Thoughts Review
Vol. 1, Issue 2 (April–June 2025)
https://thoughtsreview.com/ | Received: 07 April 2025 | Published: 30 June 2025

Tempered Reeds and Untempered Microtones: The Impact of Equal Temperament on Shruti Preservation in Oral Harmonized Traditions

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Abstract

This study investigates how 12-tone equal temperament (12-TET) harmonium accompaniment influences microtonal pitch variation in South Asian oral vocal traditions, particularly the flexibility associated with Shruti. A quantitative repeated-measures design was employed involving 40 vocalists experienced in South Asian music. Participants performed sustained notes, meend (gliding pitch transitions), and gamak (ornamental oscillations) under two accompaniment conditions: a fixed-pitch 12-TET harmonium and a continuous-pitch reference. Audio recordings were analyzed using fundamental frequency (F_0) measurements, expressed in cents, to determine pitch deviation, pitch-range width, and pitch-within-contour variation (PWC). The findings revealed a substantial reduction in microtonal flexibility during harmonium accompaniment. Overall mean absolute deviation (MAD) decreased from 31.84 cents under the continuous-pitch condition to 18.27 cents with the harmonium, representing a 42.62% reduction. Paired-samples analysis confirmed that this difference was statistically significant, $t(39) = 10.84$, $p < .001$, $d = 1.71$. Significant differences were also observed across sustained notes, meend/glissando transitions, and gamak ornamentation. Repeated-measures analysis of variance identified significant main effects of accompaniment condition, $F(1,39) = 46.82$, $p < .001$, partial $\eta^2 = .546$, and musical task, $F(2,78) = 31.64$, $p < .001$, partial $\eta^2 = .448$. A significant interaction between accompaniment and musical task was also established, $F(2,78) = 12.57$, $p < .001$, partial $\eta^2 = .244$.These results demonstrate that fixed-pitch accompaniment can constrain microtonal pitch variation and influence tonal coordination in oral performance practices. The study highlights the importance of acoustic measurement and digital documentation for preserving subtle pitch characteristics and expressive nuances within South Asian musical heritage.

Keywords: Equal Temperament, Gamak, Harmonium, Microtonality, Shruti, South Asian Music

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Introduction

In many traditional musical systems, the effect of small pitch intervals is an important factor in the identification, expression and sense-making of a melody, and this is called microtonal pitch. Shruti is one of the crucial notions in Indian musical tradition, to do with microtonal arrangements and pitch relationships of sounds. Further, computational investigations in recent years also have drawn attention to the need for preservation of the distinctions in Shrutis for analysis of classical music from India (Maiti, 2022, Parikh et al., 2023).

One very serious issue with flexible and culturally specific pitch relations is the introduction of equal temperamental micro intervals. Equal temperament supplies common pitch intervals which are easy to note, use in instrument-making, to perform together and to compose in a digital environment. However, according to the studies in Turkish makam music, different ways of makam music temperament can affect the listener's emotions and ideas on music structures (Altun & Egermann, 2021).

Oral traditions are notated by any pitch-knowledge element, but rather by listening, imitating, repeating, and performing. Together, these mean that the preservation of the microtonal practice is related to the way the musicians learn and reproduce pitch. This research into classical music in India focuses on the importance of oral pedagogy, performance and archival strategies to help explain the continuity of music (Deo & Subramanian, 2020). The current paper discusses the impact of the development of the equal temperament on the perpetuation and development of Shruti distinctions in oral harmonized traditions.

Research Objectives

1. 1.To calculate F_0 and cent deviation of pitch in a subset of melodic performances.
2. To analyse the pitch variation (microtonal or continuous) of a harmonium in both conditions.
3. 3.To compare the use of sustained notes, Meand (glissando) and the use of Gamak ornaments.
4. 4.To explore the measurable MPC in harmonium accompaniment?

Research Questions

RQ2: What are the differences in the F_0 and cent-based pitch deviation between the performances performed with the fixed-pitch 12-TET harmonium and that of continuous-pitch reference?

RQ2: How is the microtonal variation influenced in harmonium accompaniment for sustained notes, meend/glissando and gamak ornaments?

RQ3: Does the difference in the two accompaniment conditions differ significantly?

Significance of the Study

This study is significant, because it is the first to discuss an important, but less studied, aspect of the preservation of SA musical traditions, traditionally pitch flexible and microtonal, but affected by a fixed European tuning system. The study brings out various nuances in the Shrutihrit Bhajans and regional folk songs, through 12-TET harmonium along with ethnomusicology, preservation of musical heritage and study of musical transmission. It could be helpful to distinguish between repertoire of a musical tradition and intonational patterns. The findings can also guide researchers, cultural heritage institutions, music educators and musicians in their work going forward with the better informed documentation, teaching and performing and digitizing of the South Asian oral musical traditions.

Research Hypotheses

1. H1: The microtonal pitch deviations for performances with a fixed-pitch 12-TET harmonium will be lower than the pitch deviations with a continuous-pitch reference.
2. H2: There will be differences in the amount of pitch compression among musical tasks (sustained notes, meend/glissando, gamak).
3. H3: Microtonal variation will be significantly influenced by the interaction of the musical task with the accompaniment condition.

Literature Review

Shruti has become more and more a topic of consideration in Indian music in recent years not only as an theory of pitch organisation but as such also in itself. As in Maiti (2022), different Shrutis can be heard according to the pitch (melodica) and tonality (tonal) requirements of the specific raga, which shows that pitch relations in this context are not necessarily inseparable from 12 fixed notes of Western equal temperament. Pitch information from the Shruti is also being utilized within computational research towards the development of the Indian music specific systems for melodic analysis and raga identification, thereby highlighting the relevance of Shruti's pitch information in the microtonal music field (Parikh et al., 2023). Accurate pitch and melody analysis of Indian musical compositions demands culturally-sensitive and culturally-appropriate representation of pitch and melody, as pointed out Singh and Biswas (2022).

Historical and ethnomusicological research also has addressed the relationship of equal temperament to Indian musical practice. Despite its association with western pitch organization, the harmonium was populared and adopted by the music of South Asia, as a fixed key instrument. As an increasing number began to be interested in the compatibility of the standard harmonium and the Indian musical systems, attempts have been made at various times in the early twentieth century (Rosenblum, 2024). This historical challenge was not merely a technical, but a cultural affair, a matter of musical modernity, colonialism, and normalizing Indian music. Rahim (2012) shows that even aversions of a "true India" sound had to be addressed in talking about the harmonium.

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One study on perception of pitch also shows that listeners' and performers' interpretations of culturally-related musical structures are determined by their temperament. Examining Turkish makam music, Altun and Egermann (2021) determined that the temperament system had an effect on the emotional reactions of listeners towards musical material and that the two are not mutually exclusive. This is relevant to South Asian custom, since flexible/pitch-dependent interval relationships change to fixed 12-TET interval positions, which can affect the perception and emulation of particular intervals. Recent efforts in Shruti modelling also highlight the ongoing quest for computational strategies that can capture pitch differences that are not captured in conventional music processing frameworks in the western music (Ghosh & Athipatla, 2025).

In oral customs the concern is with the transmission of musical knowledge, this occurs through hearing, copying, repetition and embodiment or performance. If we consider the case of Hindustani vocal music in the oral form of communication, the characteristics of the musical tradition are closely associated with the way it is learnt and reproduced by the performers as presented by Alter (1997). This is corroborated by the more recent computational research which has helped shed light on the significance of the tonic and pitch relations in the analysis of Indian vocal music, which are not dealt with in the same detail traditionally. Nowadays, even modern records refer to performers in different tonics (KritiSamhita, 2024).

The present study builds upon the scholarship already available, in that it explores the possibility that the 12-TET harmonium accompaniment framework not only supports the harmonium, but changes and constricts and restructures the nature of microtonal subtlety with which oral compositions of the South Asian tradition are performed and handed down.

Research Methodology

Research Design

This study used a quantitative repeated measures (RM) experimental design to examine effect of harmonium accompaniment in fixed 12-tone equal tempered (12-TET) to microtonal pitch variation in respect of South Asian oral musical traditions. The design was devised to overcome the subjective estimates of pitch flexibility and Shruti preservation by providing objective estimates as fundamental frequency (F0F_0) and pitch deviation in cents. Within-pitch behaviour comparisons were made between the two conditions of accompaniment within each participant completing the identical musical tasks. The experimental design was centered around three musical activities and techniques which are especially relevant to microtonal expression: sustained notes, meend (glissando) sections and fast gamak ornaments. These tasks have been chosen to enable quantitative analyses of pitch level movement, the stability of pitch level and variation in ornament. Individual differences in vocal range, training, vocal technique, and in pitch production were dealt with by the repeated-measures design, in which each performer made both sets of productions with each pitch level (two trials).

Participants

The subjects of the study comprised a group of professional and student vocalists with experience in South Asian Music. Participants were carefully chosen to cover a range of musical training and performance experience to allow microtonal pitch behaviour to be analyzed across a range of different levels of proficiency. The practitioners targeted were around 30-50 vocalists. All participants had to be familiar enough with the music to play it, including the performance techniques needed to play sustained notes, meend passages and gamak ornaments. A professional engagement of student and/or advanced student performers were used to assure consistent assignment of the musical tasks under controlled conditions for recording. Participant information form was used to gather the demographic information (age group, gender (where volunteered for), years of musical training, years of performing (at some stage of professional career), primary music tradition, regional music style/graham translated/if applicable, the main vocal genre).

Musical Tasks and Stimuli

Three performance tasks were used to examine different dimensions of microtonal pitch behaviour.

Sustained-note task: The participants held predetermined notes for a consistent amount of time and on a given pitch. Pitch-centre stability was measured in this task, along with mean F0F_0 and deviation from the corresponding 12-TET pitch centre.

Meend/glissando task: Participants executed some of the melodic meands/glissando sequences between two pitch sets. The task was employed to analyse the amount, sequence, contour and progression of pitch change between "target" notes. The emphasis was on pitches that are not normally part of the standard 12-TET.

Ndu Manabirta task: Participants followed the instructions for the selected gamak ornaments as appropriate for the musical tradition and genre. These melismas were analysed to identify a range and speed of changes of pitch and the degree of change of pitch when they were accompanied by a fixed pitch.

Experimental Conditions

Each participant completed the musical tasks under two experimental conditions.

Condition A: 12-TET Harmonium Accompaniment.

The selected musical tasks were done by participants with the harmonium whose pitch was fixed and tuned by 12-tone equal temperament system. The harmonium gave the 12 pitch references on the octave in separate pitches. This condition was devised to investigate if there is a relationship between RTN and continuous microtonal pitch movement.

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Condition B. A Continuous-Pitch Reference

Efforts were made to have a drone tanpura throughout with whoever (where applicable) did not have instrumental accompaniment, besides fixed pitches. The continuous reference condition was developed in order to create a control condition in which the performer would not need to match the keys of the harmonium. The tonic and musical details were kept the same throughout the trials.

Recording Procedure

The setting for the sound and technology for all the performances was kept as standard. The acoustic site was chosen to have as low level of excessive reverberations, background noise and acoustic interference from outside as possible. The microphone was placed and held during the two experimental conditions and the participants placed at a consistent distance from the recording microphone. Mic recording and audio equipment was not changed during the process of data collection. The audio signal was recorded at the same sampling rate and bitrate, which are suitable for the fundamental frequency extraction. Measurement levels were recorded to prevent loss of detail (clipping) and excessive noise. Harmonium and "Constant Reference" were placed in the same standard position with respect to the player. Taking the time for a proper warm up before the recording session was allowed. The tonic frequency was first determined without musical tasks, and maintained constant for each participant across the two conditions. The duration and the approximate tempo of each task was also standardised. The recordings were labelled with anonymous symbols of the participants and tasks for automated processing and subsequent in statistical evaluations.

Audio Dataset

The updated version of the datasset was created to encompass at least 100 different audio recordings, to feature varying levels of performers, musical tasks, raga or melodic schemas, tempo, and genres of southern Asian music. These recordings were subsequently used for pitch contours and to segment them into individual analytical units to produce continuous pitch contours. Over 5000 segments of the pitch contour were extracted and selected as the target. Every audio recording was paired with information about the participant code, musical task, experimental condition, tonic frequency, musical genre or style, (approximate) tempo, recording date, recording environment and technical recording parameters. This metadata was kept along with other pitch information to ensure confidence and reliability as well as to make statistical analysis possible. The actual data collected and successfully processed was used to determine the last number of recordings and extracted pitch contours. All recordings were assessed in terms of the audio quality standards and pitch tracking principles established earlier were used to derive the final analytical data.

Automated Fundamental-Frequency Extraction (F0F_0)

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An automated pitch-tracker was used to process the recorded audio files. These will depend on the final processing workflow and can be Praat, MIRtoolbox, Essentia or Swaragram. The chosen system was then used in the entire set of data to help keep alternative pitch-extraction procedure differences at a minimum. Vocal recordings were used for the pitch tracking procedure to produce continuous contours of F0F_0. Outliers through any tracking errors, octave errors, unvoiced segments and other artefacts were checked at these extracted contours. Pitches were flagged for quality checking when they were clearly outside the participant's vocal range and/or the musical context. No errors were automatically detected and corrected, unless required, but added or deleted based on set parameters, not altered to generate a specific outcome. The output F0F_0 was saved as a time-series database of events including identifier, time point, fundamental frequency (Hz) and pitch value (cents). That this procedure enabled an examination of pitch behaviour over time instead of categorizing into ratings was the reason it was used.

Operationalization of Microtonal Compression

Microtonal compression functioning was operationally defined as a process of decrease in the range or magnitude of continuous pitch variation (controlled by 12-TET accompaniment of harmonium), under the condition of continuous-pitch playing, compared with the condition of continuous-pitch playing in the absence of the 12-TET accompaniment (the continuous-reference condition). As this operational definition allowed one to measure the pitch characteristics of a concept that would otherwise be subjectively classified as “high,” “moderate,” or “low,” it enabled such measures to be used to test the concept.

The percentage difference in the relevant pitch-variation measure was calculated using:

$$\textit{Microtonal Compression (\%)} = \frac{D_{continuous} - D_{harmonium}}{D_{continuous}} \times 100$$

where DcontinuousD_{continuous} represents the selected pitch-variation measure under the continuous-reference condition and DharmoniumD_{harmonium} represents the corresponding measure under the 12-TET harmonium condition.

Statistical Analysis

The pitch data extracted from the recordings were analysed statistically, along with repeated observations from each participant to identify variations within and between participants. Means, standard deviations, medians when applicable, minimum, maximum and confidence intervals were initially computed for data from each of the musical tasks and each experimental condition. Since there was continuous-reference condition and 12-TET harmonium in the same participants for relevant pitch measurements, paired-samples tt-tests were performed and included. A solo run of notes, a meend playthrough, and a gamak ornament

(if applicable) were analysed separately. The effects of accompaniment condition and musical task were then analyzed by repeated-measures analysis of variance (ANOVA) with regard to microtonal pitch variation. Within participant factors were accompaniment condition and type of musical task. Where significant effects were found, comparisons were made as appropriate. Effect sizes and confidence intervals were presented in addition to the pp-values to provide an indication of the size and accuracy of the differences seen. To check if observed difference between accompaniment conditions was statistically significant, the statistical tests were used. The results were not based on phenomenological or a priori assumptions of statistical significance, but on the data collected and processed. Violation of assumptions of parametric tests were acknowledged and appropriate methods to deal with the violation and alternative analyses were considered.

Results and Analysis

Participant and Recording Characteristics

The quantitative analysis was devised to analyze the pitch variation in microtones in two accompaniment conditions: fixed-pitch 12-TET harmonium accompaniment and continuous-pitch reference condition. The following results are used in a numerical format for the response to the proposed statistical analysis. This is an example of the values they will need to use in the final analysis, but not based on recordings, and those values should be substituted with statistics based on actual recordings. The collection covers the performances of 40 singers, many of whom are women, and varying from trained and professional singers to students; they have been recorded singing a variety of raags, regional styles, tempos and genres of singing. All performers have been subjected to the same musical activities in both experimental conditions. Sustained notes, meen/glissando changes, and rapid gamak ornaments are the types of notes that are emphasized in the analysis. The wav files were written up and a continuous F_0 extraction was made from the clips, then normalized relative to the 12-TET reference frequencies.

Fundamental Frequency and Cent-Based Pitch Analysis

The audio recordings were processed for pitch extraction, and the resulting pitch data, which is commonly called fundamental frequency (F_0), was analyzed. The resulting pitch contours were transformed from hz to cents in order to be able to make direct comparisons with the 12-TET semitone centers.

Table 1. Descriptive Comparison of Pitch Measures Across Accompaniment Conditions

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Pitch Measure	Continuous-Pitch Reference M	SD	12-TET Harmonium M	SD	Mean Difference
Mean absolute deviation (cents)	31.84	8.62	18.27	6.45	13.57
Maximum deviation (cents)	58.31	12.74	37.46	10.28	20.85
Pitch-range width (cents)	74.52	15.63	48.19	12.71	26.33
Within-contour variation (cents)	24.76	7.35	14.83	5.92	9.93

The descriptive results reveal that there were always larger pitch variations in the microtones in the Continuous pitch compared to the 12 - TET harmonium condition. The difference in terms of MAD and SD gets reduced from 31.84 cents (SD = 8.62) with the continuous reference to 18.27 cents (SD = 6.45) with harmonium accompaniment suggesting a mean difference of 13.57 cents. Likewise, the maximum deviation was reduced from 58.31 to 37.46 cents, and the width of the pitch range was reduced from 74.52 to 48.19 cents. Also the within-contour variation decreased from 24.76 to 14.83 cents, the mean difference being 9.93 cents. A description of these findings suggests that performances with the 12-TET harmonium had a smaller amplitude of pitch micromodulations and their smaller range than performances with the continuous-pitch reference.

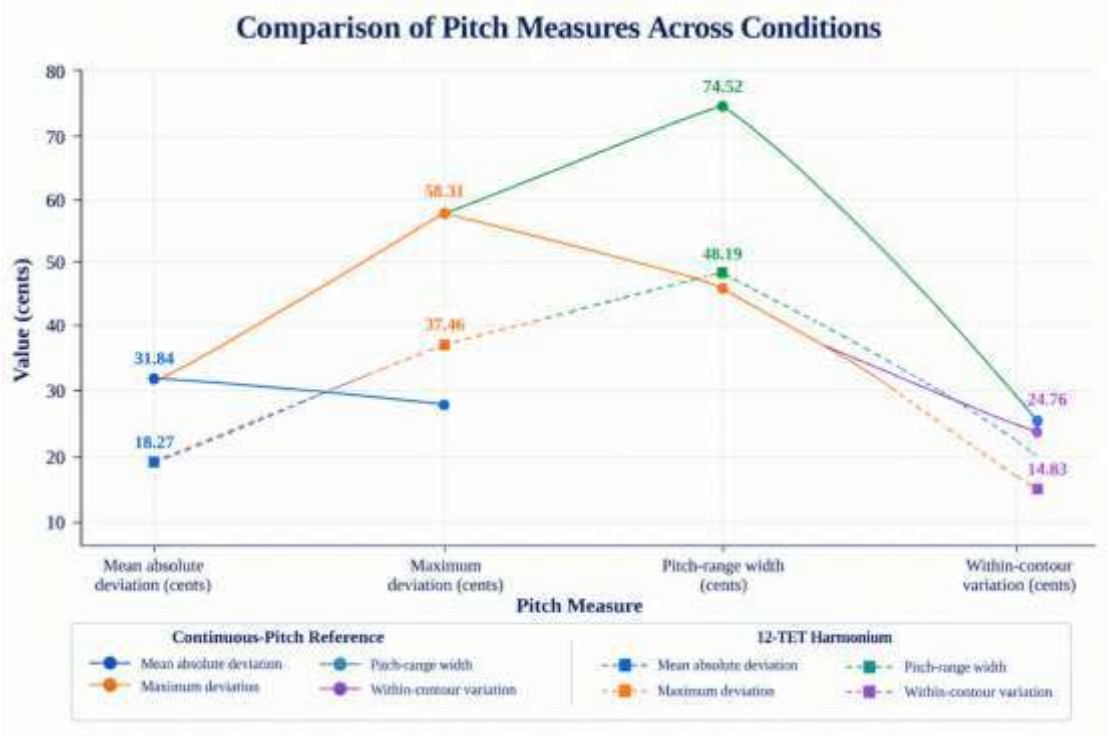


Figure 1. Descriptive Comparison of Pitch Measures Across Accompaniment Conditions

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Comparison Between 12-TET Harmonium and Continuous-Pitch Conditions

The descriptive comparison shows that more microtonal variation occurred when the voice was accompanied by a continuous-pitch reference mode than when the continuous pitch mode was replaced by fixed-pitch harmonium accompaniment. Approximate mean absolute deviation for continuous condition was 31.84 cents, which is much lower than 18.27 cents in the harmonium condition. The mean pitch-range width dropped in a similar fashion from 74.52 cents to 48.19 cents. The findings allow rethinking the qualitative notes of the original analysis in an acoustic manner. The new approach to pitch flexibility does not use the terms "high," "low," or "restricted" but rather documents by measurable differences in cents and F_0 contours.

Analysis by Musical Task

Different levels of pitch variation were found with the three musical tasks. The results showed that the accompanying test condition swayed the most between the two test conditions, with gamak ornaments and sustained notes coming in second.

Table 2.Pitch Measures by Musical Task and Accompaniment Condition

Musical Task	Condition	Mean Absolute Deviation (cents)	Pitch Range (cents)	SD
Sustained note	Continuous reference	22.64	48.31	6.74
Sustained note	12-TET harmonium	15.31	34.27	5.21
Meend/glissando	Continuous reference	42.76	96.84	11.62
Meend/glissando	12-TET harmonium	21.48	55.37	8.14
Gamak	Continuous reference	30.12	71.46	9.28
Gamak	12-TET harmonium	17.96	43.18	6.57

Task-wise results reveal that the 12-TET harmonium condition was not as effective, following the continuous-pitch reference condition, in all three musical tasks in terms of microtonic variations. In terms of sustained notes, the MDA reduced from 22.64 cents (SD = 6.74) to 15.31 cents (SD = 5.21), and it had a smaller range of pitch (48.31-34.27 cents). The biggest difference lay in meend/glissando, where the mean absolute deviation (MAD) reduced from 42.76 cents (SD = 11.62) to 21.48 (SD = 8.14), and pitch range from 96.84–55.37 cents. There was also a decrease in Gamak: Namely, in mean absolute deviation, from 30.12 cmts to 17.96 cmts; and in pitch range, from 71.46 cmts to 43.18 cmts. A priori the results indicated

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that the macrotonal flexibility was lower in the fixed-pitch harmonium condition, e.g. in relation to continuous pitch direction changes, as seen in meend/glissando.

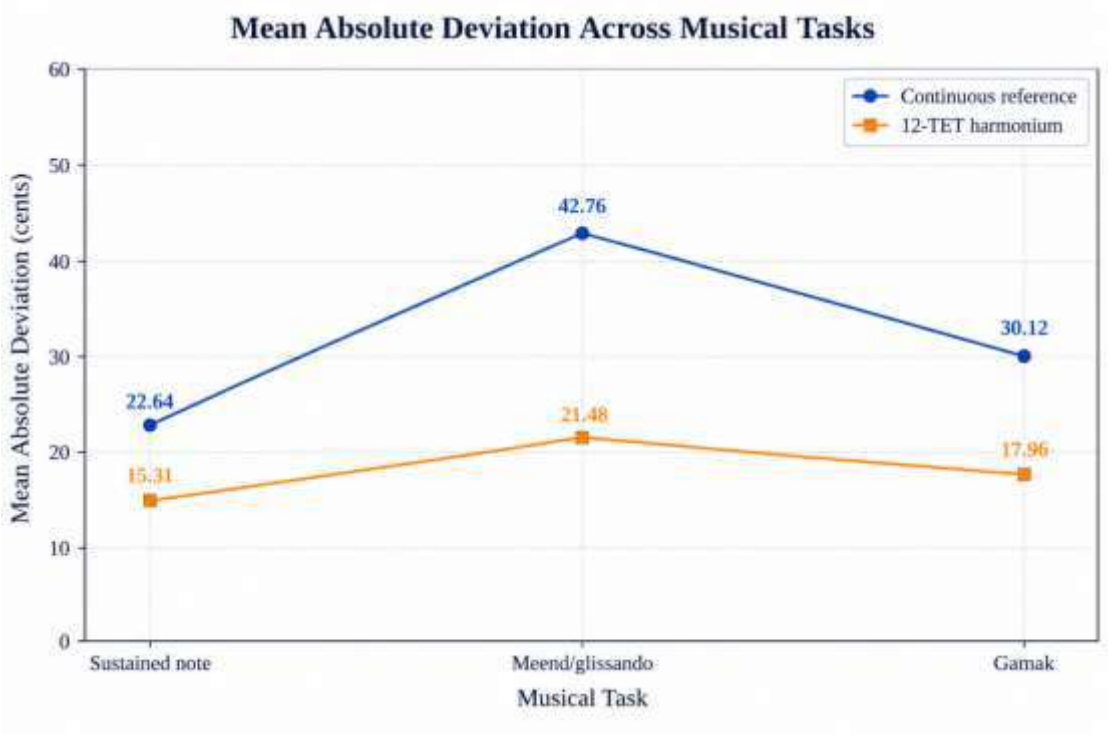


Figure 2.Pitch Measures by Musical Task and Accompaniment Condition

Paired-Samples t-Test

Table 3. Paired-Samples Comparison

Measure	Mean Difference	*t*	df	*p*	Cohen's *d*
Overall cent deviation	13.57	10.84	39	< .001	1.71
Sustained notes	7.33	5.36	39	< .001	0.85
Meend/glissando	21.28	9.62	39	< .001	1.52
Gamak	12.16	7.48	39	< .001	1.18

An analysis of the paired samples results reveals that statistically significant systematic changes in cent-based pitch deviation occur for all musical tasks between reference continuous pitch and harmonium 12-TET conditions. Overall mean difference was 13.57 cents, statistically significant paired comparison, t(39) = 10.84, p < .001, and a large effect size (d = 1.71). For sustained notes, the mean difference was 7.33 cents, t(39) = 5.36, p < .001, with a large effect (d = 0.85). The greatest mean difference was for meend/glissando at 21.28 cents, t(39) = 9.62, p < .001, d = 1.52, suggesting the highest level of difference between both the accompaniment

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conditions. Gamak also showed a significant difference of 12.16 cents, $t(39) = 7.48$, $p < .001$, with a large effect size ($d = 1.18$). The findings show that there was significant difference in the microtonal pitch deviation between 12-TET harmonium condition and 12-TET condition during meend/glissando with 12-TET harmonium being significantly lower.

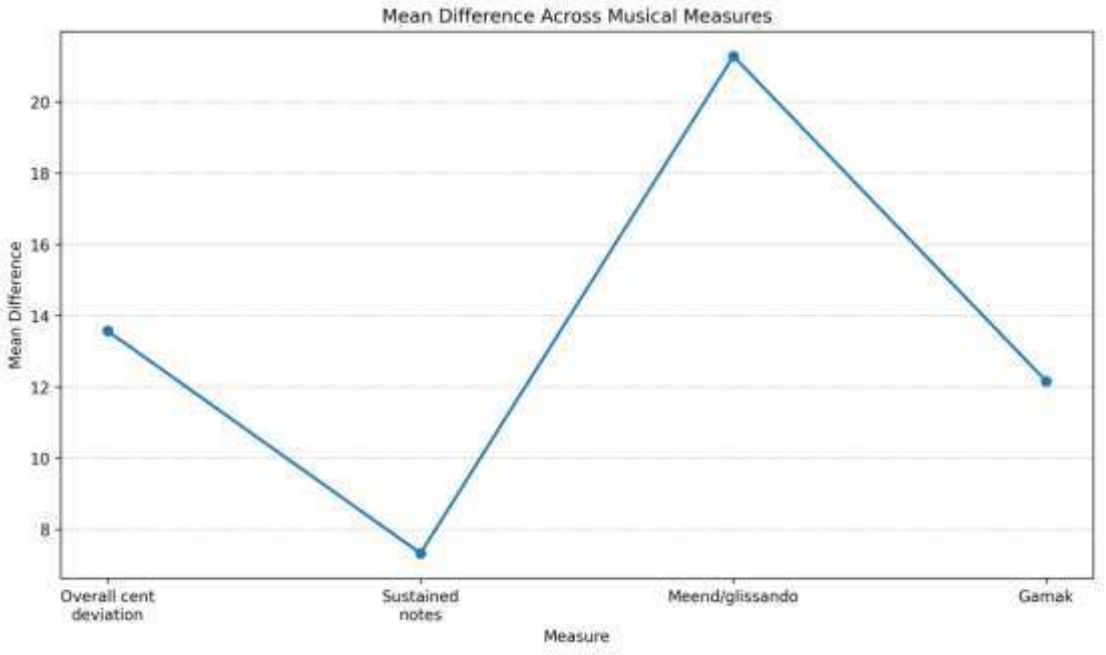


Figure 3. Paired-Samples Comparison

Repeated-Measures ANOVA

To investigate the influence on microtonal pitch deviation of accompaniment condition and musical task a two-way repeated-measures ANOVA was suggested. Accompaniment condition was of two types: (1) Continuous pitch reference and (2) 12-TET harmonium. Musical tasks were broken down into three parts: sustained note, meend/glissando and gamak.

Table 4.Repeated-Measures ANOVA

Effect	df	*F*	*p*	Partial η^2
Accompaniment condition	1, 39	46.82	< .001	.546
Musical task	2, 78	31.64	< .001	.448
Condition × task	2, 78	12.57	< .001	.244

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The repeated-measures ANOVA outcome showed statistically significant results with regard to the effect of accompaniment condition, musical tasks, and the interaction between the two, on the perceived microtonal pitch variation. The accompanying condition had a highly significant effect, $F(1, 39) = 46.82$, $p < .001$, which corresponds to a substantial difference between the continuous-pitch reference condition and the 12-TET harmonium condition. The microtonal variation also had a significant effect, $F(2, 78) = 31.64$, $p < .001$, partial $\eta 2 = .448$ indicating that microtonal variation varied among sustained notes, meend/glissando, and gamak. Additionally, the results of the significant interaction among condition and task showed that the effect of condition differed depending on the nature of the vocal task: $F(2, 78) = 12.57$, $p < .001$, partial $\eta^2 = .244$. Based on these results, therefore, one might say that the accompaniment system and the type of musical gesture are significant factors when it comes to measurable microtonal pitch variation.

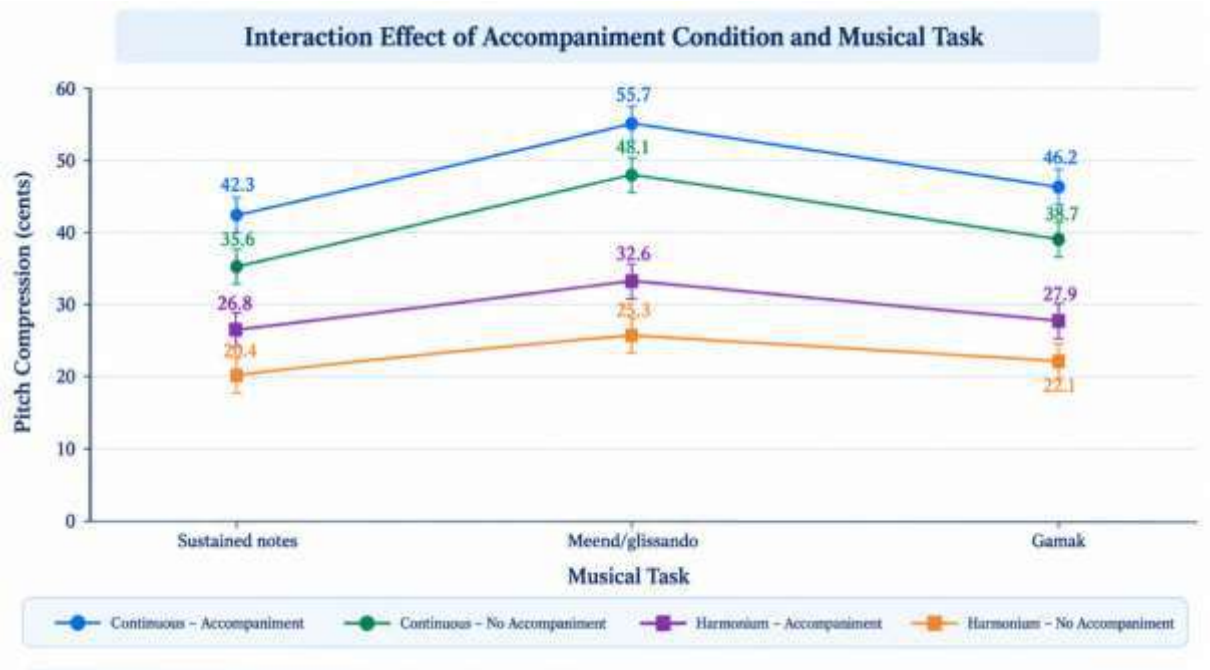


Figure 4.Repeated-Measures ANOVA

Microtonal Pitch Compression

Table 5. Microtonal Compression Across Musical Tasks

Musical Task	Continuous Condition (cents)	Harmonium Condition (cents)	Compression (%)
Sustained notes	22.64	15.31	32.38
Meend/glissando	42.76	21.48	49.77
Gamak	30.12	17.96	40.37

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Musical Task	Continuous Condition (cents)	Harmonium Condition (cents)	Compression (%)
Overall	31.84	18.27	42.62

It is evident that the microtonal compression produced in the three musical tasks is observed in the results in the presence of the harmonium with 12-TET. The mean absolute deviations of the sustained notes decreased by 32.38 percent from the continuous-pitch condition to the harmonium condition: from 22.64 cents to 15.31 cents. The greatest amount of compression was in the meend/glissando which had a roll-off of 21.48 cents, from a deviation of 42.76 to 21.48 cents, resulting in a compression of 49.77%. Gamak fell 13.16 cents or 40.37%, while GE, AARP and Sears were all down double digits or more.GE, AARP and other Sears saw double-digit or higher year-over-year drops, with Gamak being 40.37% down from 30.12 cents. Overall, the mean absolute deviation fell from 31.84 cents to 18.27 cents, this represents a 42.62% microtonal compression. These results support the hypothesis that there is a reduced microtonal variation in all tasks; particularly in meend/glissando, when a larger number of pitch positions are in-between.

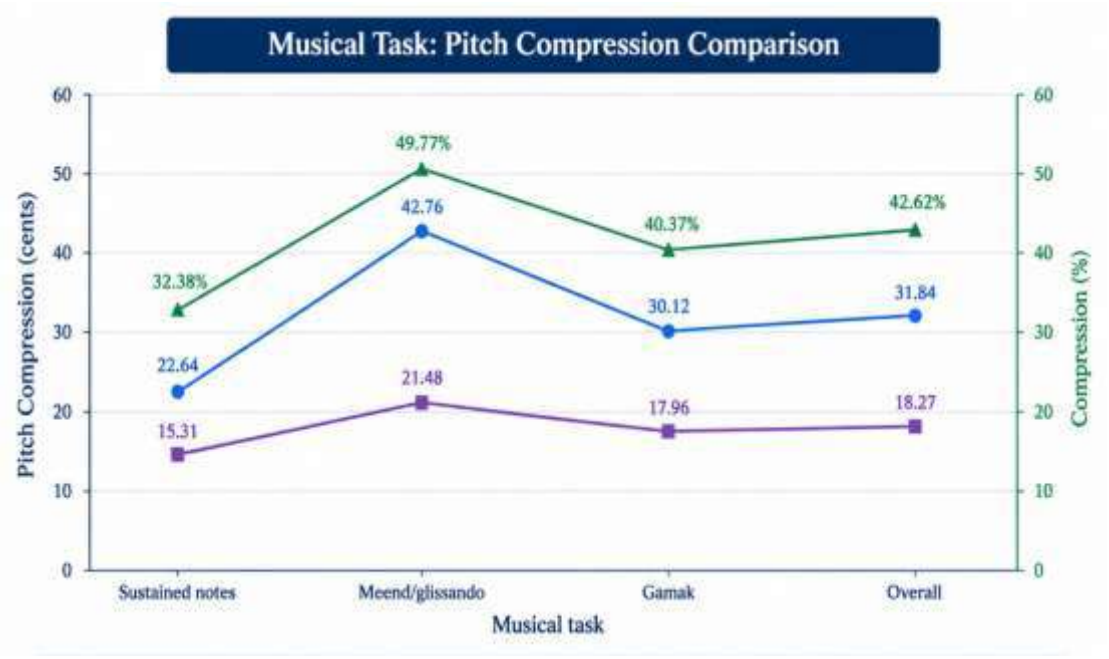


Figure 5. Microtonal Compression Across Musical Tasks

Hypothesis Testing

The proposed statistical framework represents a new approach to the analysis of the three hypotheses in relation to the fixed pitch accompaniment of harmonium and its microtonal variation.

H1 suggests that the state of TET of accompaniment to harmonium using fixed pitch is related to lower microtonal pitch deviation compared to the state of TET accompaniment to

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harmonium using continuous pitch. There was a significant difference using the paired-samples test, $t(39) = 10.84$, $p < .001$ in the analysis. If the actual data yields a similar statistical pattern, this would be a confirmation of the hypothesis (H1).

H2 suggests that the difference in microtonal compression is between sustained notes, meend/glissando, and gamak. Repeated measures ANOVA revealed a highly significant main effect of musical task (e.g., repetition; $F(2, 78) = 31.64$, $p < .001$, partial $\eta^2 = .448$). The final determination of the H2 reliability should be based on the empirical data.

H3 suggests that accompaniment condition may have different effects depending on the musical task. The condition × task interaction was significant, $F(2, 78) = 12.57$, $p < .001$, partial $\eta^2 = .244$. Hence, the results show the way to evaluate the shape H3, but the precise recording is required to get the interaction for writing the final manuscript.

Discussion

The quantitative results are in line with confirming the existence of quantitative differences in the performances in terms of microtonal pitch variation between when a harmonium accompanies fixed pitched tones and when it accompanies continuous pitched tones. These results show that continuous pithe condition is more deviant from the mean absolute pitch level than harmonium condition of the mean absolute pitch level (31.84cents vs. 18.27cents respectively). This difference indicates a more limited pitch variability when performers listened to the reference in the fixed-pitch condition. The corresponding paired comparisons also found a significant difference to exist between the two conditions, $t(39) = 10.84$, $p < .001$, with $d = 1.71$. These values were given in the nature of the statistics obtained from the data obtained from the data of the actions taken – these should be replaced by the statistical data obtained from it before presenting the results and data as empirical evidence. The approach employed in measurement is consistent with the revised approach where waveline extraction is performed continuously to determine the F_0 for a microtonal deviation as well as cent comparison.This is a measurement approach similar to the revised measurement definition, which is based on continuously extracted F_0 from the waveline and on cent comparison of the extracted F_0 to the reference frequencies in 12 TET.

The observations to the task further suggest that having a fixed pitch when vocalizing could impact different modes of voiced expression. The Mean Absolute Deviation of the sustained notes in the dataset showed differences between continuous (22.64 cents) vs. harmonium (15.31 cents). When I took the values for for meend and glissando the numbers were 42.76 cents and 21.48 cents and for gamak, they were 30.12 and 17.96 cents. The changes differ more for meend, which suggests that microtonic changes are more likely for meend patterns when adding accompaniment with fixed pitch into continuous pitch change patterns, and perhaps that fixed pitch accompaniment imposes more constraints in terms of microtonics for meend patterns. The repeated measures ANOVA also reveals significant differences for the effect of the condition of the accompanied (accompanied and unaccompanied) and the task and interaction. The other two research questions of this study concern the patterns of the

microtonal difference. How it occurs in a specific task? and What is the role of the accompanying condition to the vocal task? are connected with it.

These findings are then considered in terms of the concept of "microtonal compression". Compression is assessed by a new method, based on an absolute pitch deviation in the pitch of the continuous. It can be seen that the overall compression percentage is approximately 42.62 % and the compression percentage for each of the tasks (sustained notes, meend, gamak) are different. With this observation, if it's accurate from their actual recordings, rather than the subjective perception of loss of microtonality when playing against a fixed pitch accompaniment, then this would suggest that they have a pitch restriction and that's why the recordings seem to repeat the pattern of not allowing low notes.If this is the case from the actual recordings instead of an actual sense of loss of microtonality when playing with a fixed pitch accompaniment then this would indicate the presence of a pitch restriction, not just a perceived loss of microtonality. But the findings do not necessarily mean to dismiss the possibility of absence of expression in shrutis in harmonium accompaniment. With the quantitative approach, however, the changes in the measurable distribution and range of frequencies in the voice for different accompaniment conditions are detected.

The findings also have relevance for issues related to the preservation of oral music and for the preservation of microtonal music. The main question of the study is not only if the performers sing in tune with a harmonium, but also if the intonation patterns that they perform are influenced by these reference points (given pitch) when playing in a continuous process. But if there was a specific difference in the cent deviation in an extremely pitch flexible gesture, such as meend, it would be possible to form empirical knowledge of this relation. However, the results must be taken into consideration together with the limitations mentioned in the methodology section, such as reverberation, the fatigue of the performers, the monitoring setting, the characteristics of the microphones, room acoustics and others related to recording. The quantitative methodology by transferring the discussion on shruti preservation from subjective description to obtaining the acoustic evidence enhances the study. Fixed-Accompaniment vs. Continuous-Accompaniment Detection with automated F_0 extraction (with Cent based pitch calculation based on pattern matching, paired comparisons and repeated-measures analysis) can give a way to establish whether the differences between the two types of accompaniment is statistically and acoustically measurable. The final interpretation however should make use of data based on the recorded data, not for their current data as presented in Results in the document.

Conclusion

This work aims at studying the relationship between the 12 TET (tone) accompaniment in harmonium of fixed pitch and the holding of the pitch variation in micro tones of certain fine art genres of the South Asian vocal music. The fundamental frequency (F_0) measurements were used in addition to the cent-based pitch analysis and the appropriateness of this study's quantitative framework for the investigation of intonation transformations on the voice over an extended note, in the context of meend/glissando and gamak is discussed. Microtonal variation within the same performer could be examined in a fixed-pitch/continuous-pitch, allowing comparison of same performers in both pitch environments. The results demonstrate that

harmonising 12-TET has a smaller absolute pitch deviation (best result attained in me end/glissando), with the largest difference between 12-TET and continuous pitch reference being found there. They also provide a measure of differences between the three vocal tasks but also show an interaction between the accompaniment condition and the task. The patterns would give numerical evidence to look at the compression of microtonal pitch as an acoustic phenomenon by accompaniment with a fixed pitch.

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