsing, of course, cheek puffing, tongue lowering, and advancing the tongue root by the speaker may also allow vocal

FIGURE 1
Bilabial Implosive in *being* [🔊]



[p ɹ ˑ a: z ɓ i ɪ n ə]

fold vibration to be prolonged in the absence of implosivity. Additionally, individual differences in vocal tract length mean that it is impossible to set a universal limit to vocal fold vibration length. However, for this exploratory study, we will assume a 82-ms cutoff for the sake of simplicity while recognizing that a certain degree of variance is to be expected. The waveform in figure 1 comes from the phrase "the USS Enterprise being attacked," as spoken by Baxter Black ("Thanks, Grampa Tommy, for Saving the World," *Morning Edition*, NPR, May 25, 2009). A number of characteristics point to an implosive pronunciation: the vocal chords in the bilabial in *being* are fully vibrating throughout the plosive closure, as observable in the waveform (highlighted by the shaded region in figure 1); the amplitude of the signal in the stop closure increases over the stop closure duration; and, in this case, the closure duration is 82.5 ms long. All of these aspects suggest that we are dealing with an instance of [ɓ]. We will consider these characteristics in the [ɓ] speech of speakers of a Western variety of U.S. English.

PARTICIPANTS

Our participants are all males over the age of 50 and are all born and raised in the Western United States (see table 1). We chose two participants who, according to our impressionistic observation, used no implosive bilabials,

TABLE 1
Participants

Participant	*Age*	*Education*	*Occupation*	*State*	*Impression*
Baxter Black	71	Ph.D.	radio personality	N.M.	Implosives
Ron	61	H.S.	trucker	Utah	Implosives
Jon	60	B.A.	high school counselor	Utah	Implosives
Lon	58	Ph.D.	college professor	Utah	No implosives
Don	53	Ph.D.	college professor	Utah	No implosives

and three that seemed to pronounce bilabials with vocal fold vibration as implosives. One speaker in the implosive group, Baxter Black, is a well-known radio personality on National Public Radio who bills himself as a former large animal veterinarian and cowboy poet. He was born in New York but was raised in New Mexico. He was included in our sample because it was his speech that made us first aware of possible implosives in "cowboy" speech. In addition, his radio spots are freely available to other researchers, in contrast with those of the other participants whose Institutional Review Board consent does not permit the public release of their recordings.

METHOD

With the exception of Baxter Black, each participant read the 27 sentences that appear in the appendix (e.g., "It's a bad habit"). The sentences contain 83 instances of voiced bilabial plosives. For Baxter Black, 129 tokens were taken from his archived radio broadcasts (http://www.npr.org/series/4465029/cowboy-poet). We used Praat to perform spectrographic analysis. The increase in amplitude seen in figure 1 is actually exceptional in the data we obtained. We were disappointed to find that very few tokens from the speakers we examined show an increase in amplitude. Instead, most tokens with vocal fold vibration either maintain a stable amplitude or have a falling amplitude during the closed phase of the stop. For this reason, we did not include an amplitude variable and instead measured the length of each stop closure, from onset of closure to the initiation of voicing of the following phone (whether it appeared in a stressed or stressless syllable), the percentage of each stop closure that displayed vocal fold vibration, and the relative length of the closure of each stop.

The relative length of the consonant closure was calculated by measuring the duration of a five-syllable window that included the stop in question. When possible, the stop appeared in the middle of that five-syllable window.

The resulting duration was divided by the number of segments in the five-syllable window to yield a mean segment duration. The relative length of a stop closure is the actual length of the stop closure divided by the mean segment duration. This was calculated to normalize stop closure lengths in utterances of different speech speeds.

Stops that were mispronounced or realized as approximants were excluded from the analysis, thus removing 19% of the data for the four Utah speakers. All of Baxter Black's 129 tokens were selected because they were clearly articulated stops.

RESULTS

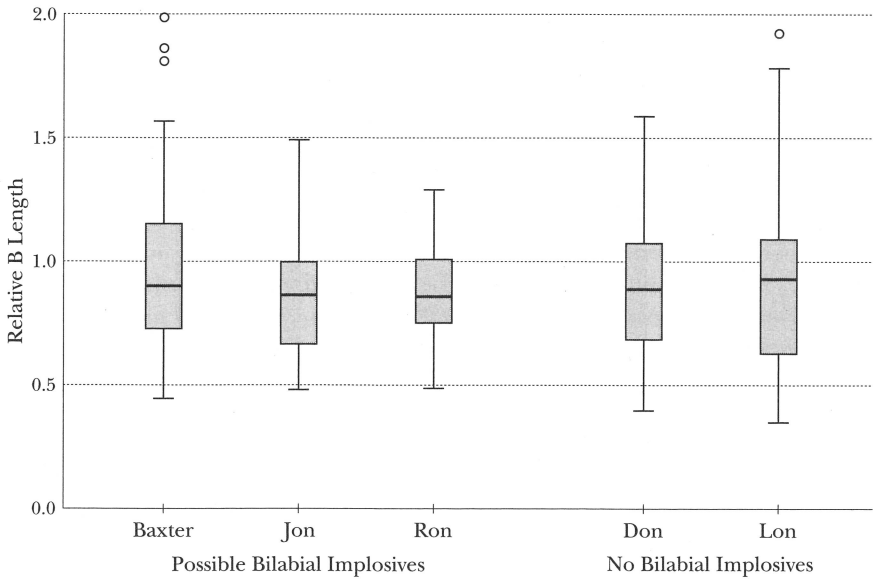
STOPS WITH FULL VIBRATION LONGER THAN 82 MS. The first notable finding is the existence of stops with full vocal fold vibration during the stop closure with a duration of 83 ms or longer; 50% of Ron's biliabial stops, 37% of Baxter's, and 19% of Jon's fall into this category. These percentages suggest that the participants made an adaptive gesture, such as lowering their glottis in order to achieve these long vocal fold vibration durations; we cannot discount the possibility that other articulatory adjustments may have achieved this as well. As far as cheek puffing is concerned, we did not observe it in our live participants. Of the four participants, Ron was the slowest speaker, which probably accounts for his producing more long stops. His mean segment duration was 105 ms, while Baxter's, Don's, Jon's, and Lon's were 86, 74, 86, and 87, respectively. In contrast, Lon produced only two bilabial stops with vibration throughout, and Don only produced four of these stops, none of which were longer than 83 ms. This is important to note because, in comparison with the other three participants, Don and Lon did not appear to have implosives from an impressionistic standpoint.

The fact that we document vocal fold vibration durations of 83 ms and longer during the stop closure durations is evidence that those particular stops may be implosive or reflect incipient implosion. What about shorter stops with complete vocal fold vibration? Of course, implosives may be of any duration, but with the kind of spectrographic evidence we considered, we can only be sure that the longer ones are the closest to sharing features of implosives found in other languages. Nevertheless, we assume that many of the stops with shorter closure duration have other implosive-like characteristics as well, but we have no way to verify their implosive status.

RELATIVE STOP DURATION. In addition to documenting implosives in American English, another goal of the present study is to find other characteristics that distinguish speakers whose speech appears to contain implosives from speakers whose speech does not. In the way of reminder, Baxter, Ron, and Jon appear to have implosives, while Don and Lon do not. One possible difference is the length of closure of the bilabial stops with vocal fold vibration. Since speech rates varied among the participants, absolute stop duration would not be a useful measure of comparison. Relative duration was used instead. As figure 2 illustrates, the relative durations do not vary much between participants. A mixed-effects analysis with random intercepts for participant shows no significant different between participants ($F_{4;280.095} = 1.734$; $p = .143$). Including random intercepts for test word yielded a statistical model that did not converge.

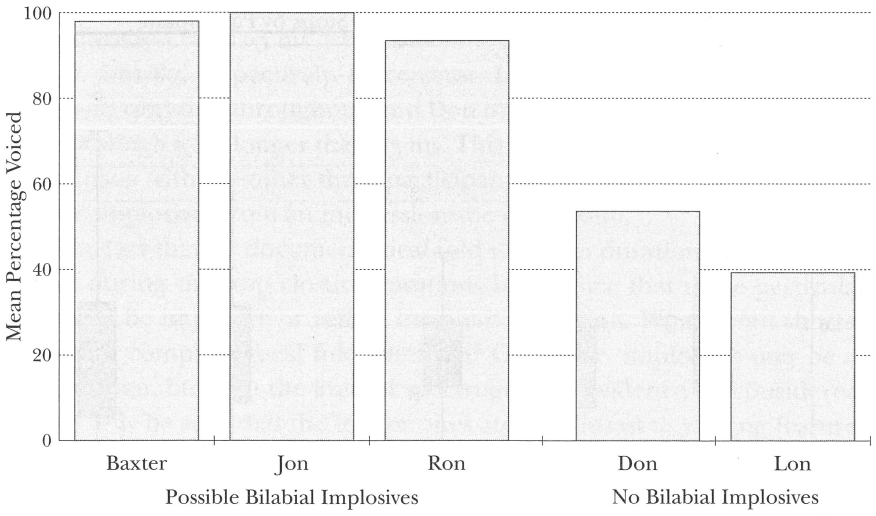
MEAN PERCENTAGE OF STOP VOCAL FOLD VIBRATION. Another possible difference we investigated was how much of each stop closure had vocal fold vibration. The initial stop closure in a word such as *boy* can range from being completely lacking in vocal fold vibration to being completely full of vocal fold vibration. It is common in English for vocal chords in voiced stops to be vibrating in the early stages of their closure, but to lack pulsing toward the

FIGURE 2
Relative Duration of Voiced Bilabial Stops by Participant



end of closure, that is, just before the oral release. Does our impressionistic grouping of participants into those who do and do not have implosives coincide with how much each participant pulses his vocal cords for labial stops? The mean percentage of vocal chord pulsing for each participant appears in figure 3. Baxter, Ron, and Jon clearly contrast with Don and Lon (98%, 93%, and 99% versus 53% and 39%, respectively). A mixed-effects analysis with random intercepts for test word shows a significant different between participants ($F_{4;293.544} = 177.480$; $p = .0005$). Including random intercepts for participants yielded a statistical model that did not converge. A least significant difference test of these data supports what the graph in figure 3 illustrates; there are no significant differences ($p < .01$) between Baxter, Jon and Ron's mean percentage of vocal fold vibration in the stop closure. In contrast, Baxter, Jon, and Ron's vocal fold vibration is significantly different ($p < .0005$) from Lon and Don's pattern of stop closure vocal fold vibration. Therefore, we conclude that speakers whose vocal chords in stop closures are almost always completely vibrating give the listener the impression that their labial stops are implosive.

FIGURE 3
Mean Percentage That Vocal Folds of Stops Were Vibrating by Participant



CONCLUSIONS

Anecdotal evidence suggests the existence of implosive labial stops in American English, but to our knowledge, phonetic collaboration has not been documented. This may be due principally to the inherent difficulty of measuring interoral air pressure (particularly when examining recordings well after the fact, as in archival recordings), as well as the lack of clear cues of ingressive airflow afforded by spectrograms. The present study focuses on bilabial implosives. We contrasted three men who sound as if they produce implosives with two that do not.

Vocal fold vibration of stops cannot be maintained for long periods of time without expanding the vocal tract in some way. Implosives result when this is achieved by lowering the glottis. In the present study, we assumed that fully voiced stops longer than 82 ms are likely to be implosives, although we realize that individuals may differ in how long they maintain vocal fold vibration, and 82 ms is merely a heuristic cutoff based on previous research. The possibility of other methods of expanding the vocal tract besides glottal lowering cannot be eliminated by our methodology. Nevertheless, the three apparent implosive producing participants, but none by the two apparent nonimplosive pronouncing participants, produced a good number of sufficiently long bilabial stops with vibrating vocal folds throughout. We present this as possible evidence for implosives in American English. No difference was found between the speakers in the duration of their bilabial stops with vocal chord vibration when stop duration was normalized to take speech rate into account.

Perhaps the most telling difference between the two groups whose pronunciation of /b/ is impressionistically different is how much of the stop closure actually has vocal fold vibration. Speakers who gave the impression of producing implosives tended to maintain vocal fold vibration throughout a much greater portion of the stop (93–99%). The other speakers only vibrated the vocal chords in the stop during about 39% and 53% of the stop closure. Therefore, the most revealing finding of our study may be this: there is an impressionistic difference in the speech of certain people in regards to their pronunciation of /b/. Some speakers pronounce this phone with vocal fold vibration through the greater portion of the closure, while others do so in a much smaller portion of the stop. In and of itself, vocal fold vibration duration in onset position is a variable that needs to be investigated in terms of how it varies along social variables, such as age, gender, region, class, and so on. The present study is exploratory in nature and included only a small

number of participants. However, there are a number of avenues that future research into this topic needs to address, which will necessitate much larger and more socially diverse sets of participants. Not only should investigation be extended to include voiced alveolar and velar stops, but more direct measures of interoral air pressure are needed in order to conclusively verify the existence of implosive stops in American English.

APPENDIX
Elicitation Sentences

1. About ten rocks flew by his head, so he bolted to the door.
2. The best kind to buy is Texas T-bone.
3. The cowboys knew it from the beginning.
4. It's a bad habit.
5. Bob and his friends were ready for the beer.
6. He was sitting on the bed with my brother Bob and the big dog.
7. Bobby chased the rabbit into the hole then placed a marker above it.
8. They found it on the bottom of an ancient rowboat.
9. He abandoned his rebellious life for the stability of a job in the Ebay district.
10. It's on the back side of the Bear River range.
11. We both accepted it right off the bat.
12. Her hubby had a bald head.
13. His ability to rob and cheat was legendary.
14. I could probably read it now, but no book is going to change my mind about what happened.
15. Soybeans aren't served at a barbecue.
16. Who Bill chooses to bail out is none of my business.
17. In Israel, stabbings go up on the Sabbath, but robbings go down.
18. It was the responsibility of the inhabitants to be on time.
19. The popularity of the exhibit rebounded after Cuba refused to show it.
20. Ruby's job is to probe into abuse by the rebellious factions.
21. The Arab on the plane going to Lebanon was Rebecca's cousin.
22. A bottle of champagne and some tobacco cost them $10 in import taxes.
23. The story was about a babysitter who became a pop star.
24. The Tribune reported a story about the hobbies of Nobel Prize winners.
25. They rode into battle with computers and robots.
26. A pair of robins kept abusing the big cow stuck in the bog.
27. There was no basis for opposing the law, but the lobbyists still saw billions in revenue.

NOTE

We are indebted to Ryan Shosted, Caroline Smith, and John Ohala for guiding us to the literature on implosives

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