Interval Sizes in Javanese Slendro

by Larry Polansky

This is the first in a series of three articles which will in some way constitute a prolegomenon to the discussion of tuning systems in American gamelan. This examination will cover: 1) tuning ideas in Java, and the underlying notions of rational tunings in the west, 2) a discussion and documentation of some of the seminal tuning systems implemented so far, and 3) a speculative look at the next stage of intonational ideas for instrument builders, including some proposals for new tunings that might serve as a basis of experimentation for those who have not yet built

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There has been considerable discussion among those interested in the music of Indonesia about the appropriateness of rational tunings in that music, and in its hybrids. Indeed, both sides of this issue seem to me to represent one of the more common dilemnas in the hybridisation of musical styles, namely, how much and what (if anything) about the "parent" music is in any way sacrosanct. My own answer to this question notwithstanding (namely, that nothing is inviolate if done in the spirit of art), this problem has become crucial in the construction of gamelan instruments on American soil, with American materials, and within, no matter how much incense one burns, the particular network of music, education and experience that is American (and European) culture.

The point is often raised that the Javanese do not use rational tunings, but rather tune "by ear" and often from what might only be called a mystical foundation. Whether or not this commits western builders to the same process is a question left to the individual instrument designer — but what is more significant is that there are indeed formal and historical bases for the Javanese tunings themselves. All of the published pitch studies, like Kunst, and the Gadja Mada study, (see references at end of article), as well as the plain aural evidence of hearing many gamelans suggests strongly that what some may consider the Javanese mystical and apparently non-theoretical tuning tradition has in fact certain canonic, or what might be called "ur" intervallic forms. By taking a look at these we might gain a greater understanding of the character and definition of slendro and pelog (and the patet), and perhaps use that as a basis for tuning experimentation of our own.

The following ideas are based on a rather small statistical sample, that of the slendro tunings from the Gadja Mada (**GM**) University study, and the same gamelan measured by Kunst (**K**) in his earlier work. I do not intend to prove conclusively, from this tiny sample, that Javanese slendro tunings obey any specific canon. However, I do think these results show definite **tendencies** towards tuning and intervallic structures that are directly relevant to western builders. Although **GM** and **K** name their gamelans differently, the former by name, the latter by location, these charts correspond exactly line by line.

Examples **1** and **2** are the cents values of the pitches measured in the Gadja Mada and Kunst studies of 8 different slendro tunings. I have rounded them off to the nearest half-cent, and though cents values are not computed in the later Gadja Mada measurements, my own measurements for the frequency intervals are within a cent of Kunst's in all cases. It is significant that Kunst, unlike the Gadja Mada team, seems to assume an octave based tuning (I refer the reader to his frequency measurements themselves for this), and the (high) I' in general (barang alit) is simply doubled in frequency from I (barang). There has been a great deal of speculation about this particular aspect of this study, centering on the now rather common assumption that many instruments utilize an octave spiral tuning as a matter of course. In this respect, intervals from VI to I' (nem - barang-alit) in **K** are suspect, but since no American builder that I know of has designed a gamelan with a systematic spiral tuning (and of course this may very well be related to the particular spectral characteristics of aluminum), ignoring this further complexity in the Javanese tradition will, in some cases, simplify matters for us at this time.

The **GM** octaves are on the average about 10 cents wide, mainly, I believe to preserve certain inner patet-related qualities of the slendro, and to achieve certain implicit and explicit multiple intervallic relationships. For example, what very quickly defines part of the character of a particular slendro is the relationship between the intervals VI-II and V-I, which in several of the tunings is nearly equal, like Rarasrum (P.A. Jogja) and Kraton Sala (Manisrenga) (or in fact, in any slendro when VI-V is the same as II-I). Another important factor is that though I' and I are not octaves, the ear very strongly perceives the octave of I, and the relationship of the intervals to this "phantom pitch" becomes important and interesting. In fact, one of the most important "embat" is this interval, I' to (2*I), or I' to the octave of I. The effect of these variant tunings on the character of the patet (manyuro and sanga) remains an important area for study, for whether or not to keep these two intervals roughly equal seems to be one of the essential decisions in constructing a tuning.

At first glance there are some striking aspects to these two charts, especially to the student of intonation. First is the predominance of intervals extremely close to the 8/7, especially between II and I (gulu and barang). Six of the **GM** and two of the **K** intervals in this position are within 8 cents of the 231 for the 8/7. The predominance of this interval in the world's music (some have called it the world's major second) leads one to expect that it will arise as a canonic ratio. The acoustic reasons for this, and for the related prevalance of intervals close to 7/6

	II-I	III-II	V-III	VI-V	I'-VI
1. Manisrenga	219.5	266.5	227	233.5	258.5
2. Kanjutmesem	224	253.5	237.5	232.5	264
3. Udanriris	255.5	256.5	223.5	235.5	234
4. Pengawesari	251.5	233.5	233.5	236	250
5. Rarasrum	229.5	227.5	253	232	261.5
6. Hardjanagara	216	249.5	216	262	261.5
7. Madukentir	268.5	242	243	230	221
8. Surak	206	231.5	238.5	265	264.5

example 1: **Kunst selected slendro tunings**

	II-I	III-II	V-III	VI-V	I'-V
1.	237	251	248	242	258
2.	252	239	242	236.5	253.5
3.	237	238.5	232.5	262	238
4.	226	252	260	234	256
5.	232	239	248	232	259.5
6.	218	238.5	244.5	244.5	260
7.	238	230	257	243	250.5
8.	232	234	249	251	257

example 2: **Gadja Mada slendro tunings**

(about 266.9 cents) derives mainly, I think, from the harmonic series, and the high energy concentration in that part of the spectra of so many sounds. Whatever the reason, those two intervals are extremely common as a major second and minor third in many of the world's cultures (including, incidentally our own — as in the blues scale). In **K**, 5 of 8 of the intervals I' to VI (nem to barang alit) are within 8 cents of the 7/6. However, this is precisely the interval in which **K** may be based on a mistaken assumption. In **GM** the 7/6 is not suggested as strongly, with 3 of 8 being within 8 cents, and 5 of 8 within ten cents. However, in the M.N. Sala tuning, I'-VI is not a "large" interval at all (I will explain this below), so a more interesting formulation might be to say that of all the "large" intervals in this scalar position, only two are outside a 10 cent radius of the 7/6. I think that like the 8/7 between II and I, the 7/6 between I' and VI is a kind of underlying tendency, though in the latter case it tends to be shaved a bit to allow for raising the mid-scale intervals (III-II and VI-V).

The averages for the intervals in both studies are:

	II-I	III-II	V-III	VI-V	I'-VI
K:	233.81	245.06	242.75	240.8	251.875
GM:	234	240.25	247.625	243.125	254

In all the intervals except I' - VI, the Kunst study is likely to be more representative of the original intent of the gamelan builders, for it is an earlier study (though Kunst is not, admittedly, nearly as clear about his measurement techniques as are the authors of the later study). These averages are a rather gross statistical measure, and interpretation of their meaning is certainly subjective, but one conclusion we might draw from them is a kind of statistical tendency for the relative tunings of the slendro measured.

In both tunings we find the first interval significantly smaller than the others, and the last significantly larger, with the three middle ones roughly equivalent. Drawing my cue from my colleague Lou Harrison, we might discuss these tunings as combinations of three **types** of intervals: Small, Equal, and Large. In this case, Small is a "major second" smaller than 240 cents; the three most likely just candidates are the 8/7 (231 cents), the 9/8 (204 cents), and the 10/9 (186 cents). Equal are those intervals between 240 and 250 cents, and the predominance of these is perhaps what prompts Raden Lurah Martopangrawit to state (see notes, **Karawitan, Volume 1**):

> "In the slendro tuning system, there are five tones in one gembyangan with [relatively] equal intervals between tones"

Were it five tone equal temperament, the interval would be 240 cents. There are two main reasons why I feel the idea of five equal tones can be a rather misleading way to think about slendro construction.

1. The slendro notion of gembyangan does not coincide with the notion of octave. This does not simply concern the difference between 8 and five tones (as the translator's (?) notes to Martopangrawit's work suggests (page 40, note)). The main differences I feel lie in the octave's definition as a doubling of frequency, and as a pitch equivalency class, since Javanese patet and melodic configuration are in no way registrally transposable in the way that octave equivalence implies. Therefore, the concept of equal division is somewhat innapropriate when one asks: "Division of what?"

2. The tuning measurements we have seen point more clearly to a system of arrangements of at least three and probably four (that is Small, Equal, (Large-Equal), and Large) distinct interval types, decidedly unequal in both size and affect.

Large intervals are those greater than 250 cents, in fact closer to what we might think of as a "minor third". The following tables (Examples **3** and **4**) show the configurations of the **GM** and **K** measurements solely in terms of these interval classes, with the averages on the bottom line. In certain cases, for example when the interval is 238 cents, I have indicated S-L to show how it is a large version of the Small class.

In the following examples, it is important to keep in mind that Kunst measured one saron only, and according to the **GM** team Kunst's "measurements might have been displaced and moved one wilahan upward, since with only one datum from the pitches of one piece of saron the possiblitiy of misplacing the results is not remote." Thus, in the Kunst tables we may be in some cases looking at shifted slendro. Ironically, there are historical examples of whole gamelans being "renumbered" by one pitch to accomodate vocal range, and because of many of the symmetric qualities of the following tables, this not only seems reasonable but quite interesting musically.

	II-I	III-II	V-III	VI-V	I'-VI
1.	S	L	S	S	L
2.	S	L	S	S	L
3.	L	L	S	S	S
4.	L	S	S	S	L
5.	S	S	L	S	L
6.	S	E-L	S	L	L
7.	L	E	E	S	S
8.	S	S	S-E	L	L
Average:	S	E	E	E	L

example 3: **Kunst interval sizes**

I think it is here that we see a more accurate representation of the kinds of slendro intonation variation possible, at least, as Lou Harrison points out, within the context of Jogja style. I think also that the two most common ways of thinking about slendro — as a five tone equal scale with certain "embat" or variations for each interval, or as a kind of simple pentatonic (which some Western builders have adopted) — are not as useful as the notion of intervallic size configuration. The 8/7 and 7/6 intervals which seem to proliferate at the extremities of these slendro are radically different from the 9/8 and 10/9 major seconds and the 6/5 minor thirds that western tuning might suggest for a pentatonic. By the same token, those two intervals would, I think, never be confused by a listener with the Equal intervals which tend to occupy the center positions.

Note also that V-III is often a bit larger than III-II and VI-V, but not as large as I'-VI (usually), and perhaps justifies the addition of a fourth interval class to this schema, E(L). Also, it might be shown that builders using a particular slendro which do not obey the S-E-E(L)-E-L formula may indeed have historical and/or stylistic reasons for reconfiguring it, but my limited knowledge of the intricacies of Javanese style preclude any suggestions

on my part about this.

As an experiment in speculation, but, I think, a rather illustrative one, we might construct a rational tuning method for the **GM** average (234, 240.25, 247.625, 243.125, 254). We could just as well pick any of the slendro in **GM** or **K**, and I think that the same mode of thought would be useful, but I choose **GM** because of its stretched octaves, and the average because in picking a slendro which does not actually exist (at least in the sample) we are in a sense constructing a new tuning which to a great extent respects the various slendro measured. Note that I am ignoring at least one very important aspect of constructing such a tuning: that the relationship between laras pelog and laras slendro is often a crucial and complex one, both in Java and in America, the latter evidenced (as we shall see in Part II) by Daniel Schmidt's intricate tunings.

	II-I	III-II	V-III	VI-V	I'-VI
1.	S	L	E-L	E	L
2.	L	S-E	E	S	L
3.	S	S	S	L	S
4.	S	L	L	S	L
5.	S	S	E	E-L	L
6.	S	S-E	E	E	L
7.	S	S	L	E	L
8.	S	S	L	L	L
Average:	S	E	E-L	E	L

example 4: **Gadja Mada interval sizes**

In the following description, I will make use of two types of interval description. The first ascribes a ratio to a pitch relative to a given 1/1. In this case pitch I is assumed, though that by no means implies that barang is in any way a "tonic" or central pitch. The second way is to describe the interval "consecutively", as a ratio above its nearest neighbor. Thus, pitch VI might be a 7/4 to pitch I, and an 8/7 to pitch V. I have tried to make it clear in all cases which type of interval I am talking about.

The first interval is so close to 8/7, that we can assign it as such. For pitch VI, we can start out with 7/6 (or about 967 cents), but I think that pitch VI exists in two incarnations, one in relation to V, II and to low I (and implicitly to I doubled in pitch, but not I'), and one in relation to I'. If I' is taken sharp of low I's octave, say around 10 or 12 cents as is common, 7/6 below that gives us what is more easily seen as 7/4 above I, and consequently 8/7 below I's phantom octave. In fact the 7/4 (about 969 cents) is more coincident with the average cents value for that interval from I itself, which is 965. This also creates a 49/32 to II. The other way to think about VI is as a 7/6 below I doubled in pitch, and this yields the interval 12/7 (about 933 cents). This way of thinking of it becomes interesting when we try to generate V (below).

The average cents value for III is about 474, and this points squarely at the 21/16, making a just fourth to the 7/4 VI. The interval created in this way between III and II is an 8/7 below a 21/16, or 147/128, which is approximately 240 cents. This is almost exactly the average.

The interval that remains is V-III. The natural assumption for V would be the common fifth from I, 3/2, but this (702 cents as compared to the average of 721.875 = II/I + III/II + V/III) does not correspond in any way I can tell with what we actually observe. For example, if we begin with this and tune **down** an 8/7 to obtain III, we get the interval III = 9/7 (435 cents) from I, and thus 9/8 from II (204 cents). These intervals (III/II and III/I) are so narrow as to be almost out of the question in the tunings we see (the only example of anything close is **K** Surak II/I). In fact the derivation of V seems to come from VI (7/4 down a 147/128) or from the octave of I (down a 21/16), the latter making it a 32/21 up from I for a fifth of 729 cents. If we assume VI to be 12/7 (933 cents), relating primarily to I, then V (down a 147/128) down becomes 729 cents (the ratio for V in relation to I, however, becomes unwieldy, stressing the importance in this case of the relative importance of stepwise motion from VI to V compared to the relationship from V to I), or a bit wide of the average (about 722). This is, I think significant, for one way to view slendro tuning is not as a stretching of octaves, but as a stretching of V. In other words, V is tuned from VI, and then I' is tuned from V! In this way, a complex and beautiful schema of multiple and paratactical relationships is created among the six tones. Ironically, it is this kind of dynamic and flexible intonation system that has become of great interest in contemporary western music, especially in the use of high technology to rapidly tune and retune intervals depending on their harmonic and melodic context.

To summarize (and also simplify) the above tuning, it might be done in the following way (starting arbitrarily on I):
Tune II an 8/7 above I.
Tune VI a 12/7 above I (or a 7/6 down from I's octave)
Tune III a 21/16 above I, or a 147/128 above II.
Tune V a 147/128 down from VI.
Tune I' to V (in any of a number of ways), possibly a 21/16, or the same as III to I.

I should repeat that the above is just one experimental postulation, and there are (as we shall see later on) many others. Also, I do not claim the Javanese tunings were in themselves arrived at this way (in fact I'm fairly sure they weren't), but I present this as a parallel language for the kinds of aural decisions a Javanese tuner must make. These manipulations are not intellectual excercises any more than the intervals 8/7 and 7/6 are abstract notions — rather they are real and musically meaningful psychoacoustical and musical phenomena that are partially responsible for the richness of a musical culture.

The main point of all this is to give us something to go on, a reference perhaps, when we next consider the tunings of western builders. For example, though most of the builders we will consider have pretty much standardized in just tunings (which tends to blunt a bit the notion of those large, "equal" major seconds), several are now reconsidering that position, and are working on "shaving" and "expanding" certain intervals (like Lou Harrison's recent work with VI-V) to get more of slendro's equality characteristic while still preserving the skewed pentatonic aspect. In fact, Javanese teachers in this country have been enthusiastic about certain just slendro which seem to approximate very closely important Javanese tunings. I think we will see that these builders have in most cases (but not all) been extraordinarily sensitive to the more subtle notions of slendro (and pelog later on), and have also made some radical and interesting experiments to suit their own musical needs.

I am grateful to those who have been generous enough to share their ideas and tunings with me — namely Lou Harrison, Daniel Schmidt, William Colvig, Henry Rosenthal and David Doty of Other Music, Joan Bell and Kent Devereux.

[see glossary and references, page 23]

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