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Co-existence of Tone and Phonation in Punjabi: An Acoustic Study

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ABSTRACT:

This study investigates the co-existence of two laryngeal speech phenomena, i.e., tone and phonation, in the Punjabi language. Punjabi is an Indo-Aryan language that is tonal with three tone types. The stimuli consisted of three sets of mono-syllabic words with each set having three words different from one another only due to their different tone. Recording of the words was done in a silent room with the help of a good-quality WAV file recorder. Ten native speakers (five male and five female) of the language were recorded five times for each word. The speakers were selected conveniently from Lahore, Pakistan. The recordings were analyzed acoustically with the help of software: Praat (Boersma and Weenink, 2014) and ProsodyPro (Xu, 2014). The acoustic correlates of phonation including H1-H2, H1*-H2*, and CPP were measured. SPSS was also used for the statistical analyses. A one-way ANOVA test was applied, followed by a post-hoc Bonferroni test. The results of the study prove that tone and phonation co-exist in the language in a significant way. The low tone co-exists with the breathy phonation type and the high tone co-exists with the tensest phonation.

Key Words: Tone, Phonation, Punjabi language, Acoustic study

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Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

1. Introduction

Punjabi is an Indo-Aryan language, spoken mainly in Pakistan and India, with three tone types. Malik and Khan (2018) report that there are three tone types in Punjabi namely, High, Mid, and Low tones, which are contour in nature. Bussmann (2006, p. 1204) describes the terms tone and toneme as: "phenomena of pitch that refer to morphologically defined segments (morphs, words) to the extent that different pitches in a language are distinctive. Such languages are known as tonal languages. Tone features in tone languages are segmental and phonemic in function (Pickett, 1999), i.e., the tone is a permanent part of words just like consonants and vowels. Baart (2003) suggests that in tone languages, tone is an important feature of a word which should be written in the script of that language in the same way as the vowels and consonants of a word are written. The Chinese Mandarin and the Punjabi spoken in Pakistan and India are good examples of tone languages.

Crystal (2008, p. 361) describes the term phonation as referring to: "any vocal activity in the larynx whose role is one neither of initiation nor of articulation. The various kinds of vocal fold vibration (voicing) are the main phonatory activities, and the study of phonation types is aimed at accounting for the various laryngeal possibilities, such as breathy and creaky voice." Heinz (2011, p. 3) suggests that: "In terms of articulation, phonation refers to the proportion of time the glottis is open and this is called the open quotient."

As both the phenomena explored in the study, i.e., tone and phonation, occur in the larynx, there is a high chance that they co-exist and affect each other; this is why this research is conducted. Kuang (2013, p. 61) explores Mandarin and states that: "different pitch ranges affect the voice quality in both low targets and high targets of Mandarin tones: low targets become breathier when pitch range is raised, but creakier when pitch range is lowered; by contrast, high targets become tenser when pitch range is raised, but breathier when pitch range is lowered."

This study aims to explore the co-existence of tone and phonation in Punjabi and look for the acoustic correlates specific to phonation that can be used to analyze the tonal contrasts and the co-existence of tone and phonation in the language.

2. Literature Review

Tone is defined primarily in terms of variation in pitch or fundamental frequency (F0) of a segment of speech which results in lexical contrasts in a language. Kuang (2013) states that most of the phonological theories have defined tone with only one phonetic dimension, i.e., pitch. Pike (1948) also states that pitch distinguishes the meanings of words in a tone language. Pike (ibid, p. 3) refers to a tone language as: "a language having lexically significant, contrastive, but relative pitch on each syllable". Catford (1988) is of the view that tones are pitch variations that are used in short stretches of syllable length, such as in small grammatical units like words.

Many languages around the globe are tonal. Some major East Asian languages such as Chinese, Vietnamese, Burmese and Thai along with a good number of the languages of Africa, the Americas and Papua Guinea are tonal (Clark, Yallop and Fletcher, 2007). Ladefoged (2000) emphasizes that these languages use pitch to signal differences in meaning between words. Baart (2003) discusses

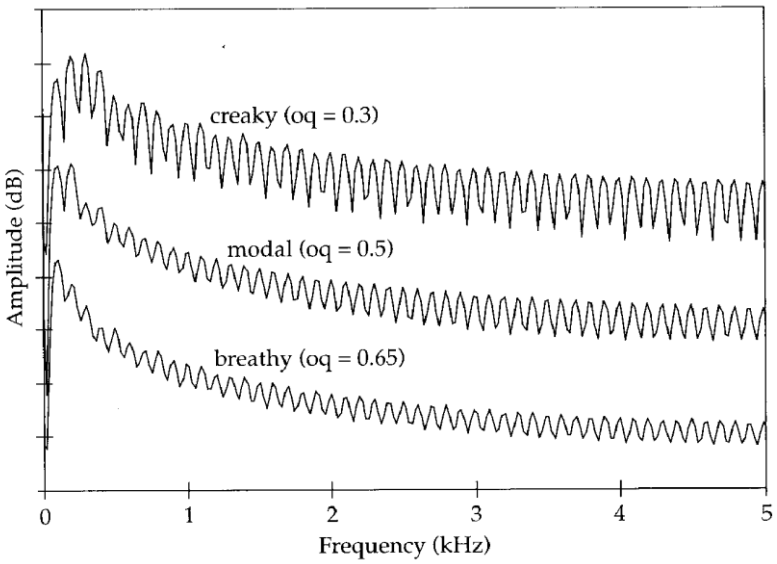
Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

Punjabi as a classic example of a tone language which is an Indo-Aryan language spoken mainly in Pakistan and India along with some other parts of the world.

The second phenomenon explored in the study is phonation. Keating and Esposito (2006) propose that the most common phonation types are breathy voice, modal voice and creaky voice. Garellek (2010, p. 1) suggests: "These phonations are often termed lax, or slack for phonation types tending towards breathy, and tense, stiff, or laryngealized for phonation that tends towards creaky." A breathy voice is produced when the vocal cords are lax whereas a creaky voice requires tense vocal cords. Modal voice lies in between the two, i.e., it is produced with vocal cords neither lax nor tense. Heinz (2011, p. 4) describes different phonation types in terms of their articulation and open quotient as under:

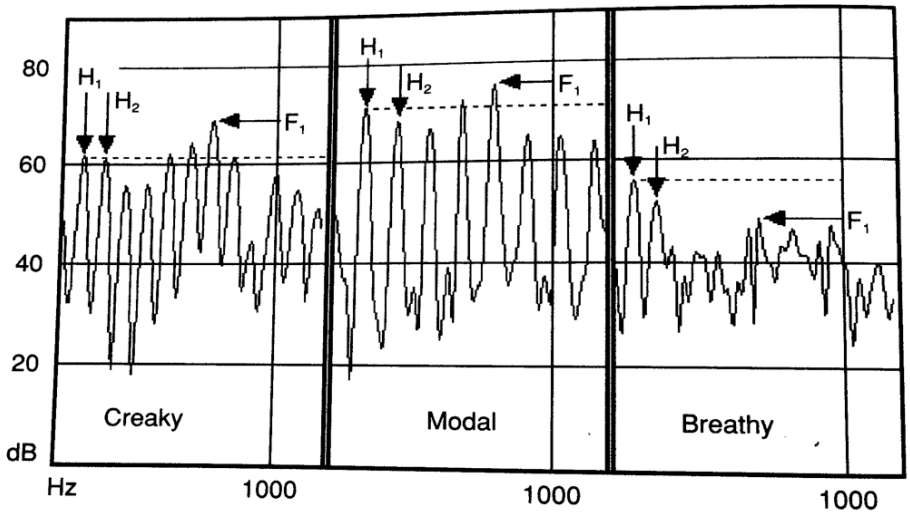
1. "When the glottis is closed (tensed) most of the time in the course of one cycle, this is called creaky;
2. When the glottis is open (loose) most of the time in the course of one cycle, this is called breathy; and
3. When the glottis is open and closed for approximately equal amounts of time in the course of one cycle, this is called modal."

Heinz (ibid, p. 9) gives the following figure which clearly distinguishes among the three phonation types with reference to the open quotient as under:



Fung (2014) describes the three phonation configurations in terms their relative rate of closure of vocal cords as presented in the following image:

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023



Keating and Esposito (2006, p. 85) refer to some studies (Ladefoged, 1971; Ladefoged and Maddieson; 1996, Gordon and Ladefoged, 2001) and suggest that there is "a simplified model of possible phonations, the glottal constriction continuum", which could be used for a better description of phonation types in a language as under:

Most open ⟷ Most closed

Voiceless Breathy Modal Creaky Glottal closure

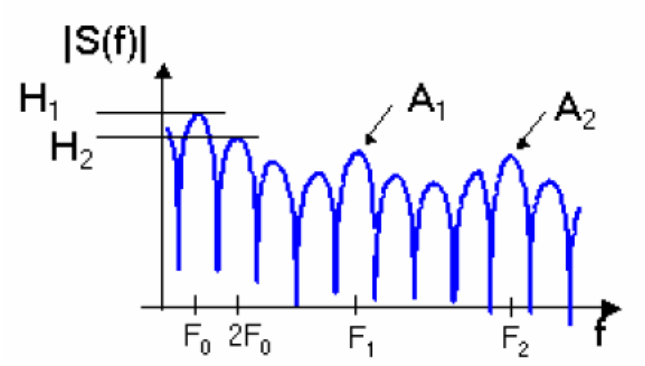
Gordon and Ladefoged (2001, p. 2) state: "Certain languages contrast breathy voiced and regular modal voiced sounds. Some of these languages, e.g. Hindi, Newar, and Tsonga make this contrast among their nasals." Gordon and Ladefoged (ibid, p. 3) further state: "Languages with contrastively breathy voiced obstruents are relatively rare cross-linguistically, although they are common in Indo-Aryan and other languages spoken in Asia, e.g. Hindi, Maithili, Telugu, in addition to Newar". Esposito (2012) discusses some studies on Jingpho, Lahu, and Yi (Madiesson & Hess, 1987) and Chong (DiCanio, 2009; Thongkum, 1991) and suggests that tense phonation is associated with a higher F0 than its non-tense counterparts. Kuang (2013) also explores the co-existence of tone and phonation and finds that the phonation contrasts are better distinguished when the pitch is low and they gradually lose their contrasts as the pitch increases.

Kuang (2013, p. 72) suggests that, in Mandarin, "voice quality co-varies with pitch in a wedge-shaped way, with breathiest voice quality in the mid-range, and creakier and tenser voice quality as pitch moves lower or higher." Kuang (ibid, pp. 108-109) further states: "Crucially, the phonation contrast has no effect on F0, the most important phonetic correlate of tone; and the tone contrast has no effect on Contact Quotient (CQ), the most important phonetic correlate of phonation for these languages. In addition, these two key dimensions, CQ and F0, are not correlated. That is, in these languages, tone and phonation are not only phonologically contrastive but phonetically completely independent. The tone is purely pitch, and phonation is purely voice quality." Gruber (2011) also suggests that phonation and pitch contrasts can exist in a language without intersecting each other like in White Hmong which contrasts five tones (High, Low, Mid, Falling, Rising) and two phonation types (creaky, breathy) and the phonation

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

types function side by side with the pitch contrasts without any overlap. Gruber (ibid) goes on and proposes that phonation and pitch can intersect and their intersection can be independent or dependent.

The acoustic cue of H1-H2 is considered one of the most important cues in distinguishing phonation types in a language. Holmberg et al. (1995) suggest that the measure of H1-H2 is correlated with the period of the glottis opening during each glottal cycle, which is referred to as the open quotient (OQ). During breathy phonation configurations, the value of H1-H2 is higher due to the dominance of the amplitude of the first harmonic, i.e., H1. Andruski and Ratliff (2000) investigate three of the seven tones of Green Mong along with its phonation configurations and find that the breathy phonation gives higher values on the measure H1-H2 than non-breathy phonation types. Also, DiCanio (2007, p. 475) finds that: "The H1-H2 values are the most closely correlated with the pitch changes." Fung (2014) presents the following image to show the difference between H1 and H2:



Heinz (2011, p. 8) suggests: "The difference between the first and second harmonic are a good indicator of the phonation type." Heinz (ibid, p. 9) further describes the three phonation types in the following way:

"H1 > H2 → breathy

H1 ≈ H2 → modal

H1 < H2 → creaky"

Esposito (2010) finds that the four measures, i.e., H1*-H2*, H1*-A1*, H1*-A2* and CPP (where the asterisk indicates that the measure is corrected for vowel formants), all distinguished well breathy from modal phonation configurations in Mazatec. Fung (2014, p. 23) states that: In the measure H1*-H2*, "Asterisks indicate that the harmonic amplitude were corrected to recover the source spectrum of the vocal fold pulses by reducing the influence of formant resonances."

3. Research Questions

This study answers the following questions:

1. Is there any contribution of phonation in the tonal contrasts in Punjabi?

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

2. Which acoustic correlates can be used to explore the co-existence of tone and phonation in the language?

4. Research Design

The study investigates to what extent the two speech related phenomena, i.e., tone and phonation, co-exist in Punjabi. The study is conducted by measuring the acoustic correlates including H1-H2, H1*-H2*, and CPP.

Ten Punjabi speakers (5 male and 5 female) were selected through convenient sampling (OK) from Lahore, the capital of Punjab province of Pakistan. All the participants were reportedly living in Lahore since birth and acquired Punjabi (Majhi dialect as spoken in Lahore) as their mother tongue. The age of the participants ranged from 28 to 45 years with an average age of 34 years. None of the participants knew about the nature of the experiment. It was also ensured that the participants did not have any physiological problems. None of the participants reported any hearing or listening impairment. The education of the participants varied from matriculation to a post-graduate degree.

The stimuli were chosen carefully. Only the mono-syllabic Punjabi words with voiceless consonants were selected. A voiceless consonant was followed by a vowel /a/ in all the words-can be represented as 'CV'. The words were written on flash cards in Urdu script along with their meaning. Based on the tonal contrast, the words made three sets of stimuli with three words in each set representing the three tones in the language. These words were then recorded, which made a total corpus of 450 tokens in the following way:

10 speakers x 3 sets x 3 words x 5 repetitions = 450 tokens

The three sets of words were composed of monosyllabic words as follows:

Low Tone		Mid Tone		High Tone	
[pa]	(price)	[pa]	(quarter)	[pa]	(track)
[ka]	(grass)	[ka]	(possession)	[ka]	(a handful pile of reaped crop)
[ʧa]	(peep through)	[ʧa]	(desire, affection)	[ʧa]	(tea)

In the above table, the words in the first column having low tone are produced as [pa] with low tone, [ka] with low tone, and [ʧa] with low tone, respectively. Similarly, the second column in the table comprises words with a level tone; whereas, the third column in the table shows words with a high tone.

The procedure was explained to the participants and they were given some practice of reading the words from the flash cards. All the instructions were given in Punjabi and Urdu. The participants were asked to read the words from the cards. They were asked to shuffle the words and say every word five times. The participants were allowed to follow their speed of reading the words. They were asked to say the words with reasonable loudness. The recording was done in a

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

silent room. A good-quality WAV file recorder was used for recording the data with a sampling rate of 44100 Hz and 16-bit amplitude resolution/quantization rate. The participants were asked to keep a fixed distance (varied from 4 inches to 6 inches) from the microphone during recordings to avoid any noise bursts during speech. Praat (Boersma and Weenink, 2014) and ProsodyPro (Xu, 2014) software were used for analyzing the data. The acoustic correlates H1-H2, H1*-H2*, and CPP were measured to see the role of phonation in the Punjabi tonal contrasts.

The descriptive statistical analyses of the three Punjabi tones on the chosen acoustic correlates of phonation which include H1-H2, H1*-H2*, and CPP are conducted to explore the coexistence of tone and phonation in the language. These measures have been proved to be the most important measures in distinguishing among the phonation types in a language including breathy, modal and creaky phonations as the most common ones. There are three groups based on three tone categories in the Punjabi language, namely, Low Tone, Mid Tone and High Tone, which are compared with one another concerning the above-mentioned acoustic correlates of phonation. SPSS was used and a one-way ANOVA test was applied. Each of the measures of H1-H2, H1*-H2*, and CPP is taken as a dependent variable and the tone types as independent variables. The one-way ANOVA test was then followed by the post hoc Bonferroni test in each case.

5. Data Analysis

In the study, the first acoustic correlate of phonation that was measured, with the help of Praat (Boersma and Weenink, 2014) and ProsodyPro (Xu, 2014) for the three tone types in Punjabi is H1-H2. The data were analyzed with the help of SPSS. A one-way ANOVA test was conducted to see whether or not there was a statistically significant difference in the three tone groups of Punjabi based on the measure of H1-H2. H1-H2 was taken as a dependent variable and the three tones were taken as independent variables in the test. Later, the post hoc Bonferroni test was also conducted to see which tone groups showed greater differences from one another concerning their H1-H2 values.

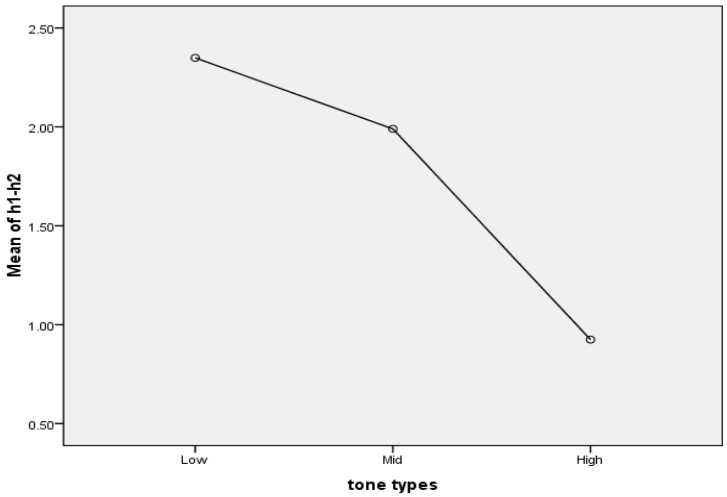
Descriptives

h1-h2

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Low	10	2.3488	2.12903	.67326	.8258	3.8718	-.17	6.11
Mid	10	1.9899	3.28881	1.04001	-.3628	4.3425	-5.76	6.82
High	10	.9245	2.71984	.86009	-1.0212	2.8702	-3.98	4.48
Total	30	1.7544	2.72722	.49792	.7360	2.7727	-5.76	6.82

The table above shows that the low-tone group shows a mean value of H1-H2 as 2.34 dB with a minimum value of -.17 dB and a maximum value of 6.11 dB. The mid-tone group shows a mean value of H1-H2 as 1.99 dB with a minimum value of -5.76 dB and a maximum value of 6.82 dB. Whereas, the high tone group shows a mean value of 0.92 dB with a minimum value of -3.98 dB and a maximum value of 4.48 dB.

Critical Review of Social Sciences and Humanities
Volume 3, Issue 2, 2023



Graphical representation of the three Punjabi tones with respect to the phonation measure H1-H2

The graph shows a gradual decline in values of H1-H2 while we move from the low-tone group to the high-tone group. The mid-tone group lies in the middle slightly downward from the low-tone group. So, a contrastive trend is visible in the figure where the low tone shows the highest H1-H2 value, the mid tone shows an intermediate value on H1-H2, and the high tone shows the lowest H1-H2 value. Therefore, the role of phonation in creating tonal contrasts in Punjabi language cannot be ignored.

ANOVA

h1-h2

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	10.975	2	5.487	.724	.494
Within Groups	204.719	27	7.582		
Total	215.694	29			

$p > 0.05$

One way ANOVA for the measure H1-H2 of Punjabi tones

The one-way ANOVA test for the phonation measure H1-H2 shows a significance value of $p = 0.494$ with [$F(2, 27) = 0.724$, $p > 0.05$]; which means that the three tone groups in the language

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

are not statistically significantly different from one another. However, a simple contrastive trend in the three tone groups is present. To see if any two of the three comparisons in the groups of tone types show a significant difference concerning their H1-H2 values, the following post hoc Bonferroni test was conducted:

Multiple Comparisons

h1-h2
Bonferroni

(I) tone types	(J) tone types	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Mid	.35893	1.23144	1.000	-2.7843	3.5021
	High	1.42430	1.23144	.773	-1.7189	4.5675
Mid	Low	-.35893	1.23144	1.000	-3.5021	2.7843
	High	1.06537	1.23144	1.000	-2.0778	4.2086
High	Low	-1.42430	1.23144	.773	-4.5675	1.7189
	Mid	-1.06537	1.23144	1.000	-4.2086	2.0778

$p > 0.05$ (for all the three comparisons)

Post hoc Bonferroni test for the phonation measure H1-H2 for Punjabi tones

The above table of post hoc Bonferroni test shows a significance value of $p = 1.00$ for the difference between the low-tone group and the mid-tone group where $p > 0.05$, which shows that these two groups are not statistically significantly different from each other. The table shows a significance value of $p = 0.773$ for the difference between the low-tone group and the high-tone group where $p > 0.05$, which also shows that these two groups are not statistically significantly different from each other. Furthermore, the table shows a significance value of $p = 1.00$ for the difference between the mid-tone group and the high-tone group where $p > 0.05$, which also shows that these two groups are not statistically significantly different from each other. So, none of the three comparisons in the post hoc Bonferroni test shows even a slight statistically significant difference which indicates that the phonation measure of H1-H2 is not responsible for any tonal contrast in the language. However, the low-tone and the high-tone groups show some contrast between them.

Statistical Analysis of H1*-H2*

The data were analyzed with the help of SPSS. A one-way ANOVA test was conducted to see whether or not there was a statistically significant difference in the three tone groups of Punjabi based on the measure of H1*-H2*. The H1*-H2* was taken as a dependent variable and the three tone groups were taken as independent variables. Later, the post hoc Bonferroni test was also conducted to see which tone groups showed greater differences from one another. The results of the tests are as under:

Critical Review of Social Sciences and Humanities
Volume 3, Issue 2, 2023

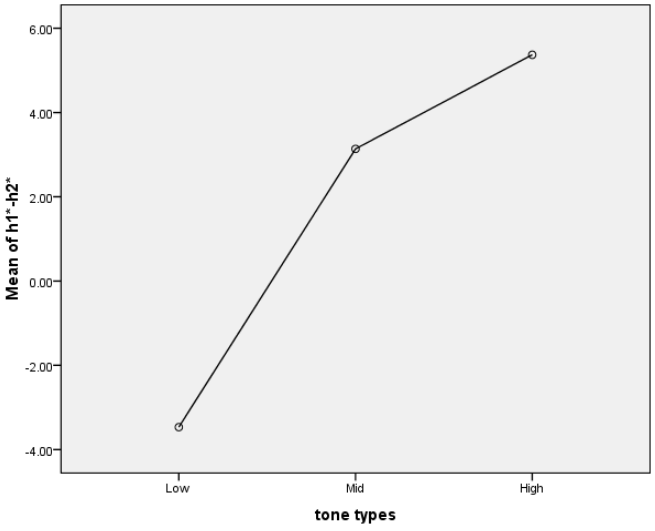
Descriptives

h1*-h2*

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Low	10	-3.4679	6.82511	2.15829	-8.3503	1.4144	-16.57	3.40
Mid	10	3.1370	9.28320	2.93560	-3.5038	9.7778	-8.41	21.00
High	10	5.3706	15.22928	4.81592	-5.5238	16.2650	-15.78	37.18
Total	30	1.6799	11.30252	2.06355	-2.5405	5.9003	-16.57	37.18

Difference in means of the phonation measure H1*-H2* for the Punjabi tones

The table above shows that the low-tone group shows a mean value of H1*-H2* as -3.47 dB with a minimum value of -16.57 dB and a maximum value of 3.40 dB. The mid-tone group shows a mean value of 3.14 dB with a minimum value of -8.41 dB and a maximum value of 21 dB. Whereas, the high-tone group shows a mean value of 5.37 dB with a minimum value of -15.78 dB and a maximum value of 37.18 dB. The p-value in the next table tells us about the statistical significance of the three groups.



Graphical Representation of the three Punjabi tones with respect to the phonation measure H1*-H2*

The graph above shows a gradual increase in the values of H1*-H2* when we move from the low-tone group to the high-tone group. The low tone is on the negative side whereas the mid tone and the high tone groups are on the positive side.

Critical Review of Social Sciences and Humanities
Volume 3, Issue 2, 2023

ANOVA

h1*-h2*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	422.447	2	211.224	1.738	.195
Within Groups	3282.218	27	121.564		
Total	3704.665	29			

$p > 0.05$

One way ANOVA for the measure H1*-H2* for Punjabi tones

The one-way ANOVA test for the phonation measure of H1*-H2* shows a significance value of $p = 0.195$ with [$F(2, 27) = 1.738$, $p > 0.05$] which means that the three tone groups in the language are not statistically significantly different from one another in terms of the phonation measure H1*-H2*. To see if any two of the three comparisons among the groups of tone types show a significant difference concerning their H1*-H2* values, the following post hoc Bonferroni test was also conducted:

Multiple Comparisons

h1*-h2*
Bonferroni

(I) tone types	(J) tone types	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Mid	-6.60495	4.93079	.575	-19.1906	5.9807
	High	-8.83854	4.93079	.253	-21.4242	3.7471
Mid	Low	6.60495	4.93079	.575	-5.9807	19.1906
	High	-2.23359	4.93079	1.000	-14.8192	10.3521
High	Low	8.83854	4.93079	.253	-3.7471	21.4242
	Mid	2.23359	4.93079	1.000	-10.3521	14.8192

$p > 0.05$ (for all the three comparisons)

Post hoc Bonferroni test for the phonation measure H1*-H2* of Punjabi Tones

The above table of post hoc Bonferroni test shows a significance value of $p = .575$ for the comparison between the low-tone group and the mid-tone group where $p > 0.05$, which shows that these two groups are not statistically significantly different from each other. The table shows a significance value of $p = 0.253$ for the comparison between the low-tone group and the high-tone group where $p > 0.05$, which also shows that these two groups are not statistically significantly

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

different from each other. Similarly, the table shows a significance value of p = 1.00 for the comparison between the mid-tone group and the high-tone group where p > 0.05, which also shows that these two groups are not statistically significantly different from each other. So, none of the three comparisons in the post hoc Bonferroni test shows even a slight statistically significant difference which indicates that the phonation measure of H1*-H2* is not responsible for any tonal contrast in the language.

Statistical Analysis of CPP

The data were analyzed with the help of SPSS. A one-way ANOVA test was conducted to see whether or not there was a statistically significant difference in the three tone groups of Punjabi based on this phonation measure of CPP. For that purpose, CPP was taken as a dependent variable and the three tones were taken as independent variables in the test. Later, the post hoc Bonferroni test was also conducted to see which tone groups show better contrast from one another concerning their CPP values. The findings of the tests are as under:

Descriptives

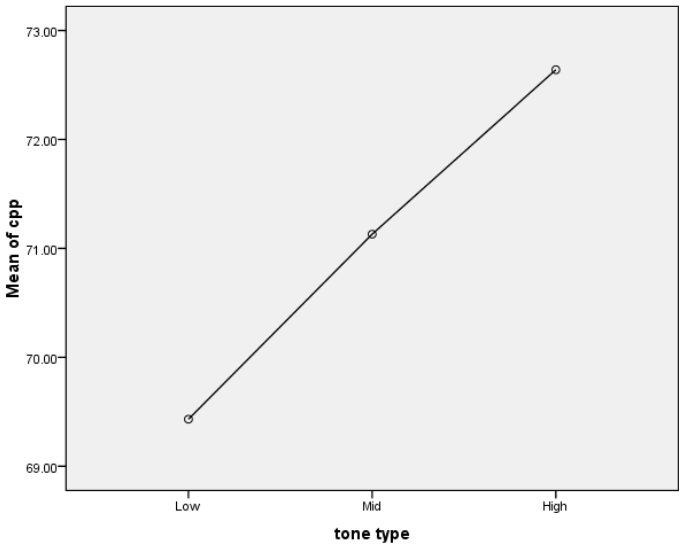
Cpp

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Low	10	69.4313	1.56356	.49444	68.3128	70.5498	67.28	72.41
Mid	10	71.1304	1.94858	.61620	69.7364	72.5243	68.84	75.90
High	10	72.6404	2.76576	.87461	70.6619	74.6189	69.15	76.88
Total	30	71.0673	2.46752	.45051	70.1460	71.9887	67.28	76.88

Difference in means of the phonation measure CPP of the Punjabi tones

The table above shows that the low-tone group (breathy phonation) shows a mean value of CPP 69.43 with a minimum value of CPP 67.28 to a maximum value of 72.41. The mid-tone group shows a mean value of CPP 71.13 with a minimum value of CPP 68.84 to a maximum value of 75.90. Whereas, the high-tone group shows a mean value of CPP 72.64 with a minimum value of CPP 69.15 to a maximum value of 76.88.

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023



Graphical representation of the three Punjabi Tones with respect to the phonation measure CPP

The above graph clearly shows that the values on the measure of CPP increase while we move from the low-tone group to the high-tone group. The mid-tone group lies in the middle. The straight line in the graph shows that the contrast among the tone groups should be statistically significant which is confirmed in the following section.

ANOVA

Cpp

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	51.551	2	25.775	5.567	.009
Within Groups	125.020	27	4.630		
Total	176.571	29			

$p < 0.05$

One way ANOVA for the phonation measure CPP for the Punjabi tones

The one-way ANOVA test for the phonation measure of CPP shows a significance value of $p = 0.009$ with [$F(2, 27) = 5.567$, $p < 0.05$] which means that the three tone groups in the language are statistically significantly different from one another in terms of the phonation measure CPP.

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

To see if any two of the three comparisons among the groups show a significant difference concerning their CPP values, the following post hoc Bonferroni test was also conducted:

Multiple Comparisons

cpp
Bonferroni

(I) tone type	(J) tone type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Mid	-1.69909	.96233	.266	-4.1554	.7572
	High	-3.20908*	.96233	.007	-5.6654	-.7528
Mid	Low	1.69909	.96233	.266	-.7572	4.1554
	High	-1.50999	.96233	.385	-3.9663	.9463
High	Low	3.20908*	.96233	.007	.7528	5.6654
	Mid	1.50999	.96233	.385	-.9463	3.9663

$p > 0.05$ (for low tone vs. mid tone; and mid tone vs. high tone)

$p < 0.05$ (for low tone vs. high tone)

Post hoc Bonferroni test for the phonation measure CPP of the Punjabi tones

The table of post hoc Bonferroni test for the measure CPP shows a significance value of $p = .266$ for the comparison between the low-tone group and the mid-tone group where $p > 0.05$, which shows that these two groups are not statistically significantly different from each other. Similarly, the table shows a significance value of $p = 0.385$ for the comparison between the mid-tone group and the high-tone group where $p > 0.05$, which also shows that these two groups are not statistically significantly different from each other. Whereas, the table shows a significance value of $p = 0.007$ for the comparison between the low-tone group and the high-tone group where $p < 0.05$, which suggests that these two groups are statistically significantly different from each other. So, one of the three comparisons in the post hoc Bonferroni test shows a statistically significant difference, i.e., between the low-tone group and the high-tone group which indicates that the phonation measure of CPP is responsible for the tonal contrast in these two tones in the language.

6. Finding and Recommendations

The experiment conducted in the study proved that tone and phonation coexist in Punjabi. Three acoustic measures namely, H1-H2, H1*-H2*, and CPP were tested for each of the three Punjabi tones. One out of three i.e., CPP distinguished two of the three tone types in Punjabi with statistical significance. The remaining two measures including H1-H2 and H1*-H2* were not statistically significant. Fung (2014) proposes that H1-H2 is the most popular measure for distinguishing phonation types in a language which is expected to be large and positive for breathy voices and small and/or negative for creaky voices. This measure is used to find out to what extent the vocal cords are in an abducted position while producing a speech segment.

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

In the study, the low tone in Punjabi showed a mean value of H1-H2 as 2.34 dB, the mid tone in the language showed a mean value of H1-H2 as 1.99 dB, whereas, the high tone in the language showed a mean value of H1-H2 as 0.92 dB. It is also discussed in the sections above that there are no absolute values for any of these measures. The phonation configurations take place in a language only relative to one another within that language. The findings in the study indicate that the value of H1 (first harmonic) is highest as compared to H2 for the low tone, intermediate for the mid tone and least for the high Punjabi tone. It showed that the vocal cords are in the most abducted position while producing the low tone, in the intermediate abducted position for the mid tone, and in the least abducted position for the high tone. All the values are positive suggesting that there is no creakiness involved in any of the three Punjabi tones.

In the study, the results of the measure H1-H2 indicate that the low tone in Punjabi is the breathiest of the three tones, the mid tone lies in the middle and the high tone is the least breathy of the three tones. Therefore, the Punjabi low tone is found to co-exist with the breathy phonation, the mid tone is found to co-exist with the modal phonation, and the high tone in the language is found to co-exist with the tensest phonation type.

H1*-H2* is also considered an effective measure in distinguishing contrasts among the phonation configurations in a language. Keating et al. (2010, p. 188) investigate and compare contrastive phonation types of four languages, i.e., Gujarati (modal vs. breathy), Hmong (modal vs. breathy vs. creaky), Mazatec (modal vs. breathy vs. creaky), and Yi (tense vs. lax) on several acoustic measures, within and across languages and states that: “While several acoustic measures distinguished phonation types within each language, only H1*- H2* did so in all four languages.” Keating et al. (ibid) find H1*-H2* to be the most important measure of phonation types across languages. Therefore, H1*-H2* has also been included in this study. Garellek (2010) suggests that the value of H1*H2* is higher in breathy phonation types and lower in creaky phonation types. As stated earlier, Fung (2014) suggests that asterisks in H1*-H2* indicate that the harmonic amplitude of the acoustic speech signals was corrected to recover the source spectrum of the vocal fold pulses by reducing the influence of formant resonances.

The findings in the study indicate that this measure also could not distinguish the three Punjabi tones with statistical significance. Kuang (2013, p. 40) suggests that: “F0 is the dominant phonetic correlate for tonal contrasts; the measures that are related to the degree of glottal opening, e.g. CQ and H1* related measures, make very little contribution to the tonal contrasts.” This study proved the point that measures like H1-H2 and H1*-H2* make little contribution to the tonal contrasts in the language as they showed only a bit of a contrastive trend among the three Punjabi tones.

The acoustic correlate Cepstral Peak Prominence (CPP, which indicates the harmonic-to-noise ratio) was also measured for the three tone types in the language. Keating et al. (2010) find that the CPP, the measure of noise and/or periodicity, distinguishes among the phonation types in the three out of four languages; it could not distinguish modal from breathy phonations in Gujarati only. Keating et al. (ibid, p. 196) further state that: “In Mazatec, the only measure that differs with tone is CPP, with Mid tones having the highest CPP value, and Low tones having the lowest value.” Fung (2014) also states that this measure is expected to be small for the breathy voices.

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

In this study, the low tone in Punjabi showed a mean value of CPP as 69.43, the mid tone in the language showed a mean value of CPP as 71.13, whereas, the high tone in the language showed a mean value of CPP as 72.64. The results indicate that the harmonic to noise ratio for the low Punjabi tone is lowest, for the mid Punjabi tone intermediate, and for the high Punjabi tone is highest. Hillenbrand et al. (1994) suggest that the measure of CPP gives lower values in breathy phonation due to the additional noise of increased airflow. Whereas, higher value of CPP indicates that the speech signal is more periodic (Keating and Esposito, 2006). This study finds that the low tone in Punjabi is the breathiest of the three tones, mid tone lies in the middle and the high tone is least breathy of the three tones. As discussed earlier, there are no absolute values for the phonation types in language, rather all the types exist in relation to one another. Therefore, the CPP values also suggest that the low tone in the language co-exists with the breathy phonation, the mid tone in the language co-exists with the modal phonation type, and the high tone in the language is produced when the vocal cords are most tense so the high tone co-exists with the tensest phonation configuration.

7. Conclusion

The study explored the coexistence of tone and phonation in Punjabi, as spoken in Lahore, by means of acoustic and statistical analyses conducted with the help of software Praat (Boersma and Weenink, 2014) and ProsodyPro (Xu, 2014) and concluded that tone and phonation co-exist in the language significantly. The Punjabi tones were measured on certain phonation specific measures (including H1-H2, H1*-H2*, and CPP) so as to explore the role of phonation in Punjabi tonal contrasts. The study concluded that the measures of H1-H2, and H1*-H2* could not distinguish the three tones in the language with statistical significance. These measures showed simple contrastive trends in the Punjabi tonal contrasts; whereas, the measure of CPP (measure of noise and periodicity) distinguished the three Punjabi tones with statistical significance. The study found that the low tone in the language was the breathiest of the three tones. The mid tone in the language co-existed with the modal phonation type. Whereas, the high tone co-existed with the most tense vocal cords. The measure of H1-H2, H1*-H2*, and CPP also showed a continuum which suggested that the Punjabi low tone which was the breathiest of the three tones was produced with the abducted vocal cords for the most time period, the mid Punjabi tone lied in the middle due to its intermediate time of abduction of the cords, whereas, the high tone in the language, which was least breathy of the three tones due to the tensest vocal cords, was produced with the abducted vocal cords for the least time period.

References:

Andruski, J. E. and Ratliff, M. (2000). Phonation types in production of phonological tone: The case of Green Mong. *Journal of the International Phonetic Association 30(1/2).* pp. 37–61.

Baart, J. L. G. (2003). Tonal features in languages of northern Pakistan. Retrieved from (http://www.fli-online.org/documents/linguistics/tone_in_np.pdf) on November 5, 2014.

Boersma, P. and Weenink, D. (2014). Praat: doing phonetics by computer [Computer program for speech analysis]. Version 5.3.71. retrieved from http://www.praat.org.

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

Bussmann, H. (2006). Dictionary of Language and Linguistics. *Published in the Taylor & Francis e-Library*. Routledge: London and New York.

Catford, J. C. (1988). A practical introduction to phonetics. New York: Oxford University Press.

Clark, J., Yallop, C. and Fletcher, J. (2007). An Introduction to Phonetics and Phonology. *Prosody*. USA: Blackwell Publishing. Pp.326-370.

Crystal, D. (2008). A Dictionary of Linguistics and Phonetics. 6th ed. USA: Blackwell Publishing Ltd.

DiCanio, C. (2007). The Phonetics of Register in Takhian Thong Chong. *UC Berkeley Phonology Lab Annual Report (2007).* University of California, Berkeley. Pp. 459-482.

Esposito, C. M. (2010). Variation in contrastive phonation in Santa Ana del Valle Zapotec. *Journal of the International Phonetic Association*, *40(2).* pp. 181–198.

Esposito, C. M. (2012). An acoustic and electroglottographic study of White Hmong tone and phonation. *Journal of Phonetics, 40.* pp. 466–476.

Fung, R. (2014). Voice Quality and Speech Prosody: An Exploration of the Phonological Distinctions of Two Accents of Cantonese. *A presentation at The Hong Kong Polytechnic University.*

Garellek, M. (2010). The Acoustics of Coarticulated Non-Modal Phonation. MA Thesis. University of California, Los Angeles.

Gordon, M. and Ladefoged, P. (2001). Phonation types: A cross-linguistic overview. *Journal of Phonetics 29*. Pp. 383–406.

Gruber, J. F. (2011). An articulatory, acoustic, and auditory study of Burmese tone. PhD Dissertation. Georgetown University.

Heinz, J. (2011). Acoustic and Auditory Phonetics. Chapter 8. Retrieved from http://udel.edu/~heinz/classes/2011/4-633/materials/chap8-slides.beamer.pdf on July 9, 2015.

Holmberg, E. B., Hillman, R. E., Perkell, J. S., Guiod, P., and Goldman, S. L. (1995). Comparisons among aerodynamic, electroglottographic, and acoustic spectral measures of female voice. *Journal of Speech, Language, and Hearing Research 38*. pp. 1212–1223.

Keating, P. A. and Esposito, C. (2006). Linguistic Voice Quality. *UCLA Working Papers in Phonetics, No. 105.* pp. 85-91.

Keating, P. et al. (2010). Phonation Contrasts Across Languages. UCLA Working Papers in Phonetics, No. 108. pp. 188-202.

Kuang, J. (2013). Phonation in Tonal Contrasts. PhD Dissertation. University of California, Los Angeles.

Critical Review of Social Sciences and Humanities Volume 3, Issue 2, 2023

Ladefoged, P. (2000). Vowels and Consonants: An Introduction to the Sounds of Languages. Cambridge, Mass., Blackwell.

Malik, T. G. and Khan, A. Q. (2018). Tone and its Acoustic Correlates in Punjabi. *Kashmir Journal of Language Research.* Vol 21. No. 2. Pp.1-13

Pickett, J. M. (1999). The Acoustic of Speech Communication Fundamentals, Speech Perception Theory, and Technology. Allan and Bacon.

Pike, K.L. (1948). Tone Languages. USA: University of Michigan Press.

Xu, Y. (2014). ProsodyPro — A Tool for Large-scale Systematic Prosody Analysis (software). Version 5.5.2. Retrieved from http://www.homepages.ucl.ac.uk/~uclyyix/ProsodyPro/