Original Article

Acoustic Correlates of Perceived Emotions among Hindustani Singers

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Abstract

Introduction: Music induces precise corporal process as well as mental processes in listener's mind which is generally perceived as emotion. A raga composition consists of a particular combination of notes which creates a mood or atmosphere which can be specialized to uniqueness of the ragas which are perceived subjectively. This study aimed to understand the correlation between acoustic parameters and emotions among Hindustani singers. **Materials and Methods:** The experiment was carried out on ten trained Hindustani singers in the age range of 20–40 years. Singing samples of ascending and descending scales were recorded for chosen ragas and each raga was analyzed for various acoustic parameters. **Results:** The results revealed a significant difference ($P < 0.01$) for the first three formants in swaras such as S2, S3, and S5. **Conclusion:** Hence it can be concluded that, among three ragas (R1, R2, and R3), change of formant frequency at the position of S2, S3, and S5 will result in perception of different emotions.

Keywords: Music, ragas, singing, swaras

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Introduction

Emotion appreciation in speech has been the topic of research.[1] Previous researches have focused on theoretical and psychological aspects of emotional expressions in speech which also helped to recognize emotions in speech.[2] In contrast, recognition of emotions in singing has mostly been flouted, although in singing, variation in emotion is highly visible and is an important phenomenon in music and singing.[3] Singing is a very special way of expressing through vocal mechanism which demands association and relation between various speech mechanisms of respiration, resonation, phonation, and articulation.[4] Music induces precise corporal and process as well as mental processes in listeners mind which is generally perceived as emotion. It is known that music activates not only pleasure centers within the brain but also consist of intensive emotions.[5,6]

Emotions in the singing voice have been given very little attention, even though the fact those emotions are easily perceived subjectively. In particular, emotions play a key part in music, and trained singers will be able to effortlessly express an extensive range of emotions. As per the traditional parameters considered for voice quality in expression of emotions, vocal expression contains a specific fundamental and formant frequencies (FFs), intensity, and duration.[7] Researchers have shown that emotional expressions of music are highly associated with attributes of music such as pitch height, intensity, and tempo, and these properties help the listeners to interpret the particular emotion.[8] When compared to reading and speaking, fundamental frequency was established to be increased in singers.[9] A study[10] reports that few attributes such as tempo and loudness provide universal cues to comprehend the meaning of emotions in singing. Music of happy emotion usually fast in tempo, and it typically has wide pitch range and high loudness, they added.

There are limited studies with keenness in karaoke singing[11] where it is near to the emotional measurement of target vocal training or arousal systems. Earlier results had discovered that the emotions in singing and speaking voice are closely related and also determines that similar approaches and acoustic parameters can be used to categorize emotions in music and

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speech.[12] Studies on emotion in singing have been carried out in Opera singers[13] reveals a high correlation between emotions and acoustic parameters. This indorses that the method in approaching speech emotion recognition can be transferred to singing emotion recognition.

In Indian classical music, ragas comprised particular combinations of tonic intervals which are successful in evoking divergent emotions.[14] Hindustani music consists of more than 400 scales which consists of different semitones.[15] A raga composition consists of a particular combination of notes which creates a mood or atmosphere which can be specialized to uniqueness of the raga. Such modifications are carried out by the performers where it becomes essential for us to understand the acoustic correlates in perceived emotions of Hindustani singing.

Need for the study

Emotions are perceived subjectively for different valence in singing, but the objective acoustic correlation with emotions is frequently ignored. Similar studies have been carried out in different forms of music such as Opera singing and Carnatic music but are hardly ever studied in Hindustani music, which is mainly a emotion-based music. Hence, there is a need to study the emotion recognition in Hindustani music to appreciate how acoustic changes can result in change of emotions.

Aim and objective

The aims of the present study were as follows:

1. To find out whether there is any relation between acoustic measures of different ragas in Hindustani music with that of the perceived emotions by the listeners.
2. To understand how the changes in acoustics of a particular raga will result in perception of a totally different emotion.

Method

Participants

Ten trained Hindustani singers (five males and five females) who have minimum 5 years of formal training and who indulge in regular practice in the age range of 20–40 years were considered. Participants with history of smoking, alcohol consumption, and any vocal pathology were excluded from the study.

Procedure

The experiment was carried out in three phases. In the first phase, three emotions (happy, sad, and calm) were considered and 3 ragas were chosen for each emotion, that is, Raag Sarang, Raag Durga, and Raag Pahadi for happy; Raag Shivaranjini, Raag Malkauns, and Raag Marwa for sad; and Raag Yaman, Raag Bhoopali, and Raag Hamsadhwani for calm, respectively. The lists of ragas were given to five experienced Hindustani musicians to validate the valence of ragas based on their emotions. The individuals selected had minimum of 10 years of experience and indulged in regular music practice. They were professional music teachers as well. They were asked to rate based on a three-point rating scale. Two indicating most relevant, 1 indicating partially relevant, and 0 indicating least relevance. There was 60% agreement across experts, and based on the rating, ragas were selected for the next phase. The selected ragas were Durga (Sa, re, ma, pa, dha, sa), Shivaranjini (Sa, re, ga, pa, dha, sa), and Bhoopali (Sa, re, ga, pa, dha, sa) and all 3 raagas consisted of 6 swaras, respectively. In the second phase, written version of the ascending and descending musical notes was given to the subjects. They were asked to sing the swaras and aalap (phonating/a/) at a comfortable and uniform pitch. Recording was done for both ascending and descending scales of each raga, by using a digital SONY ICD-PX333 recorder at a distance of 1 ft. from the singer's mouth in a room with less ambient noise and no instruments accompanied. The samples were transferred to a Dell laptop and were analyzed using PRAAT 2.0 Software developed, by Paul Boersma and David Weenink of the University of Amsterdam.

In the third phase, each raga was analyzed for parameters such as Fundamental frequency (Fo) and Formants F1, F2, and F3. These parameters were tabulated and statistically analyzed to know the significant difference in the acoustic parameters of swaras between raagas, which may result in change of emotion recognition while singing.

Results

In Phase 1, out of nine ragas given to the experienced musicians, three ragas were chosen for the experiment based on the rating. The chosen three ragas were rated as most relevant by 60% of the experts. For the purpose of tabulation and analysis, Ragas Durga, Shivranjini, and Bhopali were named as R1, R2, and R3, respectively. The six swaras in each raga were named in serial order from S1 being the first swara to S6 being the last one. The tabulated data were subjected to statistical analysis using IBM SPSS version 2.0 software. As there were two or more dependent variables, the data were subjected to multivariate ANOVA to find out the significant difference between swaras among three ragas. The results revealed that there was significant difference ($F(2) = 264.78$; $P \leq 0.05$) only in formants F1, F2, and F3 corresponding to three swaras (S2, S3, and S5) between ragas. It was also found that the mean values for R1 and R3 were greater when compared to R2, but the mean did not differ much between R1 and R3. There was no significant difference in any other acoustic parameter.

Paired sample *t*-test was carried out to find out if there is any significant difference between formants of swaras S2, S3, and S5. The results revealed that there was a significant difference ($P \leq 0.01$) in FFs of S2, S3, and S5 between R1 and R2. Significant difference ($P \leq 0.01$) was seen only for FF of S5 between R2 and R3. FF significantly differed ($P \leq 0.01$) for S2 and S3 between R1 and R3 [Tables 1-3 and Graphs 1-3].

Discussion

A latest review of the literature by[16] revealed that the outcome of 135 studies provides a vast amount of proof for the human ability to deduce a person's emotion from his/

Table 1: The mean values for swara 2

Mean	Raaga 1	Raaga 2	Raaga 3
Mean F_0	182.717	176.487	188.496
Mean F_1	702.029	434.254	468.288
Mean F_2	2379.279	2003.024	1918.429
Mean F_3	2950.797	2506.358	2455.327

Table 2: The mean values for swara 3

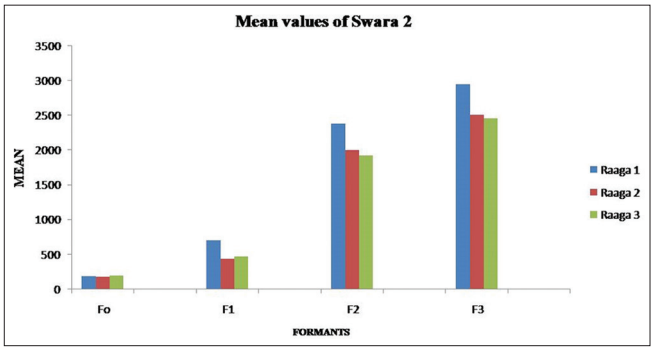
Mean	Raaga 1	Raaga 2	Raaga 3
Mean F_0	220.56	170.893	208.405
Mean F_1	711.181	513.679	525.557
Mean F_2	2778.918	1845.173	2350.373
Mean F_3	3134.615	2465.213	2709.477

Table 3: The mean values for swara 5

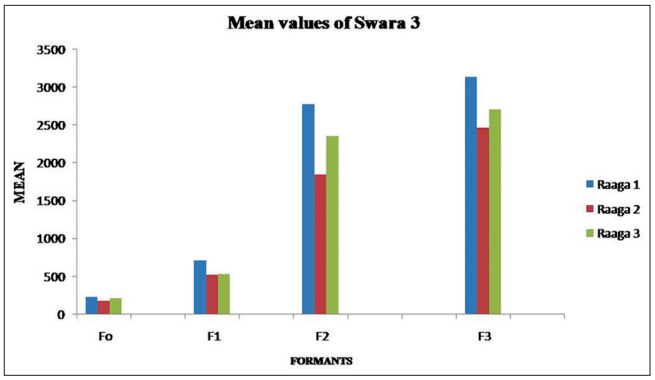
Mean	Raaga 1	Raaga 2	Raaga 3
Mean F_0	285.62	281.904	223.562
Mean F_1	726.734	502.507	721.03
Mean F_2	1614.939	1180.688	1609.269
Mean F_3	2903.241	2576.816	2889.773

her nonverbal expression with a degree of precision that by far exceeds possible expectations. Change in spectral slope and frequency parameters resulted in perception of different emotions was reported by[17] which is in concordance with the present study. A study by[13] revealed that speech emotion recognition methods can be applied to analyze emotions in singing voice. The results of the same study showed high correlation between acoustic parameters and emotions. Raga connotes personality of sound created by the progression of musical notes according to some accepted laws of melody. The laws governing the progression of swaras are from the technique of alapana as reported by.[18] A study by[19] concluded that the dominant note of raga is always seen of special prominence and it uses only vowels for musical expressions and sometimes nasals. The findings were supported by a study done by[9] where they concluded that, when compared to reading and speaking, fundamental frequency was established to be increased in singers. The findings of the study by[20] suggests that listeners are sensitive to emotion in acquainted and unfamiliar music, and this sensitivity is related with the perception of acoustic cues that exceed cultural boundaries.

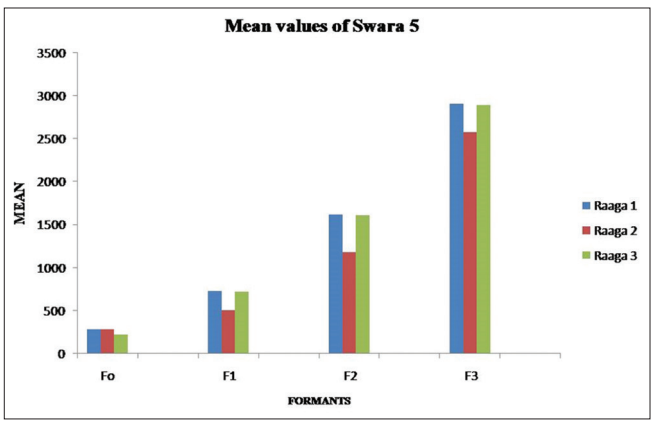
A study by[21] had a singer express diverse emotions by repetitively singing a single note and straightforward melodic sequences, asking observers to name the emotions projected (surprise, fear–pain, sorrow, and anger–hate) and concluded that both single tones and melodies can pass on emotional significance to the listener. An early on study asked 11 expert singers to sing different vocal music scores to depict four fundamental emotions, happiness, sorrow, fear,



Graph 1: Mean values of swara 2 across ragas



Graph 2: Mean values of swara 3 across ragas



Graph 3: Mean values of swara 5 across ragas

and anger, and asked listeners to distinguish the projected emotions. Literature by[22] explains that performances documented as sad were characterized by a slow rate or tempo, whereas apparent anger was associated with a higher average level and faster syllable onsets and decays of sound pressure as.

Another study by[23] discovered that emotion portrayals characterized by higher arousal levels (happy, scared, angry, and hateful) were linked with louder singing (higher sound pressure level), faster tempo, and a higher rate of intensity difference when compared with renderings of low arousal (secure, loving, and sad).

Conclusion

The aim of the study was to see whether there is any change in acoustic parameters with respect to change in emotion while singing in Hindustani music. The obtained result confirms that there is some change in acoustic parameter with change in emotions. In the study, majority of acoustic changes is seen in FF, especially for three particular swaras; S2, S3, and S5 among three ragas. Hence, it can be concluded that, among three ragas (R1, R2, and R3) change of FF at the position of S2, S3, and S5 will result in perception of different emotions. In future, this study can be extended by considering a larger sample and also a wider range of ragas and emotions.

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Conflicts of interest

There are no conflicts of interest.

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