General Acoustical Characteristics of Pansori Singing Voice

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<Abstract>

판소리 발성의 전반적인 음향학적 특징

문승재

판소리의 특질을 연구하기 위하여 여덟 명창의 소리를 분석하였다. 그 결과 모두에게서 유성음임에도 불구하고 비주기성인 소리를 찾았다. 이러한 현상은 매우 높은 성대밑 공기압에 기인한다고 보았다. 이 비주기성 유성음은 명창들의 일반 대화에서도 나타나서 이러한 현상이 곧 성대의 영구적인 변화에 의한 것임을 추정할 수 있었다. 또한 판소리에서 나타나는 vibrato는 서양의 오페라에 비해 주기가 훨씬 길고 범위는 훨씬 넓음이 확인되었다. 그 외에도 모든 명창의 경우 고주파수 영역에서 매우 높은 에너지를 보여주어서 일반인의 발성과 차이가 남을 알 수 있었고, 특히 일부 명창의 경우는 1000Hz 바로 이하에서 유별나게 강한 harmonics가 나타나서 서양 음악의 소위 singer's formant와 대조를 이루었다.

1. Introduction

Pansori is a very cherished and enjoyed folk-art form in Korea. It is an art form in which music is combined with a story. The contents and structure of the story of

Pansori have been the objects of numerous research.

But the sound itself of Pansori became the focus of research only recently (Hong, Kim. 1996; Moon, 1996; Kim, 1999). The sound of Pansori is said to be made by concentrating the energy on *Dan-Jun*, a place below a navel. Considered to be a good sound is the sound which is hoarse and powerful, yet clear in high pitch. Upon hearing a performance of Pansori for the first time, audience is usually struck by its quality of murky and coarse, yet delicate sound which could convey all kinds of emotional variations. Choi(1999, p.51-2) describes this quality as "fermented sound."

This paper aims at conducting an acoustical analysis of pansori, and thus describing some of its overall characteristics.

2. Analyses

2.1. Materials

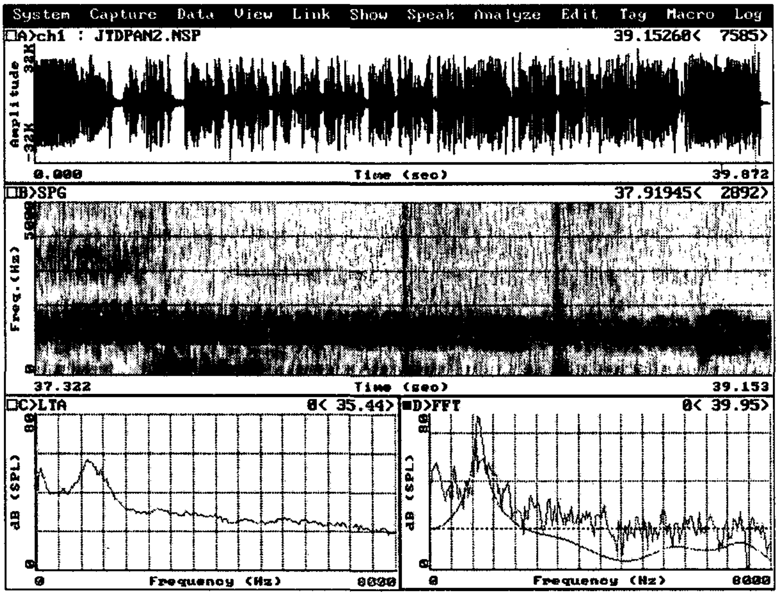
Selected for the analyses for the present study are eight Pansori singers (five males and three females, among whom three are alive) who were considered the great Pansori singers by most of Pansori experts the author consulted. Various commercial compact discs were used for the present study since some of the singers were not alive.

2.2. Sound characteristics

One of the most important, and striking characteristics of Pansori would be its sound quality itself. As mentioned above, most Pansori singers' voices sound hoarse. This hoarseness seems to contribute toward Pansori phonation's many characteristics.

2.2.1. Aperiodicity

One of the main characteristics is the aperiodicity of the supposedly periodic segments. Some (not all) instances of supposedly periodic segments such as vowels were, in reality, found to be aperiodic.



<Figure 1> A long [a] from Singer J

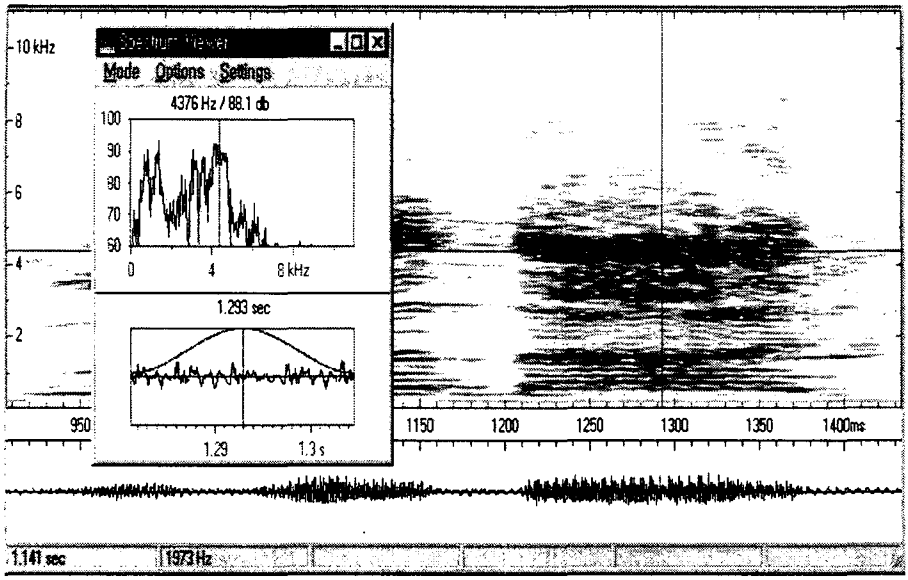
Figure 1 shows an example: a long stretch of a vowel during a performance by a male singer. To Koreans, it clearly sounds as a high-pitched [a]. However, looking at the spectra and the spectrogram, one has a great difficulty discerning regularly spaced harmonics. The left panel on the bottom of the figure is a long term average spectra of the vowel [a], and the right panel, an FFT with an LPC analysis superimposed. Looking at the waveform itself confirms the same conclusion: there is no periodicity.

More than two pitch-tracking programs were tried but they failed to indicate a consistent f_0 for this vowel. It seemed the pitch was judged based on the 1^{st} formant, not by the 1^{st} harmonic.

This aperiodicity is not idiosyncratic to this particular singer. And this aperiodicity can be observed not only in singing but also in conversational speech of Pansori singers.

Figure 2 shows a regular conversational speech (found as a form of *A-ni-ri*, which was a normal speech as a part of the performance) of another male singer.

In the zoomed-in waveform, there is no periodicity even though the cursor was placed in the middle of a vowel. This strongly suggests that this irregularity is due to a permanent physical change.



<Figure 2> An aperiodic vowel in conversational speech of a male singer

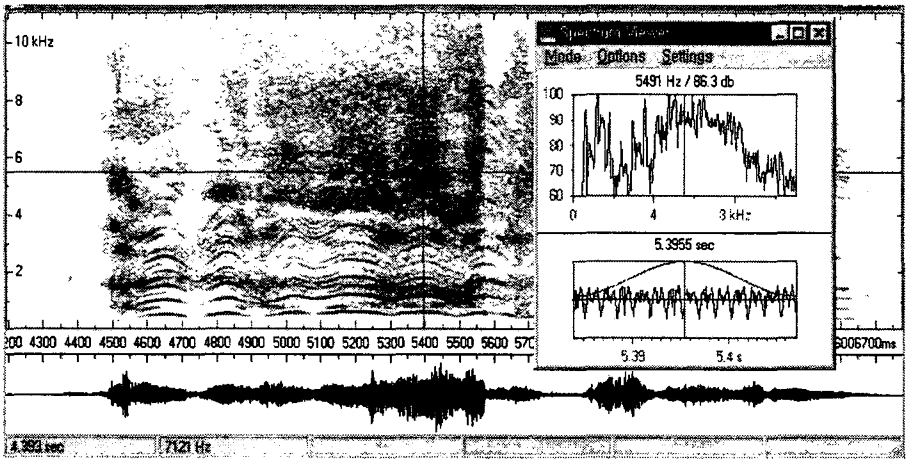
However, this is not to say that all sounds are aperiodic in Pansori. There are plenty of very clear periodic sounds in Pansori. However, there is a clear difference in sound quality: in general, periodic parts sound more clearer than aperiodic sounds.

2.2.2. Flatter spectrum envelope

Pansori singing voice reveals some peculiar spectral characteristics. As previously mentioned, the spectral slope of Pansori is much more gradual than that of average people with -6dB/octave decline. Pansori singers, in general, have relatively stronger energy in high frequency region than average people.

An example is give in Figure 3. In the figure, both the spectrum and the spectrogram reveal very strong clear harmonics all the way up to 8 kHz at the cursor, which is the limit due to the sampling rate of 16kHz.

The cursor is in the middle of a vowel. It can be verified by the clear harmonics. As mentioned above, there is a strong noise superimposed on the regular vibration of vocal folds, and this strong noise seems to contribute greatly toward this gradual decline, or even a reversed decline of spectral envelope.



<Figure 3> Strong energy in high frequency region (Male singer K)

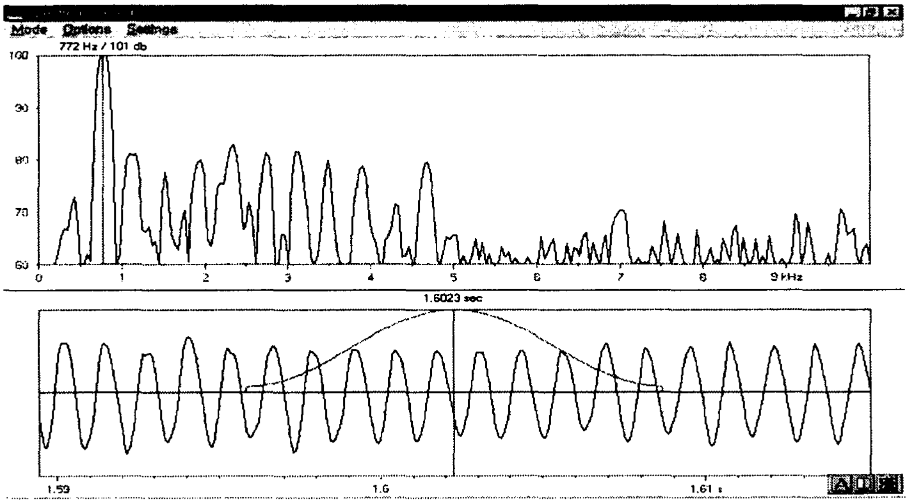
The aperiodicity with the flat spectrum envelope in high frequency range suggests very high subglottal air pressure. The fact that Pansori generally sounds very strained is in line with this speculation. However, another general quality of Pansori, hoarseness, is usually related with the breathy voice which is supposed to have a relatively lower energy in high frequency region. How can we explain these two observations?

Kim, Kim and Hong (1999) attributes this characteristics to the fact that the vocal folds of Pansori singers do not make complete closure. In Pansori, according to them, the vocal folds were pressed with stronger adduction than normal phonation. But the asymmetrical structure of the vocal folds and many irregular bumps formed along the folds due to the prolonged abuse from training prevents the folds from being completely closed.

Therefore, Pansori phonation seems to be a rare combination of pressed phonation and incomplete closure of the vocal folds. As a result, it produces pressed yet breathy voice.

2.2.3. A prominent partial

Another interesting phenomenon is the presence of a very prominent partial, that is not the fundamental, at the lower frequency. Figure 4 shows a spectrum of a female singer singing the vowel [o].



<Figure 4> A prominent second partial from a female singer

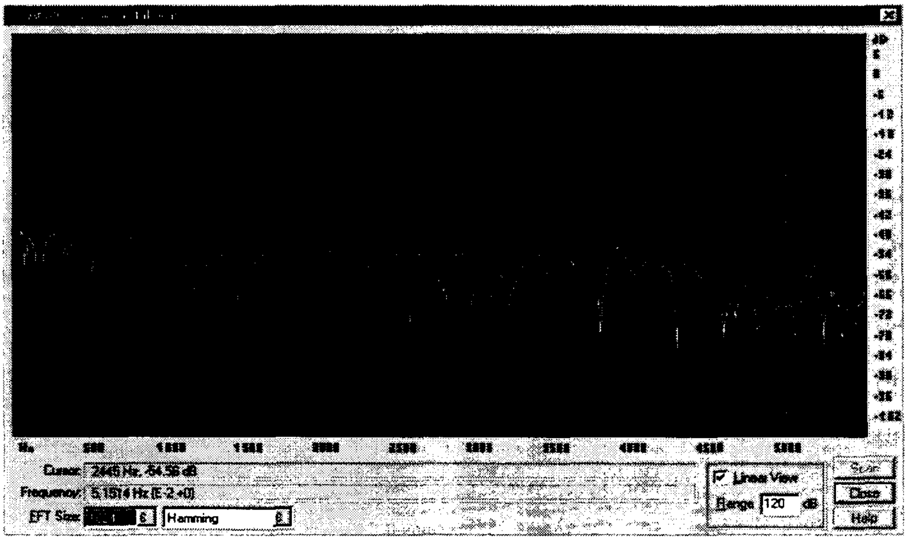
It is a prolonged [o], and throughout the whole long segment of [o], this harmonic structure remains virtually the same. As we can see, the second harmonic is very prominent. The rest of the harmonics are almost at the same level, but this particular one is more than 20dB above the rest.

The so-called singer's formant (Sundberg, 1987; p.118) is reminded of by this kind of peculiar harmonic structure. However, unlike the singer's formant, this prominent partial is located lower than 1kHz. And the singer, in this particular case, is a female while the singer's formant was observed dominantly in male singers.

The flat spectrum envelope is a much more widespread characteristic among Pansori singers than the prominent partial is.

Why do Pansori singers try to achieve the sound with this flat spectrum envelope with a possibly prominent partial? Before trying to answer this question, let's consider the environments in which these singers train themselves. Most of them practice the phonation for a long time by themselves in an isolated places. Even though it may be just a myth, let's look at the spectrum of a waterfall since it is very popular to think about Pansori singers' training with a waterfall at the background. Figure 5 is a long-term average spectra of several minutes of a waterfall.

It reveals a whitenoise-like characteristics: that is, the energy is very evenly distributed along all the frequency range.



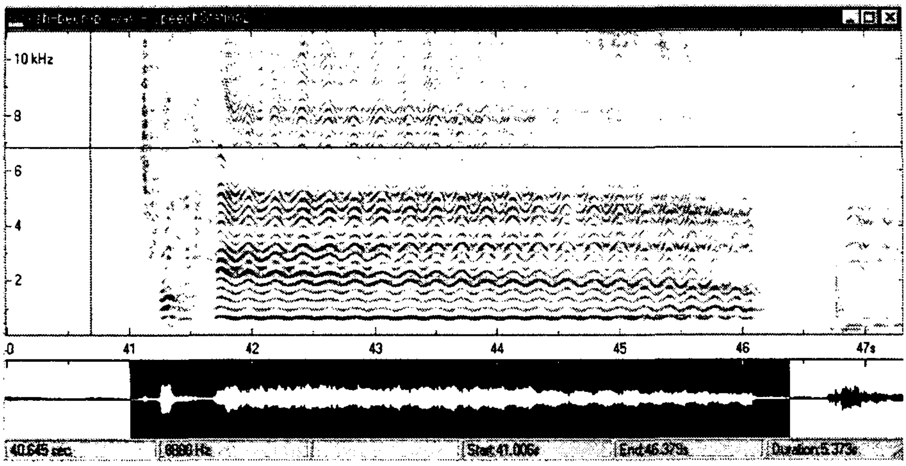
<Figure 5> Long-term average spectra of a waterfall

It is only when a singer's voice pierces through the background noise of a waterfall, that he is said to have achieved a true sound. A human voice cannot overpower the magnitude of a waterfall by sheer force. However, having a flatter distribution of the energy rather than the -6dB/oct slope may help to overcome this obstacle. In addition, having a very prominent partial like the one we observed might just make the human voice audible against the enormous white-noise. It would also make the voice easier to detect in the outside noise where Pansori was usually performed.

Thus, this prominent partial in Pansori seems analogous to the singer's formant in Western operatic singing in the sense that both have a certain mechanism to be heard over the background noise (waterfall or a natural sound in Pansori and orchestra in Western opera).

2.2.4. Vibrato?

The phenomenon similar to vibrato is easily observed in Pansori singing as can be seen in Figure 6. (Because of the reasons which will be discussed later, the term *vibrato* does not seem to be particularly suitable for describing Pansori. However, for the lack of a better term, we will use vibrato for the present study.)



<Figure 6> An example of vibrato from a female singer

Though vibrato varies according to the individual, it is generally accepted that the average rate of vibrato in Western operatic singing is about 7 Hz and the extent of pitch modulation is less than 100 cents (Rossing, 1990: p.134, Sundberg, 1987: p.163-164).

However, upon close investigation, the vibrato in Pansori seems quite different from the vibrato in Western operatic singing both in the rate and the extent of the undulation, contrary to Kim et al (1999)'s finding (p.44). The rate of frequency modulation in Pansori, when it occurs, is less than 5 Hz. And the extent of the modulation is usually more than 12%, thus bigger than 2 semi tones or 200 cents (Rossing, 1990: p. 177). Of course, the vibrato in Pansori is used intermittently and sometimes, the singing goes on without any vibrato at all for a long time.

From four singers' data, the average rates of their frequency modulations are 4.7, 4.8, 5.4 and 4.8 Hz. Their extents of modulation vary from 7% (which is very rare) to 45%. The particular example in Figure 6 shows a frequency modulation during a very long period of time.

If this kind of vibrato were heard in Western operatic singing, it would be judged completely unacceptable. Interestingly, if the vibrato with the rate of 7Hz or above and with the extent of less than 100 cents were sung in Pansori, it would be judged unacceptable as well. That kind of frequency variation is called *Bal-Bal-Seong*, where "seong" means voice and "bal-bal" is an onomatopoeic word which describes a rapid vibrating movement. This *Bal-Bal-Seong* is a kind of sound which, in Pansori, is considered to be "undignified," and thus should be avoided.

There seems to be a significant difference in the role of vibrato. In Western operatic singing, it is suggested that the vibrato is used to conceal some minor flaws which, without the vibrato, would be revealed prominently. However, in Pansori, the vibrato seems to be used as a major ornamentation. It seems the frequency modulation is supposed to be perceived as such and this is used to add some color to the performance. That may explain the lower rate and much bigger extent of Pansori vibrato.

Therefore, the term *vibrato* in its original sense in Western literature does not seem to be an appropriate term to describe the frequency (and amplitude) modulation in Pansori. In terms of the extent of undulation alone, *trillo* might be better (Sundberg, 1987: p.164), though not quite right because of its rate of undulation. And the author would like to suggest a new term for this kind of frequency modulatioin in Pansori: *t'eol-ghi*, which means 'vibrating' in Korean.

3. Conclusion

We have looked at some general characteristics of Pansori. The basic quality of the voice in Pansori can be characterized as pressed, yet breathy. This gives Pansori voice a unique characteristic of aperiodic noise superimposed on the periodic segments. It is speculated that the aperiodicity is due to the physical change: Pansori singers' vocal folds must have been permanently changed by the long and rigorous training, and as a result, the folds cannot close completely, thus producing an aperiodic noise under pressure. Further studies employing fiberscopy and/or subglottal air-pressure measurements (Sundberg, 1987; p.35) will be of great value to understand this characteristic more thoroughly.

Unlike the usual breathy voice with rapid decrease of energy in high frequency region, Pansori voice has a flatter spectrum envelope. And the presence of a very prominent partial was observed in some of Pansori singers. This partial was located below 1000 Hz range.

The investigation of the vibrato in Pansori turned out to be very interesting. It is different from the vibrato in Western operatic singing, both in the rate and the extent; Pansori's vibrato has lower rate and higher extent of frequency modulation than its counterpart in Western culture. The frequency modulation seems to play very different roles in Pansori and in Western singing.

This Pansori voice proved to be a worthwhile subject and further studies are greatly needed.

Acknowledgment

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