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Phonemic Inventory of Sindhi and Acoustic Analysis of Voiced Implosives

Abstract: Sindhi offers distinct phonetics, phonology and morphology features. These features lend Sindhi unique particularities especially in recitative form of poetry. The remarkable and unique universal alliterative structure in Shah's poetry is an eloquent testimony to this fact. This is hardly possible in world's major languages. This paper is an effort to discover phonemic inventory of such a linguistically rich language.

Keywords: Phoneme, dental affricates, retroflex nasal, retroflex oral stops, retroflex palatal fricatives, approximant, affricate, Vicholi, Lari, Lasi, Thareli, and Kacchi

1. INTRODUCTION

Sindhi language evolved over a period of 2400 years. This period was accompanied by eight waves of migration of Soythians, people from Southern Iran. The language of the people of Sindh, after coming in contact with the Aryan, became Indo-Aryan (Prakrit). Sindhi language, therefore, has a solid base of Prakrit as well as Sanskrit, the language of India, with vocabulary from Arabic, Persian, and some Dravidian descendants from Mediterranean sub-continent, also known as Moen-jo-Daro civilization. The script that is predominantly used in Sindh as well as in many states in India is in Arabic Nask, having 52 alphabets. However, in some of the circles in India, Devanagri - the Hindi script - has also been used as a script for writing Sindhi

Currently, Sindhi is spoken in Sindh province of Pakistan and in several states of India by a total of about 13 million people. Numerous dialects are prevalent including Vicholi, Lari, Lasi, Thareli, and Kacchi. Kacchi is a mixture of Sindhi and Gujarati and spoken only in India. The literature in Sindhi is known to exist since the 17th century.

Though languages are distinguished and classified by their syntax but Sindhi offers many distinct features in its phonetics, phonology and morphology. Phonetically, it is distinguished by several voiced implosive consonants. Moreover, final short vowel exists with every word and is pronounced quite weakly. Morphologically, Nominal paradigms contain a considerable number of old Indo-European inflections. The verb also includes inflected forms derived from the older participial constructions. Pronouns are often used enclitically.

2. LITERATURE REVIEW

In the field of linguistics, quite nominal researchers have endeavored for Sindhi. That is why this language lacks literature with regard to phonemic analysis and other linguistic phenomena. This paper presents the

phonemic inventory of Sindhi with acoustic analysis of voiced implosives. Voiced implosives have been chosen as a research field because they are present in very few world languages like Sindhi and Hausa.

Implosives are stops produced with above average lowering of larynx during oral closure. Voiced implosives are stops that are produced by lowering larynx with vibrating vocal folds. If a larynx is lowered rapidly enough there would be negative pressure in oral cavity so that air flows into mouth soon after release of closure. So we can say voiced implosives as glottal suction stops with ingressive air stream mechanism. Figure shows the mechanics of voiced implosives [4]. Figure 1(a) represents creation of negative pressure in oral cavity due to rapid opening of larynx during oral closure. While Figure 1 (b) is a snapshot at release of oral closure that is characterized by influx of air into mouth.

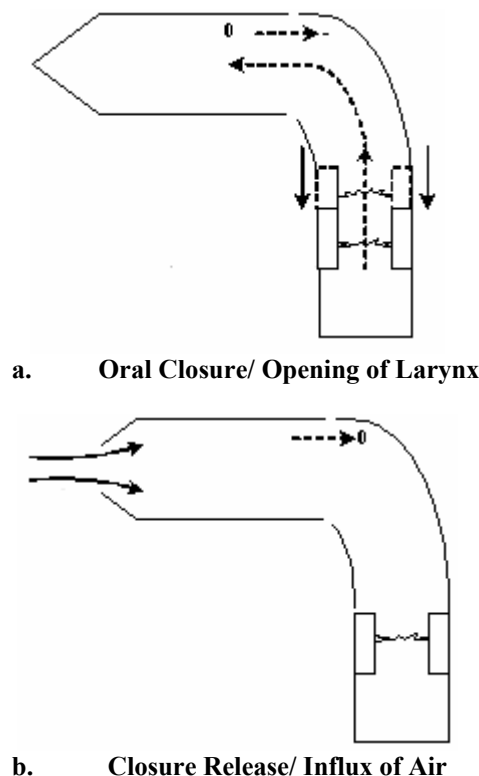


Figure 1: Mechanism of Voiced Implosives [8]

Sindhi phonemic inventory contains many voiced implosives as proposed by Nihalani Paroo. These include bilabial, retroflex, palatal and velar segments.

3. METHODOLOGY

For establishing the phonemic inventory of Sindhi, Sindhi dictionary has been consulted. Minimal pairs have been identified to confirm the existence of phonemes in the language. Articulatory properties have been confirmed by acoustics yardsticks as well. Moreover quite few Sindhi related research papers could be found on Internet that gave very little direction to our work.

For phonetic analysis of sound segments, recordings were made with the collaboration of native Sindhi speakers from Jacobabad. The equipment for recording included high fidelity microphone and two speakers with 8-ohms impedance. Apart from that, we were lucky to find high quality sound recordings from Internet as well. These recordings were from Indian Sindhi speakers so enabled us to provide a comparison between Sindhi phonemes spoken by Pakistani as well Indian speakers. Recordings were analyzed by Praat v 3.9.35, speech processing software from SIL.

3.1. Phonemic Inventory of Sindhi

3.1.1. Consonants

Apart from Urdu phonemes, additional consonants include voiced implosives, palatal and retroflex nasals. Moreover some allophones such as those correspond to / ʈ ,ɖ/ were not found in Urdu as well. For confirmation of their existence both minimal pair testing and acoustic analysis have been applied. Acoustic tests were applied in many scenarios. For example, one problem was to identify retroflex nasal /ŋ/ which was resolved by comparing its spectrogram against general acoustic properties of retroflex and nasal segments. For instance it was compared with nasal /n/ as well retroflex /ɳ/. Another problem was existence of palatal nasal /ɲ/. The spectrogram of palatal nasal was compared against the palatal nasal in words like 'minion', 'pinion', 'spaniel' etc.

Still, another problem was the place of affricates and stops in Sindhi. Nihalani Paroo [8] documents that affricates are purely palatal and so they must correspond to IPA symbols ʈ, ɖ. Worth-mentioning here is these facts were documented for Indian Sindhi speakers. But affricates spoken at Jacobabad seems to conflict with these specifications. These affricates are not palatal but must be alveo-palatal. So they must correspond to IPA symbols (tʃ and dʒ). There was another confusion about existence of alveolar or retroflex stops in Sindhi. For proving this fact spectrograms of these affricates and stops were compared against affricates and stops in Urdu.

Moreover, tests were conducted for existence of voiced palatal fricative /ʒ/. For other consonantal phonemes like aspirated form (b^h, p^h, t^h, d^h, t^h, d^h, k^h, g^h, tʃ^h, dʒ^h, ŋ^h, r^h, ʈ^h, ɖ^h), as already mentioned, both minimal pair test

and acoustic analysis have been taken as yardsticks to reach at final decision.

3.1.2. Vowels

As long as vowels are concerned, they are identified through minimal pairs. Moreover, F1 and F2 values for these vowels were later affirmed by the values given by Pickett [9].

3.2. Acoustic Analysis of Voiced Implosives

Apart from identification of voiced implosives, struggle has been put to evolve general acoustic characteristics unique to voiced implosives. For easy analysis recordings are made for simpler CVCV words. "C" refers to consonant while "V" refers to vowel. The existence of final vowel is phonological constraint by Sindhi.

It was proposed by Ladefoged [8] that amplitude of vibration goes on increasing during oral closure of voiced implosives. To confirm the results all voiced implosives were analyzed using Praat.

4. RESULTS

From scanning of dictionary, huge borrowing of Urdu words is quite evident. But cross-language pronunciation of Urdu words is not exactly same in Sindhi. The most obvious difference is attachment of vowel at the end of each borrowed word. This restriction is imposed by Sindhi phonology. Rest of the word is pronounced quite the same. So we can safely conclude that Sindhi phonemic inventory is a superset of Urdu phonemic inventory with an exception of voiced palatal fricative /ʒ/. Or simply Sindhi phonemic inventory includes all phonemes from Urdu as well its own unique phonemes like voiced implosives. The only phoneme that is present in Urdu but not in Sindhi is /ʒ/.

4.1. Phonemic Inventory of Sindhi

4.1.1. Consonants

Ten speakers have been examined for place of stops / ʈ ,ɖ/ or / t, d/. Eight out of ten responded that they pronounce these stops as retroflex / ʈ ,ɖ/. Remaining two speakers pronounced these stops as alveolar. So we can safely conclude the existence of retroflex stops.

Another interesting feature is also noted about these retroflex stops. These stops exist in complementary distribution with their allophones that start as a stop and end as a trill. We are still in confusion to give them name as affricates, because affricates start with stop but end with fricative. Anyhow we can say these allophones as /t/ colored retroflex oral stops.

Spectrogram of retroflex nasal /ŋ/ shows falling F3 formants. This phenomenon shows the retro flexing. Moreover dampness in intensity shows its nasal properties. For palatal nasal /ɲ/, duration increases relative to simple alveolar nasal /n/. Moreover F1 and F2 are relatively close to each other. These formants drops in start while rises at the end.

According to documentation of Nihalani Paroo about Indian Sindhi speakers, the affricates in Sindhi are palatal. But for Pakistani Sindhi speakers, alveo-palatal segments are detected. The reason for this territorial change is quite evident. Actually it is due to influence of Urdu alveo-palatal affricates /tʃ, dʒ/. Moreover, the spectrogram of Urdu and Sindhi affricates are exactly same that reaffirms the alveo-palatal properties of these affricates.

The Places of articulation for Sindhi are found to be same as in Urdu, namely bilabial, labio-dental, dental, alveolar, alveo-palatal, palatal, velar and glottal. If we traverse sonority hierarchy from obstruents to sonorants, we find stops first. So let us start with stops. Sindhi is unique in the context that its phonemic inventory has extensive variety of stops including both plosives and implosives. In plosives, we have /p, t, ṭ, k/ as voiceless stops and /b, d, ḍ, g, ɟ/ as their voiced counterparts. Implosives are only voiced including bilabial, retroflex,

palatal and velar segments namely /β, d, f, ɟ/. As long as affricates are concerned, they are found to be alveo-palatal /tʃ, dʒ/ rather than pure palatal. Fricatives are produced at labio-dental, alveolar, palatal, velar and glottal places and can be transcribed as /f, v, s, z, ʃ, x, ɣ/. It is notable that Sindhi does not include voiced palatal fricative. Apart from Urdu nasals /m, n, ŋ/, Sindhi includes more nasal including retroflex and palatal nasal /ɲ, ŋ/. At last near the most sonorant vowels, there exists alveolar trill /r/, retroflex flap /ɽ/, an alveolar lateral /l/ and a palatal approximant /j/. Rests are aspirated forms transcribed as /pʰ, bʰ, tʰ, dʰ, tʰ, dʰ, kʰ, gʰ, tʃʰ, dʒʰ, nʰ, rʰ, tʰ, lʰ, ŋʰ/. So Sindhi has additional ŋʰ as compared to Urdu in aspirated phonemes. This whole summary can be represented in table showing places horizontally and manner vertically.

PLACE MANNER		Bilabial		Labio-dental		Dental		Alveolar		Retroflex		Alveo-Palatal		Palatal		Velar		Glottal	
Stop	<i>Plosive</i>	p	b			ṭ	ḍ			t	d					k	g		ʔ
		pʰ	bʰ			ṭʰ	ḍʰ			tʰ	dʰ					kʰ	gʰ		
	<i>implosive</i>	β								ɖ				f	ɟ				
<i>Nasal</i>		m						n	nʰ	ɳ	ɳʰ			ɲ	ŋ				
<i>Fricative</i>				f	v			s	z					ʃ	x	ɣ		h	
<i>Affricate</i>													tʃ	dʒ					
													tʃʰ	dʒʰ					
<i>Trill</i>								r	rʰ										
<i>Flap</i>										ɽ	ɽʰ								
<i>Lateral</i>								l	lʰ										
<i>Approximant</i>														j					

Table 1: Consonantal Inventory of Sindhi

4.1.2. Vowels

As already stated, vowels have been identified from the minimal pairs. One elaboration is given in the table 2 below. They are exactly same those exist in Urdu.

/sə r ə /

Funeral

/s i r ə /

Midstream

/s u r ə /

Music

/s æ r ə /

Walk

Table 2 : Minimal Pairs for Vowels

/s u r ə /

Pain

/s i r ə /

Brick

/s e r ə /

Unit of Weight

/tʃ ə v ə n d o /

He/She will say

/tʃ ə v ə n d o /

You will say

F1 and F2 values have been taken found pretty close to values documented by Pickett. Table 3 represents average F1 and F2 values. These F1 and F2 values have been taken from vowels existing in the minimal pairs present in table 2.

Table 3 : Formants of Vowels of Sindhi

Vowels	F1	F2
u	302.58	776.67
o	464.68	895.44
ɔ	568.56	1150.63
a	907.23	1290.84
i	272.45	2536.24
e	272.14	2556.45
æ	742.81	1868.17
ə	629.78	1576.23
ɪ	445.75	1968.32
ʊ	388.65	1513.98

Sindhi, like Urdu, nasalize all long vowels. Here are some words that prove this fact.

Table 4: Words Containing Nasalized Long Vowels

/V ə ɲ ã/	May I go
/V ə ɲ õ/	Go
/ʔ ə s ỹ/	We
/a h j ũ/	Are
/m ẽ h/	Buffalo
/k æ ntʃi/	Scissor
/ʔõ/	I/We

So, Sindhi phonemic inventory consists of total of ten vowels. Three of them are short namely /ə, ɪ, ʊ/, while rests seven are long ones namely /u, o, ɔ, a, i, e, æ/. Figure 2 presents the vowel inventory of Sindhi.

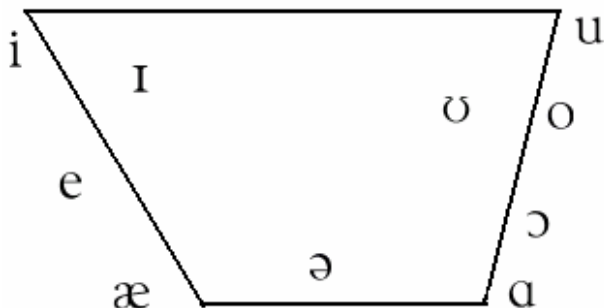
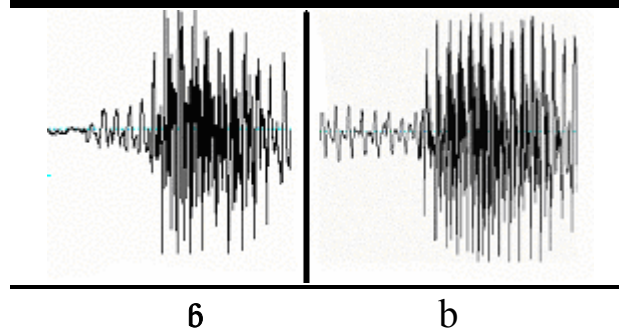


Figure 2 : Vowels of Sindhi

4.2. Acoustic Analysis of Voiced Implosives

The acoustic records show that amplitude of vibration increases during oral closure for voiced implosives. This reveals that opening the larynx counteract the oral pressure buildup. Voicing also sustains and its amplitude increases as well. The fact has been demonstrated for bilabial voiced implosive against its plosive counterpart in oscillogram shown below.

Oscillogram for Bilabial implosive and plosive stop



5. DISCUSSION

During long period of history, Sindhi language has absorbed influence of Old Iranian language during Achaemenian and Sassanian rule. This influence was followed by prakrit and pali during Buddhist and Brahman period. After the Arab conquest in eighth century A.D., Sindhi borrowed plenty of words from the Arabic language, which became the official as well as the religious language of Sindh for nearly three hundred years [10]. So approximately, Sindhi has evolved over a long history of about 2400 years. Current Sindhi morphological, phonological and phonetic structures show clear impact by these ancient languages like Varachada, Dardic, Sanskrit and Prakrit. It has clearly taken voiced implosives from Paishacha (Dardic) language, spoken by ancient Iranian people [4]. That was an old picture but now Sindhi is under wide influence of Urdu and Hindi. Much borrowed words from Urdu in common use are an eloquent testimony to this fact.

Sindhi implosives are good addition to the languages of Indian subcontinent like Panjabi plosives, Urdu velar fricatives, Assamese velar frictionless continuant, Kashmiri affricates and high central vowels. We have tried our level best to explore Sindhi but its rich linguistic features require more research work.

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APPENDIX A

Map for Distribution of Languages across Sub-continent



APPENDIX B

Minimal Pairs for Consonants

/ b ə n u / "Forest"	/ p ə n u / "Leaf"
/ ɓ a r u / "Child"	/ b a r u / "Weight"
/ t̪ ɛ r u / "Wet"	/ d̪ ɛ r u / "Door"
/ t̪ʰ ɛ k u / "Tire"	/ d̪ʰ ɛ k u / "Cut"
/ t̪ ɛ n g u / "Leg"	/ d̪ ɛ n g u / "Sting"
/ l̪ ɛ t̪ʰ u / "Stick"	/ l̪ ɛ t̪ u / "Leg"
/ d̪ ɛ r u / "Fear"	/ k̪ ɛ r u / "Do"
/ d̪ a d̪ʰ i / "Very"	/ d̪ a d̪ i / "Grand-mother"
/ k̪ ɛ d̪ʰ u / "Put out"	/ g̪ ɛ d̪ʰ u / "Donkey"
/ ʔ ɛ d̪ z / "Today"	/ h̪ ɛ d̪ z / "Hajj"

/f a r / "Net"	/tʃ a r / "Four"
/g e r o / "Pigeon"	/pʰ e r o / "Cycle"
/ m a l v / "Wealth"	/ Z a l v / "Wife"
/ g a n o / "necklace"	/ g a r o / "mud"
/s ə nʰ i / "small"	/ s ə s i / "A Name of Girl"
/ d ə ŋ / "Hoard"	/ d ə k / " "
/ m a ɲʰ u / "Man"	/ m a n u / Name of cat
/ v a r v / "Attack"	/ pʰ a r v / "Piece"
/ f ə n v / "Art"	/ b ə n v / "Forest"
/ s a l v / "Year"	/ z a l v / "Wife"

/ s e r ə / "Unit of weight"	/ ʃ e r ə / "Lion"
/ x a k v / "soil"	/ ɣ ə m v / "Sorrow"
/ ʔ ə d ʒ v / "Today"	/ ʔ ə t ʃ v / "come"
/ tʃʰ ə t v / "Crown"	/ d ʒʰ ə t v / immediately
/ ɓ a r v / "Child"	/ b a ɣ v / "Garden"
/ ɓ a rʰ ă / "Twelve"	/ ɓ a r ă / "Children"
/ m a l v / "Wealth"	/ m a r v / "Hit"
/ m ə lʰ v / "Wrestler"	/ m ə ɣ v / "Cup"
/ Kʰ ə ɾ v / "wait"	/ Kʰ ə t v / " cot "