# OBSTRUENT DEVOICING AND REGISTROGENESIS IN CHRU

Marc Brunelle[1], Tạ Thành Tấn[2], James Kirby[3], Đinh Lư Giang[4]

[1,2] University of Ottawa, [3] University of Edinburgh, [4] Hồ Chí Minh City Un. of Social Sciences and Humanities
[1] mbrunell@uottawa.ca, [2] tta061@uottawa.ca, [3] j.kirby@ed.ac.uk, [4] lugiangdinh@gmail.com

## ABSTRACT

We describe the register system of Chru, a Chamic language of Vietnam. In Chru, a historical contrast between prevoiced and voiceless stops is now a system of two registers signalled by differences in f0, voice quality, and F1 in addition to closure voicing. However, closure voicing is in a state of flux: while older men maintain closure voicing in the onsets of low-register items, younger speakers and some older women frequently have no (or only weak) closure voicing in this context. In addition, the distribution of VOT in low register onsets is bimodal, realized either with strong closure voicing or greater VOT than voiceless stops. Interestingly, f0, F1 and voice quality cues are not enhanced after devoiced low-register stops, but instead are more pronounced after stops realized with closure voicing. We argue this indicates that enhancement of cues in phonologization must in some sense be complete before neutralization takes place.

**Keywords**: Chru, voicing, register, voice quality, phonologization

## 1. INTRODUCTION

Chru is a Chamic language spoken by 19,314 speakers in the highlands of southern Vietnam (Lâm Đồng and Ninh Thuận provinces) [5]. While it has been described as preserving the Proto-Chamic voicing contrast in onset stops [9, 20, 30, 35], Fuller [8:85] notes that it "seems to have a non-contrastive feature of register in which the vowel and sometimes the syllable has a lax, breathy quality or a tense, clear quality. Often the breathy quality is concomitant of length in the vowel and voicing in the syllable initial stop.". Consonants that have developed this so-called "breathy" register are italicized in Table 1. In fact, there is evidence that some speakers fully devoice voiced stops, as illustrated by the minimal pair /tuː/ 'bamboo joint' vs. /duː/ [duː ~ tṳː] 'equal'.

Register is a common type of phonological contrast that arose from the transphonologization of voicing in many Mon-Khmer and Chamic languages [8, 10, 13, 16]. In a typical register system, vowels following original voiceless stops preserve a relatively high f0, higher formants, and modal voice quality (the *high register*), while vowels following formerly voiced stops take on a lower f0 and a breathy voice quality, and start with lower formants (the *low register*). As Chru appears to have redundant voicing and register, it is an ideal test case to understand the phonetic underpinnings of registrogenesis.

**Table 1:** Chru consonants

| | | | | |
|---|---|---|---|---|
| p | t | c | k | ʔ |
| pʰ | tʰ | | kʰ | |
| *b* | *d* | *ɟ* | *g* | |
| ɓ | ɗ | | | |
| | s | | | h |
| m | n | ɲ | ŋ | |
| w | l, r | j | | |

The first question of interest here is the relationship between onset voicing and the low register at the early stages of registrogenesis. While it has long been established that f0 and F1 are lowered after voiced obstruents [14, 15, 27-29, 33, 34], the relationship between voiced stops and voice quality is less well understood, despite claims that breathiness is the primary cue in register development [22, 36].

The second question on which Chru could shed light is the relative importance of acoustic cues in phonologization. Models of phonologization typically predict that an enhancement of secondary properties (here, f0, voice quality and formants) is necessary prior to the loss of the primary one (here voicing) [17, 18]. However, as it has been shown that greater salience of a phonetic property is often accompanied by a lesser salience of redundant properties, one might also expect acoustic cue trading in situations where redundant cues coexist in a speech community [1, 7, 21, 32].

If Chru is indeed at a stage in which voicing and register are redundant, there could be individual variation in the community. Speakers who make more use of closure voicing (here understood as negative VOT) should also have a less developed register system, and vice-versa. Finally, we would expect the acoustic cues of register to still be mostly located at the onset of the vowel.

## 2. METHODS

Twenty-six speakers (15 female) were recorded in the villages of Điom A and Proh, in Đơn Dương district, Lâm Đồng province, Vietnam. They were all highly proficient in Vietnamese.

### 2.1. Experiment

Participants were recorded producing a wordlist composed of 60 real words containing target syllables made up of all possible coronal and velar onsets /t, d, ɗ, tʰ, s, n, l, r, k, g, kʰ, ŋ/ with the vowels /iː, ɛː, aː, ɔː, uː/. Target syllables were always stressed and in word-final position. In most words, an unstressed syllable preceded the target syllable (44/60). As we know that sonorants can be affected by register spreading in other Chamic languages, onset sonorants will only be reported if they are monosyllable-initial [12, 35].

Target words were recorded 4 times each in the frame sentence:

/kəw ɗəːm bɔh akʰaːr ___ təː saʔaːj paŋ/
*I say CLF word ___ for older.sibling hear*
"I say the word ___ for you".

Participants heard the words in Vietnamese and had to translate and produce them in the frame sentence (there is no principled reason to expect interference). Data was acquired with a Beyerdynamic 55.18 Mk II microphone connected to a Marantz PMD-660 digital recorder.

### 2.2. Data processing and analysis

Annotation of the 6,119 target syllables was done out in Praat [2]. For stops, the beginning of the closure, the release and the onset of voicing were marked. The beginning and end of sonorants and vowels were also annotated. Measurements were obtained with PraatSauce, a Praat-based application for spectral measures based on VoiceSauce [23, 31].

Measurements of f0, F1, F2 and H1-H2 were also obtained at every 1 ms of the target vowel. 25 ms measurement windows were used, which means that the initial and final 12 sampling points of vowels had to be dropped. Files with tracking errors over more than a fifth of their duration were not used (6.5% of the files). Individual f0 and formant measures were also excluded if they differed from the 10 closest measures by more than 2 standard deviations.

We corrected H1-H2 measures (hence H1*-H2*) for formant frequencies and bandwidths [11, 19]. All measures were then z-normalized by speaker. To ensure readability, z-scores were converted back to familiar scales based on means and standard deviations obtained from the entire data set.

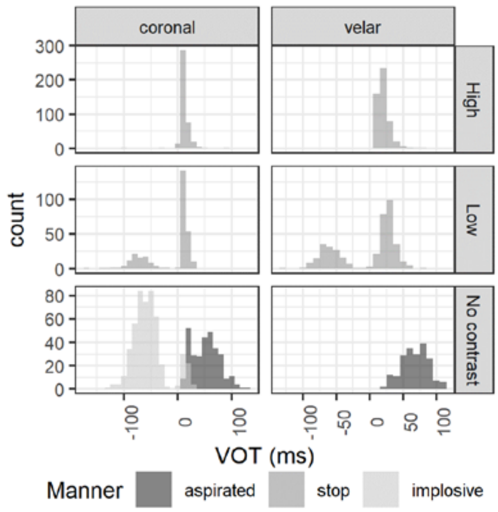
Meaningful differences were tested with mixed models using the R package lmerTest [26]. Dependant variables will be indicated where relevant. Unless indicated otherwise, *register*, *place* and *vowel* were used as fixed factors. Random effects included random intercepts for *subject* and *word*, but no random slopes, as models including slopes did not converge.

## 3. RESULTS

### 3.1 Obstruents

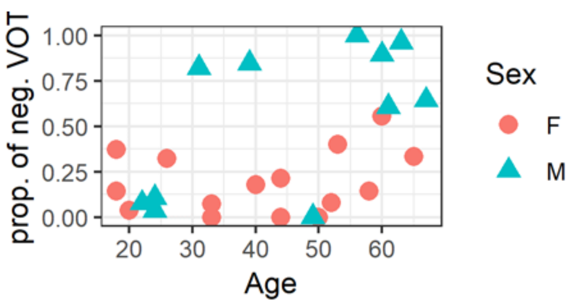
As shown in Fig. 1, results reveal that aspirated stops have a strong positive VOT while implosives have a strong negative one (implosives with a positive VOT are all instances of the word /ɗuː/, which is a proper name used in a legend that may not have been familiar to all speakers). Plain stops have a short VOT in the high register, but are split into two groups in the low register. They can either be realized with a negative VOT or with a positive VOT that is slightly longer than that of voiceless stops. Low register stops with a positive VOT are slightly more aspirated than high register stops (+5.5 ms, t=3.3), but this effect is entirely attributable to velars.

**Figure 1:** Stop VOT, by place and register




This variation in the realization of low register plain stops seems socially structured, as shown in Fig. 2. Older men appear to have a higher proportion of stops with closure voicing, but the effect is weak (a linear model with age and sex as predictors yields an estimate of 0.012 for Male*Age, p = 0.08).

**Figure 2**: Proportion of low register plain stops with negative VOT

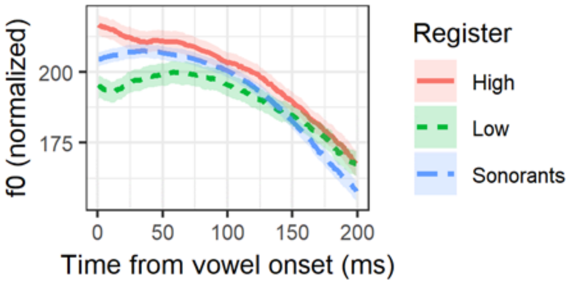


Closure duration is significantly shorter in low than in high register plain velar stops (-39 ms, t = 2.5), but not in coronals.

### 3.2 Vowels

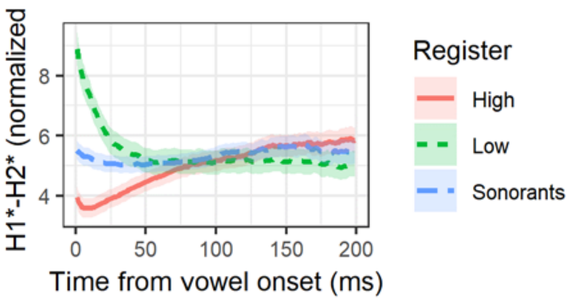
No significant difference in vowel duration was found after high and low register plain stops, but f0, voice quality and vowel quality seem to distinguish registers in a typical manner. As shown in Fig. 3, there is a difference in f0 at vowel onset after high and low register stops (this difference is significant for most, but not all, combinations of vowels and places). This difference disappears after about 75 ms. Sonorants pattern a bit closer to high register stops than to low register stops.

**Figure 3:** Mean f0 in the first 200 ms following low and high register plain stops (sonorants given as reference). Shading: 95% CI.



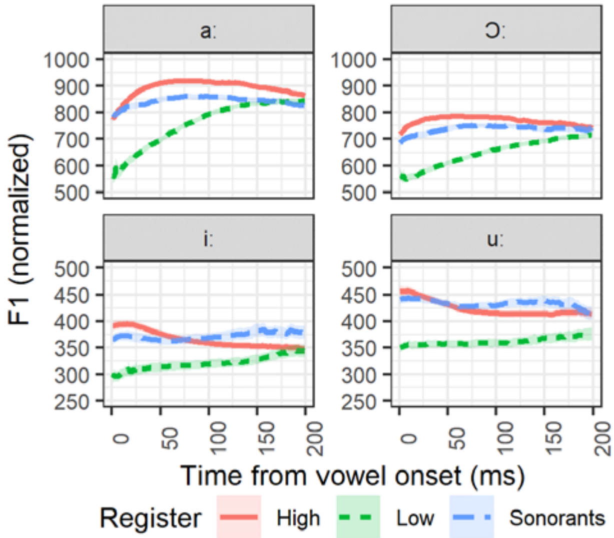

A similar difference is found for H1*-H2* in Fig. 4. Vowels following low register plain stops have a much higher H1*-H2* (i.e. are breathier) than their voiceless counterparts. This difference is significant in all combinations of vowels and places of articulations, except for /iː/ after velars and is maintained for approximately the first 50 ms of the vowel. Sonorants seem a bit closer to high than low register stops.

**Figure 4:** Mean H1*-H2* in the first 200 ms following low and high register plain stops (sonorants given as reference). Shading: 95% CI.




In Fig. 5, we see that F1 is much lower at the beginning of vowels following low than high register stops (significant for all vowels and places of articulation). This difference persists for 200-250 ms, depending on the vowel, which is a much greater temporal extent compared to other cues. Again, sonorants are much closer to high register stops than low register ones. As no significant effect was found across vowels for F2, it is not reported here.

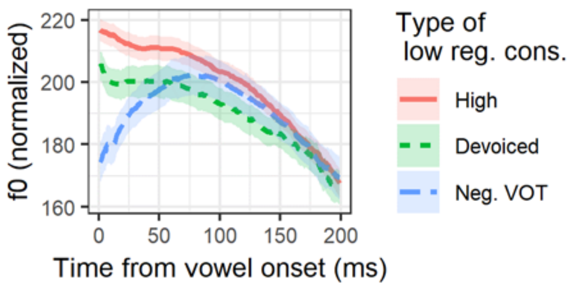
**Figure 5:** Mean F1 in the first 200 ms following low and high register plain stops (sonorants given as reference; as there is no low register /ɛː/ in the dataset, this vowel is excluded). Shading: 95% CI.




### 3.3. Acoustic cue trading

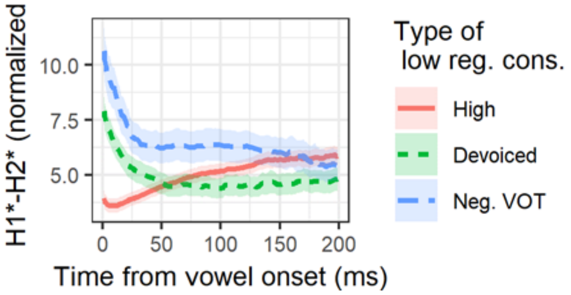
A comparison of fully devoiced low register stops with those that maintain a negative VOT reveals that the former are closer to the high register. In Fig. 6, devoiced low register stops have a higher f0 than those with negative VOT (significant for all vowels and places, except /ɔː/ after coronals).

**Figure 6:** Mean f0 in the first 200 ms following negative VOT and devoiced low register stops (high voice stops given as a reference). Shading: 95% CI.




In Fig. 7, the H1*-H2* after devoiced low register stops is also closer to high register stops, but the difference is only significant in high vowels following velars.

**Figure 7:** Mean H1*-H2* in the first 200 ms following negative VOT and devoiced low register stops (high register stops given as a reference). Shading: 95% CI.




There are too few tokens of low register stops with negative VOT in each vowel category to report formant results, but visual inspection does not indicate any difference between negative VOT and devoiced tokens.

To sum up, it can be safely claimed that there is no acoustic cue trading between voicing and register cues. In fact, results partly pattern in the opposite direction, as low register tokens with negative VOT have a lower f0 and tend to be breathier.

## 4. DISCUSSION

The results presented here confirm Fuller's claim that Chru has register. The acoustic cues of register are typical of languages of the area: H1*-H2* and F1 best distinguish the two registers, while f0 seems to play a real, but more limited role in the contrast. As expected in a conservative register system, these acoustic properties are maximally different at vowel onset, but the F1 difference is maintained for as long as 200-250 ms. F2 and vowel duration do not seem to be associated with register.

However, contrary to what was proposed by Fuller in the 1970s, register no longer seems to be fully redundant with voicing. Voiced stops are now mostly realized with a positive VOT by a majority of participants in our sample. This VOT is a bit longer than that of high-register stops in velars (+5.5 ms), but the small size of this effect and the lack of any difference in coronals would argue for a neutralization of the voicing contrast. Whether the more frequent preservation of voicing by older men indicates that change has taken place since the 1970s or that there is a stable, structured variation in the community is not a question we can answer with our limited sample.

As Chru seems to be a conservative register language, the strong difference in breathiness (H1*-H2*) associated with the register contrast could be interpreted as a confirmation of Thurgood's claim that voice quality is central in initial stages of registrogenesis [36]. However, as F1 and f0 are highly correlated with register even in tokens that have not undergone devoicing, it cannot be proved that voice quality causes the f0 and formant differences. Moreover, F1 differences endure much longer in the vowel than H1*-H2* differences, which suggests that these acoustic properties may not be produced by the same gesture.

Our results also show that there is no clear trading relation between voicing and vocalic cues. Low register stops realized with a positive VOT do not have more distinct register differences than their "truly voiced" counterparts. In fact, f0 and, to a more limited extent, voice quality differences seem greater after voiced than devoiced stops. There is no space for a full demonstration here, but this generalization even appears to hold on a speaker-by-speaker basis. Participants who systematically realize voicing seem to have more salient register differences than speakers who devoice consistently. This suggests that the realization of phonetic voicing is directly affecting register cues, and that its loss reduces acoustic differences between registers. As far as we know, no acoustic effect can explain this correlation between closure voicing and register cues, but it has been proposed that a lowering of the larynx during voicing could indirectly be responsible for it [3, 4, 36]. We do not have direct evidence about the vertical movement of the larynx, but the fact that the acoustic properties of vowels following sonorants are closer to the voiceless/high register than to the voiced/low register series would be consistent with an explanation involving more than mere vocal fold vibration.

Chru is at a diachronic stage where register is present in all speakers and has taken over the contrastive role of voicing, which is now optional and fully redundant (this is similar to recent results on the phonologization of f0 in Afrikaans [6]). That even the speakers that preserve closure voicing have exaggerated register cues (at the very least F1 and H1*-H2*), rather than the small precursor effects typically found in true voicing languages, suggests that, as argued by Hyman, the enhancement of automatic phonetic effects occurs before the loss of the primary cue [17, 18, 24, 25].

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