Proceedings of the International Symposium on Music Acoustics
(Associated Meeting of the International Congress on Acoustics)
25-31 August 2010, Sydney and Katoomba, Australia

Pitch Glide in Chinese Small Gongs: Effects of Macrostructure and Microstructure

Chen-Gia Tsai (1), and Pei-Ling Huang (1)

(1) Graduate Institute of Musicology, National Taiwan University, Taipei, Taiwan

PACS: 43.75.Kk

ABSTRACT

The nonlinear behavior in the gongs has been previously studied by Rossing and Fletcher on the big and small Chinese opera gongs, which have complex shapes and pitch-gliding sounds. There are several kinds of the small gongs in traditional Chinese music. In the present study, we compared four small gongs with two size categories. The Nanguan jiaoluo (NL) and the Nanguan xiangzhan (NX) are small gongs with the radius of 3.0-4.8 cm; the Beiguan xiangzhan (BX) and the Beijing opera xiaoluo (BL) are small gongs with the radius of 9-12 cm. The pitch of NX glides downward, while the pitch of NL, BL and BX glides upward. We used a soft mould to obtain the internal shapes (macrostructures) of these small gongs. The results suggest that the macrostructure alone cannot explain the different beahviors of pitch glide. The large pitch-gliding of NX and BL (more than two semitones) may be related to their microstructures, namely, the striae on the flat surface.

INTRODUCTION

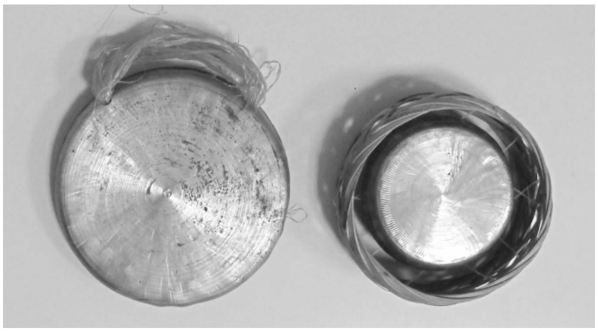
Some percussion instruments produce definite pitches, and some produce indefinite pitches. The pitch of several kinds of the gongs in Chinese music, however, glides upward or downward after striking. The pioneer work by Rossing and Fletcher reported that the glide direction was probably determined by a combination of the effects of curvature and of internal stress [1]. The theoretical investigation of vibrational behvior of a shallow spherical-cap shell emphasized the influences of the shell thickness, the cap height, and the vibration amplitude [2].

The aim of the present study was to measure the shapes and the sounds of four kinds of the small gongs in Chinese music. The Nanguan jiaoluo (NL) and the Nanguan xiangzhan (NX) are small gongs with the radius of 3.0-4.8 cm; the Beiguan xiangzhan (BX) and the Beijing opera xiaoluo (BL) are small gongs with the radius of 9-12 cm. The sound of NX is characterized by a downward gliding pitch, whereas the sound of BL is characterized by an upward gliding pitch. Both are believed to play a role in enlivening an ensemble performance. By contrary, the sounds of BX and NL do not evoke significant sensation of pitch-gliding, and acoustic measurements are needed for revealing small frquency changes of their spectral components.

From the perspective of nonlinear physics, the vibration of NX/BL manifests a hardening/softening spring effect and its frequency decreases/increase as the amplitude decreases. Effects of the curvature on the behavior of pitch-gliding predicted by theories were examined by experiments in this study. We argued that the pitch-gliding characteristics of their sounds may be related to their microstructures, i.e., the striae on the flat surface.

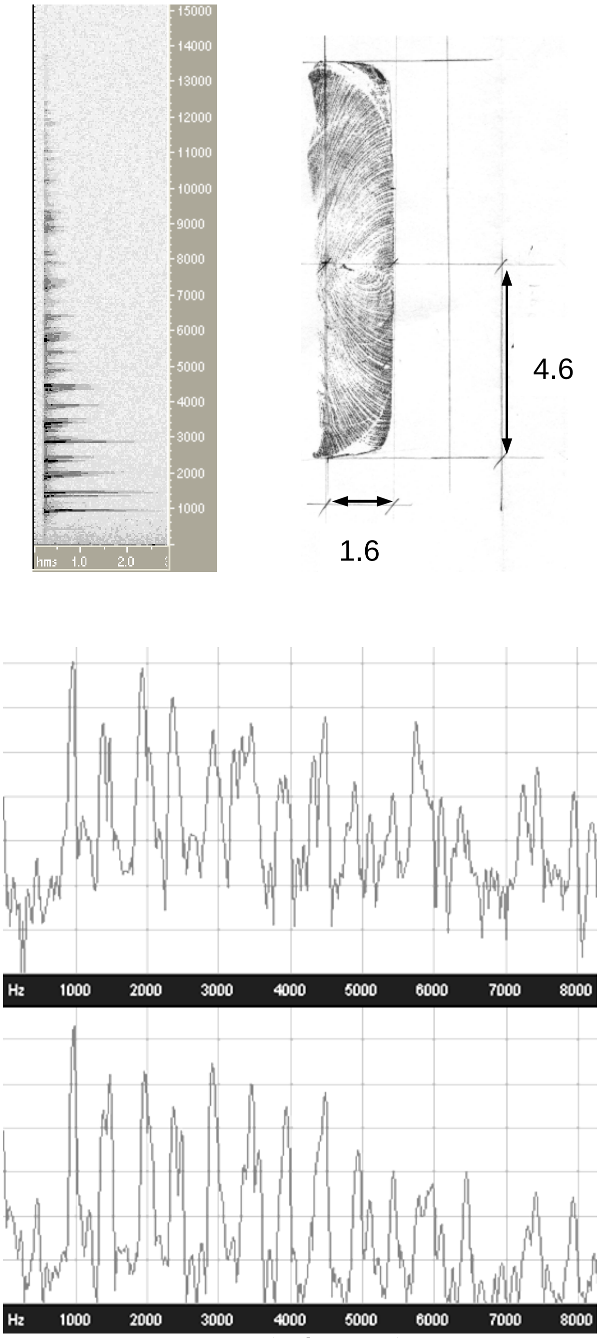
SHAPES AND SOUNDS OF SMALL GONGS

Figure 1 shows the photo of the NL (left) and the NX (right). Although their size differs slightly, their shapes are very similar. We used a soft mould to obtain the shapes of their internal space. Figs. 2 and 3 show the spectrograms, the internal shapes, and the sound spectra recorded 0.1 and 0.4 sec after striking. The frequency of the lowest spectral component of the NL sound increased from 963 Hz to 982 Hz, whereas the frequency of the lowest spectral component of the NX sound decreased from 1340 Hz to 1257 Hz. Both NL and NX show the flat surface.



Source: (Authors, 2010)

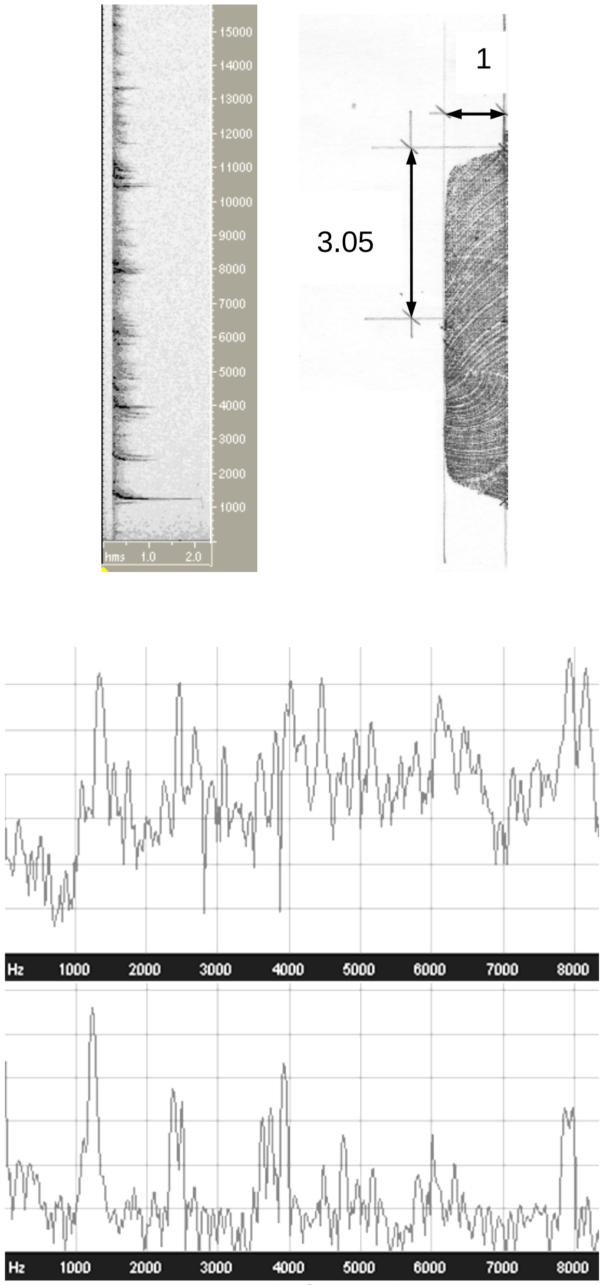
Figure 1. Photo of the NL (left) and the NX (right).



Source: (Authors, 2010)

Figure 2. Sound and internal shape of the NL. The two spectra were recorded 0.1 sec and 0.4 sec after striking. The frequency of the lowest spectral component increased from 963 Hz to 982 Hz.

Figs. 4 and 5 show the spectrograms, the internal shapes, and the sound spectra recorded 0.1 and 0.4 sec after striking. The frequency of the lowet spectral component of the BX sound increased from 849 Hz to 868 Hz, whereas the frequency of the lowest spectral component of the BL sound increased from 404 Hz to 448 Hz. Both BX and BL show a flat central section and a conical flange. In spite of the similar shapes of the BX and the BL, their gliding ranges are different. Table 1 displays the pitch-gliding data of all four small gongs. It can be noted that the sounds of NX and BL have significant pitch changes (> 2 semitones), whereas the sounds of NL and BX have minimal pitch changes (< 1 semitone).



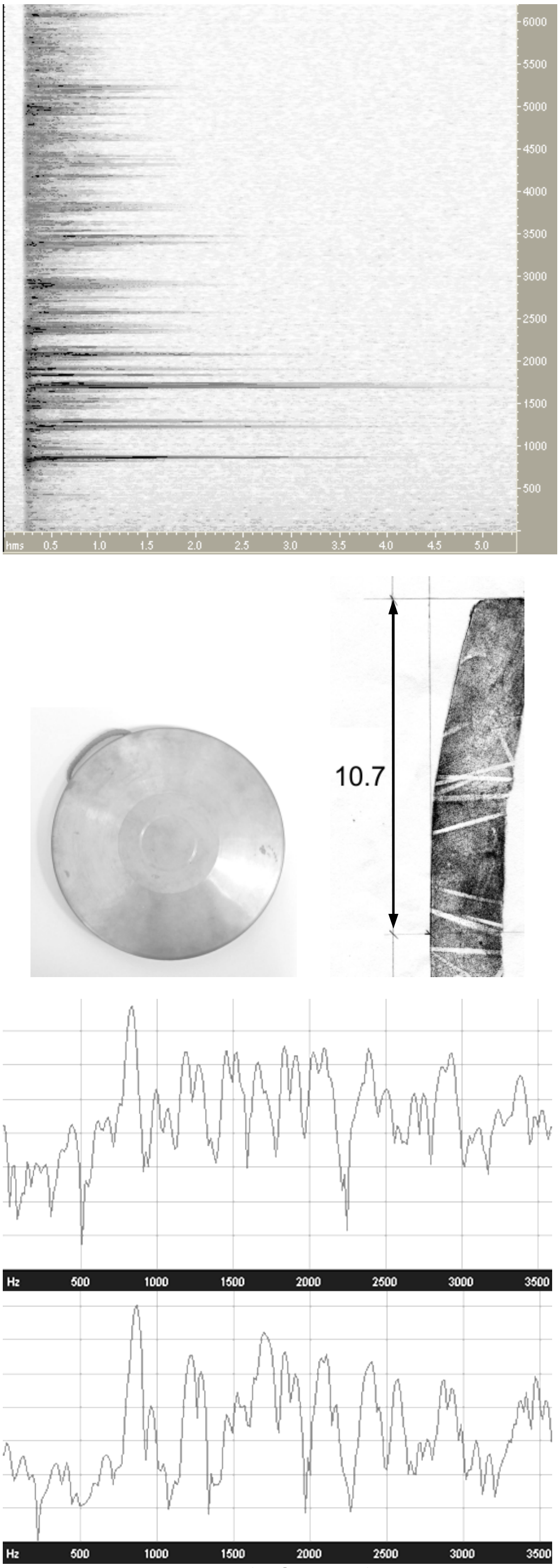
Source: (Authors, 2010)

Figure 3. Sound and internal shape of the NX. The two spectra were recorded 0.1 sec and 0.4 sec after striking. The frequency of the lowest spectral component decreased from 1340 Hz to 1257 Hz.

Table 1. Pitch-gliding data of four Chinese small gongs

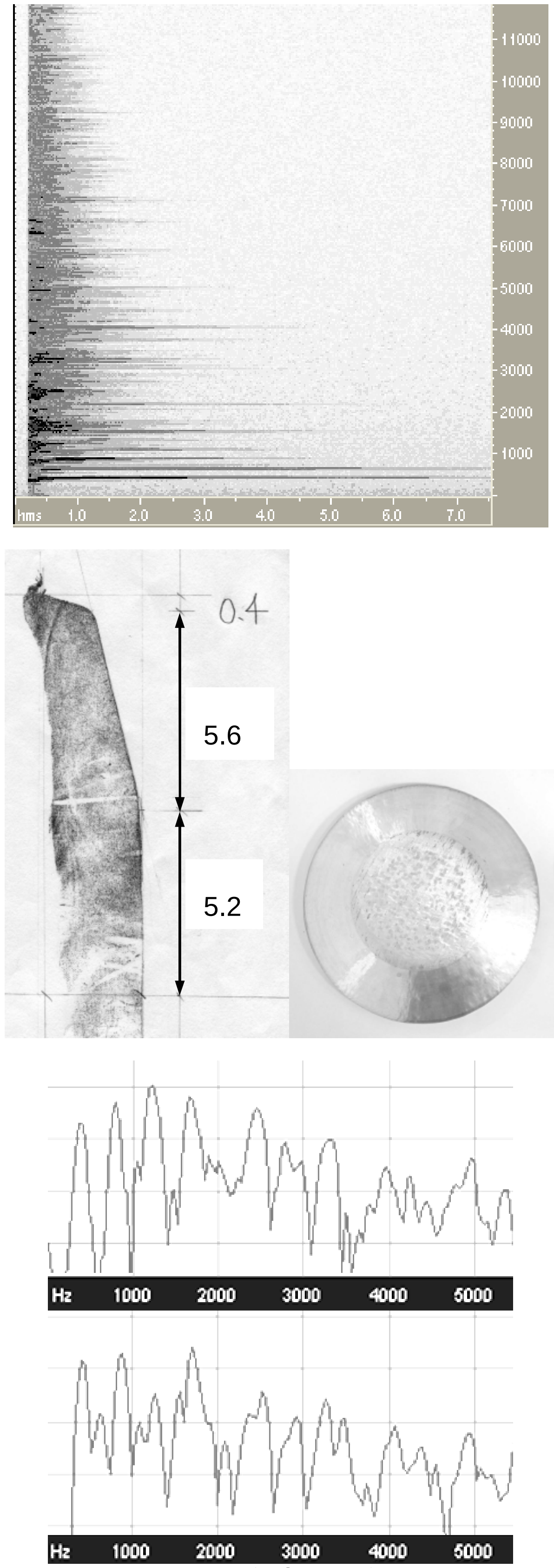
Instrument	Initial pitch	Final pitch	Gliding range
NL	963 Hz	987 Hz	+44 cent
NX	1363 Hz	1243 Hz	-242 cent
BX	831 Hz	870 Hz	+79 cent
BL	396 Hz	464 Hz	+276 cent

Source: (Authors, 2010)



Source: (Authors, 2010)

Figure 4. Sound and internal shape of the BX. Its radius is 10.7 cm. The two spectra were recorded 0.1 sec and 0.4 sec after striking. The frequency of the lowest spectral component increased from 849 Hz to 868 Hz.



Source: (Authors, 2010)

Figure 5. Sound and internal shape of the BL. Its radius is 11.2 cm. The two spectra were recorded 0.1 sec and 0.4 sec after striking. The frequency of the lowest spectral component increased from 404 Hz to 448 Hz.

DISCUSSION AND CONCLUDING REMARKS

The major aim of this study was to examine the relationship between the pitch-gliding characteristics and the structures of four kinds of the small gongs in Chinese music. Previous studies emphasized the importance of the macrostructure of the gongs, such as the ratio of the shell thickness to the shell center offset [2]. Our experimental study reveals that the macrostructure alone cannot explain the different beahaviors of pitch glide.

The sounds of NX and BL have significant pitch changes compared with their "relatives", i.e., the NL and the BX. It is interesting to note that the NX and the BL have particular microstructures: the striae on their flat surfaces (Fig. 6). By contrary, the sounds of NL and BX have minimal pitch changes and they do not have such striae on their surface.

We hypothesized that these striae enhance the nonlinear effects (hardening/softening spring) to the small gongs. Further experimental and theoretical investigations are needed to provide insights into the pitch-gliding characteristic of these Chinese small gongs. We will interview with some manufacturers of small gongs to learn more about "the art of striae-making".

Source: (Author, 2010)

Figure 6. Striae on the flat surfaces of NX (top) and BL (bottom). The parallele lines indicate the direction of striae.

REFERENCES

1 T. D. Rossing, and N. H. Fletcher, "Nonlinear vibrations in plates and gongs," *J. Acoust. Soc. Am*. **73**, 345–351 (1983)

2 N. H. Fletcher, "Nonlinear frequency shifts in quasispherical-cap shells: pitch glide in Chinese gongs," *J. Acoust. Soc. Am*. **78**, 2069–2073 (1985)