Acoustic Analyses of Vocal Vibrato of Korean Singers

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ABSTRACT

The phenomenon of vocal vibrato may be regarded as an acoustic representation of one of the most rapid and continuous changes in pitch and intensity that the human vocal mechanism is capable of producing. Singers are likely to use vibrato effectively to enrich their voice. The purpose of this study was to obtain acoustic measurements (vF0 and vAm) of 45 subjects (15 trot and 15 ballad singers and 15 non-singers) and to compare acoustic measurements of the vowel /a/ produced by 3 groups on 2 voice sampling conditions (prolongation and singing of /a/). Thirty singers of trot and ballad were selected by a producer and a concert director working for the KBS (Korean Broadcasting System). The MDVP was used to measure the acoustic parameters. A two-way MANOVA was used for statistical analyses. The results were as follows; Firstly, there was no significant difference among the 3 groups in vF0 and vAm in prolongation of /a/, but in singing voice, there was a significant difference among 3 groups in vF0 and vAm. Secondly, there was an interaction between music genre and voice sampling condition in vF0, and vAm. Finally, trot singers sing with more vibrato than ballad singers. It was concluded that it is very important to analyze singers' voice including various voice conditions (prolongation, reading, conversation, and singing) and to identify differences of singing voice characteristics among music genre.

Keywords: vibrato, singer's voice, music genre

I. Introduction

Vibrato is a series of oscillations or pulses in a tone. Vibrato is the beautification of tone. Singing without it, the tone is dull and lifeless. Generally, singers desire to develop vibrato and are likely to use vibrato effectively to enrich their voice. Vocal coach is responsible for teaching vibrato to singers through the vocal exercises. It is mandatory that singers use correct breath control and proper placement of sound. The mask register is a preferred resonance area for learning vibrato.

The phenomenon of vocal vibrato may be regarded as an acoustic representation of one of the most rapid and continuous changes in pitch and intensity that the human vocal

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mechanism is capable of producing (Mason and Zemlin, 1980). The presence of vibrato, in the singing tones of trained singers and other subjects has been demonstrated in their tones.

Trot and ballad are a representative popular music genre in Korea. Singers have tendency to sing with specific timber and vibrato according to music genre. Yoo (2004) concluded that the NHR was significantly higher in singing voice than prolongation and reading and the female trot singers have tendency to sing with a less noisy voice than the male trot, female ballad, and male ballad groups.

Recently, some studies have identified the voice characteristics of classical singers, but few studies have investigated voices of public singers. Singers have risk of developing voice disorder due to vocal overuse and inappropriate vocal techniques. Therefore, it is necessary to identify the voice characteristics of public singers to provide them with an appropriate voice counselling.

The purpose of this study was to compare the degree of vibrato in 3 groups (trot, ballad, and non-singers groups) on 2 voice conditions (prolongation and singing of /a/).

II. Methods

2.1. Subjects

This study was conducted on 45 male subjects (15 trot and 15 ballad singers and 15 non-singers). Thirty singers of trot and ballad were selected by a producer and a concert director working for the KBS (Korean Broadcasting System).

Table 1. Characteristics of the singers

genre	sex	mean age	career	vocal exercises time per day	performance time per day
trot	male	55.1 yrs	32.6 yrs	0.75 hour	3.4 hour
ballad	male	47 yrs	25.1 yrs	1.2 hour	3.1 hour

2.2. Voice samples and analyses

The MDVP was used to analyze acoustic parameters. Each subject was seated and positioned at a mouth-to-microphone distance of 10cm. Acoustic analysis used voice of the subject's best attempt at a stable production of a prolonged /a/ (approximately for 3 sec) and singing /a/ in "Arirang" song. We selected and analyzed the most stable portion of /a/ (for 1 sec). We compared acoustic measurements (vF0 and vAm) of the vowel /a/ produced by the 3 groups on 2 voice sampling conditions (prolongation and singing of /a/).

A two-way MANOVA was used for statistical analyses.

III. Results

3.1. The mean and SD of vF0

Table 2 shows the vF_0 values of the 3 groups in prolongation and singing conditions. All 3 groups showed a higher vF_0 in singing than prolongation. Therefore, it was proved that both singers and non-singers produced more vibrato when singing compared to prolongation.

Table 2. The mean and SD of vF_0 of 3 groups on 2 sampling conditions

groups	sampling conditions	M	SD
non-singer	prolongation	1.06	.30
	singing	1.66	.74
trot	prolongation	1.13	.35
	singing	2.56	1.21
ballad	prolongation	1.23	.60
	singing	2.20	1.33

3.2. The mean and SD of vAm

Table 3 shows the vAm values of the 3 groups in prolongation and singing conditions. All 3 groups showed a higher vAm in singing than prolongation. Therefore, it meant that both singers and non-singers produced more vibrato when singing compared to prolongation.

Table 3. The mean and SD of vAm of 3 groups on 2 sampling conditions

;roups	;ampling conditions	M	SD
ıon-singer	›rolongation	8.91	2.35
	;inging	10.45	2.68
rot	›rolongation	8.87	1.58
	;inging	14.51	5.30
›allad	›rolongation	7.66	.3.49
	;inging	8.46	3.38

3.3. The results of multi-variate test

Table 4 and 5 shows the MANOVA results of vibrato as a function of group and voice sampling condition.

Table 4. Multivariate test[c]

Effect	Test name	Value	F	Hypoth.df	Error df	Sig.
Intercept	Pillai's Trace	.91	415.23[a]	2	83	.00
	Wilks's Lambda	.09	415.23[a]	2	83	.00
	Hotelling's Trace	10.00	415.23[a]	2	83	.00
	Roy's Greatest Root	10.00	415.23[a]	2	83	.00
Groups	Pillai's Trace	.25	5.87	4	168	.00
	Wilks's Lambda	.77	5.93[a]	4	166	.00
	Hotelling's Trace	.29	5.98	4	164	.00
	Roy's Greatest Root	.27	9.50[b]	2	84	.00
Sampling conditions	Pillai's Trace	.29	16.54[a]	2	83	.00
	Wilks's Lambda	.72	16.54[a]	2	83	.00
	Hotelling's Trace	.40	16.54[a]	2	83	.00
	Roy's Greatest Root	.40	16.54[a]	2	83	.00
Groups * Sampling conditions	Pillai's Trace	.12	2.61	4	168	.04
	Wilks's Lambda	.89	2.62[a]	4	166	.04
	Hotelling's Trace	.19	2.63	4	164	.04
	Roy's Greatest Root	.11	4.68[b]	2	84	.01

a. Exact statistic
b. The statistic is an upper bound on F that yields a lower bound on the significance level
c. Design: Intercept+Groups+Sampling conditions+Groups * Sampling conditions

Table 5. Tests of between-subjects effect

Source	Variable	SS	df	MS	F	sig.
Corrected model	vF_0	28.85[a]	5	5.77	7.93	.00
	vAm	458.95[b]	5	91.79	8.21	.00
Intercept	vF_0	240.82	1	240.82	330.83	.00
	vAm	8669.88	1	8669.88	775.25	.00
Groups	vF_0	4.06	2	2.03	2.79	.06
	vAm	198.00	2	99.00	8.85	.00
Sampling conditions	vF_0	22.04	1	22.04	30.28	.00
	vAm	159.20	1	159.20	14.24	.00
Groups*Sampling conditions	vF_0	2.75	2	1.38	1.89	.16
	vAm	101.75	2	50.88	4.55	.01
Error	vF_0	61.15	84	.73		
	vAm	939.40	84	11.18		
Total	vF_0	330.82	90			
	vAm	10068.23	90			
Corrected total	vF_0	90.00	89			
	vAm	1398.35	89			

a. R square = .32 (adjusted R squared = .28)
b. R square = .33 (adjusted R squared = .28)

The multivariate analyses showed that there was a significant difference in vF_0 and

vAm not only in the groups but in the voicing conditions. That is, the trot group produced more vibrato than the other groups. In addition, a more vibrato was produced in singing than in prolongation. Furthermore, there was an interaction between groups and voicing conditions in that the trot singers produced more vibrato in singing whereas ballad singers and non-singers did not show the difference as much. Although trot singers showed more vibrato than the other groups in singing, there was no difference among the 3 groups in vibrato in prolongation.

IV. Conclusions and discussions

This study investigated the vocal vibrato of Korean public singers in prolongation and singing of /a/. The results were as follows;

Firstly, there was no significant difference among the 3 groups in vF_0 and vAm in prolongation of /a/, but in singing voice, there was a significant difference among the 3 groups in vF_0 and vAm.

Secondly, there was an interaction between music genre and voice sampling condition in vF_0 and vAm.

Finally, trot singers produced more vibrato than ballad singers in singing.

Over the last decade, understanding of singer voice has rapidly advanced through the availability of computer based instrumentation. Since a wide variety of tonal and articulatory demands are reflected in the different vocal genres, it seems necessary to provide a quantitative procedure which can evaluate singing voice quality and monitor the effect of singing training.

Vibrato is a 4-6 Hz tremor which appears gradually as a singer develops the neuromuscular ability to sustain vowels in a resonant vocal tract and against substantial transglottal pressure. Vibrato is an essential part of the musical quality of the voice and is not controllable other than by controlling sub-glottal pressure.

Vibrato can be described in terms of 4 parameters: the rate (number of undulations per second), the extent (how far phonation frequency departs up and down from the average during a vibrato cycle), the regularity (how similar the frequency excursions are to one another), and the waveform of the undulations (Sundberg, 1995). The rate and extent are the 2 parameters most often studied. In our study, we measured fundamental frequency variation (vF_0) and amplitude variation (vAm) to identify the vocal vibrato of singers. The vF_0 and vAm are associated with the extent. The trot singers showed more vF_0 and vAm than the other groups, which meant that the trot singers sang with more vibrato with more variations in frequency and amplitude.

Some studies have investigated vocal vibrato physiologically. Titze (1994), Hsiao et. al. (1994) concluded that the periodic undulation of the fundamental frequency involved in vibrato may be a stabilized tremor of the cricothyroid and thyroarytenoid muscles. Many structures in the vocal tract, such as velum, tongue, and the side walls of the pharynx, may be engaged in a rhythmic pulsation synchronous with the vibrato (Sundberg, 1987).

Shipp, Leanderson and Sundberg (1980) found a significantly slower vibrato rate in male singers than in female singers; vibrato rate was uninfluenced by vocal pitch or by vocal effort. However, skillful singers vary the pitch oscillation and rate of vibrato in response to artistic judgment informed by the musical style. Singers participated in this study reported that they had a tendency to change singing technique according to music genre. For example, they had a tendency to sing with more noisy voice and more vibrato in trot than ballad song.

This study used 2 acoustic parameters to identify the characteristics of vocal vibrato of singers. To investigate the vibrato of singers extensively, it is necessary to include a physiologic examination (e.g., EMG), visual examination (e.g., stroboscope) as well as an acoustic analysis.

References

Mason, M. R. & Zemlin R. W. 1980. The phenomenon of vocal vibrato. In J. Large (Ed.), *Contributions of voice research to singing* (pp.241-262). Houston, Tx: College-Hill Press.

Yoo, J. Y. 2004. *A study of acoustic analyses of singers' voice.* A doctorial dissertation. Daegu University.

Sundberg, J. 1995. Acoustic and psychoacoustic aspects of vocal vibrato. In P. Dejonckere, M. Hirano, & J. Sundberg (Eds.), *Vibrato* (pp. 35-66). San Diego, CA: Singular Publishing Group.

Titze, I. R. 1994. *Principles of voice production.* Englewood Cliffs, NJ: Prentice Hall.

Hsiao, T. Y., Solomon N. P., Luschei E. S., & Titze I. R. 1994. Modulation of fundamental frequency by laryngeal muscles during vibrato. *Journal of Voice, 8*(3), 224-229.

Sundberg, J. 1987. *The science of singing.* Dekalb, IL: Northern Illinois University Press.

Shipp, T., Leanderson R., & Sundberg J. S., 1980. Some acoustic characteristics of vocal vibrato. *Journal of Research in singing, 4,* 18-25.

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