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## **Exploiting the didactic aspect of whistled speech in Gomero Spanish and Mazatec: interactions between phonetic research and education**

**Julien Meyer and Juan N. Casimiro**

### **Introduction**

Whistled speech has been introduced at the end of the 90s in primary school in La Gomera, one of the Canary Islands (Trujillo et al 2005) and has been included in 2007 in the new official program of secondary school for the Mazatec area of the Oaxaca region in Mexico (Casimiro et al 2007). Both of these initiatives are the result of a lobbying process of the local populations to have this symbolic part of their language revitalized thanks to an introduction in official educative systems. The didactic applications of whistled Mazatec and the Gomero Spanish are different because of specific historical and educational contexts but also of phonetic differences between the strategies of emulation into whistles of tonal Mazatec and non tonal Spanish. After a phonetic description of whistled speech in these two languages, we present how these results have been exploited to pedagogic applications in Canary islands and in Mexico.

### **A prosodic emulation of the voice influenced by language phonology and frequency perception**

The practice of whistled speech consists in emulating selected acoustic cues of the complex frequency spectrum of the spoken voice into a simple modulated pitch. The way these acoustic cues are selected is influenced by the load of information they represent for intelligibility and therefore by their phonologic role in each language. At the same time, whistled speech is adapted to the fact that we perceive two different qualities of heights from the complex distribution of frequencies in the voice. One is the perceptual sensation called timbre in music, resulting from the complex aspects of the vocal frequency spectrum and that strongly characterises the quality of a vowel through the formants. The other is the perceptual sensation called pitch, resulting from the fundamental frequency. In the normal spoken voice, these two perceptual frequency levels can be combined to encode phonetic cues. But as whistled speech reduces the voice spectrum to a single melodic line, the whistlers concentrate their productions primarily on one of these qualities at each instant to select the most relevant parts.

Several languages have been compared in a typology integrating their whistled and spoken forms (Meyer 2008). This study has shown that two main strategies of whistling a language coexist (figure 1): the one that consists of whistling primarily supra-segmental cues (concerning mostly tonal languages like Mazatec) and the one that consists of whistling primarily segmental cues (concerning mostly non-tonal languages like Gomero Spanish). Meyer (2007, 2008) has also shown that there is an intermediary category of languages balancing both strategies; it contains either tonal languages with few tones like Surui of Amazonia, or non-tonal languages giving an important role to intonation like Siberian Yupik or Chepang of Nepal.

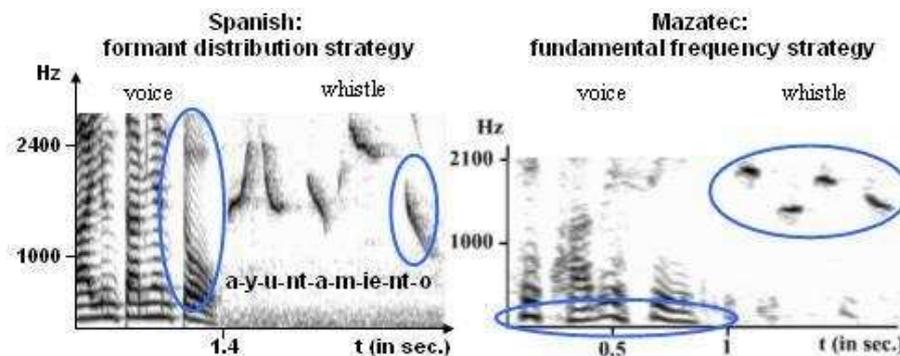


Figure 1: Through the example of Spanish and Mazatec, we present the two main whistled strategies of emulation into whistles. For Spanish (left), the final /o/ is indicated by an elliptic line in both the spoken and whistled form. For Mazatec (right), the spoken *o* and its whistled emulation are also indicated by elliptic lines.

The perception of prosody, which is one of the bases of language acquisition, is therefore reflected in an original way in the phenomenon of whistled speech. All the more that the paramount parameters selected at the frequency level by the whistlers are not systematically limited to the fundamental frequency of the voice. Indeed, in the case of a non-tonal language like Gomero Spanish, the qualities of the vowels even take the principal prosodic role. For example, the highest pitches are attributed to /i/ vowels in order to reflect the acute quality of their timbre, the lowest pitches are attributed to /o/ and /u/, while /e/ and /a/ are in between (this is illustrated on figure 2). Moreover the intervals of distribution of the vowels /i/, /e/, /a/

and /o/ are statistically different (table 1) while /o/ and /u/ highly merge<sup>1</sup>, which shows that there are at least four distinct whistled vowels in Spanish Silbo Gomero.

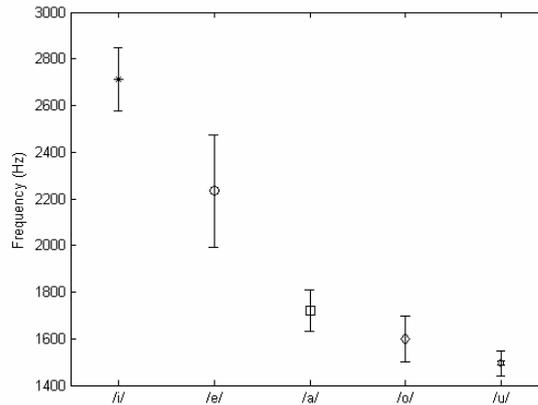


Figure 2: Frequency distribution of whistled Spanish vowels(103 vowels produced by the Maestro de Silbo Rodriguez L.)

Table 1: One-way ANOVA between vocalic groups in whistled Spanish of La Gomera island (cf. data of figure 2)

Compared groups	F	Signif.
(i) vs. (e)	F(1,43)=63.45	***
(e) vs. (a)	F(1,55)=124.57	***
(a) vs. (o)	F(1,38)=8,82	**
(a) vs. (o, u)	F(1,41)=20,13	***

This whistled strategy of Spanish with vowels shows that a kind internal prosody of segmental cues is emulated to render the perceptual importance of the most prominent formants that characterise the vowels. This is also the case for consonants. First, the whistled equivalent of a consonant is produced by articulating it in a way which is as close as possible to the spoken articulation. Of course there are additional constraints while whistling

<sup>1</sup> actually, /o/ and /u/ are already often very near in pronunciation in the spoken dialect of la Gomera. Moreover, /u/ represents only 7 % of the Spanish vowels(Classé 1957).

because the muscles of the lips and the throat are more tensed. Next, the resulting whistled signal is a combination of frequency and amplitude modulation of the pitch of the surrounding vowels. This way, the acoustic cues of the formant transients of the regular spoken form are adapted to whistles. As illustrated on figure 3, the simple frequency shapes that are obtained for each type of consonants highlight categories of similarities, mostly confined to sounds formed at close articulatory loci.

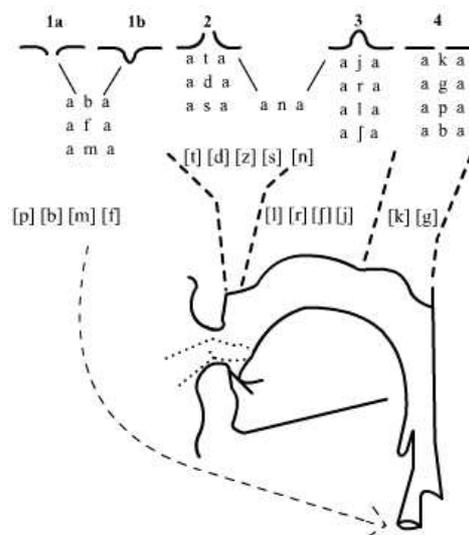


Figure 3: Frequency shapes of consonants in whistled Spanish for an intervocalic configuration /a(Consonant)a/ associated with the loci of articulation. Some consonants like /n/ adopt different close whistled shapes. Moreover, the dashed arrow indicates that the glottal occlusion may occur for [p], [b] [m] and sometimes [v],[f], in addition to [k],[g].

In the case of the four tone Mazatec language, the heavy load of information carried by the tonal system explains why the strategy of whistled speech relies this time on the simple transposition of the fundamental frequency of the voice into a simple pitch. Cowan (1948) observed that whistled Mazatec reproduces tone levels and tone glides of the spoken form. We confirmed his observations with recent recordings. First, we looked at the distribution of whistled frequencies of the whistled words produced by a same whistler in stable conditions of communication (targeted distance, labio-dental technique of whistling). For the syllable nuclei, we measured that the four tone registers are distributed in four statistically different intervals (figure 4).

Next, we observed that several categories of frequency modulations occur: a) the tonal glides internal to the syllable; there are six of them that had already been observed by Cowan (2-4, 3-4, 4-3, 1-3, 3-2 and 2-3 in tonal notations in use in central america); b) the glides between two vowels of a diphthong carrying distinct tone levels; c) and for rapid whistling pace: the glides between two different syllables carrying distinct tone levels.

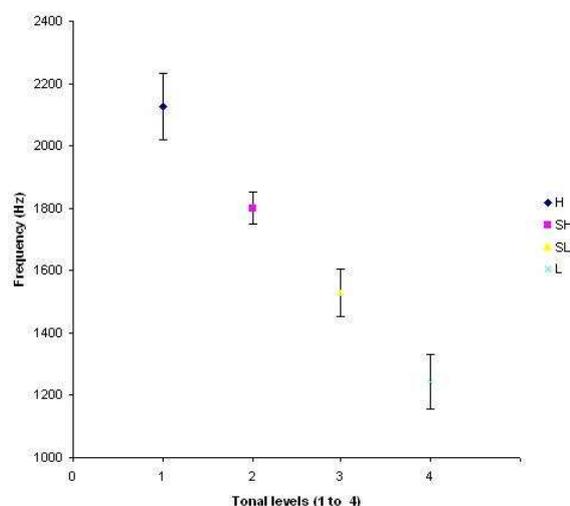


Figure 4: Whistled frequency distribution of the vowel nuclei for 6 Mazatec sentences produced by the same whistler (notation of tones H=high (n°1); SH=Semi-High (n°2); SL=Semi-Low (n°3); L=Low (n°4))

## Applications for school teaching

### *General aspects*

Whistled Spanish of la Gomera has been introduced in school teaching in primary school as a key initiative to reinforce a local process of revitalization of a practice highly devitalized, whereas whistled Mazatec is currently being introduced in secondary school as part of a program of bilingual education Mazatec/Spanish in the Mazatec speaking communities of the Oaxaca state of Mexico. In both cases the phonetic analyzes made by researchers was used as one of the arguments to justify the cultural and linguistic interest of whistled speech for language education. This helped to convince the education authorities to include it in the language lessons. The work of Trujillo et al (2005) and Casimiro et al (2007) also attest that such scientific references were used for developing teaching methods. Whistled

speech was considered as a simple natural support for the students to identify various phonetic aspects of their spoken language, especially the tonal system in Mazatec and the perceptual identity of some vowels and consonant in Gomeero Spanish. In the following sections, we present and analyse these unprecedented didactic initiatives and we propose to revisit them thanks to our latest findings.

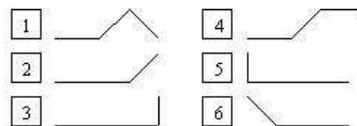
### ***The example of Mazatec***

Mazatec was introduced in the ‘curso de cultura’ in the new ‘programa de lengua y cultura mazateca para la educación secundaria tercer grado’ (Casimiro et al 2007). As Spanish remains the language of reference for teaching at school in Mexico, this pedagogic program recommends clarifying its main differences with Mazatec. In this perspective, the use of tones is first introduced by showing that Mazatec language uses them to distinguish words. It is also the occasion to present the locally used orthography to signal tones (table 2).

*Table 2: Presentation of tonal level, as it is made in the program for secondary school. (The notation between brackets refers to the phonetic alphabet in use by most linguists working in the region)*

<b>ti'</b> (/ti1/)	<b>tí</b> (/ti2/)	<b>ti</b> (/ti3/)	<b>jtí</b> (/ti4/)
Tono alto ( ´ )	Tono semi alto ( ˘ )	No tono	Tono bajo
“tiempo presente “	“quemarse”	“niño”	“pescado”

Moreover, the pitch differences between tone levels are clarified through a reference to musical notes. To explain more concretely this aspect, whistled speech is then introduced. Phonetically, it has the advantage to help the children to understand tonal levels but also tonal glides (figure 5).



*Figure 5: Glides as explained in the ‘curso de secundaria’*

We observe that the glides presented on figure 5 are simplifications coherent with the description made in phonetic research. Yet, they do not distinguish inter and intra syllabic glides (for example, the points 2, 3, 5 illustrate intra-syllabic events, the points 1 and 4 correspond to inter-syllabic events. And the point 6 concerns intra and inter syllabic glides). Moreover, this

pedagogic approach focused mainly on relative variations of whistles (no distinction between the 1-3 and 2-4 glides (point 5)).

### ***The example of Gomero Spanish***

Nowadays, Silbo Gomero is taught by three teachers at school. One of them, being illiterate, relies only on a traditional form of teaching by imitation. The two others combine the imitation model with a pedagogic discourse that consists in a simplified explanation of the phonetic characteristics of Silbo Gomero (see Trujillo et al 2005 entitled '*Materiales didacticos*'). This didactic adaptation has been developed on the basis of the phonetic and phonologic analyzes of Trujillo (1978). It doesn't take into account the linguistic analyzes published by other researchers like Classe (1957) or Rialland (2005). It presents the segmental entities of whistled Spanish as follows: '*It is constituted of four consonantal sounds and two vocalic sounds, their equivalence with vowels and consonants of Castilian are the following*' (Trujillo et al 2005, p)<sup>2</sup> (see table below)

<b>Vowels</b>		<b>Consonants</b>	
whistled	Equivalents in the Spanish written alphabet	whistled	Equivalents in the Spanish written alphabet
I	i, e	CH	t, ch, s
A	a, o, u	K	p, k
		Y	d, n, ñ, l, y, r, rr
		G	b, f, m, g, j

If we confront these interpretations with our observations presented in the previous section and the ones of Rialland (2005) which take into account the amplitude modulations, we conclude that for consonants, the pedagogic simplification fits the phonetic descriptions made by researchers. On the contrary, the simplification concerning vowels contradicts our data showing that at least four whistled vowels are statistically different in whistled Spanish of La Gomera (observations based on the production of the teachers themselves and confirmed thanks to data collected with other native whistlers of la Gomera (Meyer 2005)). Trujillo et al support their very simplified interpretation by asserting that '*sólo resulte reconocible el contraste acústico «máximo», es decir, el contraste 'agudo' / 'grave', que no admite —ni puede admitir— matices intermedios*' (Trujillo et al 2005 '*Materiales didacticos*' p.32). Such affirmations are not consistent with the

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<sup>2</sup> '*Consta de cuatro sonidos consonánticos y dos vocálicos, cuyas equivalencias con las vocales y consonantes castellanas son las siguientes*'

literature documenting the psychoacoustic abilities of discrimination of the human hearing. As a consequence, we developed a psycholinguistic experiment to test the ability of traditional whistler but also of non whistler to identify the four Spanish whistled vowels /i, e, a, o/. The results of these experiments, presented in details in Meyer et al (2007) and Meyer (2008) show that a native whistler identified these vowels in 87,5 % of the cases and that even non whistlers were able to categorize these vowels highly above chance although not as accurately (and without any learning).

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