Impossible Melodies: Octave Cycles and Illusory Pitch Shifts in a North Chinese Wind Repertoire

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THE practice of performing *shengguanyue* wind and percussion music during Buddhist rituals has been making a comeback in the monasteries of Wutaishan, Shanxi Province, China since the mid-1990s. Those monasteries had been closed and their resident monks and nuns forced into lay life during the Cultural Revolution of 1966–1976. In the 1990s, the more relaxed official stance toward religious activity of the Reform and Opening-Up period allowed some elderly monks to return to the monasteries and teach a new generation of monks to play the traditional ritual repertoires on *sheng* mouth organ, *guanzi* double-reed pipe, and *dizi* flute. Today at least four of Wutaishan's fifty active monasteries maintain *shengguan* ensembles that perform during calendrical and donor-sponsored rituals. Two of these monasteries, Pusading and Zhenhai si, are centers for the practice of Tibeto-Mongolian Buddhism, while the others, Nanshan si and Shuxiang si, house monks practicing Han Chinese Buddhism, a syncretic mix of Pure Land, Huayan, and Chan. The pieces discussed in this article are part of the repertoire at the Chinese monastery Shuxiang si. Relying on only a few elderly monks' memories for their reestablishment of *shengguanyue* practice, monks today perform a repertoire much smaller and simpler than that preserved in notation from before the founding of the People's Republic (Szczepanski 2012, 111–24). Some of the surviving pieces, however, include remarkable compositional elements. For example, a repeated section of *Qiansheng Fo* (A thousand calls to the Buddha) makes use of staggered octave shifts that, along with the overtone-rich timbre of the *sheng* mouth organ, produces an octave-cycling effect. The melody of this section sounds as if it cycles to lower and lower octaves even though the pitches performed remain within the same range of frequencies. Some other melodies are constructed such that they seem to span a range of up to a fourteenth, although the actual frequencies performed cover a range of no more than a ninth.

The idea that pitch perception does not always match pitch frequency is not new; the concept of octave cycling was first formulated by Roger Shepard (1964) in his article "Circularity in Judgments of Relative Pitch," and scholars have found this phenomenon in musics of Africa and Europe (Braus 1995; Brenner 2004; Wegner 1993). Octave cycling has not, however, been examined in East Asian traditional music. Indeed, Western scholars rarely delve into analysis of melodic structure in traditional Chinese music (Jones 2010, 27–28). This article examines the mechanics of several auditory illusions in examples of Wutaishan Buddhist music recorded at the monastery Shuxiang si between 2005 and 2007. In addition, this article demonstrates that Chinese and Western researchers' standard practice of transcribing Chinese melodies as a single line in staff notation obscures some of those melodies' most interesting structural elements.

Analytical Approaches to World Music, Vol. 4, No. 1. Published May 11, 2015.

Pitch Perception

Laboratory experiments have demonstrated that simultaneous frequencies and certain types of pitch successions can facilitate octave displacement in pitch perception. In order to explain how perception of pitch can differ by octave from actual pitch frequency, Roger Shepard (1999) employs a helical rather than linear model to represent pitch perception (shown in Figure 1). In this model, first developed by Hungarian psychologist Géza Révész (1912), a sound is distinguished both by its linear height and its cyclical chroma. Shepard (1999, 159–60) explains, "The vertical position on the pitch helix represents what is called *pitch height*. The position within an octave around the cylinder defined by the helix is called the *chroma*." In this model, frequencies an octave apart in height are closer together in chroma than those less than an octave apart. Experiments by Shepard and others have shown that when a tone's chroma is exaggerated over its height through electronic manipulation, such as by creating a tone made of multiple octaves of a single pitch class, a listener's perception of octave placement may depend on the context in which she or he hears the tone rather than solely on the frequencies that make up the tone. Sequences of electronically produced "Shepard tones," which are comprised of "many sinusoidal components locked at successive intervals of an octave and sounded simultaneously," are ideal for demonstrating this effect (Shepard 1964, 2347).[1]

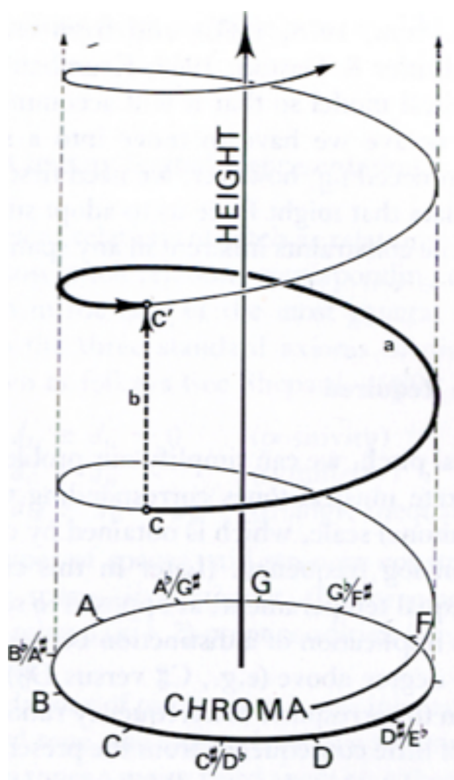

Figure 1. Helical model of pitch, from Shepard (1982, 353).

1. A demonstration of Shepard tones by David Huron can be found at http://vimeo.com/34749558.

Diana Deutsch has published the results of a number of relevant experiments based on auditory illusions (1975, 1980, 1982, 1986, 1992, 1999). She discovered, for example, that successive intervals of a tritone (half an octave) between Shepard tones can be perceived as either ascending or descending, and that the perception of interval direction can change when the interval maintains its relative pitch content but is transposed to a different pitch level (Deutsch 1986). She has also published findings that listeners group auditory stimuli by frequency proximity rather than physical location of the sound source in relation to the listener. One experiment that demonstrates this principle uses two disjunct pitch sequences that, when combined, comprise simultaneous ascending and descending major scales. When these sequences, each in a separate channel, were simultaneously presented to test subjects,s most listeners reported hearing a smooth scale in each ear rather than the two disjunct pitch sequences (Deutsch 1980, 172). More recent studies indicate that the perception of ascending and descending intervals between Shepard tones depends not only on pitch height and chroma, but also on the placement of those tones within a context. For example, Giangrande, Tuller, and Kelso found that hysteresis exerts a strong influence over how listeners perceive intervals between Shepard tones; once a listener has perceived an ascending or descending pattern, he or she is very likely to maintain that pattern in perception of succeeding intervals (2003). One need not limit oneself to the laboratory to find auditory illusions. In some of the harp and xylophone music of the Nzakara in the Central African Republic, octave doubling creates an emphasis on pitch chroma over pitch height, allowing listeners to perceive certain pitches as sounding at the octave placement that fits most smoothly in the context of a melody rather than at their actual frequency levels (Wegner 1993; Brenner 2004). Similarly, listeners' tendency to invert intervals and smooth disjunct pitch sequences in order to perceive smooth melodic contours, particularly when more than one frequency is performed at a time, make possible the auditory illusions found in some melodies performed by monks at Wutaishan. Examples of these will be discussed in detail below.

Instruments and Pitch in Wutaishan *Shengguanyue*

The *sheng* mouth organ used in Wutaishan's *shengguanyue* is pitched in D and features a uniquely simple arrangement of seventeen pipes in what is known as a "northern" pipe order. However, eight of the pipes are plugged with wax and have no reeds, leaving only nine sounding pipes.[2] The sounding pipes produce the pitches shown in Figure 2, with a one-octave range from A_4 to A_5.

The functional ranges of the *sheng, guanzi* double-reed pipe, and *dizi* flute in Wutaishan's monasteries appear in Figure 3. Skilled *guanzi* players, like those at Wutaishan's Tibeto-Mongolian monasteries, can overblow to extend the range of the instrument used in

2. It is not uncommon for musicians in north China to block unused pipes in this way, although *sheng* used by Wutaishan's monastic instrumentalists have a greater number of non-sounding pipes than any others I have encountered. This simplification of the instrument likely came about as a means to facilitate reestablishment of *shengguanyue* as part of Wutaishan's post-Cultural Revolution revival.

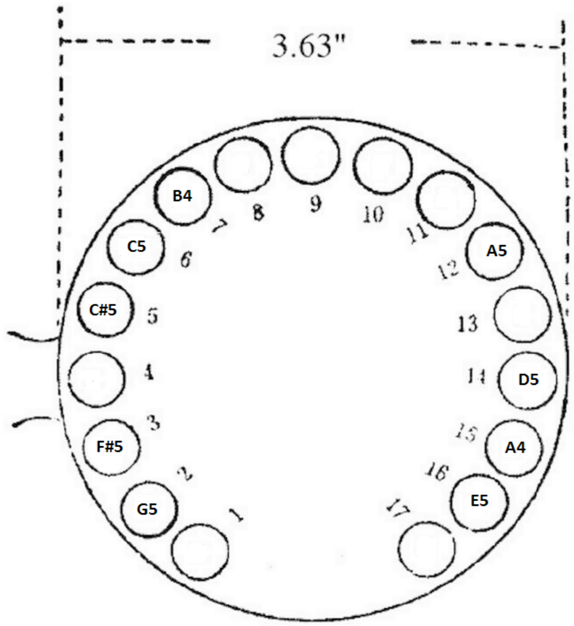

Figure 2. Diagram of Wutaishan *sheng* pipes and pitches.

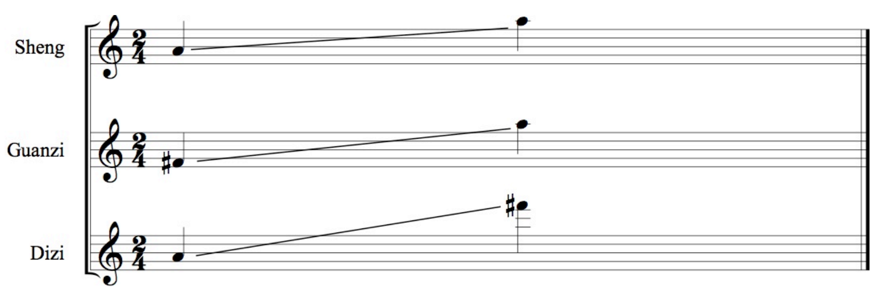

Figure 3. Functional range of *shengguan* instruments.

Wutaishan a fifth higher than shown here, reaching the pitch E_6, but monks in Wutaishan's Han Chinese Buddhist monasteries limit themselves to a peak pitch of A_5. The upper *guanzi* register is used, however, by monks in Wutaishan's Tibeto-Mongolian monasteries. The *dizi* has a range of just over two octaves, but the monks of Wutaishan's Han Chinese monasteries tend to avoid the upper and lower extremes of the range. No instrument of the ensemble produces pitches lower than $F\sharp_4$. This creates a top-heavy sound characteristic of much traditional Chinese music, though that effect is mitigated to some extent when the instruments accompany low chanting voices.

While the pitch range available to instrumentalists in *shengguanyue* is relatively narrow, that range does not constrain the composition of melodies in the *shengguanyue* repertoire. In performance, musicians freely shift octaves in relation to each piece's melodic framework in order to remain within their instrument's comfortable range. As discussed below, however, this frequent disjunct melodic motion does not generally influence the listener's perception of the basic melodic shape. Instead, the instrumentation and performance practice of the *shengguan* ensemble facilitates contour smoothing in pitch perception.

Qiansheng Fo

Qiansheng Fo is one of the most commonly performed pieces of *shengguanyue* at the monastery Shuxiang si in Wutaishan. This melody provides the basis for chanting of "Namo Emituofo" (Blessed be Amitābha Buddha) during several types of rituals that monks perform at the behest of donors. The piece accompanies circumambulation; monks play *shengguan* instruments and invoke the primary buddha of Pure Land Buddhism while walking three times around the large altar in the monastery's central hall.

The transcription in Figure 4 presents the basic skeleton of the *Qiansheng Fo* melody. Monks add instrumental and vocal ornamentation to this basic outline to produce a heterophonic texture that changes with each new performance. The pitches represented here approximate those used at Shuxiang si, though the actual pitch shifts with the tuning of the temperamental *sheng* mouth organ and generally tends to be a bit higher than notated here. The relative pitch of this tune, as in all current *shengguanyue* repertoire, falls conveniently into the framework of standard Western staff notation. The melody begins at a slow tempo, around 40 beats per minute, and gradually accelerates to approximately 70 beats per minute. I have chosen to notate this example in duple meter because it fits well with both the melody and its percussive accompaniment; in performance, a monk plays small *bo* hand cymbals on the first beat of each notated measure, while another strikes the *muyu* (temple block) on each beat.

When I first transcribed this melodic skeleton, I encountered a challenge. The passage that monks repeat to fill the time required to complete their three circuits of the hall, mm. 17–29 in Figure 4, begins and ends on the pitch class D, but the end point sounds as if it should be an octave lower than the beginning. At the repeat, however, there is no octave leap upward; the melody sounds as if it simply continues to wind downward at each repeat. In fact, the instruments and voices of the ensemble begin and end this passage at the same frequency. I suggest two plausible explanations for this discovery. First, I might be perceiving the melody in an idiosyncratic fashion; the octave cycle might exist only to my ears. To test this hypothesis, I assigned this passage of *Qiansheng Fo* as a transcription exercise for a small class of undergraduate music majors at Lewis & Clark College in Portland, Oregon. Four of the six students transcribed the melodic contour as a continuous descent. Assured that my perception of octave cycling in *Qiansheng Fo* is not entirely idiosyncratic, I explored the second possibility: that something about the sound of the *shengguan* ensemble facilitates the perception of octave cycling. I then undertook an examination of the actual frequencies performed and of the timbral characteristics of *shengguan* instruments to explore how this phenomenon comes about.

Figure 4. Basic melody of *Qiansheng Fo.*

The transcription in Figure 5 is based on one field recording of *Qiansheng Fo* from the summer of 2005 and should not be taken as a document of how the piece is always performed; as noted above, ornamentation varies from one performance to another. The transcribed performance included relatively little ornamentation. While details of ornamentation vary, all performances of this piece I have heard played by the Shuxiang si *shengguan* ensemble create the same sense of octave cycling. Note also that the starting pitch of D is approximate, but the intervals used in this repertoire are analogous to interval relations in Western notation.[3]

3. Pitch ambiguity in *shengguanyue* poses challenges to transcribers. The pitch class of each tone can be determined by examining the *gongchepu* notation and comparing it to the sound produced. Octave placement of each

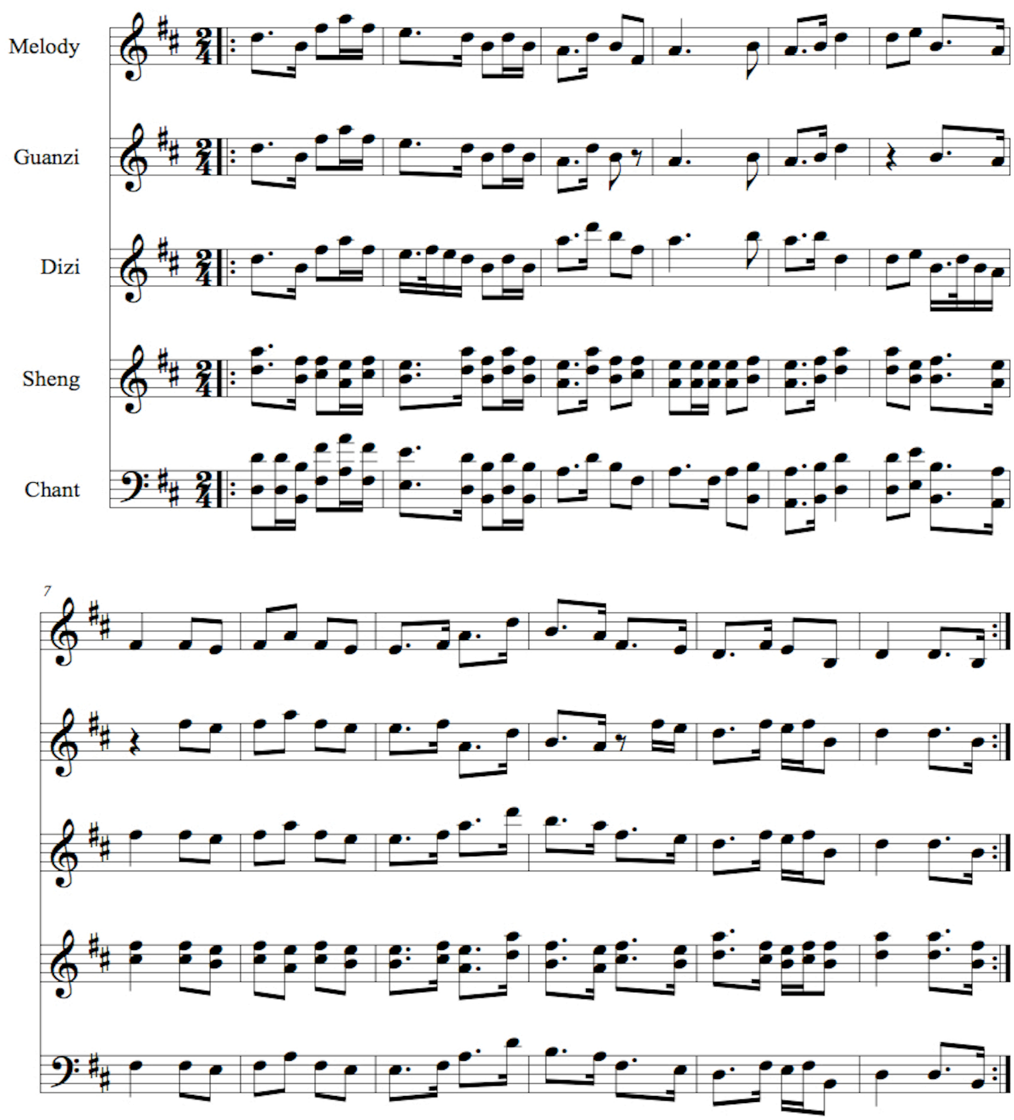

Figure 5. The repeated section of *Qiansheng Fo.* [Click here to listen to an audio example.]

As one follows each voice in the texture, one finds a number of register shifts that differ from the melody as perceived. The *guanzi* double-reed pipe, for example, reenters the texture in m. 7 at a higher pitch level than before, then leaps downward on the second beat of m. 9, only to return to a higher pitch level in the second half of m. 10. Such leaps are common in *guanzi* playing at Wutaishan because they allow the player to remain in a comfortable range on his instrument. For similar reasons, the *dizi* flute leaps upward on the first beat of m. 3, then downward in the second half of m. 5, then upward again on the first beat of m. 7. The constant

voice in the texture is more challenging. The *sheng* mouth organ produces the same pitches each time a pitch class occurs in a melody. This leaves only the octave placements for the *guanzi* double-reed pipe, *dizi* flute, and chanting voices to be determined entirely by ear. I found that through repeated listening I was able to isolate these voices for the purpose of transcription.

register shifts of these instruments train the listener's ear to overlook such octave movement, increasing the importance of chroma over pitch height in the perception of basic melodic shape. The vocal component of the performance enhances this effect, providing more simultaneous octaves of each pitch class and creating a Shepard-tone-like sound. Monks chant the melody at different pitch levels depending on their vocal range, with pre-pubescent novices generally taking the higher octave and voices continually dropping in and out of the texture.

A glance at Figure 5 might lead one to assume that this melody should not be described as an octave cycle, but rather as a tune that leaps upward by a minor sixth from A to F♯ in m. 7 and then continues on its way at a higher pitch level. Only the higher-pitched chanting voices descend by major third at that point, all other voices ascend by minor sixth. When played in the context of this melody by the *shengguan* ensemble, however, this interval sounds to me (and to most students to whom I've assigned this passage as a transcription exercise) like a descending major third. As Giangrande, Tuller, and Kelso have reported, perceptions of interval direction between ambiguous pitches can be strongly influenced by the melodic patterns a listener perceives in preceding intervals (2003). In this passage, when the rhythm of dotted-eighth, sixteenth appears, a clear melodic pattern emerges. If the interval between the dotted eighth and sixteenth note is a greater than a major second, the interval to the pitch following the sixteenth note moves in the opposite direction than the preceding interval. This can be seen in mm. 1.1, 3.1, 9.2, and 11.1. If, however, the interval between the dotted eighth and sixteenth note is a major second, as occurs in mm. 2.1, 5.1, 9.1, and 10.1, the following interval moves in the same direction as the major second. Listeners who perceive this pattern in the first five measures of the passage will be primed to hear the intervals between mm. 6 and 7.1 as a descent from A to F#; because the dotted-eighth, sixteenth pattern in m. 6.2 descends by a second, the following interval should also descend. The perception of that descending A to F♯ in m. 7.1 is reinforced when, in mm. 8–9.1, all voices except for the *sheng* present a phrase (F♯, A, F♯, E, E) that is lower in pitch and smaller in range than the phrase in mm. 6–7.1 (D, E, B, A, F♯). However, the melodic shape is remarkably similar if the interval between the A and F♯ in mm. 6 and 7 is considered a descending third. Measures 8 and 9 also prominently feature motion between F♯ and A at the interval of a third. In the context of performance of *Qiansheng Fo*, octave doublings in the voices and instruments of the *shengguan* ensemble allow the listener to perceive the A to F♯ interval spanning mm. 6.2–7.1 as a descending third because that interval creates a more conjunct melody.

While octave doubling does much to contribute to auditory illusions in *shengguanyue*, such perception is further facilitated by the use of the *sheng* mouth organ. This instrument plays two pitches at a time throughout the performance, in most cases doubling the melody pitch a fifth or a fourth above. In addition, the *sheng* plays those pitches at consistent frequencies regardless of the octave placement of pitches in the main melody. In Figure 5 the *sheng* line appears to present two melodies quite different from the melody as perceived, but the instrument's odd leaps and octave-displaced pitches do not stick out of the texture. Instead, the *sheng* contributes a fuzzy timbre that heightens the ambiguity of pitch placement and increases the likelihood that a listener will perceive this melody as a descending octave cycle. The *sheng*'s timbre is explored more thoroughly below.

Timbre and Octave Cycling in *Shengguanyue*

Spectral analysis demonstrates that instrumental timbre enhances the probability that a listener will perceive a smoothed version of a *shengguanyue* melody rather than the melodic frequencies as performed. The spectrograph in Figure 6 shows overtones that sound when the *guanzi* produces the pitch D_4.[4] The fundamental appears bright red on the graph, indicating that its sound was the loudest in the spectrum at –10 to –9 dB, or 10–12.5% of the total volume of the sample. The first overtone (D_5) appears rather strong as well sounding at –14 dB, or about 4% of the total volume. Above D_5, eleven additional yellow bands show other clearly defined but faint overtones, each sounding between –25 and –40 dB and each accounting for less than 0.3% of the total volume. The *guanzi*'s timbre, therefore, is rich with overtones, but the fundamental pitch is the most salient frequency in the spectrum. This makes perception of the *guanzi*'s pitch unambiguous when the instrument is played solo.

Even more than the *guanzi*, the sound of the *dizi* features a strong fundamental pitch, shown in Figure 7. As was the case with the *guanzi*, the *dizi*'s fundamental pitch sounds at –9

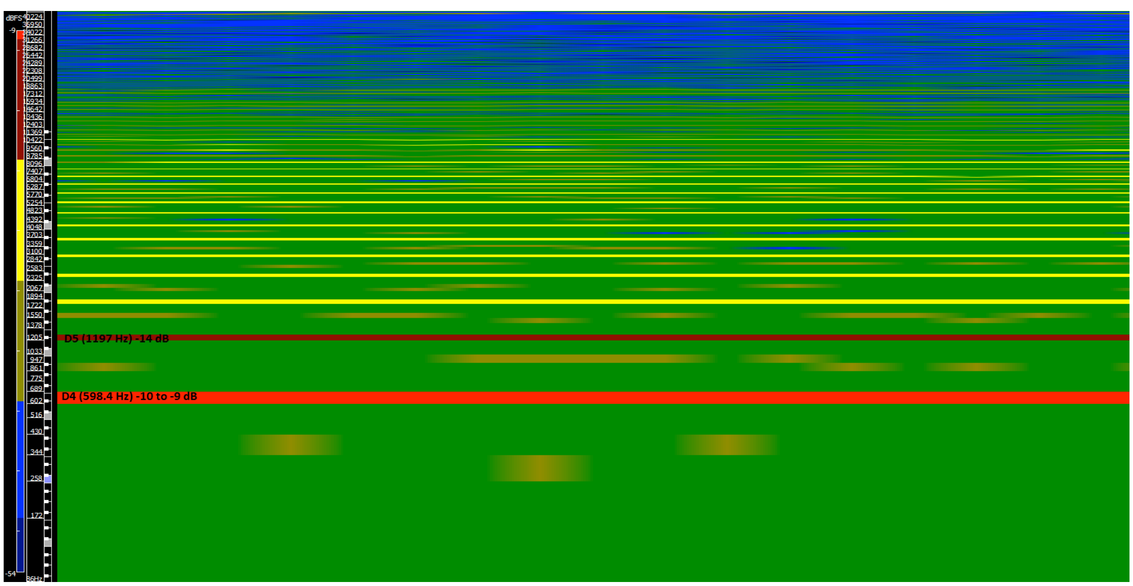

Figure 6. Spectrograph of D_4 performed on *guanzi.* Click here to listen to an audio example.

4. The sound samples analyzed were performed on each instrument by the author and encoded as WAV files on an M-AUDIO Microtrack 24/96 at 16 bits with a sample rate of 88.2. These spectrographs were produced with version 2.3 of the freeware program Sonic Visualizer at the following specifications: Color setting: Banded; Threshold: -50dB; Color rotation: 0; Color scale: dBV; Window size: 1024; Window overlap: none; Bin display: Peak bins; Frequency scale: Log; Screen view: Pane. Pitch class and frequency values were determined by changing the Bin display to Frequency.

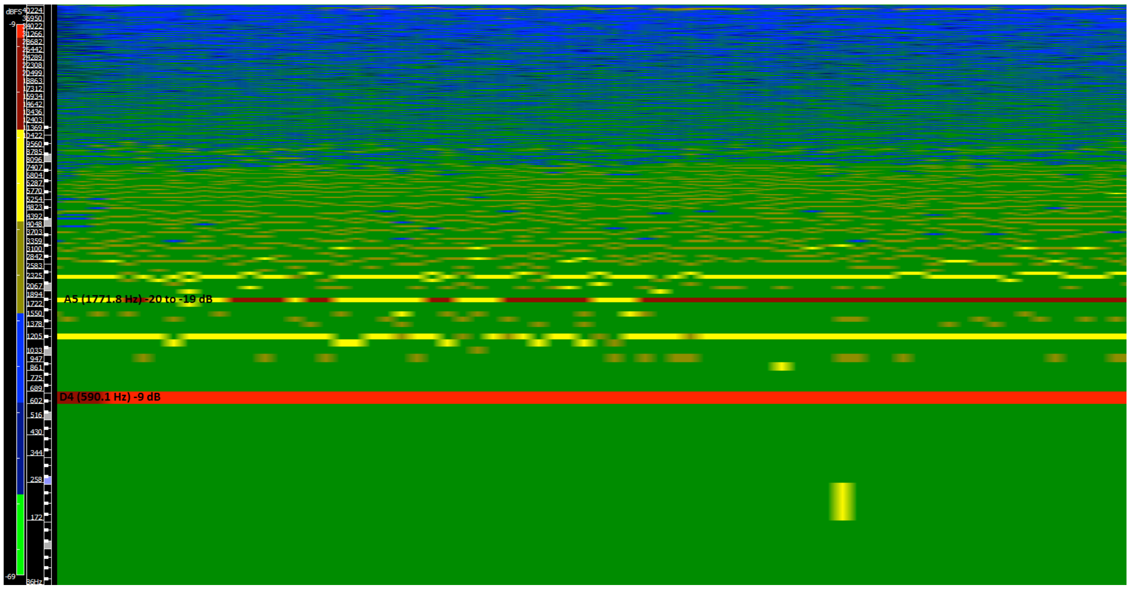

Figure 7. Spectrograph of D_4 performed on *dizi.* [Click here to listen to an audio example.]

dB, or 12.5% of the total volume. The second overtone, A_5, is also relatively strong, sounding at –20 to –19 dB, or 1–1.25% of the total volume. Other overtones appear relatively weak and unclear.[5]

Figures 8A and 8B demonstrate that the *sheng* has a very different timbral signature. When the *sheng* performs D_4, as shown in Figure 8A, a series of clear overtones sound above the fundamental pitch. While these overtones appear quite similar in clarity and number to those seen in the spectrogram of the *guanzi*'s sound (Figure 6), there is an important difference in the relative strength of each component of the sound. Whereas the *guanzi*'s overtones were all substantially less powerful than the fundamental pitch, the *sheng*'s fundamental pitch is not the loudest element. In the sounds of both the *guanzi* and the *dizi*, the fundamental pitch made up about 10–12.5% of the total volume of the sound. In the sound of the *sheng*, the fundamental pitch sounds at –17 dB, or around 2% of the sample's total volume. The first overtone, D_5, is louder than the fundamental pitch, sounding at –14 dB, or around 4% of the total volume. The third overtone, D_6, comprises the loudest component of the sound at –11 dB, about 8% of the total volume. Overtones four through eight ($F\sharp_6$, A_6, C_7, D_7, and E_7) sound at nearly the same volume as the fundamental pitch, ranging from –16 dB to –20 dB, or from 1–2.5% of the total volume of the sound. The *sheng*'s timbre strongly resembles a Shepard tone, with four different relatively powerful octaves of the pitch class D and no clearly emphasized fundamental pitch.

5. Most *dizi* have a rice paper membrane over a hole that lies between the finger holes and the embouchure hole. This membrane produces a rich, slightly buzzy tone. At Wutaishan, monks place a piece of cellophane tape over the hole rather than rice paper, so the buzz is not present. For this example, I have likewise used cellophane tape. A standard *dizi* with the rice paper in place would produce a different array of overtones.

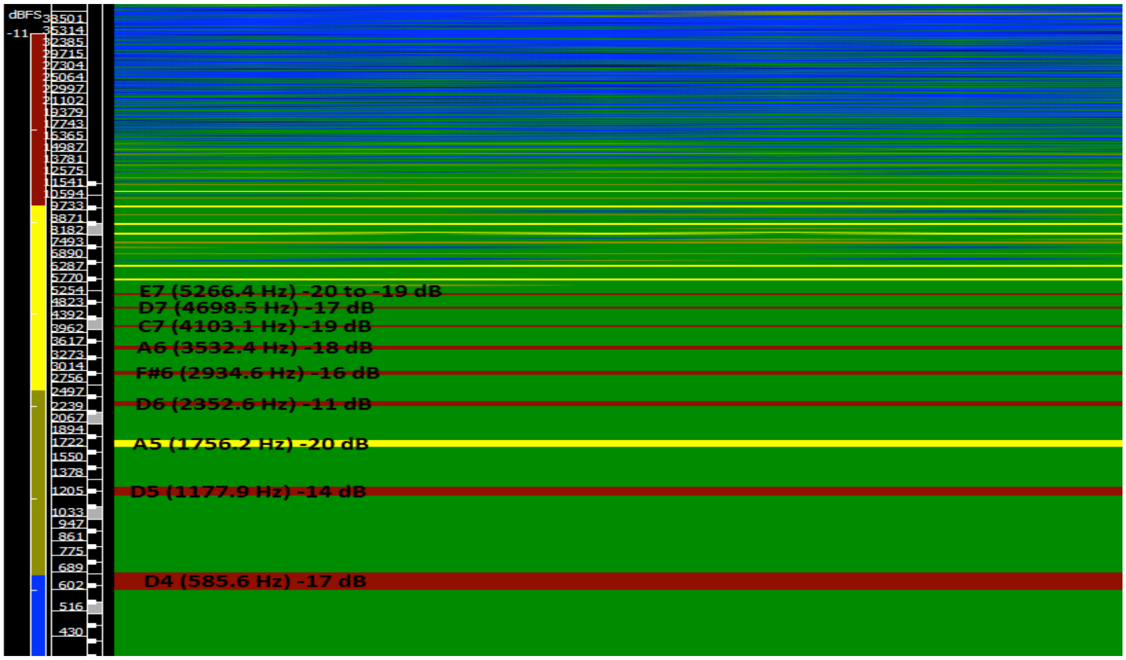

Figure 8A. Spectrograph of D_4 performed on *sheng*. [Click here to listen to an audio example.]()

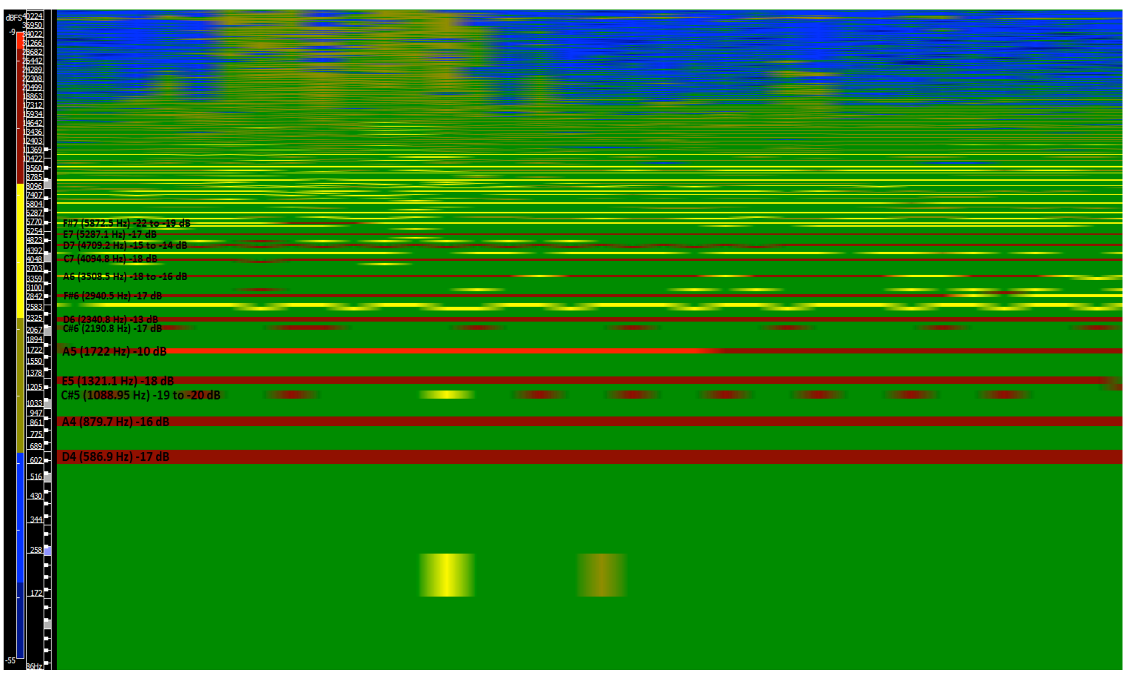

Figure 8B. Spectrograph of D_4 and A_4 performed on *sheng*. [Click here to listen to an audio example.]()

As noted above, *sheng* players always perform at least two separate pitches in performance. Figure 8B shows the thick array of overtones that contribute to the tone when the *sheng* plays both D_4 and A_4, as it would any time a melody called for the pitch class D.

While in some cases interference has caused overtones to lose strength and clarity, this sound still features overtones stronger than its fundamentals. The sound presents three strong octaves of the pitch class D: D_4 at –17 dB (about 2% of the total volume), D_6 at –13 dB (about 5% of the total volume), and D_7 at –15 dB (about 3% of the total volume). None of these Ds, though, are the loudest component of the sound; A_5, which is both the second overtone above D_4 and the first overtone above A_4, sounds at –10 dB (about 10% of the total volume). D_5, a strong component of the sound produced when a *sheng* plays only D_4, becomes lost in interference with the addition of A_4. An inconstant $C\sharp_5$ takes its place. Still, this sample retains the strong D-pitch-class overtones that allow it to function like a Shepard tone.

The overtone-thick timbre of the *sheng* heightens the Shepard-tone-like effect of the *shengguan* ensemble's sound. This instrument bombards the ear with a thick palette of pitches, giving little sense of a definite fundamental pitch and allowing the listener to smooth disjunct melodies.

Notation and Melodic Contour in Wutaishan *Shengguanyue*

The notated score for *Qiansheng Fo* provides another avenue for the exploration of octave cycling. *Shengguanyue* is preserved and transmitted through g*ongche* notation, which was probably created during the Song Dynasty (960–1279). In *gongchepu*, Chinese characters represent pitches. When learning or practicing melodies, monks sing the syllables that correspond to those characters as solfège. *Gongche* scores are not used as a detailed prescription for performance; the notation gives only a general outline of a melody's basic pitch content. In performance, monks very rarely use notation while playing, and chant texts are never included in the musical notation. In *shengguanyue* practice at Wutaishan, octave specifications in the score generally have little bearing on how each individual performs the melody. These octave designations might, however, provide some insight into how the melody's transcriber perceived its pitch contours.

At Shuxiang si, *Qiansheng Fo* is notated using the *gongche* symbols listed in Table 1. Different octaves of the same pitch class are designated with different characters, such as 合 (D) and 六 (high D), or by the addition of a "亻" stem to indicate that a higher octave of the pitch is intended (Kaufmann 1967, 76). Octave-specific characters are quite common in the *gongche* notation used to teach monks at Shuxiang si how to play *Qiansheng Fo*. The passage that seems to cycle to lower and lower octaves as it repeats (transcribed in Figure 5) is notated as shown in Figure 9A. The dots under some characters in this score indicate that those characters fall on a beat; two dots indicate a pitch that extends beyond a single beat. I have followed this beat structure in my transcriptions. This passage includes both 合 (D) and 六 (high D), 四 (E) and 五 (high E), and 尺 (A) and 伬 (high A). Taking these octave designations into account, this passage would appear as transcribed in Figure 9B. Note that in this transcription, pitch classes that are indicated with only one character (F♯ and B) are placed in the octave that fits most smoothly in the melody.

Name	Symbol	Approximate Western Equivalent
He	合	D
Si	四 / の	E
Yi	一	F♯
Chi	尺	A
Gong	工	B
Liu	六	D (8va)
Wu	五	E (8va)
Chi	伬	A (8va)

Table 1. *Gongche* symbols and their approximate Western equivalents.

1 合工一伬一四合工合

2 工尺六工一尺工尺工六六

3 五工尺一一四一尺一四四一

4 尺六工尺一四合一四工合

5 合工

Figure 9A. The *gongchepu* score of *Qiansheng Fo*, from Shi (2001, 14–15).

Figure 9B. A transnotation of *Qiansheng Fo*'s *gongchepu* score.

This transnotation is a very close match for the melody as I perceive it.[6] It differs only in the first two measures, in which the *gongche* notation indicates the lower octave of D (合) but the higher octave of A (伬), resulting in awkward leaps. After the first two measures, however, the transnotation matches the perceived melody. Between mm. 6 and 7, the *gongchepu* score reads "六 五 工 尺 一 一 四," clearly moving from a higher octave (六/high D and 五/high E) to a lower octave (四/ low E). It appears, therefore, that the original transcriber of this melody intended the interval spanning the end of m. 6 to the beginning of m. 7 to be a descending minor third. Without the upward leap at this point, and disregarding the unreasonable leaps in the first two measures of the transnotation, the melody as notated in the *gongchepu* score is clearly octave-cyclic.

As noted above, these octave specifications have little direct effect on the performance of *shengguanyue* melodies. Today, monks at Shuxiang si instruct novices to disregard octave-specific indications in *gongchepu* and perform notated pitches at whatever octave placement is comfortable on their instrument and workable in the context of each melody.

In fact, in the instructional preface to the handwritten *gongchepu* score notebook used at the monastery, Shi Changwu writes that octave-specific characters have no significance in modern *gongchepu* notation:

> Ancient musical notation used nine characters: 上, 乙, 合, 凡, 工, 尺, 六, and 五. Later, the two characters 六and 五came to be interchangeable with 五and 四, 四 being used in the place of 五 and 合 being used in the place of 六. In the notation, only seven characters are used instead of nine: 合四一上尺工凡. 四 indicates the same sound as 五, and 合 indicates the same sound as 六.
>
> [Ancient system: 上一四合凡工尺
>
> Modern system: 4 3 2 1 7 6 5]
>
> In cases where other characters appear, the sound is the same although the characters are not. (Shi 2001, 1)

Nonetheless, in the scores that Shi Changwu wrote out from memory, including *Qiansheng Fo*, octave-specific characters abound. While these octave indications might not be particularly useful for performers, they do pass along tantalizing clues regarding the octave placement of the melodic pitches as the listener is intended to perceive them. In the case of *Qiansheng Fo*, those clues point to a melody intended to cycle downward as it repeats.

6. Transnotation is a direct translation from one notation system to another. In Figure 9B, I notate the pitches indicated by the octave-specific *gongchepu* as they would appear in staff notation. I add rhythmic indications that reflect how the pitches are performed in order to facilitate comparison to the perceived melody.

PITCH SHIFTS IN *XIFU MANG* AND *YIZI BABAO*

Two other pieces commonly performed in the ritual repertoire of the *shengguan* ensemble at Shuxiang si also make use of timbre to create melodies that seem to use a greater range of frequencies than they, in fact, do. *Xifu mang* (Busy daughter-in-law) and *Yizi babao* (Eight treasures on the character "Yi") are two "small tunes" (*xiaoqu*) that are performed on *shengguan* instruments as a coda to certain rituals or as a transition between chants with or without instrumental accompaniment. Both are short melodies that begin at a tempo of at least 100 beats per minute and then accelerate from beginning to end, often concluding at a hectic tempo slightly faster than the monks can keep synchronized. In addition, both *Xifu mang* and *Yizi babao* seem to migrate from higher to lower octaves while actually remaining in the same general frequency range. These tunes act as an audible bridge, or perhaps a steeply descending ramp, between different portions of a ceremony and between ritual and non-ritual time.

As is the case with most of Wutaishan's *shengguanyue* repertoire, the origins of *Xifu mang* are unknown. It appears that this tune is a local folksong that has been absorbed into the monastic repertoire. This is no surprise; a great number of the pieces performed by monks arise from secular sources (Szczepanski 2012).

The pitch-shifting effect in *Xifu mang* is relatively subtle; the perceived melody does not range beyond the pitches that the instruments of the *shengguan* ensemble are capable of producing. Nonetheless, there is a significant portion of the melody in which perception moves in one direction while pitch frequency moves in another. In Figure 10A, that moment occurs between mm. 8 and 10. In m. 8, the *dizi* enters an octave higher than it had been playing in m. 7, while the *guanzi* remains in its lower register. In m. 9 of the performance I transcribed, the *guanzi* drops out and does not reenter the texture until the final beat of the piece. When it reenters, it does so at the same higher pitch level as the *dizi*. *Guanzi* players at Shuxiang si often pause like this, likely because the instrument is very difficult to play and they need to rest in order to make it through a long day of ritual. In this case, however, the pause also has the effect of masking the *guanzi*'s motion to a higher register because we do not hear the instrument's pitch leap upward. Staggered motion of the *dizi* and *guanzi* from the lower to higher registers helps to disguise the fact that such a register shift has occurred, leading the listener to hear a continuous descent where none is performed. This effect occurs even without the added octave doublings provided by chanting voices; multiple octaves of the same pitch class are produced only occasionally between the *sheng* and other voices, and in m. 8 between the *dizi* and *guanzi*. As was the case in *Qiansheng Fo*, the multiple pitches and fuzzy timbre of the *sheng* contribute much to a sense of auditory illusion in *Xifu mang*.

An examination of the *gongchepu* score for *Xifu mang*, shown in Figure 10B, reveals a paucity of octave indications; for all pitch classes except *che* (尺/A), Shi Changwu used only one character. (Note that this example makes use of the shorthand form of *si*/四: の. This change has no effect on how the syllable is pronounced or how the pitch is performed.)

Figure 10A. *Xifu mang*. Click here to listen to an audio example.

1 の尺一の一工工合の合の

2 工合の合の工合の伬一の一合工尺

3 工尺上上尺工工尺上工尺上の合の一尺一の

Figure 10B. The *gongchepu* score of *Xifu mang*, from Shi (2001, 22).

Furthermore, the indication that A should be performed at a higher octave (伬 rather than 尺) appears only once, corresponding to the A_5 in both the perceived melody and the *dizi* part on the second beat of m. 5 in Figure 10A. While octave distinctions are fairly unreliable in Shuxiang si's *gongchepu* score, the use of this indication is a significant clue to the melodic shape that the transcriber of this tune had in mind; the A_5 in m. 6 comprises the peak of the notated melody, after which the tune winds its way to lower frequencies. The *dizi* plays in a higher register in mm. 8–13, but each of the instances of the pitch class A in that passage are notated with 尺, implying that the main melody is intended to flow downward as perceived rather than upward as performed.

Yizi Babao, shown in Figure 11A, is one of a vast family of tunes with similar melodic structures, most of which also feature titles similar to *Baban* (eight beats). Alan Thrasher (2008, 117) calls *Baban* “the most widespread of all instrumental structures in China.” Stephen Jones (1995, 144) emphasizes the importance of this tune type in folk instrumental traditions, writing, “*Baban* is a basic ‘standard,’ known thoroughly by folk musicians: it is often the first

Figure 11A. *Yizi babao*. Click here to listen to an audio example.

piece they learn, the basis of their whole study." Little wonder, then, that this tune has found its way into the *shengguanyue* repertoire of Shuxiang si. As described below, *Yizi babao* is a unique version of the *Baban* form, both in metric arrangement and melodic construction.

Most versions of *Baban* consist of some arrangement of eight-beat phrases, sometimes mixed with phrases of twelve or four beats. In addition, most common forms are a total of 52, 60, or 68 beats long (Jones 1995, 145; Thrasher 2008, 118). Shuxiang si's *Yizi babao* is a mere 45 beats long. This version shares melodic gestures and rhythmic elements with other *Baban* examples, but it does not make use of any eight- or twelve-beat phrases. Instead, it opens with a five-beat flourish followed by two four-beat phrases. It then moves to a pattern of two two-beat phrases (mm. 4–5) followed by three three-beat phrases (mm. 6–8) followed by four four-beat phrases (mm. 9–12). A three-beat coda echoes the opening melodic gesture of the piece and clearly demonstrates the illusory nature of pitch perception in melody. Even though the instruments play this coda at the same pitch level as they do the opening phrase, the coda sounds as if it is in a lower octave than that of the opening.

This pitch-shift effect is carried out in *Yizi babao* in a manner very similar to that found in *Xifu mang*. In order to remain in a comfortable register, the *dizi* makes several leaps upward and away from the basic melody as perceived, then rejoins the register of the perceived melody after two or three beats. This occurs in Figure 11A, first at m. 2.3 and again at m. 6.3. At m. 8.3 the *dizi* moves to a register higher than the perceived melody one last time, ascending by a perfect fifth from D to A while the *guanzi* and *sheng* match the perceived melody, descending from D to B to A. From that point to the end of the piece, the *dizi* remains in the higher register while the perceived melody continues to descend. After a brief pause in m. 9, the *guanzi* joins the *dizi* in the higher register in m. 10. As was the case in *Xifu mang*, the *guanzi*'s pause masks the fact that the instrument has shifted to a higher register than what the listener perceives. From m. 10 to the end of the piece, the *dizi* and *guanzi* remain at a higher pitch level than that indicated by the perceived melodic contour.

Shi Changwu's *gongchepu* score for *Yizi babao*, reproduced as Figure 11B, makes use of all of the octave-specific characters that can be found in the Shuxiang si repertoire. In most cases, these octave specifications correlate with the melody as it is perceived rather than as it is performed. The first indication that the upper octave of the pitch class A (伬) should be performed appears at the beginning of the third line of the *gongchepu* score, and corresponds to the leap upward to the higher octave of A at the beginning of m. 3 in Figure 11A. In the performance I transcribed, this leap is not made by the *dizi*, which had already leaped to the higher register in the previous measure, but is emphasized by the entrance of the piercing *guanzi* on the high A. Near the end of line 4 of the *gongchepu* score, corresponding to m. 7.3 in Figure 11A, the score indicates the pitch class D with 六 rather than the 合 used in the previous lines, indicating that this should be a higher octave of D. In fact, the D as perceived and as performed falls in the same octave placement. Perhaps this indication was originally intended to emphasize that the motion from 工 to 六, or B to D, should be an ascending rather than

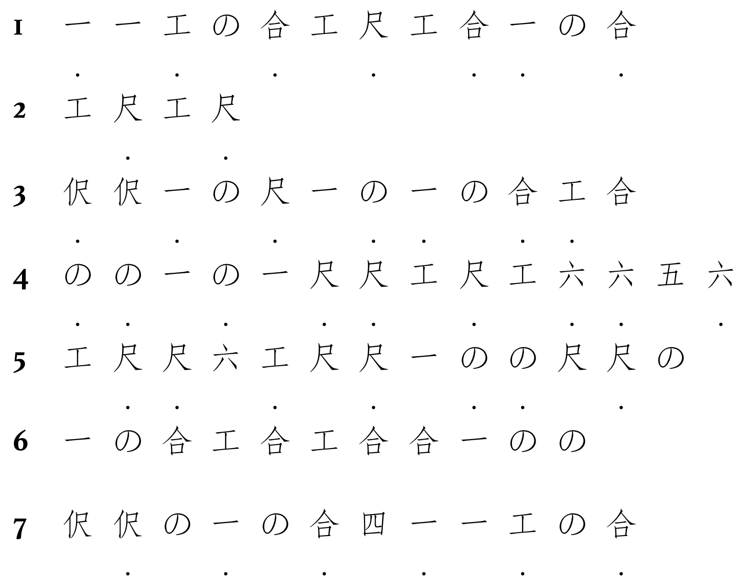

Figure 11B. The *gongchepu* score of *Yizi babao*, from Shi (2001, 17).

descending interval. The *sheng* and *guanzi* do ascend to D at this point in my transcription, while the *dizi*, already playing in a high register after leaping upward at m.6.3, drops out of the texture at m. 7.3.

The perception of a descending major sixth rather than an ascending minor third between F♯ and A in m. 6.2–6.3 requires examination. In this instance, the *sheng* moves downward from F♯ to A, but that motion is obscured by voice crossing in the instrument's added pitches. The *dizi* ascends from F♯ to A, contrary to the perceived interval direction. Only the *guanzi* makes a clear downward leap here. In *shengguanyue* texture, however, the sound of the *guanzi* carries more weight than that of the *dizi*, so the descending sixth stands out more than the ascending third. In addition, a descending interval fits into the logic of the melody at this point; in mm. 4–8 the interval leading to the final quarter note of each measure alternates between descent and ascent. Further indication that the interval in m. 6.2–6.3 was intended to descend appears in the *gongchepu* score, in which the A at m. 6.3 (the sixth character in line 4 of the *ongchepu* score) is indicated as 尺 rather than 伬.

The *gongchepu* score switches from high octave designations to low in the second half of line 5, using の rather than 五 to indicate the pitch class E. This moment corresponds to m. 9.4 in Figure 11A. The perceived melody reflects the octave change indicated in the *gongchepu* score, but the *guanzi* drops out at this point and the *dizi* plays the same arch-shaped melodic contour as the perceived melody, although at a higher octave.

A final shift in the octave designations in the *gongchepu* score appears in line 7, corresponding to m. 12 in Figure 11A. Here, the score indicates the upper octave of A (伬) but the lower octave of E (の). Motion upward from E to A, then back down to E matches the perceived melody and what is played on the *dizi*. The earlier instances of 伬 in m. 3 correspond to a leap upward to A, but in this instance melodic context leads one to place this A in a lower register than one would in m. 3. Nonetheless, the *dizi* does, in fact, perform the higher A here, while the *guanzi* is once again temporarily absent from the texture.

These analyses of *Xifu mang* and *Yizi babao* demonstrate how the instruments of the *shengguan* ensemble facilitate melodies in which perception differs from frequency content. In addition, octave-specific indications in the *gongchepu* scores for these pieces more often reflect the melodic contour as heard than as played. Performers make frequent octave shifts, not to recompose the melodic contour, but in order to remain in a comfortable range. The tendency of the *shengguan* ensemble's sound to foster auditory illusions helps obscure these octave shifts.

The significance of the illusory pitch shift in these tunes remains unclear. To my ears, the perceived octave descent, combined with the rapid and increasing tempo, creates a wonderful tumbling effect that seems appropriate as a transition into and out of ritual moments. Additional research is needed to further illuminate how this intriguing melodic construction relates to the ritual or other significance of these pieces.

Ramifications

This study demonstrates that Chinese and Western music scholars' dominant method for transcribing traditional Chinese music as a single melodic line leaves much to be desired. Not only does this form of transcription obscure the rich heterophonic texture of traditional Chinese ensemble music, but it also renders any differences between pitch performance and pitch perception invisible. Transcription always involves simplification in one way or another, but to use a single melodic line to transcribe *shengguanyue* risks overlooking some of the most fascinating elements of melodic structure in the repertoire. I do not propose that the staff notation favored by Western scholars or the cipher notation favored by Chinese scholars should be discarded completely. It happens that, due in part to historical coincidence and in part to the long-standing Western influence on music education and instrument construction in China, the pitches performed by the *shengguan* ensemble fit quite nicely within the intervallic structure represented by those styles of notation. However, I suggest that scholars should be wary of auditory illusions and should add transcribed lines and annotations as needed to indicate differences between pitches performed and pitches perceived. In addition, rigorous analysis of timbre is necessary to comprehend how pitch perception works in *shengguanyue* repertoire.

The auditory illusions in the repertoire of Shuxiang si's *shengguan* ensemble open up some intriguing lines of inquiry in the field of music cognition. The sound of the *sheng* mouth organ plays a particularly important role in the octave-shift phenomenon; cognitive experimentation might shed light on how the *sheng*'s production of a broad array of remarkably rich overtones, particularly at octaves above the fundamental pitch, creates sounds that behave much like Shepard tones. This data would further illuminate how the brain processes musical sound. The effortlessness with which the *shengguan* ensemble produces auditory illusions could also be of interest to composers. Techniques used to produce these effects in *shengguanyue*, such as the combination of staggered octave shifts in some voices, with other voices performing pitches a fourth or fifth above the main melody, might prove useful to those who would like to explore the use of pitch cycling and other auditory illusions in new works.

The phenomenon of auditory illusions in Wutaishan *shengguanyue* also leads to some interesting challenges and opportunities in the research of Chinese traditional music. More field research is needed to determine whether these auditory illusions are commonly experienced by performers and auditors local to Wutaishan, and if local music theories account in any way for differences between pitch content and perception of melodic contour. All across China, especially in the north, ensembles made up of aerophones, including the *sheng*, perform tunes with a heterophonic texture similar to that used in Wutaishan *shengguanyue*. It seems quite likely, then, that octave cycling and pitch-shifting tunes might also be found in other Chinese wind repertoires. An examination of the extent of this phenomenon might reveal some commonalities among pieces that make use of auditory illusions and reveal whether and how they relate to musical, ritual, or other considerations.

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