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PHONATION TYPES AND TONES IN ZAPOTEC LANGUAGES: A SYNCHRONIC COMPARISON

1. Introduction

Zapotec languages possess an unusual diversity of phonation contrasts in their vowel systems. Some languages present a two-way contrast — modal and non-modal phonation — and some others can have up to four contrastive phonation types. Belonging to the Otomanguean stock, Zapotec languages also have contrastive tones, the characteristic family feature. This study investigates the typological diversity of vowel phonation types in Zapotec languages and their interaction with tones. The goal of this research is twofold: 1) to provide a preliminary description of the typological diversity of phonation types in Zapotec languages, from both diachronic and synchronic perspectives, and 2) to evaluate the variety of tone and voice combinations in the same bearing unit — the vowel.

From a typological perspective, Zapotec languages present a challenge in the analysis of their prosodic patterns. Unlike most languages, Zapotec languages display exceptional prosodic patterns consisting of tone, phonation types and stress[1]. This study focus on how tone and phonation types interact providing a preliminary typological framework.

This article is structured as follows. Sections 2 and 3 present the methodology and the languages selected for the analysis. Section 4 presents a cross-linguistic overview of phonation types in order to contextualize the different phonation types in Zapotec languages. In subsection 4.1, a preliminary typology of phonation types in Zapotec languages is given along with a synchronic comparison of the languages selected and a diachronic comparison with the proto-Zapotecan language. Section 5 provides an introduction for the cross-linguistic interaction system of prosodic features used to analyse Zapotec languages

[1] The analysis of stress is out of the scope of this study.

[Kuang 2013]. In section 6 the interactions between tone and voice in the different languages are compared and analysed using the interactional system. Finally, section 7 presents the concluding remarks of this study, as well as the further research needed.

2. Methodology

In this section different methodological decisions and criteria are addressed. For this typological study ten Zapotec languages have been selected based on the availability of phonological descriptions and grammars (Appendix 1). This sample represents the different areas in which the Zapotec subgroup is traditionally divided: Valley, Isthmus, Northern and Southern Zapotec. In section 3, more information on the languages is given.

In order to analyse the distribution patterns of phonation types in Zapotec languages it is necessary to take into account the reconstructions of proto-Zapotec [Fernández de Miranda 1995 (1970); Suárez 1973]. In that sense, the comparison of the phonation types in these ten languages provided in this article is not only synchronic but also diachronic, since the proto-language will be examined to elucidate the different evolution patterns of this particular linguistic phenomenon.

Aiming at the analysis of the relation between tones and phonation types (section 5), I have collected the cases of co-occurrences of tones and phonations presented in the phonological descriptions of the languages. For instance, in San Lucas Quiaviní Zapotec, Chávez Peón [2010: 12] provides evidence of the co-occurrences of the two prosodic features in the vowels.

Figure 1. Co-occurrence of tone and voice
in San Lucas Quiaviní Zapotec vowels

	High	Low	Falling	Rising
Modal	√	√	√	√
Breathy	X	√	√	X
Creaky	√	√	√	X
Interrupted	√	√	√	X

For the analysis of the interaction between tones and phonation types in these languages, I followed the model proposed by Kuang [2013], which is overviewed in section 5. The relation between these prosodic features is scarcely described and Kuang's cross-linguistic typological study sheds light on this issue. Kuang's typology of interactions between tones and phonation types is solely exemplified by Asian languages, however, it seems possible to apply it to Zapotec languages (see [Keating 2014]).

3. Overview of the Zapotec languages

Zapotec languages are spoken in Oaxaca, a region situated in the south coast of Mexico. Oaxaca is one of the most linguistically diverse areas of the world, hosting the majority of the 300 languages [Lewis et al. 2015] spoken in Mexico. Below, Map 1 locates the State of Oaxaca geographically.

Map 1. Mexico and Oaxaca

In Oaxaca there are two language families — Otomanguean and Mixe-Zoque — and two language isolates — Huave and Chontal. It is estimated that the proto-Otomanguean language dates back to 2000 BCE.

Within the Otomanguean family, the three linguistic groups spoken in Oaxaca are Zapotecan, Popolocan and Chinantecan. The Zapotecan group is divided in two sub-groups, Zapotec and Chatino. The exact number of Zapotec languages is under debate. The SIL Ethnologue [Lewis et al. 2015] reports 58 Zapotec languages. Table 1 illustrates the Otomanguean language group structure.

Table 1. Otomanguean language group [Beam de Azcona 2004]

OTOMANGUEAN																			
WESTERN OTOMANGUEAN									**EASTERN OTOMANGUEAN**										
Oto-Pamean-Chinantecan						Tlapanecan-Chorotegan			Amuzgo-Mixtecan				**Mazatecan-Zapotec**						
Oto-Pamean					Chinantec		Chorotegan			Mixtecan			Mazatecan			**Zapotecan**			
Northern		Southern									M-C			Chochoan					
			O-M																
Chichimec	Pame	Matlatzinca-Tlahuica	Mazahua	Otomí		Subtiaba-Tlapanec	Chiapanec	Chorotega	Amuzgo	Trique	Cuicatec	Mixtec	Mazatec	Ixcatec	Popolocan-Chocho	**Zapotec**	Chatino		

Their phylogeny is Eastern Otomanguean, Mazatecan-Zapotecan, Zapotecan, Zapotec. The internal classification of Zapotec languages has been a delicate issue [Merrill 2008b]. Zapotec has been often referred to as a single language with multiple varieties or dialects. However, the time-depth of these 'dialects' is comparable to the time-depth of the Romance languages [Nader 1969]. The dialectal divergence between the Zapotec varieties is pervasive and complex, given the fact that many varieties are mutually unintelligible [Egland et al. 1983 (1978)].

In the linguistic tradition of Zapotec studies there is a strong tendency to classify the languages depending on the geographical divisions of the State of Oaxaca: Valley, Isthmus, Southern and Northern. Establishing the splits within the Zapotec subgroup has been a difficult task due to the lack of data, dialect continua, multilingualism and the problem of measuring intelligibility. In the absence of another consensual classification, I have used the traditionally accepted arrangement of Zapotec languages for this typological study. The sample of languages represents the four geographical divisions of the Zapotec subgroup (Map 2).

Map 2. Sample of languages

Valley Zapotec	1. Zaachila Zapotec	**Southern Zapotec**	6. Santo Domingo de Morelos Zapotec
	2. San Lucas Quiaviní Zapotec		7. San Pedro Mixtepec Zapotec
	3. Santa Ana Zapotec		8. San Agustín Mixtepec Zapotec
	4. San Pablo Guilá Zapotec		
Isthmus Zapotec	5. Juchitán Zapotec	**Northern Zapotec**	9. Yalálag Zapotec
			10. Betaza Zapotec

One of the many factors that can explain the extreme phonological complexity of Zapotec languages is that the native roots are predominately monosyllabic. Zapotec consonants have been described as having a fortis/lenis distinction [Nellis, Hollenbach 1980; Jaeger 1983; Munro, Lopez 1999; Avelino 2001; Beam de Azcona 2004, among others]. This categorization of consonants is used to describe numerous Otomanguean languages, such as Otomi [Gibson 1956; Blight, Pike 1976], Amuzgo [Bauernschmidt 1965] and Trique [Longacre 1952; Hollenbach 1977]. It is argued that the fortis/lenis contrast covers the whole consonantal inventory [DiCanio 2008] because it gives "additional phonetic information to a contrast primarily characterised by voiced/voiceless" [Jaeger 1983: 177].

Otomanguean languages possess an unusually large diversity of vowel phonation types. In general, Zapotec languages have been described as having two- or three-way phonation contrasts in vowels[2] (e.g. [Jones and Knudson 1977; Nellis and Hollenbach 1980; Esposito 2003; Olivares 2009; Pickett et al. 2008]). A four-way contrast is quite uncommon cross-linguistically and it has been reported in two Zapotec languages, San Lucas Quiaviní Zapotec [Chávez Peón 2010] and Zaachila Zapotec [Ariza-García 2016]. These languages display a four-way phonation contrast between modal /a/, breathy /a̤/, creaky /a̰/ and glottalized /aˀ/ vowels.

Furthermore, Zapotec languages have typologically unusual onset and coda clusters that often violate the Sonority Sequence Principle (SSP) in theoretically problematic ways. The majority of cluster types do not conform to the sonority principle, meaning that they are sonority reversals. The violation of the SSP occurs mainly in polymorphemic words, showing that the SSP is under the pressure of the agglutinative morphology of these languages. Nevertheless, there are also examples of monomorphemic words whose consonants clusters do not obey the SSP.

With respect to the Zapotecan group, Jaeger and Van Valin [1982: 127] stated that "all Zapotecan languages are tone languages". The tonal inventories and tonological patterns vary across the Zapotecan subgroup. The co-occurrence of contrastive tone and contrastive phonation has been attested especially in the Otomanguean group of Southern Mexico. Zapotec languages, with contrastive tones and phonation, have been claimed to have a laryngeal complexity in their vowels [Silverman 1997a].

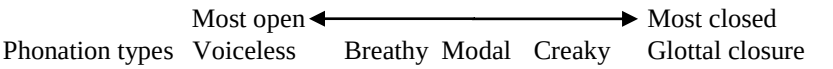
4. Cross-linguistic overview of phonation types

Phonation types result from the different manners in which vocal folds vibrate. These different states of the glottis have been represented by Ladefoged [1971] in the form of a phonation continuum, determining the degrees of aperture of the arytenoid cartilages. The degrees of aperture in the continuum are voiceless, breathy voice, modal voice,

[2] In many languages, due to the scarce documentation, the contrast of phonation types is rather based on near minimal pairs than on minimal pairs.

creaky voice and glottal closure [Gordon and Ladefoged 2001]. Figure 2 illustrates the continuum[3].

Figure 2. Continuum of phonation types [Ladefoged 1971]



The differences in phonation are caused by the adductive and longitudinal tension of the vocal folds. Modal voice is the cross-linguistic neutral phonation, not only because it is the most common phonation type, but also because the vocal folds open and close creating a regular rhythm of the spaced glottal pulses [Esposito 2003]. Breathy voice is realized when there is a minimal adductive and longitudinal tension and the vocal folds vibrate without total contact between them [Gordon, Ladefoged 2001]. Creaky voice is associated with a tightly adducted tension in the vocal folds but open enough to allow voicing, creating irregular spaced vocal pulses (see [Ladefoged 1971; Laver 1980; Gordon, Ladefoged 2001]). Glottal closure requires the absence of any vibration of the vocal cords [Gordon, Ladefoged 2001]. The vowels with glottal closure are called glottalized, interrupted or checked in the Zapotec tradition and they are described as the strongest laryngeal constriction in vowels [Chávez Peón 2010].

Phonation types are used cross-linguistically to manifest linguistic contrast. The contrast between two phonation types is quite common. A three-way contrast system is described for several Otomanguean languages, and specifically in many Zapotec languages. A four-way contrast has been reported as a rather rare system. Only San Lucas Quiaviní Zapotec [Chávez Peón 2010] and Zaachila Zapotec [Ariza-García 2016] are described as having a four-way phonation contrast system — modal, breathy, creaky, and interrupted (glottalized) vowels — within the Zapotec subgroup. Cross-linguistically, the Tuu language, !Xóõ [Traill 1985] was reported as having modal, breathy, creaky and strident vowels[4], and Edmonson and Esling [2006] describe modal,

[3] The continuum is a simplified model of possible phonations. There are many different degrees of phonations, such as lax, slack or lenis towards the breathy side, and tense, stiff, fortis or pressed towards the creaky/ laryngealized side.

[4] Strident vowels are strongly pharyngealized and have an epiglottal trill.

breathy, harsh[5] and faucal voice[6] in Dinka, a Nilo-Saharan language. The scarcity of four-way phonation contrast in Zapotec languages might be due to the different analyses of the glottalized vowels. It is not clear to what extent the glottal closure in glottalized vowels should be analysed as a vocalic feature or as a consonant glottal stop [Avelino 2004; Chávez Peón 2010]. In the next section 4.1, the status of the glottal stop is also reviewed.

4.1. Towards a typology of phonation types in Zapotec languages

The majority of Zapotec languages have a contrastive distinction between modal and non-modal vowels. However, there is a significant typological diversity of phonation types in Zapotec languages — illustrated in (1). In this representative sample of the Zapotec subgroup we can find different inventories of phonation types. Some languages have up to four contrastive phonation types — including modal voice, — other languages can have three distinct phonations and others have only two phonation types — modal and non-modal.

(1) Typological diversity of phonation types in Zapotec languages
(a) Modal vowel: /a/
(b) Breathy vowel: /a̤/
(c) Laryngealized vowel: Creaky vowel /a̰/; Rearticulated vowel /aˀa/
(d) Glottalized vowel (also called checked vowel): /aˀ/

There is some confusion in the literature regarding the definition of *glottalization*. This term refers to the complete vocal fold adduction at the end of a vowel (articulatory glottal stop). However, as this glottal stop is a secondary articulation — following a vowel — it may affect the phonation of the adjacent vowel, which is laryngealized "as the vocal folds prepare for the glottal closure" [Garellek 2013: 5]. The confusion comes when this laryngealized phonation is called glottalization (see [Huffman 2005]) in order to cover the phonetic occurrences of glottal closure and laryngealized voice [Henton et al. 1992; Michaud 2004].

[5] Harsh voice, or ventricular voice is produced by the constriction of the laryngeal cavity, involving epiglottal co-articulation and the use of ventricular folds — false vocal cords [Edmonson, Esling 2006].

[6] Faucal voice is produced by the expansion of the pharyngeal cavity and lowering of the larynx.

In this article, I would use the definition of glottalization from an articulatory point of view and thus, only restricted to the glottal closure.

One of the main controversies regarding phonation types in Zapotec languages is the status of the glottal stop. The glottal closure at the end of the vowel has been generally analysed as a vocalic feature in Zapotec languages (e.g. [Suárez 1973; Jones, Knudson 1977; Lyman, Lyman 1977; Speck 1978; Pickett et al. 2001; Smith-Stark 2003; Beam de Azcona 2004; Ramos 2007; Merrill 2008a; Arellanes 2009; Chávez Peón 2010]). Nonetheless, some linguists have supposed that the glottal closure is an independent glottal stop phoneme (e.g. [Swadesh 1947; Avelino 2004]). Two languages from the sample, Santa Ana del Valle Zapotec [Esposito 2003] and Yalálag Zapotec [Avelino 2004] have been described as having a consonant glottal stop instead of a glottalized vowel. Since Esposito [2003] and Avelino [2004] provide the most exhaustive descriptions of the phonological systems of these two languages, I have used the data that they present. However, as a methodological decision I am analysing the glottal closure at the end of the vowel as a vocalic feature, since it would be inconsistent to accept the glottalized vowel analyses from the rest of the languages selected and the glottalized consonant analyses for Santa Ana del Valle Zapotec and Yalálag Zapotec.

Reconstructions of proto-Zapotec [Fernández de Miranda 1995 (1970); Suárez 1973] suggest the presence of two types of non-modal vowel phonation: glottalized — glottal closure — and rearticulated — laryngealized. Five out of ten languages from the sample have maintained the two non-modal vowels from the proto-language. These languages represent each of the four divisions: San Pablo Guilá Zapotec (SPGZ) from the Valley, Juchitán Zapotec (JZ) from the Isthmus, San Agustín Mixtepec Zapotec (SAMX) from the South, Yalálag Zapotec (YZ) and Betaza Zapotec (BZ) from the North. Table 2 specifically highlights the languages that have retained the distribution of the two non-modal phonations of the proto-language.

Table 2. Type 1: Retention of proto-Zapotec phonation types in five languages

	Valley			Isthmus	Southern			Northern	
phonation types	ZZ	SL QZ	SA VZ	SP GZ	JZ	SD MZ	SP MZ	SA MZ	YZ	BZ
modal	*	*	*	*	*	*	*	*	*	*
glottalized	*	*	* ʔ	*	*	*	*	*	* ʔ	*
laryngea-lized	*	*	*	*	*			*	*	*
breathy	*	*	*							

The phonetic implementation of laryngealized vowels can be as rearticulated vowel [VˀV] or creaky voice [V̰], as it was shown in (1). Even though these five languages contrast laryngealized vowels their phonetic realization is different. For instance, while San Pablo Guilá Zapotec and Juchitán Zapotec have been reported as realizing creaky voice (see [Arellanes 2009; Pickett et al. 2008]) — (2ab), San Agustín Mixtepec Zapotec, Yalálag Zapotec and Betaza Zapotec have been described as having rearticulated vowels (see [Beam de Azcona 2004; Olivares 2009; Avelino 2004]) — (2cde). The examples below (2) present the contrasts between the phonation types in the five languages.

Phonation types contrast in San Pablo Guilá Zapotec, Juchitán Zapotec, San Agustín Mixtepec Zapotec, Betaza Zapotec and Yalálag Zapotec — modal vs laryngealized vs glottalized

(2a) SPGZ [Arellanes 2009: 152]

MODAL	[bɨ̀ː]	‘air’
LARYNGEALIZED	[bɨ̰̀ː]	‘red ant’
GLOTTALIZED	[bɨ̀ˀ]	‘sweet clover’

(2b) JZ [Pickett et al. 2008: 368]

MODAL	[gì]	‘fire’
LARYNGEALIZED	[ʒ̰ì]	‘nose’
GLOTTALIZED	[gìˀ]	‘excrement’

(2c) SAMZ [Beam de Azcona 2004: 4–5]

MODAL	[bɛ̀l]	‘flame’
LARYNGEALIZED	[jɛ̀ˀɛl]	‘swimming hole’
GLOTTALIZED	[mbɛ̀ˀl]	‘snake’

(2d) BZ [Olivares 2009: 90]
MODAL [jô] 'soil'
LARYNGEALIZED [jóʔo] 'lime stone'
GLOTTALIZED [jôʔ] 'house'

(2e) YZ [Avelino 2004: 172, 178]
MODAL [gà] 'nine'
LARYNGEALIZED [gàʔa̰] 'basket'
GLOTTALIZED [kàʔ] 'no'

In the following type of phonations inventory, two languages have simplified the contrast reducing it to one type of non-modal vowels. Santo Domingo de Morelos Zapotec (SDMZ) and San Pedro Mixtec Zapotec (SPMZ), from the South, display a contrast between modal and glottalized vowels. The laryngealized vowel of the proto-language has been probably lost. The norm in the varieties of the South is to contrast modal voice and one type of non-modal voice.

Table 3. Type 2: Languages with two phonation types — modal and non-modal

	Valley				Isthmus	Southern			Northern	
phonation types	ZZ	SL QZ	SA VZ	SP GZ	JZ	SD MZ	SP MZ	SA MZ	YZ	BZ
modal	*	*	*	*	*	*	*	*	*	*
glottalized	*	*	* ?	*	*	*	*	*	* ?	*
laryngea-lized	*	*	*	*	*			*	*	*
breathy	*	*	*							

In Santo Domingo de Morelos Zapotec (SDMZ) and San Pedro Mixtepec Zapotec (SPMZ) the realization of laryngealized vowels occurs but as allophones of glottalized vowels (see [Covarrubias 2010; Ramos 2007]). Glottalized vowels contrast with modal vowels, as shown in example (3), and laryngealized vowels occur in complementary distribution with glottalized ones depending on tone (see [Ramos 2007]).

Phonation types contrast in Santo Domingo de Morelos Zapotec and San Pedro Mixtepec Zapotec — modal vs glottalized

(3a) SDMZ [Covarrubias 2010: 7, 11]
MODAL [dí:s] 'word'
GLOTTALIZED [ʃi:ˀs] pineapple

(3b) SPMZ [Ramos 2007: 72, 80]
MODAL [lù] 'root'
GLOTTALIZED [lùˀ] 'you'

The three following languages from the Valley have developed a new phonation type: breathy voice. Zaachila Zapotec (ZZ) and San Lucas Quiaviní Zapotec (SLQZ) have retained the phonation types contrast from the proto-Zapotec, but they have developed breathy voice as well. In Santa Ana del Valle Zapotec (SAVZ) breathy voice has also developed but there is no data on the existence of glottalized vowels. In the description of Santa Ana del Valle Zapotec [Esposito 2003] glottalized vowels are non-existent because these are analysed as consonant glottal stops at the end of a modal vowel. Table 4 presents the languages that have developed breathy voice.

Table 4. Type 3: Innovation of breathy voice

	Valley			Isthmus	Southern			Northern	
phonation types	ZZ	SL QZ	SA VZ	SP GZ	JZ	SD MZ	SP MZ	SA MZ	YZ	BZ
modal	*	*	*	*	*	*	*	*	*	*
glottalized	*	*	* ?	*	*	*	*	*	* ?	*
laryngea-lized	*	*	*	*	*			*	*	*
breathy	*	*	*							

The incorporation of breathy voice to the phonation types inventory of some Zapotec languages is probably due to areal contacts. Breathy voice has been attested in other Otomanguean languages spoken in geographical areas close to Zapotec languages, such as Chinantec and Mazatec [Rensch, Rensch 1966; Ladefoged et al. 1988]. The following examples (4) illustrate the innovation of breathy voice in the inventory

of contrastive phonation types in Zaachila Zapotec, San Lucas Quiaviní Zapotec, and Santa Ana del Valle Zapotec.

Phonation types contrast in Zaachila Zapotec, San Lucas Quiaviní Zapotec, and Santa Ana del Valle Zapotec

(4a) ZZ [Ariza-García 2016: 120–126]

MODAL	[ná.**zà**]	‘I grab’
GLOTTALIZED	[nà.**jàˀ**]	‘my hand’
LARYNGEALIZED	[lḛ́.**jà̰**]	‘close’
BREATHY	[**jà̤**]	‘noise’

(4b) SLQZ [Chávez Peón 2010: 105, 221]

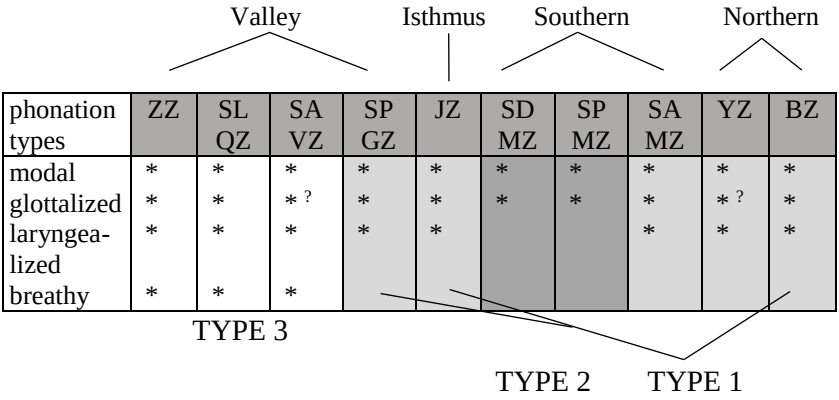
MODAL	[bè:]	‘mesquite bean’
GLOTTALIZED	[rbèˀ]	‘takes out’
LARYNGEALIZED	[bḛ̀]	‘Tanivet’
BREATHY	[bè̤]	‘mold’

(4c) SAVZ [Esposito 2010: 186]

MODAL	[lát]	‘can’
GLOTTALIZED	no data	
LARYNGEALIZED	[lâ̰ts]	‘field’
BREATHY	[lâ̤d]	‘clothes’

In summary, the distribution of phonation types in Zapotec languages can be classified into three types. The languages belonging to the first type have retained the contrastive non-modal vowels from the proto-Zapotec language — glottalized and laryngealized vowels. From the sample, this type is statistically high and the most geographically distributed, since it comprises five out of ten languages that belong to the four different areas of internal division. The second type of languages has reduced the proto-phonation to one non-modal vowel — glottalized in the cases of Santo Domingo de Morelos Zapotec and San Pedro Mixtepec Zapotec. Finally, those languages from the Valley that have developed contrastive breathy voice belong to the third type. Table 5 summarizes all the information given on the typology of phonation types in these Zapotec languages.

Table 5. Phonation types distribution in the ten Zapotec languages sampled



5. Phonation types and tones: a cross-linguistic overview

Tones are produced by modifications of the configuration of the larynx, therefore it is not surprising to find an interaction with laryngeal features, such as phonation types. There are several ways in which tone and phonation might interact. Phonation types can differ in F0 — for instance, non-modal phonation can be associated with pitch lowering effects [Gordon, Ladefoged 2001]. Nevertheless, some studies [Holmberg et al. 1989; Epstein 2002] have not found a strong correlation between pitch and glottal parameters.

The American languages provide good examples of this interaction, but also in many Asian languages phonation types are fully contrastive and co-exist with pitch distinctions [Egerod 1971]. In languages with tonal contrasts, certain tones are often accompanied by non-modal phonation. Silverman [1997a] gives an overview of the languages with tones and phonation types, and classifies the languages of the world as *laryngeally simplex* or *laryngeally complex*. The majority of the languages are *laryngeally simplex*. These are languages that 1) do not have contrastive tone or contrastive phonation, such as English, 2) have contrastive tone, but no contrastive phonation, like many African and Asian languages — e.g., Mandarin Chinese, 3) have contrastive phonation, but no contrastive tone, like Sedang (Austro-Asiatic) and 4) have tonal and phonation distinctions in complementary distribution, as Burmese [Silverman 1997a].

Laryngeally complex languages are those that have both contrastive phonation types and contrastive tones. However, in some *laryngeally*

complex languages tone and phonation can be independent, meaning that they would not restrict each other. For instance, Jalapa Mazatec, an Otomanguean language, is unusual in having independent level tones and phonation types [Garellek, Keating 2011]. The same is true for the Tibeto-Burman languages, Jingpho [Maddieson, Hess 1986] and Bai [Edmonson, Li 1994], that have cross-cutting contrastive tonal and voice quality distinctions. In some Zapotec languages, such as Tilquiapan Zapotec [Merrill 2008a], San Guelavía Zapotec [Jones, Knudson 1977] and Choapan Zapotec [Donnelly 2013] there is no link between tone and phonation, meaning that any tone can combine with any vowel phonation type.

In other *laryngeally complex* languages there are constraints on which phonation and tone combinations are legal. In Southern Yi, phonation contrast is not observed with a high tone, however it is in Northern Yi [Kuang 2011]. In San Lucas Quiaviní Zapotec, non-modal phonation types combine with low and falling tones, except for glottalized and creaky voice that also occurs with high tone [Munro, Lopez 1999; Chávez Peón 2010]. In Santa Ana del Valle Zapotec [Esposito 2010], only modal phonation combines with high and rising tones while non-modal phonation is found only with falling tones.

In many *laryngeally complex* languages, lexical contrast depends on phonation types in a similar way it depends on tone, and at the same time tone and phonation types co-vary. Zsiga [2011] raises the question of whether should the definition of tone be modified to include laryngeal contrast other than pitch. The interaction between tone and phonation types in diachronic and synchronic studies of mixed systems is an active area of research.

Following the same line of Silverman's typology, Kuang's [2013] interactional system also classifies languages depending on their interaction between tones and phonation types: dependent system — *laryngeally simplex*, independent system and mixed system — both *laryngeally complex*. Kuang's typological analysis on the relationships between tones and phonation types in Asian languages is based on the general contrast of dependence/independence between pitch and phonation. Cross-linguistically it has been reported that certain languages can have orthogonal phonemic contrast between tones and phonation types, meaning that they display an independent relation between these prosodic features. That is, in languages like Jalapa Mazatec [Garellek, Keating 2011], all

three level tones combine with the three phonation types in all the five vowels (see [Silverman 1997a; Avelino 2015]). There are no restrictions in the simultaneous occurrence of all tones and phonation types. The examples below (1) show the orthogonal contrast between phonation types and tones in this language [Garellek, Keating 2011: 190].

(5) Orthogonal contrast for tones and phonation types in Jalapa Mazatec

	laryngealized		modal		breathy	
Low tone	[βa̰]	thus	[ja̰]	kind of ant	[ⁿdja̰]	animal horn
Mid tone	[βā]	carries	[hǣ]	finished	[ⁿdā]	good
High tone	[βá̰]	hits	[há]	men	[**ⁿdʒá̰**ʃú]	‘chocolate drink’

Moreover, in the languages of this type, the measurements of the phonetic correlates of tone — F0 *fundamental frequency* — and phonation — CQ *Contact Quotient* — demonstrate a very independent articulation of these features, since they do not affect each other. Therefore, tone and phonation are phonologically contrastive and phonetically independent — “phonation can be kept constant while changing pitch, and pitch can be kept constant while changing phonation” [Kuang 2013: 42].

The dependent system — *laryngeally simplex* — has been illustrated by such languages as Mandarin Chinese or Cantonese [Keating 2014; Kuang 2013]. Non-modal phonation in Mandarin is allophonic or a secondary cue for pitch. Tones 3 and 4 can be realized with creaky voice. Voice quality is strictly tied to F0 in languages like Mandarin Chinese and therefore highly predictable from F0. Since non-modal voice is not contrastive it behaves as another phonetic cue to distinguish tone.

The mixed system — *laryngeally complex* — regards the interaction between phonation types and tones both dependent and independent. Black Miao [Kuang 2013] or some Zapotec languages have contrastive tones and phonation types that combine contrast and correlation in their interaction. On the one hand, laryngealized phonation in Black Miao is dependent to pitch since its realization depends on the tone it co-occurs with — high tone laryngealized phonation is uniquely realized as tense voice while with low tone it is realized as creaky or vocal fry [Kuang 2013]. On the other hand, breathy and modal phonations are realized in the same way independently of

the tone they co-occur with. Therefore, some phonation types can be pitch-independent and thus phonemic, but at the same time some other phonations can be pitch-dependent. In section 6, Zapotec languages are analysed as belonging to this model. Kuang [2013] bases the evidence on acoustic measurements[7] that unfortunately are out of the scope of this investigation.

6. Phonation types and tones interaction in Zapotec languages

Zapotec languages have been described as having contrastive tones and contrastive phonation. However, the interaction between these two prosodic features is highly complex. Zapotec tone inventories are diverse. Most of the languages have four contrastive tones, but some have reduced the inventory to three tones. In this analysis the most significant pattern of relation between tone and phonation types classifies these languages as having a mixed system of interaction [Kuang 2013]. Most of the languages analysed here — but not all of them — display legal combinations of certain tones with *all* the phonation types while at the same time some tones are restricted to *certain* phonation types. In this section, I will analyse the associations between these two features for the ten languages selected.

Zaachila Zapotec and San Lucas Quiaviní Zapotec have the same interaction patterns between the four contrastive phonation types and the four tones. Tables 6 and 7 show the patterns of co-occurrence.

Table 6. San Lucas Quiaviní Zapotec tone and voice combinations

SAN LUCAS QUIAVINI ZAPOTEC				
	H	L	F	R
Modal	√	√	√	√
Laryngealized	√	√	√	
Glottalized	√	√	√	
Breathy		√	√	

[7] Such as the frequency of harmonics for phonation-related measures and electroglottography parameters [Kuang 2013].

Table 7. Zaachila Zapotec tone and voice combinations

ZAACHILA ZAPOTEC	H	L	F	R
Modal	√	√	√	√
Laryngealized	√	√	√	
Glottalized	√	√	√	
Breathy		√	√	

Some languages of the world can combine all the phonation types and tones (independent system), however, in San Lucas Quiaviní Zapotec and Zaachila Zapotec only low and falling tones can co-occur with all the contrastive phonation types. This means that there is a contrast between tones and phonation types since all phonation types combine with low and falling tones without any allophonic variation reported. Furthermore, there are also restrictions in the correlations of tone and phonation types. In both languages rising tone does not co-occur with non-modal vowels. Breathy voice is the only non-modal phonation that does not co-occur with high tone, being restricted to low and falling tones. The following examples (6) of minimal and near minimal pairs illustrate the contrast of tones for all the non-modal phonations.

Contrast of tone in non-modal vowels in Zaachila Zapotec and San Lucas Quiaviní Zapotec

(6a) SLQZ [Chávez Peón 2010: 188, 179, 212]

	laryngealized	glottalized	breathy
H	[bḛ́l] ‘(woman’s) sister’	[rgá^{ʔ}] ‘gets green again’	X
L	[bḛ̀l] ‘snake’	[rgà^{ʔ}] ‘gets caught’	[bè̤] ‘mold’
F	[bḛ̂l] ‘meat’	[rgâ^{ʔ}] ‘pours’	[beṳ̂] ‘turtle’

(6b) ZZ [Ariza-García 2016: 120–125]

	laryngealized	glottalized	breathy
H	[bḛ́] ‘fungus’	[rí^{ʔ}] ‘here’	X
L	[bḛ̀] ‘signs’	[rì^{ʔ}] ‘jug’	[bè̤r] ‘chicken’
F	[bḛ̂s] ‘bee’	[sî^{ʔ}l] ‘lunch’	[bḛ̂ld] ‘fish’

High tone combines with laryngealized and glottalized vowels. Since glottalized vowels have modal voice throughout the whole vowel

until the glottal closure, high tone can be easily implemented in the vowel. Cross-linguistically, laryngealized voice is associated with low fundamental frequency, therefore the combination of high pitch and laryngealized voice is uncommon. In these two languages, laryngealized vowels co-occur with high tone, but the actual realization of a laryngealized vowel bearing high tone is a weak laryngealization. This was interpreted by Ladefoged et al. [1996: 48] as an intermediate point between modal and creaky voice. Acoustically it can be described as tense or stiff voice (see [Chávez Peón 2010; Ariza-García 2016]). This is an allophonic realization of laryngealized voice influenced by high pitch.

While the relation between some tones — low and falling — and *all* the phonation types is independent, since *all* combinations are possible without apparent phonetic changes, the co-ordination between other tones — high and rising — and the non–modal phonation types is restricted. In the three languages from the sample that display breathy voice, this seems to be always restricted to co-occur with low tones.

In Santa Ana de Valle Zapotec there is a similar relationship between phonation types and tones — e.g., rising tone is restricted to modal voice. From the description by Esposito [2003] we do not have any information on the realization of glottalized vowels, since these are analysed as common modal vowels with a glottal plosive in coda position. Table 8 shows the interactions between tone and voice in Santa Ana del Valle Zapotec [Esposito 2003].

Table 8. Santa Ana del Valle Zapotec tone and voice combinations

SANTA ANA DEL VALLE ZAPOTEC			
	H	F	R
Modal	√		√
Laryngealized		√	
Breathy		√	
Glottalized	?	?	?

Santa Ana del Valle Zapotec has only three contrastive tones — one level tone, high, and two contour tones, falling and rising. The correlation patterns of the prosodic features are similar to these of the previously discussed languages in that non-modal vowels occur with the lowest tone — in this case falling tone. Esposito [2003] claims that the first

part of a non-modal vowel with falling tone is modal-like — the higher pitch of a falling tone — while in the second part of the vowel the laryngealization or breathiness is realized — the lower pitch of a falling tone. The examples below (7) present the contrast of non-modal phonation types in Santa Ana del Valle Zapotec.

Contrast of non-modal vowels in Santa Ana del Valle Zapotec

(7) SAVZ [Esposito 2003: 88]

	laryngealized	breathy	glottalized
F	[bə̰l] 'meat'	[bə̤l] 'fish'	?

The most striking difference from all the other languages from the sample is that modal voice can not bear falling tone. The association between tones and modal/non-modal vowels is exclusive and highly dependent in this language. The dependency between the two prosodic features is shown by their exclusive correlation — e.g., modal voice only combines with high and low tones, and vice versa. However, since there is no access to any other analysis of glottalized vowels in Santa Ana del Valle Zapotec, it is inconclusive whether it has a mixed or dependent system regarding the interaction between these two prosodic features.

Santo Domingo de Morelos Zapotec also has four contrastive tones but only two phonation types — modal and glottalized voices. This language shows similar patterns with the languages from the Valley — no rising tone in non-modal vowels and, like Zaachila Zapotec and San Lucas Quiaviní Zapotec, high tone co-occurs with glottalized vowels. It is the only language from the sample that does not display an interaction between low tone and non-modal voice. In Table 9 illustrates the combinations between tone and voice in Santo Domingo de Morelos Zapotec.

Table 9. Santo Domingo de Morelos Zapotec tone and voice combinations

SANTO DOMINGO DE MORELOS ZAPOTEC				
	H	L	F	R
Modal	√	√	√	√
Glottalized	√		√	

Like in the previous languages, there is an independence of voice for certain tones — high and falling allow all voice combinations, —

but also there are restrictions for low and rising tone, which can only be realized in modal vowels. The examples below (8) show the contrast between tones — high and falling — in non-modal voice.

Contrast of tone in non-modal vowels in Santo Domingo de Morelos Zapotec

(8) SDMZ [Hernández Luna 2014: 170]
glottalized
H [jéˀr] 'ocote (Mexican pine)'
F [jêˀr] 'hole'

While in the previously discussed Zapotec languages modal voice is the only phonation type allowed to bear any tone, in San Agustin Mixtepec Zapotec and Betaza Zapotec non-modal voice also co-occurs with every tone. In the case of San Agustin Mixtepec Zapotec it is the glottalized vowel that combines with all the three tones, and in Betaza Zapotec every tone can be contrasted in laryngealized vowels. Tables 10 and 11 show the combinations of the prosodic features in these two languages.

Tables 10. San Agustín Mixtepec Zapotec tone and voice combinations

SAN AGUSTIN MIXTEPEC ZAPOTEC			
	H	L	R
Modal	√	√	√
Laryngealized	√	√	
Glottalized	√	√	√

Tables 11. Betaza Zapotec tone and voice combinations

BETAZA ZAPOTEC				
	H	L	F	R
Modal	√	√	√	√
Laryngealized	√	√	√	√
Glottalized		√	√	

San Agustín Mixtepec Zapotec combines three phonation types with two tones — high and low. Modal and glottalized vowels can co-occur with three tones, including rising, while laryngealized vowels[8] are associated only with high and low tones. A similar pattern is displayed in Betaza Zapotec, a language from the North, where two of the three phonation types — modal and laryngealized — can co-occur with any of the four contrastive tones. Glottalized vowels in Betaza Zapotec are restricted to low and falling tones. The following examples of near minimal pairs (9) illustrate the contrast of tones for the different non-modal phonations of these two languages.

Contrast of tone in non-modal vowels in San Agustín Mixtepec Zapotec (South) and Betaza Zapotec (North)

(9a) SAMZ [Beam de Azcona 2008: 20–22]

	laryngealized		glottalized	
H	[jéˀes]	‘grain’	[jéˀn]	‘dog’
L	[jèˀer]	‘ocote (Mexican pine)’	[jèˀn]	‘nopal’
R	X		[nděˀ]	‘corncob’

(9b) BZ [Olivares 2009: 155, 157, 158]

	laryngealized		glottalized	
H	[gáˀa]	‘basket’	X	
L	[làˀas]	‘slim’	[nàˀ]	‘my hand’
F	[lâˀas]	‘Lázaro’	[lâˀ]	‘Oaxaca’
R	[gǎˀa]	‘nine’	X	

San Pedro Mixtepec Zapotec has four tones, two level tones — high and low — and two contour tones — low-rising and high-rising. San Pedro Mixtepec Zapotec and Juchitán Zapotec are the only languages from the sample where all the phonation types can bear rising tone. Tables 12 and 13 illustrate the combinations.

Tables 12. San Pedro Mixtepec Zapotec tone and voice combinations

SAN PEDRO MIXTEPEC ZAPOTEC				
	H	L	LR	HR
Modal	√	√	√	√
Glottalized	√	√	√	

[8] In the examples (9) of SAMZ and BZ laryngealized vowels are represented as rearticulated.

Tables 13. Juchitán Zapotec tone and voice combinations

JUCHITAN ZAPOTEC			
	H	L	R
Modal	√	√	√
Laryngealized		√	√
Glottalized		√	√

San Pedro Mixtepec Zapotec contrast high, low and low-rising tones in glottalized vowels, whereas modal vowels contrast a fourth tone, high-rising. Juchitán Zapotec allows the co-occurrence of laryngealized and glottalized vowels with low and rising tones, but high tone is restricted to occur with modal vowels. The examples (10) below present the contrast of tones for the non-modal phonation types in these languages.

Contrast of tone in non-modal vowels in San Pedro Mixtepec Zapotec (South) and Juchitán Zapotec (Isthmus)

(10a) SPMZ [Ramos 2007: 112]

	glottalized
H	[kó^{ʔ}] ‘negative’
L	[ɾò^{ʔ}] ‘shore’
LR	[bõ^{ʔ}] ‘coal’

(10b) JZ [Pickett 2007: 17, 30]

	laryngealized		glottalized	
L	[rìgə̀]	‘to empty’	[là^{ʔ}]	‘please’
R	[rìgə̌]	‘to kindle’	[lǎ^{ʔ}]	‘to name’

San Pablo Guilá Zapotec has an exceptional interaction between phonation types and tones that has not been reported for any of the previously compared languages. In this language, all the combinations of tone and voice are allowed, meaning that the two prosodic features have an orthogonal contrast. Languages with an orthogonal contrast between tone and voice have been described as having an independent system, where tone and voice are prosodic features that do not affect each other (see [Kuang 2013; Keating 2014; Avelino 2015]). A similar behaviour can be observed in Yalálag Zapotec, which also has an orthogonal contrast between the four tones and three phonations

reported by Avelino [2004]. Tables 14 and 15 illustrate the orthogonal contrast between tone and voice in these two languages.

Table 14. Orthogonal contrast between tone and voice in San Pablo Guilá Zapotec

SAN PABLO GUILA ZAPOTEC				
	H	L	F	R
Modal	√	√	√	√
Laryngealized	√	√	√	√
Glottalized	√	√	√	√

Table 15. Orthogonal contrast between tone and voice in Yalálag Zapotec

YALALAG ZAPOTEC			
	H	L	F
Modal	√	√	√
Laryngealized	√	√	√
Glottalized	?	?	?

As said in section 4.1, Avelino [2004] interprets the glottal closure at the end of the vowel as a glottal plosive rather than a vocalic feature. In section 4.1 this phenomenon was regarded as a vocalic feature for all the languages — except for Santa Ana del Valle, for which Esposito [2003] does not provide any examples of glottal stop in coda position. Therefore, the interaction pattern — independent, dependent or mixed, — between the two prosodic features, depends on whether the glottal closure is analysed as a vocalic feature — hence, a phonation type — or a consonant. Yalálag Zapotec analysis on the interaction between tone and voice remains inconclusive in this study, like for Santa Ana del Valle, since the data needed for the typological comparison are not accessible. In the examples (11) below, the contrast of tones in non–modal phonations is illustrated below.

Contrast of tone in non-modal vowels in San Pablo Guilá Zapotec (Valley) and Yalálag Zapotec (North): an orthogonal contrast.

(11a) SPGZ [Arellanes 2009: 157]

	laryngealized		glottalized	
H	[ʒḭl]	'sheep'	[ɸtí^{ʔ}]	'blister'
L	[gà.**s̬ì**]	'intestine'	[gì^{ʔ}]	'excrement'
F	[ʒḭ̂ʃ]	'pineapple'	[tʃî^{ʔ}]	'covered'
R	[ʒḭ̌l]	'cotton'	[tʃǐ^{ʔ}]	'then'

(11b) YZ [Avelino 2004: 163]

	laryngealized	
H	[lé^{ʔ}e]	'he/she'
L	[wè^{ʔ}e]	'to carry on'
F	[lê^{ʔ}e]	'his name'

Avelino [2015], following Silverman [1997b], states that the phonetic implementation of laryngealized phonation and pitch depends on the sequencing of modal and non-modal phonation in the same laryngealized vowel. The sequencing strategy facilitates the combination of high and rising pitch with laryngealization — since the latter is generally associated with the lowering of the fundamental frequency. In most of the Zapotec languages, where tone and phonation are contrastive, this is a recurrent mechanism for the phonetic implementation of both prosodic features in the same bearing unit (see [Esposito 2003; Avelino 2004; Chávez Peón 2010; Ariza-García 2016]).

In summary, most of the Zapotec languages from the sample have a mixed system with regards to the interaction between tone and phonation. While phonation types are pitch-independent, since there is a free combination of *all* the phonation types and certain tones — generally low and falling tones, — there are different restrictions for certain tones and certain phonations in each language. The variety of restrictions and combinations is significantly high but a few patterns can be found. Some languages, like San Lucas Quiaviní Zapotec, Zaachila Zapotec and Santo Domingo de Morelos Zapotec do not allow the occurrence of non-modal phonation and rising tone. Nevertheless, the rest of the languages from the sample do not restrict this combination for one or even both non-modal vowels — see the discussion for San Pedro Mixtepec Zapotec and Juchitán Zapotec. The combination of high pitch and laryngealized voice is cross-linguistically uncommon.

The languages with laryngealized vowels co-occurring with high tone display a weak laryngealization, which is an intermediate point between modal and creaky — acoustically described as tense or stiff voice. Therefore, laryngealized vowels with high tone are pitch-dependent. In most of the languages sampled, only modal voice can co-occur with all the tones, however, San Agustín Mixtepec Zapotec and Betaza Zapotec have one non-modal phonation that can bear all the tones. Santa Ana del Valle Zapotec is the only language where modal vowels do not bear falling tone, which is constrained to be only associated with high and rising tone, while non-modal phonations — laryngealized and breathy voice — uniquely can bear falling tone. Finally, San Pablo Guilá Zapotec and Yalálag Zapotec[9] are the only languages from the sample that display an independent interaction between tone and voice, since these two prosodic features have an orthogonal contrast — meaning that every tone can be associated with every phonation type without restrictions.

7. Conclusion and further research

The interaction between tone and voice remains scarcely described. This typological study tries to shed light on the diversity of phonation types in Zapotec languages and their interaction with tones. In the first part of this study, the phonation type inventories of ten Zapotec languages are compared, together with the proto-Zapotec language, in order to explain the extreme variety of phonation types and work towards a preliminary synchronic and diachronic typology. Three types of languages are distinguished with regards to their phonation types distribution: 1) the languages that have retained the three proto-Zapotec phonation types — modal, laryngealized and glottalized, 2) the languages that have reduced the proto-Zapotec phonation types inventory to modal voice and one non-modal voice, and 3) those languages that not only have retained the proto-language phonations but also developed a fourth phonation type — breathy voice.

The second part of the study deals with the phonological interaction between tone and voice in these languages. By comparing the combinations and restrictions of tones and phonation types in the ten Zapotec languages, some patterns have been found out. Most of the

[9] If the glottal closure is analysed as a consonant and not as a vocalic feature.

Zapotec languages from the sample display a mixed interaction between tones and phonation types. On the one hand, a language can have a free combination of *all* phonation types and *certain* tones, which tend to be low and falling tones. On the other hand, this same language can display restrictions in the combinations of *certain* tones and *certain* phonation types. High pitch and laryngealized voice co-occur in some Zapotec languages through the weakening of laryngealization being realized in an intermediate point between modal and creaky voice — tense or stiff voice. Furthermore, two languages from the sample have an independent interaction, since tone and voice display an orthogonal contrast, meaning that all combinations of tones and phonation types are allowed.

This investigation is a preliminary typological study based on the data reported in the phonological descriptions of these ten languages, but it is mandatory to examine the phonetic correlates of tone — F0 *fundamental frequency* — and phonation — CQ *Contact Quotient* — to determine if they are phonetically independent. Therefore, further research is needed on the phonetic measurements to illustrate the phonemic categories of tone and phonation in Zapotec languages. Moreover, the comparative analyses of more Zapotec languages is essential to define the distribution of phonation types in this subgroup and the relational systems generated by the interactions between pitch and voice quality.

Bibliography

Arellanes 2009 — F. Arellanes. El sistema fonológico y las propiedades fonéticas del zapoteco de San Pablo Güila. Descripción y análisis formal. Doctoral Dissertation, El Colegio de México, Mexico, 2009.

Ariza-García 2016 — A. Ariza-García. Phonology of Zaachila Zapotec: a segmental and suprasegmental analysis. MA Dissertation, Aarhus University, Aarhus, 2016.

Avelino 2001 — H. Avelino. The phonetic correlates of fortis-lenis in Yalálag Zapotec Consonants. MA dissertation, UCLA, Los Angeles, 2001.

Avelino 2004 — H. Avelino. Topics in Yalálag Zapotec, with particular reference to its phonetic structures. Doctoral Dissertation, UCLA, Los Angeles, 2004.

Avelino 2015 — H. Avelino. Phonetics in phonology: A cross-linguistic study on laryngeal contrast // H. Avelino, M. Coler, L. Wetzels (eds.). Phonetics and Phonology of laryngeal features in native American languages. Brill: Boston, 2015. P. 157–180.

Bauernschmidt 1965 — A. Bauernschmidt. Amuzgo syllable dynamics // Language 41, 1965. P. 471–483.

Beam de Azcona 2004 — R. Beam de Azcona. Introducing San Agustín Mixtepec Zapotec // C. Jany (ed.). Proceedings of the 7th Annual Workshop on American Indigenous Languages. UC Santa Barbara, 2004.

Beam de Azcona 2008 — R. Beam de Azcona. Estudio comparativo de los tones del zapoteco sureño // A. de Avila, A. López Cruz, V. Marcial, M. Swanton (eds.). Memorias del Coloquio Francisco Belmar: Las lenguas otomangueas y oaxaqueñas ante el siglo XXI. Oaxaca: Fondo editorial IEEPO/ INALI/ Universidad Autónoma Beníto Juarez de Oaxaca, 2008. P. 161–185.

Blankenship 1997 — B. Blankenship. The time course of breathiness and laryngealization in vowels. Doctoral dissertation, UCLA, Los Angeles, 1997.

Blight, Pike 1976 — R. C. Blight, E. V. Pike. The phonology of Tenango Otomi // International Journal of American Linguistics 42, 1976. P. 51–57.

Chávez Peón 2010 — M. E. Chávez Peón. The interaction of metrical structure, tone, and phonation types in Quivianí Zapotec. Doctoral Dissertation, UNAM, Mexico, 2010.

Covarrubias 2010 — A. Covarrubias. El tono y la glotalización en el zapoteco de Santo Domingo de Morelos. Ponencia presentada en el VIII Coloquio Internacional de Lingüística. Mexico: Escuela Nacional de Antropología e Historia, 2010.

DiCanio 2008 — Ch. T. DiCanio. The Phonetics and Phonology of San Martín Itunyoso Trique. Doctoral Dissertation, University of California, Berkeley, 2008.

DiCanio 2009 — Ch. T. DiCanio. The Phonetics of Register in Takhian Thong Chong // Journal of the International Phonetic Association 39, 2009. P. 162–188.

Donnelly 2013 — E. Donnelly. When /n/ isn't just a nasal: codas in Choapan Zapotec. Berkeley Phonetics and Phonology forum. Berkeley: University of California, 2013.

Edmonson, Li 1994 — J. Edmonson, Sh. Li. Voice quality and voice quality change in the Bai language of Yunnan province // Linguistics of the Tibeto-Burman Area 17, 1994. P. 49–68.

Edmonson, Esling 2006 — J. A. Edmonson, J. H. Esling. The Valves of the Throat and Their Functioning in Tone, Vocal Register and Stress: Laryngoscopic Case Studies // Phonology 23, 2006. P. 157–191.

Egerod 1971 — S. Egerod. Phonation types in Chinese and South East Asian languages // Acta Linguistica Hafniensia 13, 1971. P. 159–179.

Esposito 2003 — Ch. Esposito. Santa Ana del Valle Zapotec Phonation MA Dissertation, UCLA, Los Angeles, 2003.

Esposito 2010 — Ch. M. Esposito. Variation in contrastive phonation in Santa Ana del Valle Zapotec // Journal of the International Phonetic Association 40, 2010. P. 181–198.

Epstein 2002 — M. Epstein. Voice quality and prosody in English. Doctoral dissertation, UCLA, Los Angeles, 2002.

Egland et al. 1983 (1978) — S. Egland, D. Bartholomew, S. C. Ramos. La inteligibilidad interdialectal en México: Resultados de algunos sondeos. Mexico City: SIL, 1983 (1978).

Fernández de Miranda 1995 (1970) — M. T. Fernández de Miranda. El Protozapoteco // M. J. Piper, D. A. Bartholomew (eds.). Serie estudios de lingüística y literatura 28. Mexico City: El Colegio de México and Instituto Nacional de Antropología e Historia, 1995 (1970).

Garellek 2013 — M. Garellek. Production and perception of glottal stops. Doctoral Dissertation, University of California, Los Angeles, 2013.

Garellek, Keating 2011 — M. Garellek, P. Keating. The acoustic consequences of phonation and tone interactions in Jalapa Mazatec // Journal of the International Phonetic Association 41, 2011. P. 185–205.

Gibson 1956 — L. F. Gibson. Pame (Otomí) Phonemics and Morphophonemics // International Journal of American Linguistics 22, 1956. P. 242–265.

Gordon, Ladefoged 2001 — M. Gordon, P. Ladefoged. Phonation Types: A Cross-Linguistic Overview // Journal of Phonetics 29, 2001. P. 383–406.

Henton et al. 1992 — C. Henton, P. Ladefoged, I. Maddieson. Stops in the world's languages // Phonetica 49, 1992. P. 65–101.

Hernández, Ulises 2014 — L. Hernández, M. Ulises. Desarrollo histórico y análisis sincrónico del sistema fonológico del Zapoteco de Santo Domingo de Morelos. Doctoral Dissertation, Escuela Nacional de Antropología e Historia, INAH, Mexico City, 2014.

Hollenbach 1977 — B. E. Hollenbach. Phonetic vs. phonemic correspondence in two Trique dialects // W. R. Merrifield (ed.). Studies in Otomanguean Phonology. Dallas: Summer Institute of Linguistics, 1977. P. 35–67.

Holmberg et al. 1989 — E. B. Holmberg, R. E. Hillman, J. S. Perkell. Glottal airflow and transglottal air pressure measurements for male and female speakers in low, normal, and high pitch // Journal of Voice 3, 1989. P. 294–305.

Huffman 2005 — M. K. Huffman. Segmental and prosodic effects on coda glottalization // Journal of Phonetics 33, 2005. P. 335–362.

Jaeger 1983 — J. Jaeger. The fortis-lenis question: evidence from Zapotec and Jawoñ // Journal of Phonetics 11, 1983. P. 177–189.

Jaeger, Van Valin 1982 — J. J. Jaeger, R. D. Van Valin. Initial Consonant Clusters in Yatee Zapotec // International Journal of American Linguistics 48, 1982. P. 125–138.

Jones, Knudson 1977 — T. E. Jones, L. M. Knudson. Guelavia Zapotec Phonemes // W. R. Merrifield (ed.). Studies in Otomanguean Phonology. Dallas: SIL / Univerisity of Texas, Arlington, 1977. P. 163–180.

Keating 2014 — P. Keating. Linguistic voice quality. Berkeley: University of California, 2014.

Kuang 2011 — J. J. Kuang. Production and Perception of the Phonation Contrast in Yi. MA Dissertation, UCLA, Los Angeles, 2011.

Kuang 2013 — J. J. Kuang. Phonation in tonal contrast. Doctoral Dissertation, UCLA, Los Angeles, 2013.

Ladefoged 1971 — P. Ladefoged. Preliminaries to linguistic phonetics. Chicago: University of Chicago press, 1971.

Ladefoged et al. 1988 — P. Ladefoged, I. Maddieson, M. Jackson. Investigating Phonation Types in Different Languages // University of California Working Papers in Phonetics, 1988. P. 126–131.

Ladefoged et al. 1996 — P. Ladefoged, I. Maddieson, M. Jackson. The sound of the world's languages. Cambridge: MA Blackwells, 1996.

Laver 1980 — J. Laver. The phonetic description of voice quality. NewYork: Cambridge University Press, 1980.

Lewis et al. 2015 — M. P. Lewis, G. F. Simons, Ch. D. Fennig. Ethnologue: Languages of the World. Seventeenth edition. Dallas, Texas: SIL, 2015. Online version: http//www.ethnologue.com

Longacre 1952 — R. E. Longacre. Five phonemic pitch levels in Trique // Acta Linguistica 7, 1952. P. 62–81.

Lyman, Lyman 1977 — L. Lyman, R. Lyman. Choapan Zapotec Phonology // W. R. Merrifield (ed.). Studies in Otomanguean Phonology 54. Mexico: SIL and the University of Texas at Arlington, 1977. P. 137–161.

Maddieson, Hess 1986 — I. Maddieson, S. Hess. "Tense" and "lax" in four minority languages of China // Journal of Phonetics 13, 1986. P. 433–454.

Merrill 2008a — E. D. Merrill. Tilquiapan Zapotec // Journal of the International Phonetic Association 38, 2008. P. 107–114.

Merrill 2008b — E. D. Merrill. Classification of Zapotec languages by regions as an aid to language development programs. SIL International Introduction, 2008.

Michaud 2004 — A. Michaud. Final consonants and glottalization: New perspectives from Hanoi Vietnamese // Phonetica 61, 2004. P. 119–146.

Munro, Lopez 1999 — P. Munro, F. H. Lopez. Di'csyonaary x:tèe'n dìi'zh sah Sann Lu'uc (San Lucas Quiaviní Zapotec Dictionary / Diccionario Zapoteco de San Lucas Quiaviní). Los Angeles: UCLA Chicano Studies Research Center Publications, 1999.

Nader 1969 — L. Nader. The Zapotee of Oaxaca // R. Wauchope (ed.). Handbook of Middle American Indians. Vol. 7, E. Z. Vogt (ed.). Ethnology, Part One. Austin: University of Texas Press, 1969. P. 329–357.

Nellis, Hollenbach 1980 — D. G. Nellis, B. E. Hollenbach. Fortis versus Lenis in Cajonos Zapotec Phonology // International Journal of American Linguistics 46, 1980. P. 92–105.

Olivares 2009 — A. T. Olivares. Betaza Zapotec Phonology: Segmental and Suprasegmental Features. Doctoral Dissertation, The University of Texas Austin, Austin, 2009.

Pickett et al. 2001 — V. B. Pickett, Ch. Black, V. M. Cerqueda. Gramática popular del zapoteco del Istmo. 2nd Edition. Juchitán, Oaxaca and Tucson: Centro de Investigación y Desarrollo Binnizá and Instituto Lingüístico de Verano, 2001.

Pickett 2007 — V. B. Pickett. Vocabulario zapoteco del Istmo: español-zapoteco y zapoteco-español. 5th Edition. Mexico City: Instituto Lingüístico de Verano, 2007.

Pickett et al. 2008 — V. B. Pickett, M. V. Villalobos, S. A. Marlett. Isthmus Zapotec (Juchitán) // Journal of the International Phonetic Association 40.3, 2008. P. 365–372.

Ramos 2007 — A. Ramos. Las Propiedades Fonológicas y Morfofonológicas del Zapoteco de San Pedro Mixtepec, Miahuatlán, Oaxaca. MA Dissertation, CIESAS, 2007.

Rensch, Rensch 1966 — C. R. Rensch, C. M. Rensch. The Lalana Chinantec syllable // A. Pompa y Pompa (ed.). Summa antropológica: en homenaje a Roberto J. Weitlaner. Mexico: Instituto Nacional de Antropología e Historia, 1966. P. 455–463.

Silverman 1997a — D. Silverman. Laryngeal Complexity in Otomanguean Vowels // Phonology 14, 1997. P. 235–261.

Silverman 1997b — D. Silverman. Phasing and recoverability. Outstanding Dissertations in Linguistics. London: Routledge, 1997.

Smith Stark 2003 — Th. Smith Stark. Clasificación de las lenguas Indígenas de México // C. Buenrostro, S. H. Castro, Y. Lastra, F. Nava López, J. J. Rendón Monzón, O. Schumann Gálvez, L. Valiñas Coalla, M. A. Vargas Monroy (eds.). Memorias del III Coloquio Internacional de Lingüística Mauricio Swadesh. México City: Universidad Nacional Autónoma de México-Instituto Nacional de Lenguas Indígenas, 2003.

Speck 1978 — Ch. H. Speck. Texmelucan Zapotec suprasegmental phonology // Work Papers of the Summer Institute of Linguistics, University of North Dakota 22, 1978. P. 1–28.

Suárez 1973 — J. A. Suárez. On Proto-Zapotec Phonology // International Journal of American Linguistics 39, 1973. P. 236–249.

Swadesh 1947 — M. Swadesh. The Phonemic Structure of Proto-Zapotec // International Journal of American Linguistics 13, 1947. P. 220–230.

Traill 1985 — A. Traill. Phonetic and phonological studies of !Xóõ Bushman. Hamburg: Helmut Buske Verlag, 1985.

Zsiga 2011 — E. C. Zsiga. Contrastive tone and its implementation // A. Cohn, M. Huffman, A. Rialland (eds.). The Handbook of Laboratory Phonology. Oxford: Oxford University Press, 2011. P. 196–207.

Appendix 1. Languages and references

LANGUAGES	INTERNAL CLASSIFICATION	REFERENCES
1. Santa Ana del Valle Zapotec	Valley	Esposito [2003; 2010]
2. San Lucas Quiaviní Zapotec	Valley	Munro and Lopez [1999], Chávez Peón [2010]
3. San Pablo Guilá Zapotec	Valley	Arellanes [2009]
4. Zaachila Zapotec	Valley	Ariza-García [2016]
5. Isthmus Juchitán Zapotec	Isthmus	Pickett et al. [2008], Pickett et al. [2007]
6. San Agustín Mixtepec Zapotec	Southern	Beam de Azcona [2004; 2008]
7. Santo Domingo Morelos Zapotec	Southern	Covarrubias [2010], Luna [2014]
8. San Pedro Mixtepec Zapotec	Southern	Ramos [2007]
9. Betaza Zapotec	Northern	Olivares [2009]
10. Yalálag Zapotec	Northern	Avelino [2004; 2015]