AN ACOUSTIC DESCRIPTION OF THE VOWEL SYSTEM OF SANTIAGO MEXQUITITLÁN OTOMI (HÑÄÑHO)

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ABSTRACT

The Otomi language belongs to the Oto-Pamean branch of the Oto-Manguean languages in Mexico. The variety of Otomi (Hñäñho) spoken in Santiago Mexquititlán, Querétaro, is an endangered language that is still largely unexamined from an instrumental point of view. The present study is the first to provide an acoustic description of the Hñäñho vowel system. We report on the oral vowel inventory of Hñäñho by means of acoustic analyses of production data from four native speakers. While it is common for moribund indigenous languages to lose phonemic distinctions when in extensive contact with a majority language (i.e., Spanish), our results indicate that the vowel system of Hñäñho spoken in Santiago Mexquititlán consists of nine oral vowel phonemes, maintaining all phonemic contrasts. This acoustic description provides novel data on an endangered language while also contributing to the growing body of studies on cross-linguistic influence in the context of Mexican indigenous bilingualism.

Keywords: Otomi, Hñäñho, indigenous language, acoustic description, oral vowels.

1 INTRODUCTION

Otomi belongs to the Otomian branch of the Oto-Pamean subdivision of the Oto-Manguean language family, spoken in central Mexico [26]. Otomi from Santiago Mexquititlán, located in the Mexican state of Querétaro, is referred to as Hñäñho by its native speakers [14]. Hñäñho is spoken as a first (L1) or second language (L2) almost exclusively by Otomi Mexican indigenous people from the rural community of Santiago Mexquititlán. This language is largely underdescribed from an instrumental point of view, which makes it difficult to predict cross-linguistic effects in native and heritage speakers of Hñäñho acquiring Spanish and/or other languages in a situation of extensive language contact with Spanish in central Mexico.

Previous studies have described the Hñäñho vowel system using impressionistic techniques [11, 14, 15]. However, it could serve a useful purpose to compare such descriptions with instrumental measurements of the Hñäñho vowel inventory obtained in a carefully controlled experimental setting. Thus, the present study is the first to acoustically describe the Hñäñho oral vowel system. We discuss the oral vowel inventory of four native speakers of Hñäñho from a small urban Hñäñho community in the city of Santiago de Querétaro (Mexico), all of whom were born and raised in Santiago Mexquititlán.

There are 9 Otomi varieties, namely Mezquital Otomi, Tilapa Otomi, Eastern Highland Otomi, Tenango Otomi, Querétaro Otomi, Estado de México Otomi, Temoaya Otomi, Texcatepec Otomi, and Ixtenco Otomi [15, 22]. According to UNESCO, 3 of these varieties are considered "severely endangered", 3 are "definitely endangered", and 3, including the Hñäñho variety spoken in the state of Querétaro, are catalogued as "vulnerable" [19]. Otomi speakers who leave rural areas for larger cities are exposed to an exclusively Spanish-speaking urban environment as well as to negative attitudes towards them and their language [10, 13, 24], which can lead to a complete loss of the native language within as little as three generations [10].

Linguistic features of the Otomi language are being lost due to extensive contact and shift towards Spanish [13, 24]. Mexican Spanish has a symmetrical five-vowel system (/a/, /e/, /i/, /o/, and /u/) and no nasal vowels. On the other hand, Otomi vowel systems are usually comprised of a rich set of oral and nasal vowels [11, 20, 26]. The most common vowel system found across the nine Otomi varieties is one consisting of 9 oral vowels [2, 3, 4, 5, 17, 23], with an additional set of one to five nasal vowels [11].

In a situation of continuous language contact with Spanish, the potential influence that these vowel systems might exert on each other is especially relevant. It is not infrequent for vowel systems to be affected in situations of language contact [1, 7, 12]. In the case of Otomi-Spanish language contact, the Otomi vowel system exhibits a greater degree of complexity in comparison to the Spanish vowel system, and as a result of language contact there could be a tendency towards simplification [18], in which phonemic contrasts in Otomi not present in Mexican Spanish would be lost in the process of language shift from Hñäñho to Spanish.

1.1 Hñäñho vowels

There are very few acoustic studies of Otomi varieties and these focus mainly on suprasegmental

features of the language, such as lexical prosody [26] and tonal patterns [11]. Hñäñho has been described as having 9 oral vowels (Table 1) and one nasal vowel /ã/ [11, 14, 15]. The description of Hñäñho vowels in Table 1 is based on minimal pairs; however, no acoustic measurements were performed. These phonological transcriptions will benefit from acoustic data in order to confirm that these vowel contrasts are phonemic in the production of Hñäñho native speakers. Acoustic studies describing vowel systems of other Otomi varieties are also extremely scarce (but see [23] for a thesis on Acazulco Otomi vowels).

Table 1: Hñäñho oral vowels [11, 14, 15].

	Front	Central	Back
Close	i	ɨ	u
Close-mid	e	ɘ	o
Open-mid	ɛ		ɔ
Open		a	

As in other Otomi varieties, Hñäñho vowels can carry three tones: low, high, and rising [14, 15]. The study of the tone system of Hñäñho is beyond the scope of this paper; however, the possible effects of vowel tones were controlled for in the list of experimental stimuli (see section *2.2 Materials* for more details). Despite the lack of consensus on the interaction of the tonal and accentual phenomena in Otomi, disyllabic words seem to mostly be stressed on the first syllable, regardless of the tone [11, 26].

The main goal of this study is to acoustically describe the Hñäñho oral vowels[1]. Moreover, we seek to determine whether phonemic contrasts between the Hñäñho vowels, as previously described impressionistically [11, 14, 15], are maintained in the oral production of native speakers or if Hñäñho phonemic categories are merging due to the influence of Spanish.

2 METHOD

2.1 Participants

Four native speakers of Hñäñho (two males and two females) were recruited for this study. Their ages ranged from 54-69 (M=62.0, SD=6.2). Participants reported that Hñäñho was their only mother tongue; however, all of them were also very proficient Spanish speakers. They started learning Spanish at the age of 7-17 years old (M=13.3, SD=4.3), when they left their rural home community in Santiago Mexquititlán to move to Santiago de Querétaro. However, they use Hñäñho on a daily basis with their family members, acquaintances, and co-workers.

All participants reported normal speech and hearing. They signed an informed consent form and received monetary compensation for taking part in the study.

2.2 Materials

A list of 81 common disyllabic Hñäñho nouns was extracted from a Hñäñho-Spanish dictionary [14]. The list was carefully designed to contain three different nouns for each one of the 27 possible vowel-tone combinations (9 oral vowels × 3 tones × 3 nouns = 81). All nouns on the list were corroborated by a native speaker before being selected as target items in the production task. The list was randomized and split into two counterbalanced blocks.

The target vowel in each experimental item appeared in stressed position, forming the nucleus of the first syllable. The syllabic structure of all words was (C)C**V**-(C)CV (target vowel in bold), typical of disyllabic Otomi words [11, 20, 26]. Consonant sounds directly preceding and following the target vowel included stops, fricatives, and affricates. Words with nasal and lateral consonants were avoided since they can complicate vowel formant measurements [16].

2.3 Recording procedure

The oral production recording was conducted individually in a sound-attenuated booth with participants comfortably seated at the same table as the experimenter. The production of the target Hñäñho vowels was elicited by a Spanish-Hñäñho translation task. Participants were asked to provide Hñäñho translations of Spanish words by embedding them in a carrier phrase, *Dí mää ar* ***targetword*** *gatho ya pa* 'I say the ***targetword*** every day'.

The speech samples were recorded using a head-mounted microphone (Shure SM10A) and a solid-state digital recorder (Marantz PMD660), digitized (44 kHz, 16 bit quantization), and computer-edited for subsequent acoustic analysis. Three repetitions of the 81 words embedded in the carrier phrase yielded 243 target vowel tokens per participant. Fifty-nine tokens were excluded from the analysis due to mispronunciations or recording errors, resulting in a total of 913 tokens.

2.4 Acoustic analysis

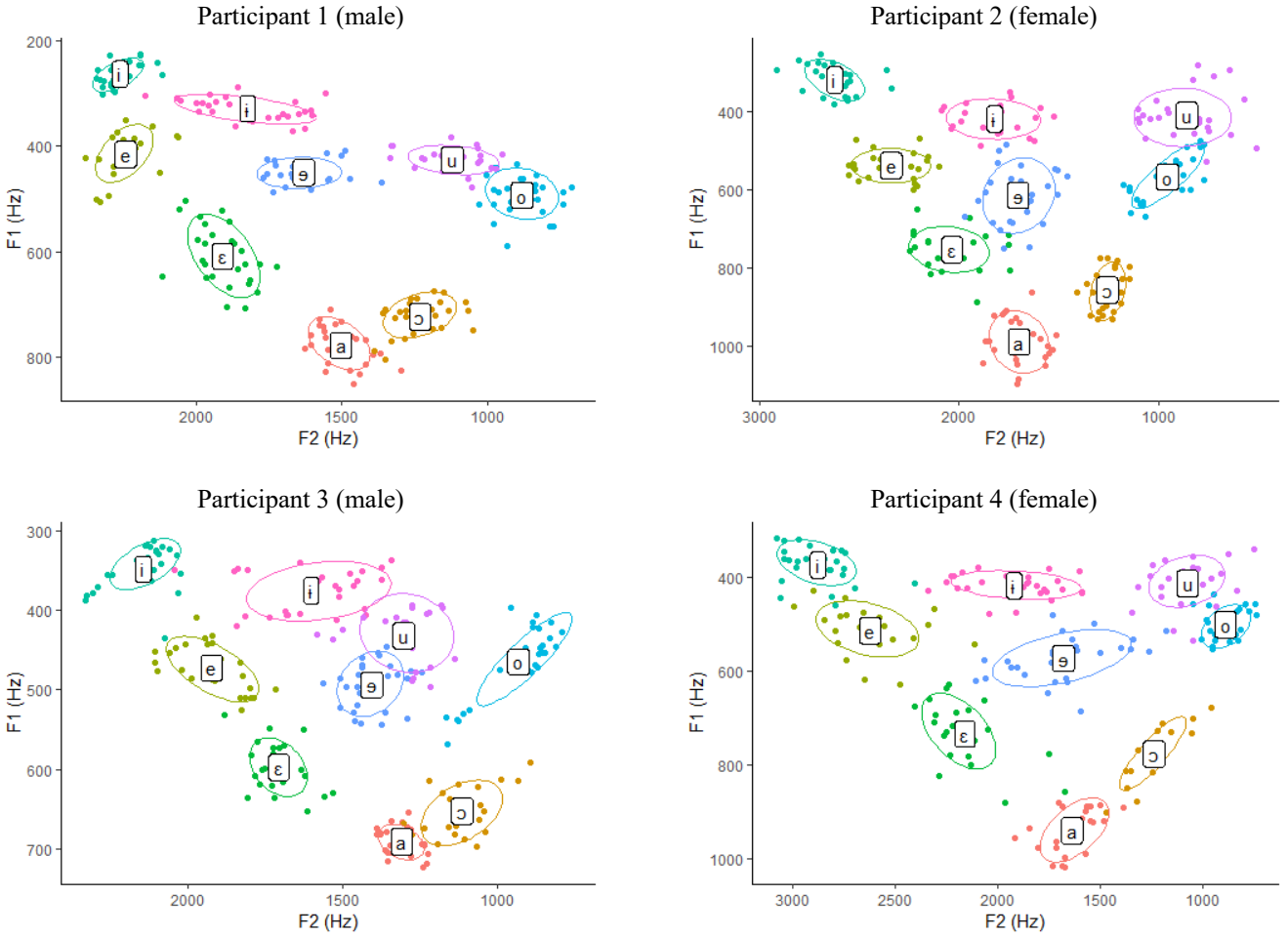
Vowels were segmented using synchronized waveform and spectrographic displays in Praat [6]. Formant trajectories as well as intensity displays were taken as indicators of vowel onsets and offsets. Vowel formant measurements (f0, F1, F2) were automatically extracted at the center of the vowel steady-state period. Formant tracks were calculated with the Burg algorithm as implemented in the Praat program. The effective window length for the calculation was set at 25 ms and was maintained

across tokens and speakers. The maximum number of formants to be located by the formant tracker was always five, and the ceiling was set at 5.0 kHz for males and 5.5 kHz for females. These gender-specific formant ceilings reflect the different average vocal tract lengths of men versus women and were deemed appropriate after visual inspection of the sound files. Formant values were extracted, analyzed, and plotted in Hertz (Hz).

3 RESULTS

Figure 1 shows four vowel plots of F1 (*y* axis) and F2 values (*x* axis) at the vowel midpoint for the nine Hñäñho oral vowels, as produced by the four participants. Mean F1 and F2 values are plotted as vowel labels, around which a standard-deviation ellipsis is drawn (±1 SD). The plots were generated in R [21] using the ggplot2 package [27].

Figure 1: Nine Hñäñho oral vowels plotted by F1(Hz) and F2(Hz), as produced by four native speakers.



After visual inspection of the four vowel plots, it seems clear that the 9 Hñäñho oral vowels are distinct phonemes since they appear to be spectrally differentiated (the ellipses show none or minimal overlap). However, there seems to be considerable variability between the four Hñäñho native speakers in the organization of the vowel space, especially concerning back and central vowels. Therefore, a one-way ANOVA with *VOWEL* as the independent variable and *F1* and *F2* as dependent variables was performed for each participant separately. This type of analysis has been previously performed on the vowel data of other underdescribed languages, such as Roper Kriol [8].

Table 2 shows *p* values of Tukey-corrected post-hoc comparisons of all possible vowel pairs. These results confirm the impressionistic interpretation of the data, since each vowel pair comparison was significantly different ($p<0.05$) at least in one of the two dimensions of the vowel space (F1: vowel height; F2: vowel frontness/backness) in the vowel production of all four participants.

Table 2: Tukey-corrected *p* values of post-hoc comparisons of F1 (bottom-left triangle) and F2 (top-right triangle) of Hñäñho oral vowels, as produced by four native speakers. Non-significant cells are highlighted in grey.

Participant 1

	i	ɨ	e	ə	ɛ	a	ɔ	o	u
i		<.001	0.999	<.001	<.001	<.001	<.001	<.001	<.001
ɨ	<.001		<.001	<.001	0.068	<.001	<.001	<.001	<.001
e	<.001	<.001		<.001	<.001	<.001	<.001	<.001	<.001
ə	<.001	<.001	0.037		<.001	0.001	<.001	<.001	<.001
ɛ	<.001	<.001	<.001	<.001		<.001	<.001	<.001	<.001
a	<.001	<.001	<.001	<.001	0.055		<.001	<.001	<.001
ɔ	<.001	<.001	<.001	<.001	<.001	<.001		<.001	0.007
o	<.001	<.001	<.001	<.001	<.001	<.001	<.001		<.001
u	<.001	<.001	0.988	0.347	<.001	<.001	<.001	<.001	

Participant 2

	i	ɨ	e	ə	ɛ	a	ɔ	o	u
i		<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
ɨ	<.001		<.001	0.067	<.001	0.046	<.001	<.001	<.001
e	<.001	<.001		<.001	<.001	<.001	<.001	<.001	<.001
ə	<.001	<.001	<.001		<.001	1.000	<.001	<.001	<.001
ɛ	<.001	<.001	<.001	<.001		<.001	<.001	<.001	<.001
a	<.001	<.001	<.001	<.001	<.001		<.001	<.001	<.001
ɔ	<.001	<.001	<.001	<.001	<.001	<.001		<.001	<.001
o	<.001	<.001	0.499	0.028	<.001	<.001	<.001		0.209
u	<.001	1.000	<.001	<.001	<.001	<.001	<.001	<.001	

Participant 3

	i	ɨ	e	ə	ɛ	a	ɔ	o	u
i		<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
ɨ	0.038		<.001	<.001	0.013	<.001	<.001	<.001	<.001
e	<.001	<.001		<.001	<.001	<.001	<.001	<.001	<.001
ə	<.001	<.001	0.209		<.001	0.031	<.001	<.001	0.030
ɛ	<.001	<.001	<.001	<.001		<.001	<.001	<.001	<.001
a	<.001	<.001	<.001	<.001	<.001		<.001	<.001	1.000
ɔ	<.001	<.001	<.001	<.001	<.001	<.001		<.001	<.001
o	<.001	<.001	0.992	0.018	<.001	<.001	<.001		<.001
u	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.009	

Participant 4

	i	ɨ	e	ə	ɛ	a	ɔ	o	u
i		<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
ɨ	0.020		<.001	<.001	<.001	<.001	<.001	<.001	<.001
e	<.001	<.001		<.001	<.001	<.001	<.001	<.001	<.001
ə	<.001	<.001	<.001		<.001	0.995	<.001	<.001	<.001
ɛ	<.001	<.001	<.001	<.001		<.001	<.001	<.001	<.001
a	<.001	<.001	<.001	<.001	<.001		<.001	<.001	<.001
ɔ	<.001	<.001	<.001	<.001	0.084	<.001		<.001	0.052
o	<.001	<.001	0.988	<.001	<.001	<.001	<.001		0.004
u	0.055	1.000	<.001	<.001	<.001	<.001	<.001	<.001	

4 DISCUSSION AND CONCLUSIONS

The present study provides the first instrumentally-based description of the vowel system of Otomi (Hñäñho) from Santiago Mexquititlán, Mexico. The acoustic analyses reveal that all nine Hñäñho oral vowels, impressionistically transcribed in previous phonological descriptions of this Otomi variety [11, 14, 15], are indeed produced as distinct phonemic categories by Hñäñho native speakers.

Even though the four native speakers of Hñäñho who participated in this study moved away from Santiago Mexquititlán, where Hñäñho is spoken, to a Spanish-dominant urban environment several decades ago, and despite the fact that they reported using almost twice as much Spanish as Hñäñho on a daily basis, no evidence for mergers due to this language contact was found in their production. Therefore, we assume the phonemic distinctions between all nine Hñäñho oral vowels are robust and maintained in the vowel system of these speakers.

These 9 Hñäñho oral vowel phonemes can be phonologically stylized into a highly-symmetrical vowel system with three contrasting heights, with 3 high vowels /i/, /ɨ/, and /u/; 3 mid vowels /e/, /ə/, and /o/; and 3 low vowels /ɛ/, /a/, and /ɔ/, as in previous descriptions of Otomi vowel systems [2, 3, 4, 5, 17, 23]. However, surface manifestations of these systems might require the phoneme /a/ to be placed a step lower than /ɛ/ and /ɔ/ [23], yielding the Hñäñho oral vowel system shown in Table 1 [11, 14, 15].

The acoustic data show that some Hñäñho speakers produced a fronted /u/, as previously also noted in Acazulco Otomi [25]. Moreover, our data also suggest that the vowel /ɔ/ might be phonetically realized lower than [ɔ]. A similar phenomenon was previously reported for Hñöñhö (another Querétaro Otomi variety), suggesting [ɒ] as the phonetic realization of the phoneme /ɔ/ [20]. This could be a common characteristic of Querétaro Otomi varieties, pointing to a possible future phonemic merger /ɔ/-/a/, already observed in some Otomi varieties [9].

In conclusion, the acoustic description of Hñäñho oral vowels provides novel data on an endangered and understudied Mexican language. Such information is essential for future experiments on vowel perception and production in Hñäñho speakers, which will contribute to the growing body of studies on cross-linguistic influence in the context of Mexican indigenous bilingualism.

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[1] Note that we are not analyzing the nasal vowel /ã/, and we focus exclusively on oral vowels. Although the preliminary data on F1 and F2 of the nasal vowel /ã/ suggest that it shares the vowel space with the oral vowels /ɔ/ and /o/, the nasal quality of the vowel /ã/ may be sufficient for it to be distinguished from the oral vowels. This, however, should be analyzed in future studies.