Post-vocalic Stop Consonants in Mebengokre (Northern Jê, Brazil): A Preliminary Investigation

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ABSTRACT

This paper presents the first acoustic phonetic investigation of Mebengokre, a Jê language spoken in the brazilian Amazon. Our focus lies in one conspicuous property of this language's phonetic structure: the frequent occurrence of unreleased stops in post-vocalic position. Based on auditory impressions from the field and on theoretical considerations we expected to observe variation in vowel duration and patterns of formant transition (especially F2) as a function of the presence or absence of a following consonant. Vowels in CVC syllables were found to be significantly shorter than those in CV, while formant patterns (F2 offset transitions) are less reliable in distinguishing the two conditions, due, arguably, to the highly context-dependent nature of this parameter. Finally, a large majority of the tokens analyzed contained no stop release burst that could be identified from the inspection of waveforms.

Keywords: Mebengokre; Jê languages; stop consonants; acoustic phonetics.

1. INTRODUCTION

All studies on the phonology and phonetics of Mebengokre have documented the presence of a context-dependent or phonetically conditioned variation in the realization of stop consonants: while stop consonants occur as plain, released stops in pre-vocalic or onset position, the same phonological segments show unreleased stop allophones in post-vocalic (or syllable coda) position [3].

The goal of the present study is that of offering the first acoustic characterization of this phenomenon, producing, in effect, the first instrumental phonetic description of this language. Given that the absence of audible release bursts is detrimental to the identification of stop consonant place [2], the main goal of this pilot investigation was to identify patterns of (1) V-to-C formant transition and (2) vowel duration that may cue the presence of post-vocalic unreleased stop and provide information on its place of articulation.

2. THE PHONETICS AND PHONOLOGY OF MEBENGOKRE STOPS SO FAR

The descriptive literature on Mebengokre is unanimous in identifying the following set of consonant phonemes for the language: /p b t d k g ʔ ʧ ʤ m n ɲ ŋ ɾ/, plus the two semivowels /j w/. The opposition between voiced and voiceless stops is an innovation of Mebengokre among Jê languages and the voiced variants have a very restricted distribution in the lexicon, though /b/ and /g/ occur in high-frequency items such as personal pronouns (e.g. *ba* 'I', *ga* 'you'). The voicing opposition is, in addition, neutralized in word-final position [3].

Mebengokre has a rather crowded vowel inventory, similar to the vowel systems found in other northern Jê languages: /i e ɛ ɨ ə ʌ a u o ɔ/ ([3], [4]).

A conspicuous phonetic property of Mebengokre is the frequent occurrence of unreleased stops. Stops in postvocalic position, before pause (VC#) or before another stop consonant (VCC), are often produced with no audible release. This characteristic of the realization of stop consonants is often noted in the phonetic transcriptions found in the published literature (see pgs. 23 and 30 of [3]) but there is no extensive discussion of it. This is the gap we aim to start filling with the present study.

3. METHODS AND STUDY DESIGN

The study was designed with the goal of assessing whether vowel duration and formant transition patterns were systematically and robustly affected by the presence versus absence of a postvocalic stop. Auditory impressions in the field suggest that, in the absence of an audible release burst, the presence of post-vocalic consonants is more easily cued by the occurrence of shorter vowels.

A list of Mebengokre words opposed minimally (or almost so) by the presence of a post-vocalic stop consonant was prepared:

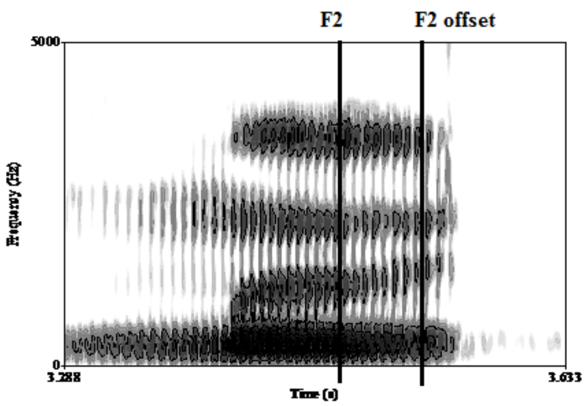
(1) *mɨ*	‘male, penis’	*mɨt*	‘sun’
(2) *tɛ*	‘leg’	*tɛp*	‘fish’
(3) *nɔ*	‘eye’	*rɔp*	‘dog. jaguar’
(4) *bʌ*	‘woods’	*pʌt*	‘anteater’
(5) *ʤa*	‘to stand’	*tak*	‘to beat, hit’

Five male speakers (age range: 20-26) of the Xikrín variety of Mebengokre, all residents at the Cateté village, Pará state, Brazil, were asked to produce these words in randomized order. Each item was produced several times. For one of the subjects, the second production was systematically longer (as if produced in a ‘teaching style’), yielding outlier values that were systematically excluded from the measurements. It was not possible for this first, pilot study, to obtain recordings from female subjects or to have balanced samples for all subjects. As a consequence of this limitation, no discussion of speaker-specific effects is possible at this point.

Recordings were made in .wav format using a *Zoom H4* hand recorder, with 48 KHz of sampling frequency and a transmission rate of 16 bits. The microphone was placed at approximately 10 cm from the subject’s lips. Acoustic analysis was done with *PRAAT* and statistical analysis, including the production of graphs was carried with *SPSS 17.0*.

Formant transition patterns were assessed qualitatively by visual inspection of spectrograms and quantitatively by measuring F2 values at the center portion of vowels and at the offset transitions:

Figure 1. Example of points at which F2 and F2 offset measurements were made.

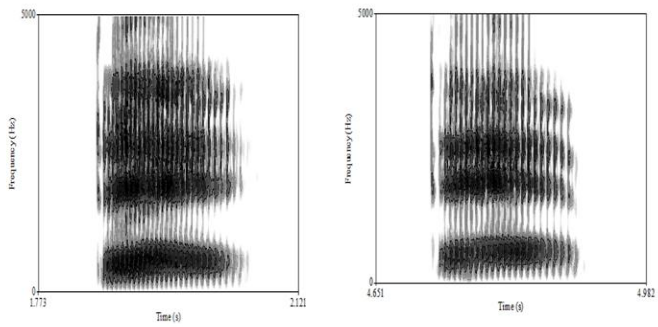


4. RESULTS

4.1. Formant patterns

Visual inspection of spectrographic displays revealed differences in formant trajectories in broad agreement with expectations based on the acoustic theory of speech production. Thus, front vowels, which have relatively high F2 values, showed marked downward F2 transitions where followed by a bilabial stop. This F2 transition pattern was absent in the ‘no coda’ or V condition:

Figure 2: Spectrograms for *tɛ* ‘leg’ (left) and *tɛp* ‘fish’ (right).

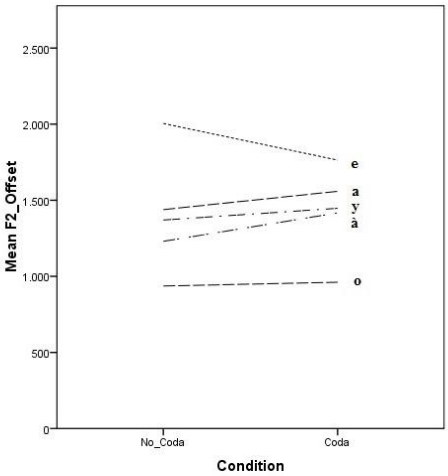


[t ɛ]   [t ɛ p]

Equally expected was the F2 upward shift seen in the case of non-front vowels followed by a coronal consonant (as in *mɨ* vs. *mɨt* and *bʌ* vs. *pʌt*). The other pairs, that is, *nɔ* - *rɔp* and *ʤa* - *tak*, were less markedly distinct on the basis of this simple visual assessment.

These general F2 transition patterns can be depicted by comparing mean values of F2 measured at the vowel offset between the two conditions (Mebengokre orthographic symbols are used in the graphs: e /ɛ/, a /a/, à /ʌ/, o /ɔ/ and y /ɨ/):

Figure 3. Mean F2 offset as a function of the two conditions.



As seen above, mean F2 offset for the vowel ɛ is lower in *tɛp* than it is in *tɛ* (topmost line), a plausible effect of the labial constriction of the following consonant. This effect is much less marked in the case of a back vowel, as in the contrast *rɔp* and *nɔ* (bottom line), arguably due to the fact that the F2 'locus' for the vowel is in itself relatively low. In the middle range of F2 offset values, *mɨt*, *pʌt* and *tak* show higher mean F2 offset values than *mɨ*, *bʌ* and *ʤa*, respectively.

Descriptive statistics summarizing the patterns graphically presented above are given below. The mean F2 offset values on the base of which figure 3 was derived are in bold:

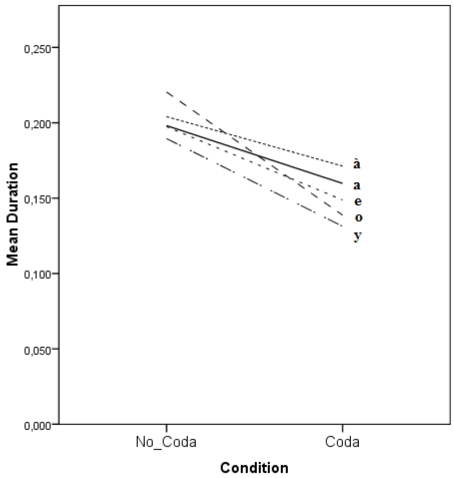
Table 1. Summary statistics (mean/Standard Deviation) for measurements of F2 and F2 offset.

	F2 (mean/SD)	F2 Offset (mean/ SD)
ʤa	1495 / 92.245	**1438** / 84.520
tak	1462 / 121.566	**1558** / 144.305
tɛ	1991 / 113.639	**2004** / 120.327
tɛp	1875 / 65.015	**1763** / 46.187
nɔ	1041 / 65.362	**936** / 69.115
rɔp	1040 / 90.060	**961** / 84.182
bʌ	1247 / 46.927	**1230** / 79.554
pʌt	1169 / 115.769	**1416** / 97.774
mɨ	1294/ 69.589	**1369** / 85.573
mɨt	1266 / 101.186	**1497** / 123.800

4.2. Duration

Mean vowel duration was markedly different in the two conditions, with vowels being consistently shorter when followed by a consonant:

Figure 4. Mean vowel duration as a function of the two conditions.



Statistical analysis of the duration data shows that mean duration in the V condition was significantly larger than mean duration in the VC condition (all with $P < .05$; two samples *t*- test, no equality of variances assumed):

Table 2. Statistics for the duration data.

Vowel	Condition	Mean Duration (msc)	SD	*t*
a	V	0.198	0.025	3.504
	VC	0.159	0.022	$df = 18$
ʌ	V	0.204	0.035	2.153
	VC	0.171	0.040	$df = 23$
ɔ	V	0.220	0.065	3.525
	VC	0.138	0.027	$df = 18$
ɛ	V	0.197	0.028	4.166
	VC	0.148	0.025	$df = 20$
ɨ	V	0.189	0.024	4.373
	VC	0.141	0.030	$df = 26$

The impression we had in the field, that the presence of a following unreleased stop is cued by a relatively shorter duration of the vowel preceding it, is borne out by the data.

4.3. Presence of Stop Consonant Release

Following [1], it is crucial to distinguish between articulatory and acoustic notions of 'consonantal release'; while release gestures are always present (unless germination occurs in a particular domain), audible effects of this event can be missing from the acoustic record. Accordingly, we present here preliminary frequency counts that provide an estimate of how often an audible release (i.e. one detectable in a waveform) is found for the Mebengokre word-final stops:

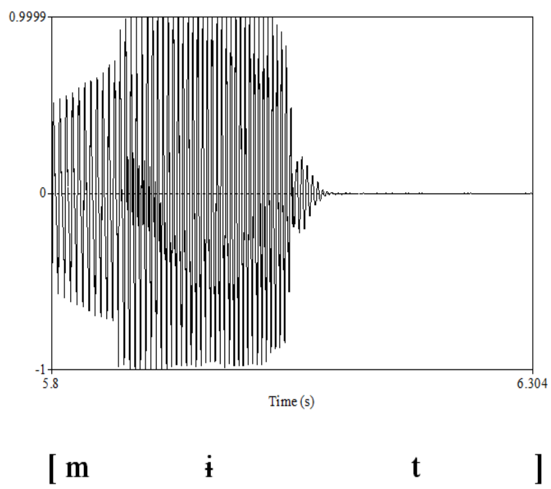
Table 3. Percent forms with a stop release detectable from the acoustic record (waveforms):

Form	**% audible release**
mɨt	1
pʌt	0
tak	5
ɾɔp	1
tɛp	0
Total	5.4

Thus, 94.6% of the tokens had no audible release. The great majority of the forms showing a detectable stop burst were tokens of *tak*, a result likely attributable to the usual greater intensity of the noise burst of velar stops *vis-à-vis* those of stops produced at labial and alveolar places.

The typical production of word-final stop consonants in Mebengokre is illustrated with the spectrogram in figure 5 below: a sudden decrease in the amplitude of voicing as the consonant constriction is formed, followed by a signal without any clear evidence of a release burst:

Figure 5. Token of *mɨt* showing voicing inhibition and absence of release burst



5. DISCUSSION AND DIRECTIONS FOR FUTURE INVESTIGATION

The present study was designed as a pilot investigation laying the foundations for a more extensive and systematic investigation of Mebengokre.

Overall, in comparison to the formant transition patterns, vowel length seems to be a stronger cue to the presence of a post-vocalic consonant. This is likely a consequence of the place-dependent nature of F2 transition cues. Thus, the F2 lowering effect of a following labial stop is much stronger with preceding *ɛ* than with preceding *ɔ* (cf. table 1). In addition, release bursts were absent for the vast majority of measured forms. These results constitute a valuable accretion to the available descriptions of Mebengokre phonetics, so far based exclusively on auditory impressions and transcription data.

Our immediate goals for the continuation of this investigation are (1) to create a more representative data base including female speakers and a larger set of phonotactic contexts/vowels and (2) to design perceptual studies probing directly at the relative weight of particular cues in the identification of an unreleased stop consonant, and its place features, in (C)VC structures. With respect to (1) we are currently developing balanced data sets having an equal number of tokens for each subject, so that statistical analysis of speaker-dependent variation becomes possible.

7. REFERENCES

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