THE MATHEMATICS OF TIBETAN ROL MO

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Rol mo (pronounced “rōmo”), the music of the Tibetan Buddhist monastery instrumental ensemble, is a classical tradition that can be traced back through more than a thousand years of Tibetan history to even older roots in Indian Buddhist music. Transmitted and elaborated by lineages of carefully trained and selected professional leader-directors (dbu mdzad, “umdze”), it had developed by the middle of the 20th century into a vast repertoire of named and notated compositions. Many of the hundreds of pieces that once existed are still played today in the Tibetan refugee monasteries of India and Nepal.

Yet, rol mo remains a strangely unexplored form of musical art. Some Western writers deny altogether that much of it is music, claiming rather that it is “magical sound” created for (usually unspecified) “ritual reasons.” Tibetan musicians and educated listeners, with detailed standards of musical esthetics used to support their judgments, reject such ethnocentric speculations. Rol mo is indeed performed in a ritual context, in order to make a sensually pleasing offering (mchod pa) to the Buddhist “gods” (Buddhas, Bodhisattvas, Protectors, Yi dam). For precisely this reason, it must be both skillfully executed (mkhas pa) and aurally pleasant (snyan pa). If such considerations suggest an “esthetic of the alien,” designed to please the ears of gods rather than men, it must be remembered that the “gods” themselves are visualized by Tibetans as idealized representations of human qualities. Rol mo esthetics simply represent human esthetics in an extreme form. Music appropriate to such an esthetic will have both extremely heightened emotional effect and extremely elaborated formal structures, to please the emotional and cognitive faculties of its idealized audience.

This paper focuses on the latter aspect, that of the extreme elaboration of formal structure in rol mo. We will deal with one aspect of this subject: the complex mathematical organization of rhythmic structures. If it is possible to generalize about rhythmic structure in different world musical systems, we might say that most music is rhythmically organized in one of two ways: 1) cyclically, with groups of a specific number of beats recurring in regular cycles (Western measures, Indian tāla, Java-
nese gongan); or 2) irregularly, with either unequal beats or groups of varying numbers of equal beats, either of which are combined in musically unpredictable sequences (operatic recitative, Vedics and Thai Buddhist prose chant, etc.). Rol mo rhythmic structure, by contrast, is usually neither cyclic nor irregular. Although the lengths of both individual beats and beat groups vary, they are organized into sequences that can attain degrees of mathematical complexity unknown in other music.

Although the organizational principles discussed here seem to apply (with some changes in terminology) to other Tibetan rol mo performing traditions, the pieces and specific terminology described belong to Swayambhu Kargyu Monastery (formally, bShad grub Chos 'khor Dar rgyas gling), Swayambhu, Nepal, following the performing tradition of Nang chen Dil yag, a monastery of the Kar ma sublineage of the Dru gs po branch of the bKa' brgyud Method of Tibetan Buddhism. The only stylistic peculiarity of this tradition relevant to this discussion is that specific pieces are assigned to the repertoires of either sil snyan or shub 'chal cymbals (see below), while other traditions use both cymbal types together in the same piece.

BEATS, COUNTS, FALLS

The structural outline of a rol mo piece is furnished by the cymbals, played by the ritual and musical leader/director (du bu mdzad). The cymbals may be either the shallow conical small-bossed sil snyan, or the slightly-flattened hemispherical large-bossed shub 'chal. Double-skinned frame drums (rnga) of various types reinforce the structural outline by playing a simplified version of the cymbal part. Although a rol mo piece can be played as a cymbal solo, a skilled performer will, whenever possible, even in solo performance provide his own drum “doubling” of the cymbal part.

Cymbals are held and played in various ways, depending on the performing tradition. Whatever method is used, they must be loosely balanced in the player’s hands to allow both a fine degree of control and a free oscillation along one diameter of their striking surfaces. The player holds them close to one another, planes parallel, and uses a short, fast diagonal stroke to bring a point on the rim of one into contact with a point on the rim of the other. As the player holds them loosely in close parallel position, they rebound from the initial point of contact (0°) to strike together at diametrically opposite (180°) points on their rims. Successive rebounds produce a series of pulses that both accelerate and decrease in volume, as gravity and inertia exhaust the force of the original stroke and bring the cymbals to rest. When the accelerating and diminishing pulses have blended together into an indistinct hum, the player separates the cymbals and allows the sound to fade out. This entire sequence, from initial stroke through accelerating pulses to concluding hum, constitutes a “beat” (brdung, “dung”).

The beat thus consists of a series of pulses that decrease steadily in intensity and increase steadily in tempo. Its length and loudness are a product of 3 factors: the kinetic energy or strength (shugs) of the initial stroke, the potential energy or “rebound” (’phar) of the cymbals, and the cymbals’ physical dimensions (tshad) of size and mass. Whatever its quantitative value, a beat always has the internal structural pattern of regularly accelerating pulses, producing an acoustical pattern whose closest visual analog is the diminishing line patterns of a logarithmic graph. The “logarithmic” structure found in the beat may be converted to structural units of other kinds by fragmentation, serialization, or expansion:

A) Fragmentation omits part of the initial stroke/accelerating pulses/final hum sequence. The two forms most frequently played are mithams rgyag, “touching rims,” in which the player separates the cymbals immediately after the initial stroke, and kha rgyag, “touching mouths,” in which he separates them before the accelerating pulses blend together into the final hum. Both are normally used as transitional signals, not as part of a rol mo piece (in transitions from vocal to rol mo pieces, the player may play mithams rgyag as a short but complete beat). Other fragmented beats include the muted single strokes and “clicks” (made by striking one cymbal with a ring, rosary, or some other object) used to accompany dbyangs chant. Although fragmented beats may, like regular beats, be serialized or expanded, they are normally used for special purposes and not included in rol mo pieces.

B) Serialization produces grouped sequences of numbered beats, or “counts” (grangs). “Counts” may range from “1 beat” (brdung gcig), “2 beats” (brdung gnis), etc., up to and beyond the 180-beat group found in “Invitation to Mahâkâla” (p. 235 below). The beats of such a group are often of nearly equal length; but beginning and final beats may be 2 or more times as long as some of the intermediate beats (Fig. 1B). When grangs series of the same number of beats follow one another, the effect produced is that of a repeating beat cycle. Although such effects sometimes occur (for example, in some dance pieces), it is more typical for the numbers of beats in succeeding groups to differ from one another.
A: Modified Tibetan notation symbols
- Counted ‘beats’: 1 2 3 etc. Accelerating “fall”:
- Clockwise “circle”: 0 Counterclockwise “circle”: 0
- Intermediate strokes within beat:
- Body turns: –(R), –(L)
- Loud/soft contrasts: 1, 1, 1

B: Gsum brdung, “Three Beats”

\[\begin{array}{cccccc}
\text{Sec:} & 0 & 5 & 10 & 15 & 20 & 25 & 30 & 35 & 40 & 45 & 50 & 55 & 60 \\
\hline
\text{1} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} & \phantom{\text{fall}} \\
\text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} \\
\end{array}\]

C: Gsum brdung ‘Ur phab Gsum brdung, “Three Beats–Humming Fall–Three Beats”

(Three Beats)

\[\begin{array}{cccccc}
\text{Sec:} & 0 & 1 & 2 & 3 & 4 & 5 & 10 & 15 \\
\hline
\text{1} & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
\text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} & \text{mf} \\
\end{array}\]

(Three Beats)

\[\begin{array}{cccccc}
\text{Sec:} & 15 & 20 & 25 & 30 \\
\hline
\text{1} & 1 & 1 & 1 \\
\text{mf} & \text{mf} & \text{mf} & \text{mf} \\
\end{array}\]

Figure 1. Notation Symbols With Examples of Short Pieces.

Serialized beat groups often include “afterbeats” (‘dzag). These are counted as part of the preceding beat; but, rather than being subdivisions of it, they are added to it. They are usually shorter and softer than the preceding “main” beat, but in final position in a series may actually be louder and longer. In such cases, they can be recognized by their internal dynamic structure: rather than beginning loudly and ending softly like a regular beat, they begin softly, grow louder as the pulses accelerate, and become softer as the ending is reached (Fig. 1C).

C) Expansion prolongs the normal “logarithmic” acceleration of pulses following the initial stroke. This is achieved in two ways: by moving the cymbals apart at selected intervals to produce “spacing” in the normal acceleration sequence, and by adding deliberate intermediate strokes (thang thang) to prolong the series. For an oversimplified ex-

ample, if the normal intervals between pulses following the initial stroke were 1 sec., ½ sec., ¼ sec., etc., interruptions and intermediate strokes would produce the series 4 sec., 2 sec., 1 sec., ½ sec., etc.

A certain amount of expansion is used to produce length contrasts in regular beats. However, expanded patterns may reach such extremes of length that they contrast markedly with regular beats and can no longer be mistaken for them. Such expanded accelerating patterns are called phab, “fall.” Although a quickly-played fall may be shorter than a slow beat, falls can be distinguished by their accompanying drumstrokes on every pulse of the acceleration, rather than just on the initial stroke as in a regular beat. “Large Falls” (phab chen) can be elaborated in various ways: for example, by accelerating 3-beat sequences instead of single beats, or by playing sequences of accelerating patterns, each faster than the one before, to produce an acceleration of accelerations (p. 239 below).

One form of expanded beat that calls for special mention is the “circle” (‘khor), played on the shallow-conical sil snyan cymbals. The cymbals are played with their planes vertical for the initial stroke, held at half-arm’s-length in front of the player’s chest. In the initial stroke, the cymbals come into contact at about the 6 o’clock point on their rims (bottom) and rebound to strike at their 12 o’clock points (top). The player continues the accelerating-pulse series by striking the right cymbal at about 1-to-2 o’clock on the left cymbal; and, holding the left cymbal stationary, he plays an accelerating pattern of pulses as he moves the right cymbal clockwise around the rim of the left. As he does this, he rotates the right cymbal until, as it finally reaches the 3 o’clock point on the left cymbal rim, it has changed from vertical to horizontal position with its face no longer directed leftwards, but upwards. As he moves the cymbals clockwise from parallel to perpendicular position, the player finishes out his accelerating-pulse series by lightly rubbing (rather than striking) the two cymbals’ rims together in a continuous frictional “bowstroke” that produces an unbroken ringing sound. This “circle” begins the piece “Invitation to Mahakala” (p. 235 below). If the player then reverses the circle and executes a counterclockwise “bowstroke” to return the cymbals to parallel vertical position, we have a “double circle” (‘khor gnyis). The double circle and an even more elaborate version are found in “Days of the Waxing Moon” (p. 233 below).

NOTATION

Since traditional Tibetan rol mo notation provides an extremely clear picture of piece structure, we will use it in the following examples, with
the slight modification of substituting Arabic for Tibetan numerals. Thus, a 3-beat series of “counts” will be indicated by:

\[
\begin{array}{ccc}
1 & 2 & 3 \\
\end{array}
\]

A fall, or prolonged acceleration, will be indicated by:

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/ \\
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A musically significant feature in the organization of count series and fall accelerations into rol mo pieces is rol ldan, cymbal “holding” or manipulation. Both the loudness and length of a beat depend on the energy (shugs) of the initial stroke. Contrasts in strength are indicated by contrasts in notation size, position, and “flags.” We will indicate size contrasts by underlining: (large, strong)/l (small, weaker). Strong/weak contrasts, at least for the initial strokes of beats, can also be indicated by high/low position contrasts (1 1), and by contrasts in the upward/downward directions of “flags” attached to beat symbols (1 1). Because beat strength is a variable acting upon fixed physical characteristics of a pair of cymbals, contrasts in strength imply contrasts in length and “voice” (skad, tone color/overtone configuration). Modification of the basic beat structure is shown by zigzags in the attached “flags” (1 1), indicating the use of intermediate (thang thang) strokes. The number of zigzags is a relative indication of the number of intermediate strokes (Fig. 1A).

COMPONENT PIECES

The simplest rol mo pieces may be used as brief instrumental interludes between vocal sections in a ritual, or used as component sections of larger compositions. One of the simplest forms used is a short 2-part symmetrical arrangement of counted beats. A common example is Gnyis brdung, “Two Beats”—capitalized here to distinguish it from brdung gnyis, “two beats,” which actually means a series of 2 beats (p. 227). Gnyis brdung, “Two Beats,” by contrast means a short form whose primary structural organization consists of a repeated set of 2 beats:

\[
\begin{array}{ccc}
Gnyis brdung, Two Beats \\
1 & 1 & 2 \\
2 & 2 & 2 \\
\end{array}
\]

Forms of this type consist of: A) an introductory loud, long beat (1 1); B) a group of counted beats (1 2), played twice through; and C) a 'dzag afterbeat added to the last beat of each count group (2 ). The final 'dzag of each piece is played as a bzhag rol cadence, the player drawing out the accelerating pulses as he rotates the cymbals in parallel position and eventually settles them into his lap just as the sound dies out.

Such forms may be built around any number of counted beats, although those based on 2-to-5 beat groups are by far the most common. Perhaps the most frequently played form of this type is Gsum brdung, “Three Beats.” In Figure 1B time and dynamic indications are added to clarify important acoustical features of the Tibetan “beat.” The dynamic patterns seen in this example seem to hold true generally in other rol mo: initial beats tend to be louder, and 'dzag afterbeats much softer than the average main beat. If, as in this example, the piece is played slowly enough to allow some elaboration on the basic beat pattern, the afterbeats will include a crescendo and decrescendo after the soft beginning.

However, the main feature to note here is time organization. Although the symmetrical regularity of the piece’s beat structure might suggest equally-proportioned time units to Western eyes, in fact, only 3 beats (2 in the first group, 1 and 2 in the second) share an approximately equal duration in the 4-to-4.5 second range. Since initial, final, and 'dzag beats are characteristically prolonged in rol mo pieces, we have time values for initial and cadential ('dzag) beats more than twice as long as the “standard” main-sequence beats (8.5 and 9 seconds respectively). Moreover, if we follow the Tibetan concept of beat organization by counting the afterbeat as part of the preceding beat, we would have a duration of 15.5 seconds for the third beat of the second group—nearly 4 times that of the preceding 2 beats.

Thus we see that time organization in Tibetan music involves structuring units of time by ordered sequences of musical events (beats). In cyclically-organized music, by contrast, uniformly-structured units of time (cycles) provide the structural framework for organizing musical events. In the Tibetan system, time is not a mechanical, metronomically regular unit of measure that continues on an abstract level regardless of the presence or absence of any musical sound. Rather, time is a product of perceptual experience, meaningful only in the presence of perceived events with concrete durations. Thus, there is no symbol for a “rest” in Tibetan musical notation. Parts of instruments that play only in certain sections of a piece and are silent in others are coordinated to the ensemble not by reference to their place in an abstract time scale, but rather by their occurrence “together with” specified events in the parts of other instruments. Time is organized experientially rather than mechanically.
Experiential, event-centered time organization has been noted in the cognitive systems of non-Western peoples (Pocock 1967:305 ff.), and it occurs musically in the non-cyclical, prose-text vocal forms cited above (p. 226). However, it seems unusual for a culture that utilizes patterned numerical beat organization not to organize musical time into equally proportioned cycles. In the Tibetan case, this is particularly remarkable when we consider that Indo-Tibetan Buddhist theory of cosmic, calendric, and personal-experiential duration rests on a basic foundation of time conceived as a cycle: in fact, one of the most important Tibetan Buddhist texts is called Kalacakra, “Cycle [or Wheel] of Time.” On the other hand, Tibetan texts contain detailed explanations of certain Indian musical concepts, and we must assume that such a basic concept as tāla cycles was a part of the Indian musical theory known to, but deliberately not used by, Tibetan musicians. There seems to be a plausible reason for the rejection of cyclic time organization in rol mo in the fact that rol mo is played for an audience of Buddhas—for Buddhists, unlike the ordinary beings trapped within cycles of life and death, joy and suffering, are uniquely able to transcend the cyclic nature of time by their superior understanding of the structure of experiential reality.

Whatever the esthetic and symbolic causes, the fact remains that rol mo rhythmic organization characteristically restructures “normal” time/event relationships into new forms. In a large-scale “Fall” acceleration, the first few pulses may be so slow as to leave the hearer in doubt that a coherent musical sequence is being played, and the final sequence of pulses at the end of the acceleration so fast as to defy perception of rhythmic structure. The inclusion of time units in the middle of the sequence that approximate the length of normal beats serves to heighten the contrast between slow beginning and fast ending; the slow beginning transcends normal human event-perception, as does the fast ending. When such an acceleration is juxtaposed with sequences of even approximately equal beats, the effect of a complete transformation of perceived time values is overwhelming.

Another frequently played class of short, component-type pieces is built on just such a juxtaposition of beats and falls. This class has a symmetrical 3-part A-B-A form, consisting of one of the short “Three Beats”-type pieces discussed above, a fall-acceleration, and a repeat of the first section. In the example of Figure 1C I have again added an elapsing-time scale. In a performance this fast, there is less opportunity for ornamental elaboration and lengthening of the individual beats; thus, they tend to be of relatively equal length. The change from beats to acceleration interrupts and transforms the time structure established by the first beat series. The transformation is from perceivable and recognizable time units into a continuously shifting sequence of events (accelerating pulses) that finally leads into an infinite dimension—in the sense that discrete events and their durations can no longer be perceived or recognized. If we were to imagine a perceptually similar transformation in Western music, we might, for example, think of a piece that establishes a specific tonality and then proceeds to modulate rapidly through successively more distant major and minor keys, bitonal and multimodal pitch combinations, and finally ends in complete atonality—after which the original key is suddenly reintroduced. Similarly, this example returns abruptly to a finite, recognizable structure with the reintroduction of the “Three Beats” motif.

“DAYS OF THE WAXING MOON”

In contrast to the short component-type pieces we have been discussing up to now, there is a large class of much longer rol mo compositions that have individual names and more complex, unique rhythmic structures, occur in the context of only one specific ritual, and must be played on only one of the two types of cymbals (p. 226 above). The structure of these longer compositions may be so complex as to give the impression that they are through-composed and structurally unpredictable. Some pieces, however, reveal structures based on one or more complex mathematical formulas. These mathematical structures may be abstract or may have a specific symbolic referent. An example of the latter type of piece is Zla ba Yar tshes, “Days of the Waxing Moon,” played on the day before the new moon. This is program music based on a sequence of beat groups that increase by twos from 1 to 15. The changing beat groups represent the progression from the 1st (new moon) to the 15th day (full moon) of the lunar calendar; while the lengthening beat groups depict the filling out of the moon.

Each of these beat groups ends with a double khor (clockwise/ counterclockwise circular cymbal stroke; p. 229 above), noted by the symbol. After the khor the player turns ninety degrees to the right and plays four beats, then to the left for four more beats, and then back to the center to begin the next odd-numbered pictorial beat series. The turns, which we will indicate by right and left arrows, provide both a visually decorative element and a change in cymbal tone color to a listener standing in a fixed position.

“Days of the Waxing Moon” is the conclusion of the new moon ritual Sdang ba rNam sreg addressed to the Protector Mahākāla. In addition to
two dung chen long trumpets, two dung dkar conch trumpets, and two rgya gling double reeds (none of whose parts will be discussed here), it calls for as many drums and sil snyan cymbals as the monastery has available. In the recorded performance discussed here, 4 pairs of cymbals and 6 drums are used (Fig. 2).

Beat durations are extremely regular in this piece, averaging about 2 seconds per beat, or about 30 beats per minute. Of course, as in most rol mo pieces, the beats that end each group are prolonged to 2 or 3 times the length of the other beats in the group; while the special cadential figure on the last beat (see note accompanying Fig. 2) lasts about 20 seconds.

The structural core of this piece is the series of beat groups expanding from 1 to 15. This can be represented by the mathematical sequence formula 1, 3, 5, . . . , 15., but inclusion of the 4-right and 4-left beat series, and the fact that the piece begins and ends with odd-numbered beat groups ending with the double circular strokes, produces a more complex mathematical structure. One of the simpler ways of representing this structure is to factor out a 2 from the odd-numbered groups (since they increase by twos) and to combine mathematical notation with musical repeat signs (/: /:) to give the following structural formula:

/:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Coda

The "Coda" is the final beat specially prolonged into the complex cymbal manipulations of Zla ba yar tshes bzhag rol (Fig. 2, note). The formula should be read: "Play 1 beat with a double circle, 4 beats right, 4 left, then 2 and (repeat) 1 with double circle, 4 right, 4 left, then 1 with double circle, 4 right, 4 left, then 6 . . . etc., up to 14 (2 × 2) and 1 with the Coda (the special 15th-beat cadence)."

"Days of the Waxing Moon" thus embodies quite a complex mathematical structure. This mathematical complexity might appear to be a more or less accidental consequence of the composition's programmatic, pictorial nature and of the musical means chosen to express its visual imagery. However, in the next piece to be discussed, we will encounter similar mathematical sequences without any symbolic referent, which seem to be used purely for their mathematical structure and acoustico-structural effect.

*INVITATION TO MAHĀKĀLA*

Mgon po spyan 'dren, "Invitation to Mahākāla," belongs to a class of compositions called spyan 'dren, "Invitation," typically among the longest and most elaborate pieces in the rituals in which they are included. This piece is the longest instrumental composition in the ritual Sdang bu rnam sreg (p. 233 above). In the performance discussed here, it lasts 17 minutes, and employs 2 pair of sil snyan cymbals and 8 drums. Instruments whose parts are not discussed here include 6 dril bu bells (all played in the first section, and only 1 in the last section), 1 da ma ru hourglass drum (last section), 2 rkang gling short trumpets (first and last sections), 2 dung chen long trumpets.

"Invitation to Mahākāla" consists of 3 sections: A) "Chönjug Nöma," based on the standard geometrical construction for a hexagram inscribed in a circle; B) a long middle section, omitted in short performances of the ritual, based on two mathematical sequences: 180, 170, 160, . . . 15., and 10, 9, 8, . . . 1. C) a long and a short fall-acceleration, followed by "Three Beats" (p. 228 above).

A) "Chönjug Nöma," the first section, consists of a clockwise 'khor circular stroke of the right cymbal against the rim of the left, followed by 3 slow beats, the first 2 including equally slow afterbeats, and 4 single
pulses. The way in which these beats and pulses are played represents a geometrical construction, drawn by the right cymbal upon the face of the left. Figure 3 shows the placement of strokes on the face of the left cymbal. The steps of the geometric construction are given in parentheses following the description of the cymbal strokes.

"Khor": following the initial impact of the cymbals, the player accelerates pulses while striking one point on the rim of the right cymbal against the rim of the left, completing a clockwise circle around the left cymbal rim, and rotating the right cymbal so that it completes the circle in perpendicular relation to the vertical left cymbal, horizontal and face upwards. The cymbals remain in this relationship for the rest of the first section. (Construct a circle.)

Beat 1: The player strikes the horizontal right cymbal against the center of the vertical left cymbal, and plays a long accelerating pattern while moving the right cymbal down to the lower rim of the left cymbal. (Construct a radius.)

Afterbeat: The player plays a long acceleration beginning at 10 o'clock on the left cymbal rim and extending to the intersection of the Beat 1 radius on the lower rim. (Construct a chord at a 60° angle to 1, subtending an arc of 120°. There are several standard construction methods when radius 1 is known.)

Beat 2: Beginning at 12 o'clock on the left cymbal, the player executes an acceleration extending to 4 o'clock. (Construct a chord parallel and equal to la. Again, several methods can be used.)

Afterbeat: An acceleration from 2 o'clock to 6 o'clock. (Construct a chord intersecting the intersection of 1 and 1a, equal to 1a.)

Beat 3: An acceleration from 12 o'clock to 8 o'clock. (Construct a chord parallel and equal to 2a.)

Pulses: The player sounds single pulses at the points represented by the Sanskrit syllables Dza, Hūm, Baṃ, and Ho on the left cymbal’s rim, moving horizontally between the already-marked points of 2 and 10 o’clock and 4 and 8 o’clock, respectively. (Connect chord 2a with 1a, and 2 with 3.)

The geometric figure produced in this section is a mandala, a ritual diagram used in Buddhism and Hinduism to create a structural, diagrammatic “map” of various levels of reality, from the cosmic to the personal. Interpretations of general cognitive and symbolic aspects of the mandala in Indo-Tibetan Buddhism can be found in Tucci (1970) and Ellingston (1974). In this particular case, the mandala is considered to be symbolically attractive to the “god” Mahākāla, and so effective in “inviting” his presence. The symbolism is so important here that the 4 final syllable-pulses are placed on the diagram in reverse position to their

Figure 3. “Chönjung Nöma” (Notation 2): Beat Sequence.
normal order (right-to-left instead of left-to-right), "so they'll look right to him (Mahâkâla) as he comes towards you."

This transformation of visual into musical symbolism is in accord with the general esthetic orientation of rol mo. In the sense that rol mo is a structured representation of the specific natures of the particular "gods" for whom it is played, it can be called a "Mandala of Sound" (Gsong gi dkyil 'khor), or a "sonorous ikon" (Lhadungpa 1969:6). The diagram played here is simply a very specific case of a general esthetic principle. The use of the cymbals to "voice" the 4 ritual syllables (mantras) at the end is similarly a specific case of the general symbolic and communicative-meditational functions of rol mo. In some rol mo, instrumental sounding of syllables is so elaborate as to constitute a special form of an "instrument language" (Ellingson n.d.).

However important the symbolisms here, we should note that again the musical sounds are organized in a strict mathematical structure. The "radius" formed by beat 1 would be superfluous in the completed structure if this piece were simply organized by pictorial symbolism rather than by mathematical rules.

It should also be emphasized that the changing beat positions create an acoustical as well as a pictorial effect, since different positions on the cymbal surface have different sound qualities. These differences would of course be audible to the perfected perceptual and cognitive faculties of a Buddha; but even a sufficiently nearby human observer will have little difficulty in distinguishing the differences in duration of sound and partial spectrum of a stroke at the cymbal’s center from one on its rim.

B) The middle section of the piece, omitted in short performances of the ritual, is by far the longest, lasting slightly more than 13 minutes. It consists of 2 regularly decreasing sequences of beat groups.

The first sequence begins with a group of 180 beats. These are played without letting the cymbals complete their normal accelerating pulse pattern after the initial stroke, and without drum accompaniment, a style often heard in another class of compositions called Mchod rol. The first beat lasts about 2 seconds, the second, about a second; by about the 10th beat, a uniform rate of about 140/minute is reached. The tempo accelerates very slightly after this point. Beat 180 is played with prolonged accelerating pulses, and is followed by an equally prolonged afterbeat with accompanying drumstroke.

The next group consists of 170 beats, and ends with the prolonged beat-afterbeat combination. Beat groups continue to decrease regularly by tens, until finally a 15-beat group is reached. At this point, the tempo is 180 beats/minute.

With a sudden shift to a tempo of 120 beats/minute, the performers play a group of 10 beats, again ending with the prolonged final beat-afterbeat combination. There follows a series of 9 beats, then 8, then 7, and so on down to 1. The 1-beat “group” or unit is actually played as the first part of the compound Fall acceleration that begins the last section.

This section thus constitutes an immensely prolonged acceleration pattern whose accelerating units are beat groups rather than individual beats. This is especially clear in the drumbeats that end each group, as they slowly and almost imperceptibly begin to follow one another at increasingly closer intervals. As the end approaches, there is a clear progression towards an impending climax, especially in the final 10, 9, 8... sequence. From a purely Western perspective, this last sequence has the tension-building effect of a space-technology "countdown"—except that the transition to the climax begins on 1, and zero is never reached. The formulas for the 180-15 and 10-1 beat group sequences are given in Figure 4B.

C) The final section of the piece consists of one long and one short Fall acceleration followed by Three Beats. It begins with Phab chen Thang thang gsum, "Large Fall with Three Thang Tang." This is an extended acceleration with intermediate accelerating patterns added after

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A: First section, "Chödung Numa" (see also Figure 3)

B: Middle section, two decreasing beat group sequences (13% min) 180+1, 170+1, 160+1, 150+1, (140-180 beats/minute) 10+1, 9+1, 8+1,... 14, 13,... (120/min; 1*beginning of section C)

C: Final section, Long and Short Falls and Three Beats Phab chen Thang thang gsum, Large Fall with Three Thang thang, and Phab chung, Small Fall; first beat of Three Beats\(^5\)

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\[^{5}\text{In this performance, beat 1 of Three Beats is played as a short fall, with a three-second pause between the initial stroke and the beginning of the accelerating pulse series.}\]

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Figure 4. mGon po spyin 'dren, "Invitation to Mahâkâla"
each of its first 3 strokes, producing a pattern of 3 gradually accelerating accelerations. The next few strokes are played with normally accelerating pulses, each stroke increasingly faster, giving the impression that the series of Falls have now accelerated to the length of normal beats. The acceleration continues until, in every Fall pattern, separate strokes shorten to individual pulses which finally blur together into a final soft hum. This compound acceleration lasts 22 seconds, and is immediately followed by a 7-second ordinary short Fall (Fig. 4C).

The first beat of the concluding “Three Beats” is also played as a short Fall, with a 3-second pause between the initial stroke and the first pulse of the accelerating pulse series that ends the beat. During this pause the resonance from the initial stroke is the only sound heard (the full ensemble had entered for the first time in the piece at the beginning of section C, and suddenly drops out here). After the 3-second pause, cymbals and drums play the rest of the beat as a short Fall (Fig. 3C). The remainder of “Three Beats” is played with its normal beat pattern (p. 228 above). On the final ‘dzag afterbeat, the players extend the pulse acceleration into a bzhag rol cadence (p. 231), rotating the cymbals as they play and finally settling them in their laps to bring the piece to a close.

CONCLUSION

I implied in the introductory remarks that a question remains unresolved concerning Western perceptions of rol mo: Why do Western musicologists, much less laymen, so often turn to symbolically-oriented explanations of rol mo as “ritual sound,” rather than to structural explanations of musical sound?

Part of the cause might lie in still-pervasive Western romantic notions of “mystic Tibet,” but our study suggests another explanation. Most published studies of Tibetan Buddhist music have apparently been based on quantitative and formal analyses of recorded performances. Although the quantitative time measurements used in this paper have been quite rudimentary, they should still be adequate to show that the non-uniform handling of time/event relationships in rol mo make a purely quantitative analysis appear quite chaotic. Consider, for example, the 40-second (with afterbeat) beats found in the first section of “Invitation to Mahākāla,” the 180-per-minute beats in the middle section, and the varying-length 2-to-7-second (without afterbeat!) beats in the last section. Likewise, the complex mathematical structure of this piece would hardly be apparent in a recording, however carefully listened to, without some idea of what to listen for.

The research on which this paper is based utilized the “cognitive” or “ethnoscientific” approach of beginning with an attempt to discover the musical categories significant to the performers themselves. The significant musical categories were simultaneously correlated with significant differences in musical sounds. This was done in the context of performance lessons, in which answers were with equal frequency volunteered by the teacher or given in response to questions. In order to avoid suggesting terms in which the answer might be couched, most initial questions were kept at the most general level possible: “How do you play that sound?” “What is it?”

The result is a systematic basis for analyzing rol mo that tells us something not only about Tibetan musical categories, but about Tibetan musical sounds as well. Ethnomusicology, more than the other ethosciences, is relatively open to adopting the use of “native categories” for scientific purposes: we not only study tāla as an Indian theoretical concept, but thankfully use it in place of our own less appropriate “measures” for describing and analyzing Indian musical performances. In some cases, concepts like the Javanese slendroplelog and gongan have opened new approaches that allow us to broaden and redefine our own views of the nature of music. Further study of Tibetan concepts such as brdung, 'dzag, grang, and phab may bring similarly wide-reaching results. We have introduced concepts such as “logarithmic structure,” “component pieces,” “structural transformations,” and even the “countdown” metaphor to characterize certain striking aspects of rol mo organization; but a great deal of less tentative description, analysis, and comparison remains to be done to evaluate the significance of Tibetan musical concepts and sounds.

The most spectacular feature of rol mo rhythmic structure is the complex mathematical organization of some of the longer compositions. We certainly ought to ask in what sense these mathematical structures are actually a part of the Tibetan “cognitive map.” Tibetan notation, in its original or our modified version, presents us with a set of symbols that not only correlate specifically with specific sounds, but reveal numerically organized, patterned sequences of units. The musicians do not write out the abstract mathematical formulas for such sequences; but, on the other hand, a musician did draw out the steps of the geometric construction of the mandala figure in “Invitation to Mahākāla.” Furthermore, such geometric constructions, done with compass and straightedge, are widely used in Tibetan art and architecture. If, by contrast, the use of complex mathematical sequences in Tibetan culture is primarily or uniquely found in music, this would suggest a central role for music in the development of human modes of cognition and abstract thought.
Such a role, at least, is suggested by certain Tibetan scholars. The historian Dpa’ to gtsug lag ’phrangs ba, discussing the growth of the performing arts (Zlos gar) in Tibet, refers to 3 types of early religious and musical specialists:

In general, in the beginning in Tibet, the Srigs, Lde’as, and Bon opened the intellect. Later, intellectuals became sharper because of the spread of writing, mathematics, etc. . . .

(1565: Vol. Tsa. 42a)

And the 13th-century scholar Sa sky system Pandita, in the conclusion to his Treatise on Music, presents this argument for why one ought to study music:

Until in your own mind you have cultivated all objects of cognition, Omnisence will be as far away as the utmost limits of space.
By such reasoning, it is well that the Buddhas and their sons
Have said: “ Cultivate all of the sciences!”

(Sa sky system Pandita n.d.: 7a)

ACKNOWLEDGMENTS

This paper was delivered at the meetings of the Society for Ethnomusicology at Austin, Texas, in November, 1977. The information and recordings upon which it is based were collected in Nepal during 1973-4 in fieldwork sponsored by NDEA Title VI and Wisconsin Vilas Travel grants.

Although many individuals, both Tibetan and non-Tibetan, contributed help and information that made this study possible, I owe special acknowledgement and thanks to my teacher and friend, Phursang, of Swayambhunath Karyagad Monastery. Most of the Tibetan musical concepts and notations presented here were furnished by him; and, of course, the musical recordings which have contributed to this analysis reflect his musical performance skills. Most of my own work has consisted of editing, rearranging, translating, and analyzing his contributions. The analysis, of course, is my own responsibility.

NOTES

1. For an example of a pre-9th-century-A.D. Indian Buddhist instrumental notation, with 14th-century Tibetan performance instructions, see Ellingson n.d. In this example, rhythm is treated in the “Indian” way; i.e., organized in repeating cycles of regular beats. The type of rhythmic organization described in this paper was a later Tibetan innovation, the chronological development of which may become clearer as new historical sources become available. All Tibetan Buddhist musical traditions still continue to make use of regular beats and repeating groups (cf. Fig. 2); and the actual treatment of playing techniques, pulse subdivisions of beats, and construction of beat groups and larger structural units varies considerably from one tradition to another.

2. Some of the spellings and notational symbols used in this study have been borrowed from other performing traditions, either to increase clarity or to make use of more widely-understood terminology. For example, the universally-understood dbyangs (p. 227) is used to replace gdangs; the rather unwieldy spelling ‘Beb’ (’phab”) is replaced by the spelling phab (p. 229) from the Bon po religious/musical tradition; and, in the notations, to convey the nature of an increasing acceleration, the graphic symbol has been adapted from Bon po to replace the written-out word ‘bebs.

3. In some monasteries the dbu mdzad is designated byang ‘dren or byings ‘dren. In certain monasteries of the Sa skyas pa religious tradition, the cymbals are played by a musician designated Rol dpon, who follows the structural outline begun by the dbu mdzad on the drum.

4. Dbyangs is a special type of vocal music, the melodic structure of which is based on sequential arrangements of subtly varying tone contours rather than discretely separated pitches. For a brief discussion of dbyangs, see Ellingson 1979.

5. Time and dynamic indications are added from the author’s Tapes #74-2-15-a-s, recorded at Shes grub Chos ’khor Dar gyes gling Monastery, Swayambhunath, Nepal, February, 1974.

6. When this paper was read at the 1977 SEM meetings, a tape recorded example was played, and the perceptual problem pointed out. Out of the dozen or so persons who responded, all agreed that they had been unable to perceive a coherent sound structure at the beginning and ending of a “fall,” but had heard recognizable beats in the middle.

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