CHRAU REGISTER AND THE TRANSPHONOLOGIZATION OF VOICING

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ABSTRACT

Chrau, a Mon-Khmer language of southern Vietnam, has been described as preserving a voicing contrast in onset stops. Instead of voicing, closely related languages have a register contrast in which voiced and voiceless stops have respectively evolved into breathy and modal registers.

Unexpectedly, the Chrau dialect investigated in this paper has a register system based on f0, voice quality and vowel quality, just like its sister languages. However, onset stop voicing is not fully neutralized: stops have a short positive VOT in the modal register, but in the breathy register, they either have closure voicing or a VOT slightly longer than modal register stops. There is no evidence for an acoustic trade-off between voicing and register cues. The preservation of VOT differences in onset stops suggests that Chrau has a conservative register system. We discuss how the cooccurrence of VOT and register cues sheds light on models of registrogenesis.

Keywords: Chrau, phonologization, voicing, VOT, Mon-Khmer register

1. INTRODUCTION

Chrau is a Mon-Khmer language of the South Bahnaric branch spoken by about 26,885 people in the provinces of Đồng Nai, Bà Rịa-Vũng Tàu and Bình Thuận, in southern Vietnam [1]. Most Bahnaric languages have lost the Proto-Mon-Khmer voicing contrast in onset stops and have replaced it with a register distinction, i.e. a two-way phonological contrast realized on vowels by means of a bundle of acoustic properties such as f0, vowel quality and voice quality [2, 3, 5, 7, 10, 21]. Chrau seems different in that it has been described as preserving a voicing contrast in onset stops and has not been reported as having a register system [24, 25, 28].

In this paper, we investigate a Chrau dialect spoken near Bà Rịa and show that contrary to expectations, it has a full-fledged register system. The contrast between the two registers can be illustrated with the minimal pair /tiː/ ‘hand’ vs. /ti̤ː/ ‘ordinal marker’. We will call the registers that have developed from voiceless and voiced obstruents *modal* and *breathy* respectively; this does not entail that voice quality is primary. Impressionistically, the Chrau dialect described here seems relatively conservative as breathy register stops can optionally be voiced (italicized in Table 1).

Table 1: Chrau consonants

p	t	c	k	ʔ
pʰ	tʰ	cʰ	kʰ	
b/p̤	*d/t̤*	*ɟ/c̤*	*g/k̤*	
ɓ	ɗ			
	s			h
m	n	ɲ	ŋ	
w	l, r	j		

Starting with Haudricourt (1965), early diachronic accounts of registrogenesis adopted the view that it is the ‘laxness’ of the voiced stops that triggered the development of breathiness, lower f0, and formant changes. However, none of these accounts were very explicit on the phonetic nature of this laxness [2, 5, 12]. More recent models have suggested that specific articulatory mechanisms (larynx lowering, tongue-root advancement) are instrumental in registrogenesis [3, 27], and it has been proposed that voice quality differences conditioned by voicing are responsible for the f0 and formant modulations associated with register [14, 27]. As there is so far no acoustic evidence for early stages of the Mon-Khmer shift, these scenarios are all based on phonetic reconstruction. Acoustic evidence on a conservative register system could help assess their validity.

We will therefore describe the register system of a Chrau dialect that has already undergone registrogenesis and establish if it preserves consonantal remnants of its original voicing contrast. Based on this description, we will try to determine if the register system is representative of an early stage of registrogenesis and how it could shed light on previous diachronic scenarios.

2. METHODS

Twenty-two native speakers (12 women) of Chrau were recorded in the town of Ngãi Giao, in Bà Rịa-Vũng Tàu province, Vietnam.

2.1. Experiment

Speakers recorded a wordlist composed of 58 Chrau words with a target syllable in stressed word-final position, beginning with a coronal or velar onset /ɗ, t, tʰ, s, l, r, n, k, kʰ, ŋ/. Out of these, onsets /t, k/ can occur in both modal and breathy registers (breathy register /t/ and /k/ are reflexes of *b and *g). Target syllables contained the vowels /iː, ɛː, aː, ɔː, uː/ and an optional coda (one word had the diphthong /uo/, but will not be reported here). Monosyllabic words were preferred (44/58); all other words were sesquisyllabic (the main stressed syllable was preceded by an unstressed initial syllable). Sonorants in sesquisyllables are not reported here to avoid a possible confound caused by register spreading, a common process in register languages [4, 11, 26].

Target words were produced in the frame sentence:

/aɲ ɲaːj ___ ruː ruː aːn gruː caŋ/
"I say ___ slow slow for teacher hear.'
(I say ___ slowly for the teacher to hear)

Speakers recorded the wordlist in a sound-attenuated booth normally used for recording amateur singers. They were given each word in Vietnamese and had to translate and pronounce it in Chrau, inserted in the frame sentence. Data was recorded with a Behringer ECM8000 microphone connected to a Rothenberg EG2PCX electroglottograph (EGG).

2.2 Data processing and analysis

As the EG2PCX has a low frequency noise component, recordings were high-pass filtered at a frequency of 70 Hz to remove low frequency noise (the lowest f0 found in the dataset is 85 Hz). All 4593 recorded target words were then annotated in Praat textgrids. The beginning and endpoint of sonorants and vowels were annotated. For stops, the beginning of the closure, the release and the onset of voicing were marked. Results were extracted using PraatSauce, a Praat-based application for spectral measures inspired by VoiceSauce [15, 20].

F0, F1, F2 and H1-H2 were measured at every 1 ms in the target vowel. Since measurement windows were set at 25 ms, the first and last 12 vocalic measures were excluded to avoid the effect of adjacent consonants. Files were excluded if the f0, F1 or F2 of the target vowel was incorrectly tracked over more than 20% of their duration (5.5% of the data). In all other files, f0, F1 and F2 individual measures were excluded if they were more than 2 standard deviations away from the 10 closest sampling points.

Spectral slope measurements (only H1-H2 is reported here) were formant-corrected [6, 13]. H1*-H2*, f0 and formant frequencies were speaker-normalized with z-scores and then reported back on intuitive scales using means and standard deviations obtained from all speakers.

Mixed models were fitted on the results and will be reported as needed. Regardless of the dependant variable, fixed effects were *register*, *place* and *vowel*. The structure of random effects always included a random intercept for *subject*, but no random slope. Random intercepts for *word* were not included as model comparisons systematically revealed that inclusion of the random effect did not improve the Akaike Information Criterion.

3. RESULTS

3.1 Realization of register on vowels

The spectral slope contours (H1*-H2*) of vowels following the stops /t/ and /k/ and the sonorants /l, r, n, ŋ/ are given in Fig. 1. At vowel onset, the H1*-H2* of breathy register tokens is on average 7.2 dB greater than that of modal voice tokens (significant for all combinations of factors except /uː/ after velars). The contrast between registers is maintained for about 100 ms before the modal and breathy registers start merging. Vowels following sonorants fall in between.

Figure 1: Mean H1*-H2* in the first 200 ms following breathy and modal plain stops (sonorants given as reference). Shading: 95% CI.

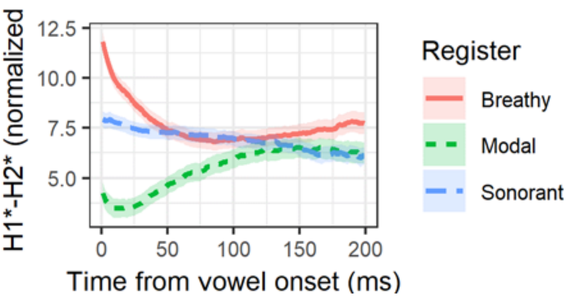


Fig. 2 reports f0 following the same three onset types. The modal register is on average 23 Hz higher than the breathy register (significant in seven out of

Figure 2: Mean f0 in the first 200 ms following breathy and modal plain stops (sonorants given as reference). Shading: 95% CI.

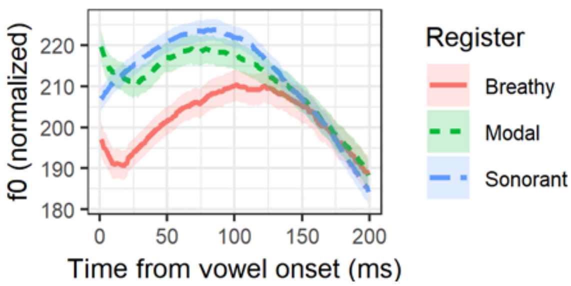
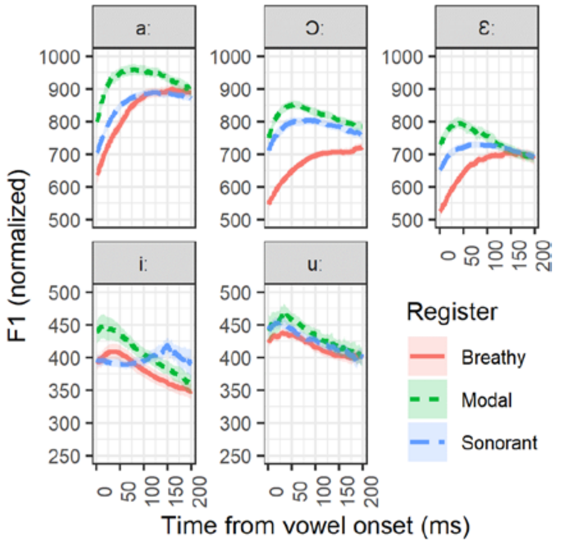
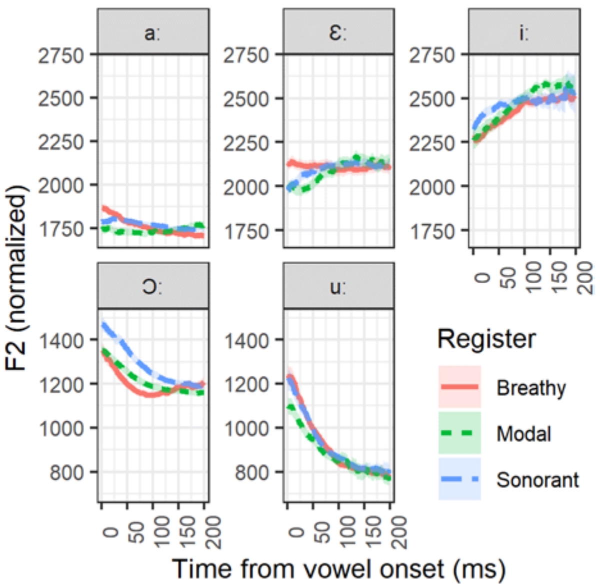


Figure 3: Mean F1 in the first 200 ms following breathy and modal plain stops (sonorants given as reference). Shading: 95% CI.



10 combinations of vowels and places). The contrast between registers wanes after about 125 ms. Sonorants pattern with modal stops.

Figure 4: Mean F2 in the first 200 ms following breathy and modal plain stops (sonorants given as reference). Shading: 95% CI.



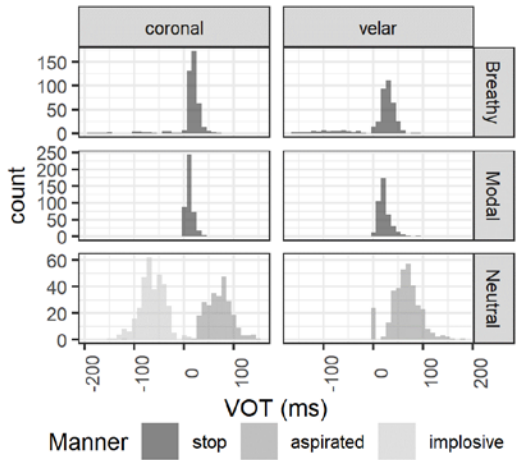
Vowel formants also differ in the two registers. In Fig. 3 vowels start with a lower F1 in the breathy than in the modal register (significant in all categories except /iː, uː/ after velars). This difference is maintained for a longer portion of the vowel than f0 and spectral slope differences (150-250 ms, depending on the vowel). As for F2, a close inspection of Fig. 4 reveals that differences between registers are small but consistent, with vowel having a lower onset F2 after modal than breathy register stops (overall average of -177 Hz, significant in all combinations of vowels and places).

There is a tendency for vowel duration to be longer in the breathy than the modal register (means of 310 vs. 271 ms), but this difference is only significant in the expected direction for five out of the 10 combinations of places and vowels.

3.2 Consonants

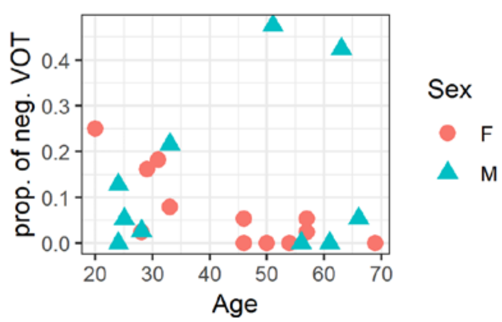
Inspection of closure duration reveals small significant differences between registers, but going in different directions depending on combinations of vowels and places of articulation. However, their VOT reveals two robust generalizations, illustrated in Fig. 5: 1) plain stops are mostly devoiced and rarely preserve a negative VOT in the breathy register, 2) when they are realized without closure voicing, their VOT is larger than that of voiceless stops by an average of 7.5 ms (significant for all combinations of factors except for /uː/ after velars).

Figure 5: Stop VOT, by place and register



While the relative proportion of tokens with a negative VOT is highly variable in the community, as shown in Fig. 6, a linear model with this proportion as the dependant variable and *age* and *sex* as independent variables reveals no significant effect.

Figure 6: Proportion of plain stops in the breathy register with a negative VOT, by age and sex

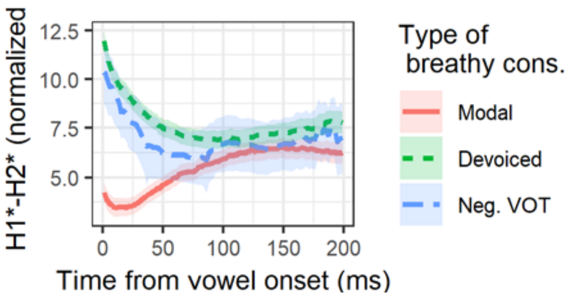


3.3 A trade-off between voicing and register?

Are the acoustic properties of the register contrast more clearly realized when breathy register plain stops have lost closure voicing?

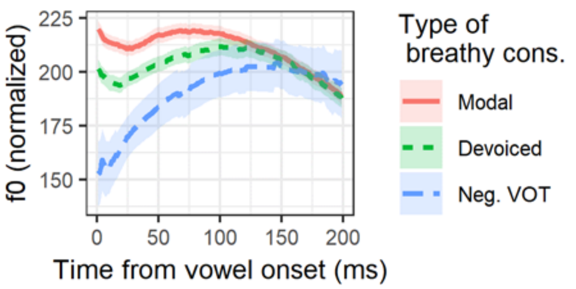
As shown in Fig. 7, there is no significant difference in H1*-H2* between the breathy register stops that preserve closure voicing (neg. VOT) and those that are devoiced (positive VOT).

Figure 7: Mean H1*-H2* of voiced and devoiced stops (modal register stops as reference). Shading: 95% CI.



There is also little evidence of cue trading between voicing and f0. As illustrated in Fig. 8, the difference between the two types of breathy register stops is not significant at vowel onset for most combinations of vowels and places (6/10), and when it is, it is the stops with negative VOT that have the lowest f0.

Figure 8: Mean f0 of voiced and devoiced stops (modal register stops as reference). Shading: 95% CI.



There are too few words with negative VOT in each vowel category to obtain results on acoustic cue trading between consonant voicing and register.

4. DISCUSSION

Ngãi Giao Chrau has a well-developed register system: the two registers have distinct H1*-H2*, f0, F1 and F2. Overall, the low register could be described as having breathier and lower-pitched vowels with a higher, more fronted vowel quality. There is weak evidence that vowels are longer in the breathy register. The size of acoustic differences and their realization over a fairly long portion of the vowel (at least the first 100 ms) suggest these effects are greater than the intrinsic perturbations expected after voiced and voiceless stops [8, 9, 16-19, 22, 23].

Interestingly, the consonantal properties that gave rise to register may not been entirely neutralized. Breathy register stops either preserve closure voicing (i.e. a negative VOT) or tend to have a VOT longer than modal register stops, but it is unclear if the slight difference in VOT between modal register stops and devoiced breathy register stops is perceptually significant. A perception experiment is needed, but it is clear that the vocalic properties of register have become the primary bearers of the contrast and that closure voicing is an optional redundant property for some speakers. Moreover, in the absence of a trading relation between the realization of breathy register stops and vocalic register cues, a functional scenario in which some speakers would put more weight on voicing while others would privilege register properties cannot be invoked. The only difference in vocalic cues between devoiced and voiced breathy register stops is that the latter have a lower f0, which is expected in "true voicing" languages [29].

There may be another way of interpreting the small, though significant, VOT differences between breathy and modal register stops: they could be an epiphenomenon of an articulatory maneuver responsible for the realization of register. Although this is speculative, the most likely candidate would be larynx lowering, an articulation that can affect f0, voice quality and vowel quality [30-33], is involved in the production of voicing [34, 35] and has been claimed to be instrumental in registrogenesis [12].

The discrepancy between our results and previous accounts of Chrau, which described a voicing contrast, but no register, could be due to inaccurate reports, dialectal differences, or phonetic change in the past 50 years [24, 25, 28]. Since there is no evidence of a higher prevalence of closure voicing in breathy register stops in older than younger speakers and since the vocalic properties of register are large and extend over a significant portion of the vowel, a recent change seems ruled out. We therefore have to assume that the variation between Ngãi Giao Chrau speakers is unstructured and stable. Unless other Chrau dialects turn out to preserve a voicing contrast, there is little ground to claim that the Chrau register system represents an early stage of registrogenesis.

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