

Do Rate And Extent Of Vibrato Vary With Gender In Untrained Singers?

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Abstract: Vibrato is a phenomenon that is often perceived in both instrumental and vocal music. It is believed that it adds beauty to the vocal tone. Hence, in Western Classical music, it is considered as a requirement in the singer's voice. Vibrato is characterized by the speed of fluctuation and the extent of fluctuation. However, it is not very clear if these parameters (rate and extent) vary in males and females. Research has not focused so much on gender differences pertaining to vibrato rate and extent, although they may have included gender related information as a very small part of a study. Hence, the objective of the present study is aimed at investigating if vibrato rate and extent would vary in males and females. Method: 30 professional singers (untrained), both male and female were instructed to sing the chorus of a Hymn (common to all). Their voice signals were recorded in a sound treated room directly on Praat software and digitized at 44.1 KHz. Each of these samples was analyzed using the Voice and Tremor Protocol available in the Motor Speech Profile module in Computerized Speech Lab software model 4500. Mann-Whitney U test was carried out to find differences in vibrato rate and vibrato extent between males and females.

Keywords: vibrato, rate, extent, gender difference, untrained singers.

1. INTRODUCTION

Vibrato beautifies music and is perceived in both instrumental and vocal music. This phenomenon is considered a characteristic feature of Western operatic singing and is also quite apparent in other genres of music, such as pop, rock, gospel, country, Jazz, Indian- Hindustani music and so on. Singers believe that vibrato adds an aesthetic quality to the singing voice and "every great voice of all time has had a vibrato" [1]. It is used for expressive purposes [2] to bring out emotion, as it is said to "reflect genuine feeling by the singer" [3]. Vibrato has been described by Seashore [4] as early as 1967, as "a pulsation of pitch, usually accompanied with synchronous pulsations of loudness and timbre, of such extent and rate as to give a pleasing flexibility, tenderness and richness to the tone." Similarly, [5] Zemlin (1998) describes these oscillations as "small and rapid pitch and intensity changes that occur primarily during singing".

The production of vocal vibrato involves such minute laryngeal adjustments while singing. It has been studied since 1920's and is still the subject of study in the present day. The rate and extent of vibrato are the two major parameters that can best define a vibrato. Rothman and Arroyo [6] found that the parameters vital for the perception of vibrato are "the frequency and amplitude variations around their respective means". They could be either frequency and amplitude variations or both. Acoustic analysis of these parameters of vibrato have been performed in the past using different software modules such as MATLAB, PRAAT, Spectrograph, Soundswell and the like. Multidimensional Voice Program (MDVP) and or Motor Speech Profile (MSP) belonging to Kay Elemetrics Computerized Speech Lab (CSL) have been used to analyze vibrato in the recent years [7]. The same authors have also used MSP software module for analyzing frequency and amplitude modulations of vibrato.

Seashore, (1936) [8] found no significant gender related differences in vibrato rate between his subjects. However, Shipp, Leanderson and Sundberg, [8] did find gender differences (5 male and 5 female) in vibrato rate. The electrographic waveform of vibrato was investigated in ten trained singers who were seven women and three men. EGG waveforms which were produced with and without vibrato on four singing tasks (ascending tones in both chest and falsetto) were

compared. However, they did not show significant differences between males and females, but showed similarity in the waveforms [9]. Most of these studies showed unequal numbers of male and female subjects. Prame [8] studied vibrato rate in seven women and three men and did not find differences related to gender. The vibrato rate was 6.3 Hz for women and 5.7 Hz for men. He attributed this to unequal numbers of male and female subjects that could result in statistical insignificance.

Other researchers [10] have considered a larger number of subjects (29 subjects) who were trained Classical singers and studied the influence of gender on the rate and extent of vocal vibrato. They reported of gender related differences in both vibrato rate and extent. Vibrato is considered by vocal pedagogues as the result of good singing technique. Therefore, trained singers should ideally not show gender differences in vibrato, albeit the rate and extent may vary with different genres of music. Since, the previous studies studied vibrato rate and extent in trained singers but had lesser number of subjects, or unequal numbers of female and male subjects, the objective of the present study focused on investigating the rate and extent of vocal vibrato across gender in untrained singers, with a slightly larger sample size.

2. METHOD

The aim of the present study was to investigate 1) if differences exist in the rate of vibrato in female and male singers and 2) if differences exist in the extent of vibrato in female and male singers. The participants who had been performing on stage for a minimum of one year, and who produced vibrato during the act of singing, who reported of no vocal pathology for the past three years and those who did not have neurological disorders, chest diseases, hyper or hypo thyroidism, hormonal imbalances and hearing loss, were selected for the study.

Participants

Thirty participants who were untrained Professional singers volunteered to participate in the present study. They were both female (13) and male (17). They all sang different styles of Western Music such as Contemporary music, Pop, Gospel and Jazz. The age of the participants ranged from 15- 56 years with a mean of 33.30 and Standard Deviation (SD) of 12.78. The mean and SD values for age in females were 33.85 and 13.09 respectively. The mean and SD for age in males were 30.76 and 8.75 respectively. The stage performance in this group ranged from 1 year to 45 years, with a mean of 18.85 and a SD of 14.47.

Untrained Singers

Untrained singers are those who have not had formal training in Western vocals in the past. They should have been performing Western music on stage for a minimum of 1 year.

EQUIPMENT:

PRAAT software version (5.3.05) with a High Definition Shure microphone (SM48 Dynamic hand-held microphone) belonging to Computerized Speech Lab (CSL) MODEL 4500 of Kay Pentax was used for recording. The Advanced Motor Speech Profile (model 5141) program on CSL 4500 was used for analyzing the voice samples.

TEST ENVIRONMENT:

All recordings were done in a sound treated room where the reading on the SLM Bruel & Kjaer 2231 was 32dB SPL (with the computer switched on), on A weighting scale.

PROCEDURE:

The thirty singers who were willing to participate in the present study were asked to sign a consent form prior to recording. All singers reported of being in good vocal and physical health at the time of recording. All singers had clinically normal hearing. A brief description of the study and details of tasks were explained to them. This study was approved by the Board of Studies for Speech and Hearing, Bangalore University.

A preliminary acoustic analysis of voice of each singer was carried out using 'Multi-Dimensional Voice Program' of Computerized Speech Lab, Model 4500. This software provides 33 parameters of voice, which are grouped under seven aspects. The voice parameters are listed as follows:

Average Fundamental Frequency (F0, in Hz), Average Pitch Period (T0, in ms), Highest Fundamental Frequency (Fhi, in Hz), Lowest Fundamental Frequency (Flo, in Hz), Standard Deviation of the Fundamental Frequency (STD, in Hz), Phonatory Fundamental Frequency Range (PFR, in Semi tones), Fundamental Frequency Tremor (Fftr, in Hz), Amplitude tremor Frequency (Fatr, in Hz), Absolute Jitter (Jita, in μ sec), Jitter percent (Jitt, in %), Relative Average perturbation (RAP, in %), Pitch Period Perturbation quotient (PPQ, in %), Smoothed Pitch Period Perturbation Quotient (sPPQ, in %), Co-efficient of variation (vF0, in %), Shimmer in dB (ShdB, in dB), Shimmer Percent (Shim, in %), Amplitude Perturbation Quotient (APQ, in %), Smoothed Amplitude Perturbation Quotient (sAPQ, in %), Co-efficient of Amplitude, Variation (vAM, in %), Noise-Harmonic Ratio (NHR), Voice Turbulence Index (VTI), Soft Phonation Index (SPI), Frequency Tremor Intensity Index (FTRI, in %), Amplitude Tremor, Intensity Index (ATRI, in %)

Voice screening was done to ensure that each singer's voice was within normal limits. A total of 31 singers had volunteered for the study out of which one female singer had high jitter values and hence was excluded from the study. Once the screening was completed, they proceeded for recording of their singing voice which was carried out in a sound treated lab. All singers were given warm up time of approximately 10 minutes, prior to recording their samples. They also practiced the chorus of the song selected for the study apart from their vocal warm up.

“Then sings my soul,
My Saviour God to Thee,
How great Thou art,
How great Thou art.” (Repeat from the beginning)

The chorus of this hymn had been chosen for the study for two reasons: 1) it was common to all singers and 2) there are excerpts/ pieces of music where the notes have to be sustained for a given period. These excerpts were useful in obtaining a vibrato for acoustic analysis. The total duration of the sample was approximately a little more than 40 seconds. The singers were asked to sing the chorus, so that the voice and vibrato would be produced most naturally. All recordings were made in a sound treated room. All singers were given one trial recording prior to the actual recording for the study, so that the singers had a direct display (on PRAAT window) of their loudness level. This was executed in order that a certain level of loudness could be maintained during the entire recording, thereby ensuring that the signal would not be clipped. A 4 to 6 inch (as specified in the manual) mic to mouth distance was maintained throughout recording. All singers performed the task in standing position. The singers were instructed to sing in a slow tempo in each of their comfortable pitch and loudness levels, in order to ensure their most natural production. The sample of each singer was recorded directly into PRAAT software which is loaded on the same computer as CSL, model 4500. The Shure microphone belonging to CSL model 4500 was used for recording. All samples were digitized at a sampling frequency of 44.1 kHz and were saved as '.wav' files and were subjected to acoustic analysis. Only the sustained portion of /a/ of the word “a.....rt” (art) was selected for acoustic analysis. This segment lasted to about 3 to 4 seconds. The parameters selected for acoustic analysis were vibrato rate and extent. They have been defined as follows:

Vibrato rate is the number of frequency and/ or amplitude modulations per second. These modulations are displayed as peaks and troughs of each cycle across the length of the selected segment (chosen for acoustic analysis) of a sustained phonation during the act of singing.

Vibrato extent represents the peak to peak amplitude of each cycle (difference between each peak and trough (maximum F0 minus minimum F0), relative to the average frequency and /or amplitude, of the entire length of the selected segment).

Motor Speech profile module, available on CSL model 4500 software was used for acoustic analysis. This software is used as a diagnostic and therapeutic tool in all types of speech disorders (articulation, voice, intonation) for both children and adults.

Motor Speech Profile Analysis:

Motor Speech Profile' (MSP), (model no. 5141; Issue D, June 2008) on CSL 4500 provides 'voice and tremor protocol' for analysis of neurologic tremor. This program can be used to measure vibrato, since vibrato is characterized by periodic/non-periodic modulations of fundamental frequency and intensity. The following parameters, such as Fundamental frequency (F0), Variations in Fundamental frequency (vF0), Variations in Amplitude (vAm), Rate of frequency tremor (Rftr), Rate of amplitude tremor (Ratr), Magnitude of frequency tremor (Mftr), Magnitude of amplitude

tremor (Matr), Periodicity of frequency tremor (Pftr) and Periodicity of amplitude tremor (Patr) are available on MSP. Out of all these parameters, only two parameters such as Rate of frequency tremor (Rftr) and Magnitude of frequency tremor (Mftr) were chosen for acoustic analysis. The Rate of frequency tremor (Rftr, measured in Hz) represents vibrato rate and Magnitude of frequency tremor (Mftr, measured in %) represents vibrato extent.

Statistical Analysis

Mann Whitney test was performed to find differences between female and male singers on rate (Rftr, in Hz) and extent (Mftr, in %) of vibrato.

3. RESULTS

Mann-Whitney U test was carried out to find differences in the rate and extent of vibrato between female singers and male singers. The results for each parameter have been discussed below:

Vibrato Rate (Rate of frequency tremor)

Vibrato rate for 13 female singers showed a mean of 6.06, median of 6.06 and a standard deviation of .88955. The rate of vibrato however ranged from 4.76 Hz to 7.40 Hz. However, for the 17 male singers, the vibrato rate showed a mean of 5.45, median of 5.26 and a standard deviation of .80890. The vibrato rate ranged from 4.25 Hz to 7.40 Hz. The mean and median values for females were slightly higher than males. Although, Mann-Whitney U test results showed a trend of difference, yet it was not statistically significant.

Table.1 shows the results of Mann-Whitney U test of vibrato rate in females and males.

Gender	Number	Mean	Median	SD	Minimum	Maximum	Mann-Whitney U test
Female	13	6.06	6.06	.88955	4.76 Hz	7.40 Hz	.085
Male	17	5.45	5.26	.80890	4.25 Hz	7.40 Hz	

Vibrato extent (Magnitude of frequency tremor, %)

Vibrato extent for females showed a mean of 2.242, median of 1.74 and a standard deviation of 2.644. The vibrato extent ranged from .84 % to 10.91%. For the 17 male singers, the extent of vibrato showed a mean of 1.8, median of 1.66 and a standard deviation .6082. The minimum extent value was .95 % and the maximum extent value was 3.21%. The maximum range for extent of vibrato in female singers was comparatively larger than males. One female singer showed higher amplitude variation (10.91%) in her vibrato. However, Mann-Whitney U test results showed no significant difference (.544) between females and males.

TABLE 2 shows the results of Mann-Whitney U test of vibrato extent in females and males.

Gender	Number	Mean	Median	SD	Minimum	Maximum	Mann-Whitney U test
Female	13	2.242	1.74	2.644	.84	10.91	.544
Male	17	1.8	1.66	.6082	.95	3.21	

4. DISCUSSION

The rate of vibrato for both male and female singers was well within the range reported by other researchers [11], [12], [13], [14]. Some reported of vibrato rate ranging from 5-8 Hz [15]. This may be attributable to auditory memory, auditory perception or a premonition of a certain rate that is generally followed. Similarly, the extent of vibrato did not show a significant difference. One female singer extent did show a high upper limit (maximum value), although not statistically not significant. She used a throat vibrato by moving the larynx in an up and down movement. Her vibrato rate was slower (4 Hz) and vibrato extent was wider (10.91%). This has been stated by Sundberg [16]. If this female singer's extent value was taken out, the values of other female singers would match the male singers' extent values. Most researchers have measured vibrato extent in terms of cents or semitones. Voice & Tremor Protocol measures magnitude of amplitude variations in terms of percentage, hence the values of vibrato extent in this study have been given in percentage. So the disadvantage is that vibrato extent values measured in percentage, in this study could not be compared with the extent values reported by other researchers.

5. CONCLUSION

It is important that equal numbers of subjects be considered in gender related studies. This study fell short of female subjects, as they were slightly lesser in number than male subjects. In this study, utmost care was taken in considering the same genres of music that all the singers in the present study performed. In future a comparison of female singers and male singers in a particular genre of music can be analyzed.

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