

4aSC23 Variation in stop consonant voicing in two regional varieties of American English

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ABSTRACT

This study is an acoustic investigation of the nature and extent of consonant voicing of the stop /b/ in two dialectal varieties of American English spoken in south-central Wisconsin and western North Carolina. The stop /b/ occurred at the juncture of two words such as *small bids*, in a position between two voiced sonorants, i.e. the liquid /l/ and a vowel. Twenty women participated, ten representing the Wisconsin and the North Carolina variety, respectively. Significant dialectal differences were found in the voicing patterns. The Wisconsin stop closures were usually not fully voiced and terminated in a complete silence followed by a noisy and voiceless closure release whereas North Carolina speakers produced mostly fully voiced closures. Further dialectal differences included the proportion of closure voicing as a function of word emphasis. For WI speakers, the proportion of closure voicing was smallest when the word was emphasized and it was greatest in non-emphatic positions. For North Carolina speakers, the degree of word emphasis did not have an effect on the proportion of closure voicing. The results are discussed in terms of differences in the way voicing is maintained during the closure by the speakers of respective dialects.

INTRODUCTION

Conditions for voicing in voiced stop consonants are more favorable in the **intervocalic** position than in word-initial or word-final positions. The intervocalic position enhances the "articulatory ease" (Westbury & Keating 1986) which can facilitate continuous voicing through the oral closure of a single voiced stop (e.g., Westbury 1983). In intervocalic positions, speakers sustain the vibration of the vocal folds longer so that the low-frequency periodic energy lasts for an extended period of time of stop closure duration.

A voiced stop in the **intersonorant position** shares similar characteristics with the voiced stop in the intervocalic position. Glottal vibration can still continue during the stop closure especially if the volume of the vocal tract increases and the stop closure duration is short.

Systematic differences in the production of voicing patterns of voiced stops in intervocalic position were found for young children whose voiced stops are devoiced and do not have less closure voicing than adults (Kewley-Port & Preston 1974; Smith 1979). Koenig & Lucero (2008) found notable variation in the proportion of closure voicing in children: For the voiced stop /b/ in intervocalic position, the proportion of closure voicing increased over age so that it was 36% for the 5 year olds, 59% for the 10 year olds, and 64% for women.

Are there systematic differences in closure voicing related to different dialectal backgrounds of the speakers?

Impressionistic listening to speakers from western North Carolina (Appalachian English) has led to the observation that many bilabial stops /b/ are strongly pre-voiced and sound very sonorous, sometimes even slightly pre-nasalized. In contrast, the same stops in the production of Wisconsin speakers appeared weak and almost devoiced. Most importantly, these differences have been observed for the intersonorant position of the stop.

METHODS

Speakers: 10 women from south-central Wisconsin (Madison area) and 10 women from western North Carolina (Cullowhee area) aged 51-65 years.

Stimuli: 30 sentence pairs which contained the target words *bids/bids*, *bets/beds*, *bats/bads*, *bais/bades*, *bites/bides* (bVts/ and bVdz), where V was one of the following vowels: /i, e, a, u, ʌ/. The stop /b/ was produced between two voiced sonorants at the juncture of two words such as *small bids*, i.e. between the liquid /l/ and a vowel. These two words constituted an ad-noun phrase in which one would not expect a phrasal break. Prosodic variations were systematically introduced to create three levels of emphasis of the target: high, intermediate and low.

HIGH
Ted thinks the fall SALES are low.
Not Ted thinks the FALL BIDS are low.

INTERMEDIATE
Ted thinks the SPRING bids are low.
Not Ted thinks the FALL bids are low.

LOW
Ted thinks the fall bids are HIGH.
Not Ted thinks the fall BIDS are LOW.

Procedure: Recordings were controlled by a custom Matlab program. The participant read each sentence pair speaking into a head-mounted microphone placed approximately 1-inch distance from the lips. Sentences were recorded directly onto a hard drive at a sampling rate of 44.1 kHz.

Acoustic measurements: Acoustic locations were marked: stop closure onset, closure release, voicing offset during the stop closure, voicing onset for the vowel, word onset and word offset. Measurements were made by hand using Adobe Audition 1.0 Speech Analysis Program and entered into an Excel file. From these measurements the following variables were calculated: word duration, closure duration, proportion of closure duration to word duration, duration of voicing during closure, proportion of voicing in closure, VOT and frequency of occurrence of complete voicing through closure in the whole data set.

Statistical analysis: Repeated-measures ANOVAs were conducted on each variable. The within-subject factors were final consonant in the word (/ts/ or /dz/), emphasis position (high, intermediate, low) and vowel. Dialect was the between-subject factor.

1 Waveforms of the stop closure

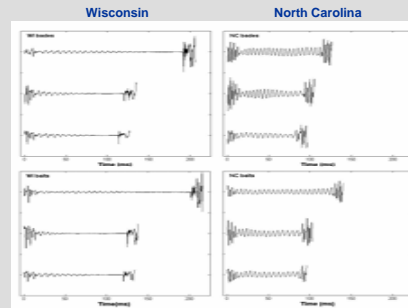


Figure 1. Waveforms of closures of the stop /b/ in the words *bades* and *bats* produced by a 55-year old female Wisconsin speaker and a 59-year old female North Carolina speaker. The waveform displays include closures for each emphasis position examined here (high, intem, low). All NC closures are fully voiced whereas WI closures begin with a period of voicing which ceases gradually and the closure terminates in a complete silence. There is a clearly marked release burst for this particular WI speaker.

2 Duration of closure voicing

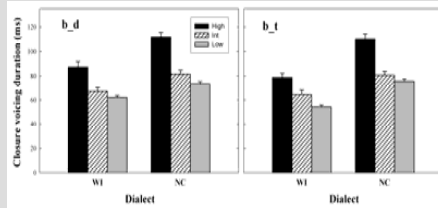


Figure 2. Mean closure voicing duration for WI and NC speakers as a function of word emphasis.

The main effect of **dialect** was significant ($F(1, 18) = 6.43, p = 0.021, \eta^2 = 0.263$); mean closure voicing duration for WI speakers was shorter than for NC speakers (69 vs. 89 ms).

The effect of **final consonant** in the word (either /dz/ or /ts/) was also significant ($F(1, 18) = 9.34, p = 0.007, \eta^2 = 0.342$); the voicing portion of the closure was shorter in *b_{ts}* words as compared to *b_{dz}* words.

The effect of **word emphasis** was significant ($F(1, 18, 31.8) = 27, p < 0.001, \eta^2 = 0.600$); the extent of voicing was greatest in high emphasis position, followed by intermediate and low, respectively.

There was a significant interaction between the **final consonant** and **dialect**; voicing duration was shorter in *b_{ts}* than in *b_{dz}* words for WI speakers (66 vs. 72 ms) but not for NC speakers (both 89 ms).

3 Proportion of closure voicing

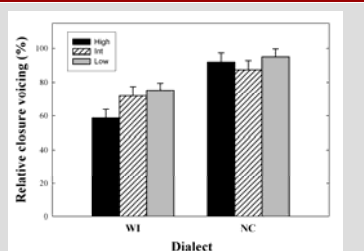


Figure 3. Proportion of voicing in closure as a function of word emphasis and dialect.

The main effect of **dialect** was significant ($F(1, 18) = 18.1, p < 0.001, \eta^2 = 0.501$); proportion of voicing was smaller for WI speakers than for NC speakers (67 vs. 92%), indicating that NC variant of /b/ is almost entirely voiced during the stop closure.

As can be seen, there are clear dialectal differences in the proportion of closure voicing. For WI speakers, there is a relationship between the length of the closure and the proportion of voicing: The shorter the closure duration, the greater the proportion of voicing in closure. For NC speakers, there is no such relationship and the closure is almost entirely voiced regardless of the variation in closure duration.

4 Closure duration and proportion of closure voicing

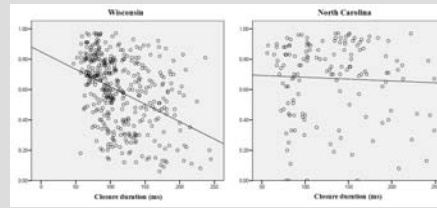


Figure 4. A regression between the proportion of voicing in closure and closure duration for Wisconsin and North Carolina speakers.

Dialectal differences were found in the relationship between the closure duration and the proportion of closure voicing.

Wisconsin: As closure duration increases (as a function of either word emphasis or the word-final voiceless consonant cluster), the proportion of voicing in closure decreases. Linear regression analysis indicated that closure duration was a significant predictor of proportion of closure voicing ($r^2 = 0.176, p < 0.001$).

North Carolina: The variation in closure duration has no effect on the proportion of closure voicing. The NC closures could be fully voiced even if the closure was long such as in highly emphasized words. Linear regression analysis showed that closure duration was not a significant predictor of Prop VC for NC speakers as indicated by an almost straight regression line fitted to the data ($r^2 = 0.002, p = 0.582$).

DISCUSSION

The results supported the impressionistic perception that North Carolina speakers seem to produce more sonorous variants of voiced stops as compared to Wisconsin speakers.

The results for Wisconsin are consistent with the predictions stemming from the model of the breath-stream control mechanism (Westbury & Keating 1986) which suggests that a stop occurring in the intervocalic position should naturally be largely voiced if its closure is short. However, the data from North Carolina speakers cannot easily be explained by this model: the NC closures can be fully voiced even if their durations are long.

Closure differences

In general, we found Wisconsin speakers producing stops with longer closures despite shorter durations of their words. The closure duration differences were greatest (and the closures themselves were longest) when the word received high emphasis and tended to diminish with each position of lower emphasis. Considering the proportion of closure-to-word duration, the WI speakers showed a pattern which was absent in NC productions: The proportion of closure-to-word duration was greater for words terminating in voiceless consonants than in voiced.

Voicing differences

The WI closures were usually not fully voiced and the average voicing portion of the closure did not last longer than 67% of its duration, which terminated in a complete silence followed by a closure release. Produced by NC speakers, the proportion of closure voicing was much higher, reaching an average of 92%. For WI speakers, words in high emphatic positions had the smallest proportion of closure voicing whereas the non-emphatic positions yielded the greatest proportion. For NC speakers, the same variation in closure length did not have an effect on the proportion of closure voicing.

The most dramatic dialectal difference is the number of closures that were fully voiced. The majority of the fully voiced closures in the present sample were produced by North Carolina speakers. For Wisconsin speakers, the fully voiced closures were sparse and occurred mostly in the non-emphatic positions.

The NC speakers demonstrated a different way of maintaining voicing during the stop closure. The closures were mostly fully voiced and the proportion of voicing during the closure was generally not sensitive to the variation in closure duration as a function of word emphasis. In addition, the energetic closure release was not present in NC productions as it was the case in WI productions.

We interpret these results as an indication of dialectal differences in the way voicing is maintained during the stop closure. It appears that NC speakers were able to maintain transglottal pressure during the stop closure by additional articulatory maneuvers, most likely by lowering the velum and venting the air through the nose. It is the case that Appalachian speech has long been described (and stereotyped) as having at least some degree of nasality present even in words that have no nasal segments (the so called "nasal twang"). Although we did not complete an acoustic analysis of the presence of nasalization in these Appalachian speakers, we were able to detect at least some degree of a "nasal twang" in their recorded speech samples.

Further research

The current findings should be explored in future research. There are limited resources regarding the effects of dialect on stop consonant voicing. Other variables of interest would be the effects of age and gender. It will be instructive to determine whether these dialectal patterns are maintained in unconstrained informal speech.

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