TOWARDS A HARMONIC APPROACH TO COMPOSING FOR CENTRAL JAVANESE GAMELAN

Thesis

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By

Stephen Parris

Approved by:
Reading Committee

_____
Chris Brown
Director of Thesis

_____
Fred Frith
Reader of Thesis

_____
David Bernstein
Head of the Music Department

_____
David M. Donohue
Interim Provost and Dean of the Faculty

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DEDICATIONS

My time at Mills would not have been so focused on gamelan without my mentor/carpool partner/buddy Daniel Schmidt. Daniel introduced himself to me after hearing a performance of Lou Harrison's "Concerto for Piano and Javanese Gamelan" that used the piano tuning that is explained later in this thesis. If it weren't for his invitation to come build instruments with him, his interest in having me at Mills, and his encouragement of my interest in composing for gamelan, I would have happily spent my time writing text-based scores that involve rolling dice. I still write those, but also do this other thing now as well.

Chris Brown has been very helpful in talking me down from big picture ideas to a more focused concept for a thesis. His guidance and support through the writing process has been incredibly bolstering.

I am happy Fred Frith is my reader. I respect his opinion and appreciate his insights. My first class at Mills was with Fred. His feedback from that class eased me back into academia and helped acclimatize me to the environment at Mills. I am hoping that he will want to change the "z" in "acclimatize" to an "s". It would be even better if he wants to change it to "acclimate".

Zeena Parkins and Roscoe Mitchell deserve praise for putting up with me in practicums while I babbled about gamelan. Their support, questions, and interest helped me rethink how I approach this music. All other music department faculty deserve thanks as well.

All of my past gamelan teachers and cohorts deserve my gratitude. Midiyanto and Ben Brinner with Sari Raras at UC Berkeley, Jarrad Powell and Jesse Snyder with

Gamelan Pacifica in Seattle, Wayne Vitale and all of the wonderful people at Gamelan Sekar Jaya, and Stephen Fandrich, my dear friend and fellow composer/improviser. His compositions for harmonic voice and gamelan have stuck in my head throughout this process. I hope he has fun reading this.

Not-so-secret readers and editors Brandy Parris and Sean Owen deserve not-so-clandestine thanks.

Finally, both sides of my family deserve credit for supporting me and putting up with me. Especially Angelique. Thank you for not killing me.

INTRODUCTION

The purpose of this thesis is to share the process behind the development of an approach to composing for central Javanese gamelans that utilizes vertical harmony. This paper will include my history with Javanese gamelan, work on the development of a piano tuning that would work with a gamelan, compositional works that led to the development of the system, a study of existing Javanese gamelan tunings, and a presentation of intervallic relationships and cadences that can be utilized with any gamelan. All of this is done with hope that others who may take interest in writing for central Javanese gamelan will have a new tool at their disposal, and to pique the interest of others in the rich world of possibilities that exist within the instruments.

I highly recommend a reader uninitiated in central Javanese gamelan read through the primer located in appendix 1 and the glossary before reading the rest of this work.

A STORIED HISTORY WITH JAVANESE GAMELAN

My relationship with Javanese gamelan music stretches back about 25 years. I made a mistake on an order form at a record store I worked at, and ordered a JVC recording of the STSI gamelan led by Rahayu Suppangah performing music for dance. We left it on the shelf for half a year to see if anyone would buy it. When it came time to return it to the distributor, I decided to purchase it for myself. Upon listening, I was instantly fascinated by the interplay of the *rebab* (two-string bowed instrument) and *gerong* (male choir) at the beginning of the first track. I was drawn to the slow, somber, and meditative quality of the music. Once the hard-style instruments came in, and the first full cycle of the piece was marked by the low-pitched ring of the *gong ageng*, I was hooked. I began pestering people to listen to it, to play it in cars with excessive bass systems, to marvel at the way it could stretch and condense time. Despite my efforts, I was unfortunately alone in my love of this music in the small navy town where I lived.

Later, when applying for undergraduate studies in music composition, I was drawn to Cornish College of the Arts in Seattle in part because they had a gamelan and offered two levels of gamelan ensemble classes. The school did not let students below the junior year take the gamelan class. However, when I wrote a piece titled "Pelog Caricature" for 4 or more voices, violin, and guitar that did the best imitation of Javanese gamelan music I could muster, it caught the attention of Jarrad Powell. After hearing my piece, Powell, the director of the Cornish Gamelan Ensemble and of Gamelan Pacifica (a professional ensemble that has been in-residence at Cornish for a long time) allowed me to take the gamelan class a year early.

I took both the basic gamelan class and the advanced gamelan class over the following school year. After depleting class options available, I began to show up for all the classes, retaking them even though I was not registered. In my senior year, Jarrad asked if I would be willing to join Gamelan Pacifica, which I gladly accepted.

I performed regularly with Gamelan Pacifica for the next 12 years. Over that period of time, I had the opportunity to perform a mix of contemporary and traditional works for Javanese gamelan. We collaborated with many artists, including Rahayu Suppangah, Sutrisno Hartana, Kathy Foley, and Jody Diamond. We also performed and recorded a lot of Lou Harrison's music, including the Concerto for Piano and Gamelan. Several times we worked with Midiyanto, a *Dhalang* (leader and puppet master of a *wayang*, which are Javanese shadow puppet plays) and professor of gamelan at UC Berkeley. He let me know that if I ever came to the Bay Area, I would be welcome to join Sari Raras, the professional ensemble based at UC Berkeley.

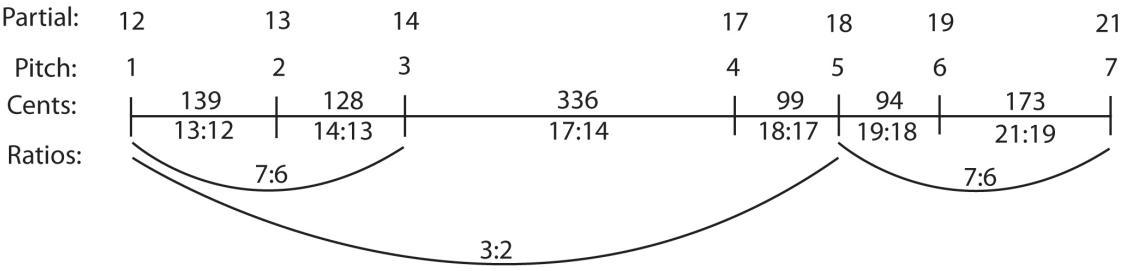
Although I spent 12 years as a performer of traditional and contemporary music for central Javanese gamelan, I never composed for the instruments during that time. I yearned to write for gamelan but felt that I lacked enough mastery of the tradition to write anything decent. It wasn't until I started working with Daniel Schmidt that I had the encouragement, feedback, and support necessary to begin finding my compositional voice with the gamelan.

ADVENTURES IN COMPOSING FOR JAVANESE GAMELAN

In 2013, I began writing for gamelan mainly to see how the process of composing for the instrument could help inform and advance my knowledge of *pathet* (put simply,

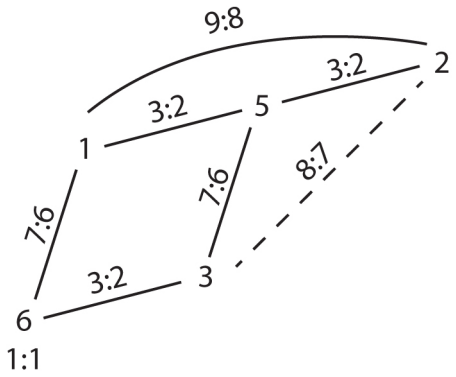
mode) and form in traditional Javanese gamelan. All of these pieces were written for the Mills College Gamelan, which is tuned in Lou Harrison's septimal just tuning. Just tuning systems use intervals derived from harmonic partials. These tend to be represented as low number ratios. For example, the *pelog* (heptatonic scale used for half of the instruments of a set of gamelan) tuning for Si Madeleine is best explained as being the 12th, 13th, 14th, 17th, 18th, 19th, and 21st harmonic partials from the overtone series of an equal temperament G tuned from A440. The ratio between the 12th and 13th partial is 13:12. The following chart is a representation of the tuning for Si Madeleine that shows the *pelog* pitch number with the corresponding partial above. The interval is shown in cents (hundredths of an equal-tempered semitone) above the line. The underside shows the intervals in ratios, and a few prominent, larger just intervals that occur in this tuning.

Pelog:



The *slendro* tuning for Si Darius is best described as a grouping of 3:2 and 7:6 intervals. I find it useful to view this tuning in a lattice to show all the strong relationships.

Slendro:



I refer to this tuning as a septimal just tuning, due to the use of septimal minor thirds (7:6). These are smaller than the more commonly seen 6:5 and 19:16 minor thirds by 49 and 32 cents respectively.

Here is a chart that combines both *pelog* and *slendro* scales of the Harrison tuning. Pitches unique to *pelog* are denoted with a "p". Pitches unique to *slendro* are denoted by an "s". All intervallic relationships are mapped out in cents vertically and horizontally so that the inversion of the interval can be found as well.

	6	P5	P4	S5	S3	P3	P2	S2	P1	S1	P7	6
6	**1200**	94	193	267	498	529	657	729	796	933	1027	0
p5	1106	**1200**	99	173	404	435	563	635	702	839	933	94
p4	1007	1101	**1200**	74	305	336	464	536	603	740	834	193
s5	933	1027	1126	**1200**	231	262	390	462	529	666	760	267
s3	702	796	895	969	**1200**	31	159	231	298	435	529	498
p3	671	765	864	938	1169	**1200**	128	200	267	404	498	529
p2	543	637	736	810	1041	1072	**1200**	72	139	276	370	657
s2	471	565	664	738	969	1000	1128	**1200**	67	204	298	729
p1	404	498	597	671	902	933	1061	1133	**1200**	137	231	796
s1	267	361	460	534	765	796	924	996	1063	**1200**	94	933
p7	173	267	366	440	671	702	830	902	969	1106	**1200**	1027
6	0	94	193	267	498	529	657	729	796	933	1027	**1200**

The first few pieces I wrote stuck to simpler forms like *bubaran,* which uses 8 beats to each gong, and *lancaran*, which uses 16 beats to each gong, and attempted to focus on one *pathet*. After a few pieces written this way, I composed "Clear Day, Shimmering Water". This piece was an attempt to bring out the core *padhang* and *ulihan*

(the Javanese terms of describing antecedent and consequent relationships) inherent in different *pathet*. It consists of four sections, all in *laras (*scale) *slendro*. The first three sections explore the relationship of two pitches by allowing them to sustain throughout. (In traditional practice, the previous pitch is muted when a new pitch is played). The first section investigates tones 1 and 5, the second section tones 6 and 3, and the third section tones 2 and 6. These are the strong fifths found in *slendro*. The final section uses each pairing to create one *gongan lancaran* that travels through all three previous spaces in quick succession. Instead of bringing out the *padhang* and *ulihan*, the first 3 sections create a very harmonic texture built on those strong fifths. By the final section, when the pairings change more quickly, the *padhang* and *ulihan* relationships are more noticeable.

Instead of helping to clarify *pathet*, as I had expected, this piece showed me that the Mills just-tuned gamelan has a vertical harmonic potential not utilized in the traditional music, which led to the composition of "Devil Box". Like "Clear Day, Shimmering Water", "Devil Box" allows pitches to ring out. It was originally written as a solo piece for a *pelog saron* (a metallophone in the middle register of the whole gamelan with a sharp attack), where pitches are allowed to sustain, causing interesting difference tones (pitches below the instrument's normal range) to emerge. It also begins to compare relationships between three pitches by allowing three at a time to ring out. In its most recent iteration, a *pelog slenthem* and *slendro* gongs have been added to help shape the piece. The *slenthem* plays two pitches at a time, which creates distinct two and three part vertical harmony at certain points in the piece.

Since "Devil Box" was written with a tuning that uses just intervals, I assumed that the difference tones were a result of the just intervals strong harmonic relationship,

and would not occur if the piece were played on a traditional set of instruments not tuned to just intervals, thus limiting the ability to have the piece performed more widely. I decided to give it a try on *Udan Mas* (the bronze set of instruments at UC Berkeley, which is not just tuned) and was pleasantly surprised to hear the difference tones. They weren't as strong as they were on the aluminum instruments at Mills, but were present enough for the effect needed for the success of the piece. On a visit to Seattle, I had the opportunity to try the piece also on Si Thomas (the iron set used by Gamelan Pacifica at Cornish College of the Arts). The same result occurred. The tunings were noticeably different, but the character of the piece transferred; not unlike a different person singing the same song. I began to wonder if a sort of vertical harmony could work on most gamelan.

After hearing *slendro* gongs played with *pelog* instruments, I began to explore the potential for composing works that utilize both *laras* (scales) at the same time. The result is "In Light of a Proper Solution, an Unjust and Excessive Response" (henceforth referred to as "In Light…"). This piece was difficult to write, as it departs starkly from tradition. There are pieces in traditional gamelan that will use both *laras*, but never sounded in unison, whereas "In Light…" begins to explore the potential for two and three part vertical harmony that can be produced by combining the two *laras*. As with "Devil Box", I tested parts of it on the same two traditional sets previously mentioned, with very promising results.

After composing "In Light…" I had reached a point where I wanted to know how far a vertical harmonic system could be used, and how far a blending of *laras* could be implemented beyond the safety of the Harrison just tuning. This required an examination

of a broader collection of gamelan tunings than I previously had access to. I will describe this research in more detail below. For now, a few details from that research are relevant. Even though every gamelan is tuned to itself, some things remain pretty constant across sets that help to give each Javanese gamelan its particular character. One unifying factor of Javanese gamelans is that pitch 6 in the middle octave of almost any given set sits somewhere between 430 and 500 Hz (a slightly flat A to a slightly flat C in western tuning.) This may seem like a large range, but when one considers that tuning a gamelan involves shaving metal from the keys to balance them with the other pitches in the scale, as opposed to focusing on a pitch being an absolute, it begins to be more reasonable. The fact that many of these gamelans were built over a century ago when tuning was handled differently, means the average range is much smaller.

There are some relative intervallic constants as well, which help to define the prime relationships in *pathet*. For example, in *slendro*, the interval between pitches 1 and 5 is heard as a strong fifth. Measured strictly, the pitch can vary, but I have been hard-pressed to hear a gamelan where it does not sound like a fifth. In taking the average of all gamelan tunings measured in my research, pitches 1 and 5 are approximately 718 cents apart. Extreme examples sit at 744 cents and 695 cents. Although 44 cents seems like a big range, it is important to keep in mind that it is the *anomaly* of the tunings measured. If we drop the two highest and two lowest examples, the average lowers to 715 cents. The anomalies tend to exist on gamelans that are not tuned periodically, for whatever reason. A good example would be a temple gamelan that has sacred and historical implications. These sets will not get tuned, are only played on special occasions, and play a very limited repertoire. From the standpoint of a composer writing contemporary

music for gamelan, these instruments can be ignored, as it will be highly unlikely that new works will be played with them.

We musicians, with our trained ears, can be sensitive to these tuning deviations, but our recognition of them as intervals like fifths and thirds is still there, and when we hear them function in their roles musically, we can recognize their intentions. Our minds adjust to hear them functioning in their usual roles. Regarding this cognitive reality, James Tenney has proposed that:

> "within the tolerance range, a mistuned interval will still carry the same harmonic sense as the accurately-tuned interval does, although its timbral quality will be different = less "clear" or "transparent", for example, or more "harsh", "tense", or "unstable", etc."[1]

I have taken to referring to this phenomenon as "fuzzy interval". Although an interval may be fuzzy, we can recognize its role in context of other intervals, be they fuzzy or not.

These fuzzy intervals have given me a deeper understanding of the concept of *embat*. The simple definition of *embat* is interval. Every gamelan is built with its own *embat* (sharpening or flattening of certain pitches depending on the preference of either the tuner, builder, commissioner of the gamelan, or a combination thereof), and this *embat* changes over time as the instruments age and are retuned. There are two basic types of *embat;* one characterized as more demure with softer character and less stretch to the octave, and the other as more outgoing and brash, with a bigger stretch at the octave, causing a bright, shimmering effect when played. The latter is preferred for *wayangs*. American just-tuned gamelans like the ones at Mills tend to be *pleng*, which means there

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[1] Tenney, James, "The Several Dimensions of Pitch" in *The Ratio Book: A Documentation of the Ratio Symposium,* ed. Clarence Barlow (Cologne: Feedback Studio Verlag, 1999).

is no stretch of the octave. A *pleng* gamelan is not necessarily looked down upon by the Javanese, but it is not considered ideal; indeed, some would say it is bland. Even with these differences, there is still enough integrity to the *embat* within the scales that *slendro* and *pelog* will be recognizable. Through this retention of the character of the *laras*, one can begin to derive three-part vertical harmony from the scales that would translate to any given set of gamelan instruments, as long as one is willing to accept the coloration that any given *embat* will impart upon the given piece.

TAKING AWAY LOU HARRISON'S "CONCERTO FOR PIANO AND JAVANESE GAMELAN" FROM JUST INTONATION

When writing for gamelan, I was informed by previous work I had done both as a performer, and as the designer of a piano tuning for Lou Harrison's "Concerto for Piano and Javanese Gamelan". The Concerto is a delicate piece that requires significant planning and preparation to achieve a successful performance. The marriage of the piano—arguably the keystone harmonic instrument in western music—and a Javanese Gamelan, which utilizes its own melodically based musical tradition and tunings, poses a daunting challenge. Matching the tuning of the piano and the gamelan while retaining a pleasing piano tone quality is the biggest hurdle. From my research, I assume it was written for a tuning similar to Si Darius and Si Madeleine, the gamelan that Lou Harrison and Bill Colvig built with the help of Mills College students using a septimal just intonation of Harrison's design. By tuning the piano to the same just intonation scheme as the gamelan, the overtones of the piano blended easily with the percussion instruments. But matching the piano to a Javanese gamelan tuning poses different issues.

Since the tone of a piano string closely aligns to harmonic overtones, it does not work well to stretch an interval too far. An interval of a fifth tuned too wide on the piano will be very noticeable, whereas a fifth on the Javanese *saron* tuned too wide will still convey fifth-like qualities because the irregular overtones of a hammered piece of bronze helps to cover the wideness or narrowness of an interval.

The performance of Harrison's piece by Gamelan Pacifica in Seattle done for the 2010 recording[2] with Adrienne Varner on piano was made possible by adjusting the gamelan instruments to a just intonation tuning developed by Jarrad Powell and Stephen Fandrich. The pelog tuning used by Powell and Fandrich uses the 8th to the 14th partial of an equal temperament B tuned to A440. The results of this approach and tuning are beautiful, but the process of tuning the gamelan is quite laborious. Most of the instruments of Si Thomas (the gamelan used in the recording) are made of iron, and were retuned for the first performance of the piece by strategically placing sculpting clay in key areas to adjust pitch.

In 2013, I was lucky to be part of the gamelan ensemble Sari Raras during the preparation and performances of Lou Harrison's works at the Ojai Music Festival in 2013 that utilized gamelan Udan Mas (a bronze set with a colorful history that resides at UC Berkeley). The closing piece in the festival was the Concerto for Piano and Gamelan. From my experience as a performer with Gamelan Pacifica, I knew how important tuning was to the success of the piece. No one in Sari Raras seemed interested in working on a tuning, leaning instead towards simply tuning the piano to the gamelan. I expressed to the directors the importance of finding a more balanced tuning, and asked their

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[2] Lou Harrison, *Scenes From Cavafy – Music for Gamelan,* Gamelan Pacifica, New World Records, 80710, 2010.

permission to take on the task of finding a way to make the piece work better with Udan Mas. Since they were opposed to adjusting the tuning of the gamelan and did not want to try to borrow Si Darius and Si Madeleine from Mills, we had to develop something that would work with Udan Mas as it was tuned. We decided to take a third route, which entailed finding a tuning that works well on the piano, and matches *closely enough* the tuning of the gamelan that it avoids clashing between the two instruments. We achieved this by identifying the *seleh* tones (pitches where the melodic material resolves) that are emphasized in the piece, and adjusting certain fifths related to *seleh tones* on the piano to be closer to just-tuned fifths. Having key *seleh* tones tuned to match well with the gamelan helps reinforce those strong points. Since less emphasis is given to pitches that are not *seleh* tones in the piece, a wider deviation from the gamelan on those pitches is less noticeable. Even though the piano is not tuned to exactly match the pitches of the gamelan, it is tuned closely enough that the timbre of the gamelan helps blur the imperfection.

The biggest adjustments were made to clean up some intervals (fifths and fourths) that sounded quite awful on piano during the large sections of the piece where the gamelan was not playing. The most noticeable was the retuning of the fourth between G# and C# (*slendro* 5 and 1) to 490 cents, which is very prominent in the ending of the first movement. On the gamelan used, that interval was around 479 cents, which was not very pleasant on the piano, but acceptable on the gamelan. Here is a chart that lists the western pitch name, deviation in cents from equal temperament on Udan Mas, and the deviation in cents from equal temperament used for the piano tuning.

Gamelan pitch name	s1	p1	s2	p2	P3	S3	P4	S5 / P4	P5	6	6	P7
Western pitch name	C#	D	D#	E	F	F#	G#	G#	A	A#	B	C
Piano tuning deviation in cents	-10	8.2	8	-54	-12	-60	0	0	0	30	-70	-16
Udan Mas deviation in cents	-20.8	8.2	8	-53.8	-11.7	-55.5	-11	-6.8	-12.3	24.6	-76.4	-16

A complete transcription of the piano part of the score was required. After comparing the tuning to equal temperament, it became clear that the piano would have to be tuned down, and the score would have to be transposed to match the new piano tuning. Although Sari Raras is generally sharper in pitch than Si Madeleine and Si Darius, the piano tuners involved at both performances disapproved of raising pitches. Most piano technicians are not willing to tune a piano too sharp or flat. After discussions with Ron Elliot (piano tuner for the L.A. Philharmonic and Ojai Festival), we decided to keep the pitches of every piano note within 50 cents of its pitch in equal temperament. Since we did not have the luxury of keeping a piano in this tuning for a long period of time for the instrument to settle in to the new tension, keeping it closer to equal temperament would help its tuning be more stable. However, there were a few cases where we had to stretch beyond the 50-cent mark, most notably B being lowered by 70 cents. This was done at the pianist Colin Fowler's request, so that he would have two options for pitch 6. This allowed *slendro* to live entirely on the black keys, and *pelog* to reside mostly on the white keys. The one exception is pitch *pelog* 4, which we decided to combine with *slendro* 5. On Udan Mas, they are only 6 cents apart.

Here is a chart that shows the central octave of gamelan Udan Mas with all of its pitch relations mapped in cents:

	6	P5	P4	S5	S3	P3	P2	S2	P1	S1	P7	6
6	**1206**	155	253	259	498	559	702	734	839	939	1062	0
p5	1051	**1206**	98	104	343	404	547	579	684	784	907	155
p4	953	1108	**1206**	6	245	306	449	481	586	686	809	253
s5	947	1102	1200	**1206**	239	300	443	475	580	680	803	259
s3	708	863	961	967	**1206**	61	204	236	341	441	564	498
p3	647	802	900	906	1145	**1206**	143	175	280	380	503	559
p2	504	659	757	763	1002	1063	**1206**	32	137	237	360	702
s2	472	627	725	731	970	1031	1174	**1206**	105	205	328	734
p1	367	522	620	626	865	926	1069	1101	**1206**	100	223	839
s1	267	422	520	526	765	826	969	1001	1106	**1206**	123	939
p7	144	299	397	403	642	703	846	878	983	1083	**1206**	1062
6	0	155	253	259	498	559	702	734	839	939	1062	**1206**

(p=*pelog*, s=*slendro*)

After working on this project, I began to also think of the importance of vertical harmonic relationships in writing for gamelan instead of considering only a strictly melodic or heterophonic perspective. I also began to notice harmonic ideas that could be expressed outside of *pathet* within *slendro* and *pelog* scales, and, consequently, possibilities that exist when combining both scales.

Even though I did the bulk of the work on the transcription and development of the tuning, none of this would have happened without the input, editing, and willingness to discuss issues and indulge in experimentation that Ben Brinner, Midiyanto (co-directors of Sari Raras), Ron Elliot, and Colin Fowler provided.

BEYOND THE SAFETY OF HARRISON'S SEPTIMAL JUST INTONATION

Although I felt that it was possible to perform the compositions I had written on a large number of gamelans, I needed to do more research into the tunings of existing gamelans to see if there was any actual substance to my beliefs. So, I turned to a collection of tunings of exceptional and historically important gamelans found in the book "Tone Measurements of Outstanding Javanese Gamelan in Jogyakarta and

Surakarta" (Wasisto Surjodiningrat, 1972). I entered all the tunings in cents into a spreadsheet to allow easier manipulation of the data (appendix 5). I also added tunings that I had collected for Udan Mas at UC Berkeley, Si Thomas at Cornish College of the Arts, Daniel Schmidt's Berkeley and Sonoma State gamelans, and Si Madeleine and Si Darius at Mills. This gave me 31 *slendro* tunings and 28 *pelog* tunings. I attempted to collect more tunings, but since the number received was too small to make any statistical difference, I have decided to leave them out.

There has also been a trend in the last 50 years to model new gamelans on existing sets, most notably the Radio Republik Indonesia gamelan. When I discussed what I was doing with Midiyanto, he informed me that a close look at active gamelans used worldwide would probably show less intervallic deviation than my research shows.

I want to point out at this time that I am in no way attempting to homogenize or create some sort of Javanese universal temperament. I am only attempting to share some commonalities and potentials that exist across most gamelans. I think of each instrument's *embat* as part of its character.

Even though every gamelan is tuned to itself (with the exception of a few American just tuned gamelans), there are a few features that remain pretty consistent. Pitch 6 in the middle octave of any given set used is somewhere between 430 and 500 Hz (a slightly flat A to a slightly flat C in western tuning). There are some relative intervallic constants as well, which help to define the prime relationships in *pathet*. For example, when I calculated the average interval in cents between pitches 1 and 5 in *slendro*, the average was 718 cents. On every gamelan I have played, the interval between 1 and 5 has always sounded like a fifth. The most extreme example in the

tunings used was 744 cents. Keep in mind, this tuning is the anomaly. When dropping the two highest and two lowest tunings of the thirty *slendro* tunings used, the average jumps down to 715 cents.

For the sake of this study, when I am speaking of using both *pelog* and *slendro* tunings of a gamelan, I am referring to gamelans with a *tumbuk* 6. *Tumbuk* is a pitch that is shared between the two scales. Most gamelans in regular use have a *tumbuk* 6. Exceptions to this are mostly very old temple gamelans used only for special occasions and limited repertoire.

It is also good to keep in mind that on most *tumbuk* 6 gamelans, *pelog* 4 and *slendro* 5 can be considered the same pitch. Daniel Schmidt's American gamelan tuning utilizes the closeness of these pitches to make for a more portable set of instruments, where one set is built, and keys are swapped to change tunings. On *tumbuk* 6 gamelans that were measured, the biggest interval between *slendro* 5 and *pelog* 4 is 40 cents, with the average balancing out to around 17 cents.

Going forward, I will refer to pitches by their cipher notation name. When necessary for clarification, I will use "s" before the numeral to indicate that a pitch is in *slendro*, and "p' to indicate *pelog*. I will refer to the intervals between pitches using western terms. For example, s1 to s5 is a fifth. p1 to p5 is also a fifth. I may also use cents to show distance between pitches. If an interval tends to be flatter on average, I will refer to it as "dark". If it is sharper on average, I will call it "bright". If an interval tends to fall in the middle of what would be a western major or minor interval, I will refer to it as "neutral".

Before I move further, it is important to explain a bit more about *pathet,* rather than simply reducing it to the concept of mode as I did in the introduction. Defining *pathet* as mode is problematic for a deeper understanding of traditional Javanese gamelan music since *pathet* affects how the elaboration part for any specific instrument can be realized in any given piece, and is determined more by the mood of the piece than by any *seleh* or gong tones. For example, although *pathet Sanga* could be said to focus on the relationship of pitches 2 and 5, there are plenty of pieces in that *pathet* that do not resolve to those pitches, thus blurring the concept of a modal center in *pathet* even further.

Since this approach to writing is not deeply fastened to the tradition, I will use *pathet* in *slendro* to describe a focus on key pitch relationships and the tendency of resolution towards one pitch, which will act like a root for harmonic structures. I will also show the harmonic potential of focus on pitches that are not ordinarily a tonic in traditional *pathet*. From here, we can look at intervallic relationships in each *pathet*, and begin to see which vertical harmonic possibilities are available. After expressing possibilities within one *laras*, I will show what is possible by combining both *laras* into a unified scale, using scales and chords available in both tunings. When the mode is similar to a traditional Javanese *pathet* I will use the traditional name. When it is a *pathet* not found in the tradition, or from some derivation of the two scales, I will focus on which pitch is being used as the tonal center.

Each example has two accompanying audio tracks; the first is played on an aluminum instrument tuned to the previously discussed Harrison tuning, and the second is played on a traditionally tuned bronze instrument from Udan Mas. I recorded the

aluminum tracks. The bronze tracks were assembled from recordings of individual pitches by Dan VanHassel.

SLENDRO

Here is a chart that shows the average distance in cents between pitches in *slendro* of all gamelans surveyed.

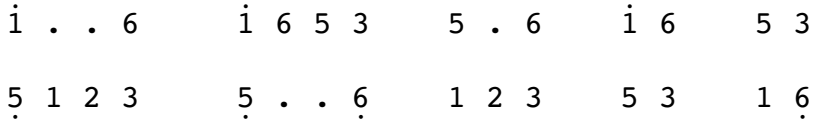
	6	**5**	**3**	**2**	**1**	**6**
6	**1213**	243	490	729	961	0
5	970	**1213**	247	486	718	243
3	723	966	**1213**	239	471	490
2	484	727	974	**1213**	232	729
1	252	495	742	981	**1213**	961
6	0	243	490	729	961	**1213**

Pathet Manyura emphasizes the relationship between pitches 6, 2, and 3. Pitches 2 and 3 both have a strong fourth or fifth relationship to 6. Pieces in *Manyura* normally resolve to pitch 6, so the fifth from 6 to 3 feels dominant.

Here are intervals in *slendro* in relation to pitch 6:

6 to 1 Bright 2nd, dark minor 3rd - 252 cents
6 to 2 Dark 4th - 484 cents
6 to 3 Bright 5th – 723 cents
6 to 5 Dark minor 7th – 970 cents

Here are some 2-part cadences to 6 and 3 (tracks 1 and 2):



Here are some samples of 3-part cadences to 6 and 3 (tracks 3 and 4):

5 6 5 . 6 5 . 6

3 3 3 . 3 3 . 3

1 ṗ 1 2 . 1 2 ṗ

Pathet Sanga emphasizes the relationship between pitches 5, 1, and 2. Pitches 1 and 2 both have a strong fourth or fifth relationship to 5. Pieces in *Sanga* tend to resolve to pitch 5, so the fifth from 5 to 2 feels dominant.

Here are intervals in *slendro* in relation to pitch 5:

5 to 6	Bright major 2nd - 243 cents
5 to 1	4th - 495 cents
5 to 2	Bright 5th - 727 cents
5 to 3	Minor 7th - 966 cents (almost a 7:4 just 7th)

Here are some 2-part cadences to 5 and 2 (tracks 5 and 6):

3 . 2 6 5 3 2 3 5 3 . 2 . 2 2 . 5

ṗ 1 ṗ 3 2 ṗ ṗ 1 2 1 ṗ ṗ 1 ṗ ṗ 3 2

Here are some 3-part cadences to 5 and 2 (tracks 7 and 8):

6 i̇ ȧ 3 5 i̇ ȧ i̇ ȧ

3 . 5 1 2 6 5 6 5

1 . 2 ṗ ṗ 3 5 3 2

Using 3 as a tonic for vertical harmony doesn't work well. There is no 5th above to give it any gravity.

Pathet Nem emphasizes the relationship between pitches 2, 5, and 6. Pitches 5 and 6 have a strong fourth or fifth relationship to 2. Pieces in *Nem* tend to resolve to pitch 2, so the fifth from 2 to 6 feels dominant. Here are intervals in *slendro* in relation to pitch 2:

2 to 3	Bright major 2nd - 239 cents
2 to 5	Dark 4th - 486 cents
2 to 6	Bright 5th - 729 cents
2 to 1	Dark minor 7th - 981 cents

Here are some 2-part cadences to 6 and 2 (tracks 9 and 10):

i 6	5 6	i . 6	1 2	5 3 2	5 2
5 2	1 2	5 1 2	5̣ 6̣	1 . 6̣	1 6̣

Here are some 3-part cadences to 6 and 2 (tracks 11 and 12):

5 6	i 2̇	3 .
3 2	5 6	1 2
1 6̣	3 2	5̣ 6̣

What we can begin to see is that the intervallic spacing of *slendro*, although not an equal division of the octave, is pretty close to an even 250 cents between pitches. Intervallically, the distance between any given pitch to others maintains very similar proportions. However, we can also see that *Manyura* has the biggest leap from the pitch it usually centers around to the second pitch. *Nem* has the smallest leap from its central pitch to its ascending neighbor and the smallest distance to its lower neighbor. Fifths and fourths remain pretty consistent between *pathet*.

Pitch 1 - We can also consider pitch 1 a tonal center, with 5 acting as its fifth. There is a strong relationship between 1 and 3 that, depending on the gamelan, can function as a fourth, or a major third, or both.

Here are intervals in *slendro* in relation to pitch 1:

1 to 2 Bright major 2nd - 232 cents
1 to 3 Dark 4th - 471 cents
1 to 5 Bright 5th - 718 cents
1 to 6 Dark minor 7 – 961 cents

Here are some 2-part cadences to 5 and 1 (tracks 13 and 14):

6 5 3 5 6 5 5 5 5 5

2 1 6̣ 1 3 2 1 2 1 3 2 1

Here are 3-part cadences to 5, 1; and 5, 3, and 1 (tracks 15 and 16):

6 i̇ 2̇ i̇ 3 5 6 5 6 5

3 5 3 5 2 1 3 3 2 3

2 1 6̣ 1 6̣ 5̣ 1 1 1 1

Here are some 2-part cadences, and one 3-part cadence to 3 and 1 (track 17 and 18):

2 3 5 3 5 3

6̣ 1 2 1 2 .

1 1

PELOG

There will be no comparison to *pathet* for *pelog*, as *pathet* gets even more mercurial in this *laras* to the point that using any pitch as a tonal center for any *pathet* is

far too misleading. Here is a chart that shows the average distance between pitches in cents in *pelog* of all gamelans surveyed.

	6	5	4	3	2	1	7	6
6	**1213**	111	235	526	663	787	1045	0
5	1102	**1213**	124	415	552	676	934	111
4	978	1089	**1213**	291	428	552	810	235
3	687	798	922	**1213**	137	261	519	526
2	550	661	785	1076	**1213**	124	382	663
1	426	537	661	952	1089	**1213**	258	787
7	168	279	403	694	831	955	**1213**	1045
6	0	111	235	526	663	787	1045	**1213**

Pitch 1 - If we use pitch 1 as a tonal center, there is a strong fifth relationship between 1 and 5, and a minor third between 1 and 3. The relationship of 1 and 6 will be explored with 6 as a tonal center.

1 to 2 Bright minor 2nd - 124 cents
1 to 3 Dark minor 3rd - 261 cents
1 to 4 Bright 4th (a low tritone) - 552 cents
1 to 5 Dark 5th - 676 cents
1 to 6 Dark minor 6th - 787 cents
1 to 7 Dark minor 7th - 955 cents

Here are some 2-part cadences to 5 and 1 (tracks 19 and 20):

```
4  5      4  5      4    5      6  5      6    5
3  1      2  1      3  2  1      2  1      3  2  1
```

Here are some 2-part cadences to 3 and 1 (tracks 21 and 22):

```
2  3      5  3      4  3      4  3      2  3
7̇  1      2  1      2  1      7̇  1      .  1
```

Here are some 3-part cadences to 5, 3, and 1 (tracks 23 and 24):

```
6   5     4 5     4 5     4 5     6 5     6 5     6 5
4 . 3     2 3     3 3     2 3     3 3     3 3     . 3
3 2 1     7̇ 1     7̇ 1     . 1     7̇ 1     1 1     2 1
```

Pitch 2 doesn't seem to make a good tonal center for my taste. Its location in the *laras* tends to go to 1 or 3. The fifth between 2 and 6 tends to be too flat to feel really stable. The fourth between 2 and 5 can feel too much like a tritone. I consider any cadence with pitch 2 in its final chord to be a half cadence.

2 to 3	Bright minor or neutral 2nd - 137 cents
2 to 4	Bright major 3rd - 428 cents
2 to 5	Bright 4th (kind of a tritone) - 552 cents
2 to 6	Dark 5th - 663 cents
2 to 7	Bright minor 6th - 831 cents
2 to 1	Pretty much a major 7th - 1089 cents

Here are some 2-part half cadences to 2 and 5 (tracks 25 and 26):

```
4 5       4 5       3 5       3 4 5       6 5       6 5       6   5
3 2       1 2       1 2       1   2       3 2       7̇ 2       7̇ 1 2
```

Here are some 2-part cadences to 2 and 4 (tracks 27 and 28):

```
5 4       3 4       5 4
3 2       1 2       1 2
```

Pitch 3 - There is a very strong fifth relationship between pitches 3 and 7, and a strong third between 3 and 5. A convincing major chord can be played combining all these notes. The relationship of 3 and 6 will be explored with 6 as the tonal center.

3 to 4 Minor 3rd - 291 cents
3 to 5 Bright major 3rd - 415 cents
3 to 6 Bright 4th (almost an 11:8 tritone) - 526 cents
3 to 7 Dark 5th - 694 cents
3 to 1 Bright 6th - 952 cents
3 to 2 Dark major 7th - 1076 cents

Here are some 2-part cadences to 7 and 3 (tracks 29 and 30):

i 7	6 7	4 7	6 7	i 7	6 7
5 3	2 3	2 3	4 3	5 4 3	1 2 3

Here are some 2-part cadences to 5 and 3 (tracks 31 and 32):

6 5	4 5	6 5	7 5	7 5
2 3	2 3	4 3	3 3	4 3

Here are some 3-part cadences to 7, 5, and 3 (tracks 33 and 34):

6 7	i 7	i 7	i 7
4 5	5 5	6 5	4 5
2 3	2 3	4 3	2 3

Pitch 4 is inherently unstable in this *laras*, so I will not explore its potential as a tonal center at this time. However, its role as a pivot between the *laras* will be seen in the next section.

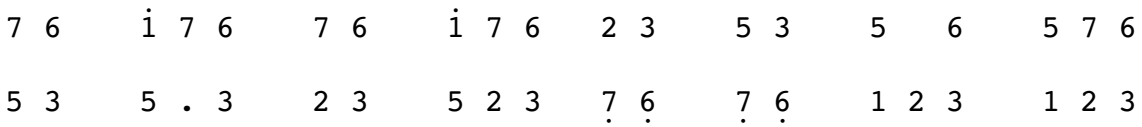
Pitch 5 - I feel that pitch 5 does not work too well as a tonal center, due to the fifth between 2 and 5 being too flat. It has the same issue as using 2 as a tonal center presents above. Here are the intervals in relation to pitch 5:

5 to 6 Minor 2nd - 111 cents
5 to 7 Dark minor 3rd - 279 cents
5 to 1 Bright 4th (kind of a tritone) - 537 cents
5 to 2 Dark 5th or tritone- 661 cents
5 to 3 Minor 6th - 798 cents
5 to 4 Pretty much a major 7th - 1089 cents

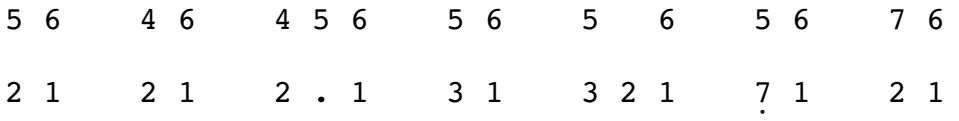
Pitch 6 - If we use 6 as a tonal center, we have a strong fifth between pitches 6 and 3, and a major third between 6 and 1. Here are the intervallic relationships using 6 as a tonal center:

6 to 7 Dark major 2nd - 168 cents
6 to 1 Bright major 3rd - 426 cents
6 to 2 Bright 4th (kind of a tritone) - 550 cents
6 to 3 Dark 5th - 687 cents
6 to 4 Dark minor 7th - 978 cents
6 to 5 Pretty much a major 7th - 1102 cents

Here are some 2-part cadences to 6 and 3 (tracks 35 and 36):



Here are some 2-part cadences to 6 and 1 (tracks 37 and 38):



Here are some 3-part cadences to 6, 3, and 1 (tracks 39 and 40):

5 6 5 6 6 6 7 6

2 3 3 3 4 3 4 3

$\dot{7}$ 1 1 1 2 1 2 1

Pitch 7 - If we use 7 as a tonal center, we have a strong major third between 7 and 2.

7 to 1 Dark minor 2nd - 258 cents
7 to 2 Major 3rd - 382 cents (almost a 5:4 just 3rd)
7 to 3 Bright 4th - 519 cents
7 to 4 Minor 6th - 810 cents (almost an 8:5 just minor 6th)
7 to 5 Bright major 6th, or Dark minor 7th – 934 cents
7 to 6 Dark major 7th or bright minor 7th - 1045 cents

Here are some cadences to 7 and 2 (tracks 41 and 42):

3 2 1 2 4 2 5 3 2 4 2

1 $\dot{7}$ $\dot{6}$ $\dot{7}$ 1 $\dot{7}$ 1 . $\dot{7}$ $\dot{6}$ $\dot{7}$

MIXED *LARAS*

The following unified scale is derived from taking the average distance between intervals in both *Pelog* and *Slendro* from a collection of approximately 25 gamelans and presenting them as a unified scale.

	6	P5	P4	S5	S3	P3	P2	S2	P1	S1	P7	6
6	**1213**	111	235	243	490	526	663	729	787	961	1045	0
p5	1102	**1213**	124	132	379	415	552	618	676	850	934	111
p4	978	1089	**1213**	8	255	291	428	494	552	726	810	235
s5	970	1081	1205	**1213**	247	283	420	486	544	718	802	243
s3	723	834	958	966	**1213**	36	173	239	297	471	555	490
p3	687	798	922	930	1177	**1213**	137	203	261	435	519	526
p2	550	661	785	793	1040	1076	**1213**	66	124	298	382	663
s2	484	595	719	727	974	1010	1147	**1213**	58	232	316	729
p1	426	537	661	669	916	952	1089	1155	**1213**	174	258	787
s1	252	363	487	495	742	778	915	981	1039	**1213**	84	961
p7	168	279	403	411	658	694	831	897	955	1129	**1213**	1045
6	0	111	235	243	490	526	663	729	787	961	1045	**1213**

When we combine both *laras,* we can develop new modes and chords not available in the material above. There is even the possibility of modal modulation. With each tonal center, I will provide a few examples of possible modes, and cadences within those modes. It is important to mention that certain pitches and modes may work better on some gamelans than others. Pitches p3 and s3 are often within 50 cents of each other; which makes them very useful as pivots between *laras*. This is applicable with pitch 6 and pitches s5 and 4 as well.

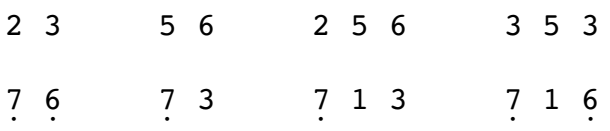
Pitch 6 - Here are the intervals in relationship to pitch 6:

6 to 7	Neutral 2nd, or dark minor 2nd – 168 cents
6 to s1	Dark minor 3rd – 252 cents
6 to p1	Bright major 3rd – 426 cents
6 to s2	Dark 4th – 484 cents
6 to p2	Bright 4th (kind of a tritone) – 550 cents
6 to p3	Dark 5th – 687 cents
6 to s3	Bright 5th – 723 cents
6 to 4/s5	Dark minor 7th – 970 to 978 cents
6 to p5	Pretty much a major 7th – 1102 cents

There are some nice modes that can be found with 6 as a tonic. Some are simply found by adding or swapping one pitch from *pelog* to *slendro*. For example, this is a very minor feeling mode (tracks 43 and 44):

6 7 s1 s2 s3 s5 6.

Here are a few 2-part cadences to 6 and 3 using this mode (tracks 45 and 46):



Here are some 3-part cadences to 6, 3, and 1 (tracks 47 and 48):

5 6 5 3 5 6

2 3 2 1 3 3

7̇ 1 7̇ 6 7̇ 6

Swapping pitch s5 with p5 produces a nice pentatonic scale with a major 7th (tracks 49 and 50): 6 s1 s2 s3 p5 6

Here are some 2-part cadences using this mode (tracks 51 and 52):

5 6 5 3 5 6

1 2 1 6̇ 1 3

Here is a cadence to 6, 1, 3, and 5; which makes a nice major 7th chord (tracks 53 and 54):

5 5

2 3

1 1

. 6̇

Swapping two pitches can provide some interesting results as well. Swapping s1 and s2 with p1 and p2 produces a nice major mode akin to Lydian (tracks 55 and 56):

6 p1 p2 s3 s5 6

Here are a few 2 part cadences to 6 and 3 (tracks 57 and 58):

5 6 6 5 6 5 . 3

2 3 2 1 3 2 1 6̇

Pitch 7 – Here are the intervals in relation to pitch 7:

7 to s1	Dark minor 2nd - 84 cents
7 to p1	Dark minor 3rd - 258 cents
7 to s2	Bright major 3rd - 316 cents
7 to p2	Dark major 3rd - 382 cents
7 to p3	Bright 4th - 519 cents
7 to s3	Tritone - 555 cents
7 to s5/4	Minor 6th – 802 or 810 cents
7 to p5	Bright major 6th - 934 cents
7 to 6	Neutral 7th – 1045 cents

There is an interesting mode that can be used by using *pelog* and swapping p1 with s1 (tracks 59 and 60):

7, s1, p2, p3, 4, 6.

Here are some 2-part cadences to 7 and 3, and some to 7 and 4 (tracks 61 and 62):

4 3 6 7 2 3 3 4 6 4 6 3 4 2 3 4

1 $\dot{7}$ 1 3 1 $\dot{7}$ 1 $\dot{7}$ 2 $\dot{7}$ 2 1 $\dot{7}$ 1 . $\dot{7}$

Here are some 3-part cadences to 7, 4, and 3 (tracks 63 and 64):

6 4 6 4 4 4 4 4

2 3 3 3 2 3 3 3

1 $\dot{7}$ 1 $\dot{7}$ 1 $\dot{7}$ 1 $\dot{7}$

Adding p5 creates interesting supporting harmonic ground for this mode, allowing more chord possibilities, and a modulation to a major chord: (tracks 65 and 66):

4 4 6 5

3 2 3 3

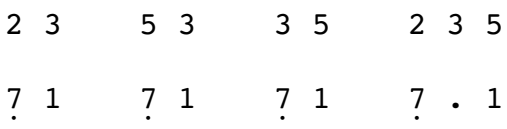
$\dot{7}$ 1 1 $\dot{7}$

Pitch s1 – Here are the intervals in relation to pitch s1:

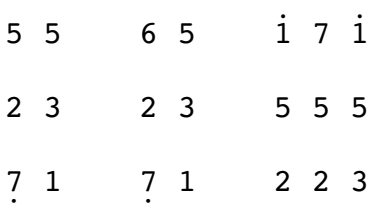
S1 to p1	Dark major 2nd - 174 cents
S1 to s2	Bright major 2nd - 232 cents
S1 to p2	Minor 3rd - 298 cents
S1 to p3	Bright major 3rd - 435 cents
S1 to s3	Dark 4th - 471 cents
S1 to s5/4	Bright 5th – 718 or 726 cents
S1 to p5	Minor 6th – 850 cents
S1 to 6	Bright major 6th or Dark minor 7 - 961 cents
S1 to 7	Bright Major 7th – 1129 cents

Adding 7 from *pelog* to *slendro* (tracks 43 and 44) gives us a nice major 7th to work with.

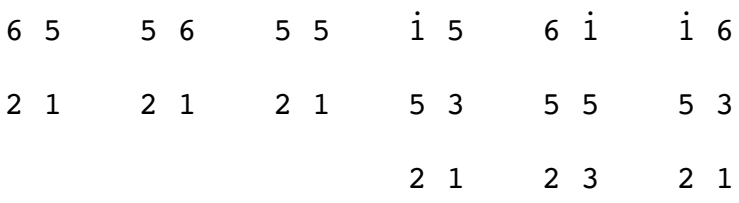
Here are some 2 part cadences to 1and 3, and to 1 and 5 (tracks 67 and 68):



Here are some 3-part cadences to 1, 3, and 5 (tracks 69 and 70):



Adding p2 gives us a nice minor 3rd to work with. Here are some 2 and 3-part cadences utilizing that minor 3rd (tracks 71 and 72):



Pitch p1 - Here are the intervals in relation to pitch p1:

P1 to S2	Very dark minor 2nd - 58 cents
P1 to P2	Bright minor 2nd - 124 cents
P1 to P3	Very dark minor 3rd - 261 cents
P1 to S3	Minor 3rd – 297 cents
P1 to S5/4	Tritone or very bright 4th – 544 or 552 cents
P1 to P5	Dark 5th – 676 cents
P1 to 6	Dark minor 6th – 787 cents
P1 to 7	Bright major 6th or Dark minor 7 - 955 cents
P1 to P1	Bright minor 7th – 1039 cents

I don't think there are many interesting pitch swaps to be made when using p1 as a tonic. The one that can be a bit interesting is to swap 7 with s1. We can do this with all the p1 cadences that are provided in the *pelog*.

Here are some 2 and 3-part cadences using s1 in place of 7 (tracks 73 and 74):

```
 2 3      4  3

s1 p1    s1 p1


 4 5      4  5      6 5

 2 3      3  3      3 3

s1 p1    s1 p1    s1 p1
```

Even so, when used in vertical harmony, using s1 is not that different from how 7 functions. Melodically, it does create some nice chromatic movement. For example (tracks 75 and 76):

```
p1 s1 7

 6  . 5
 .    .
```

Pitch s2 - Here are the intervals in relation to pitch s2:

S2 to p2	Really dark minor 2nd - 66 cents
S2 to p3	Major 2nd - 203 cents
S2 to s3	Bright major 2nd - 239 cents
S2 to s5/4	Dark 4th - 486 or 494 cents
S2 to p5	Tritone - 618 cents
S2 to 6	Bright 5th - 729 cents
S2 to 7	Major 6th - 897 cents
S2 to s1	Dark minor 7th - 981 cents
S2 to p1	Dark major 7th - 1155 cents

If we take *slendro* and swap out s1 with p1, all examples from the *slendro 2 section* work.

Here are some 2-part cadences to 6 and 2 (tracks 77 and 78):

1̇ 6	5 6	1̇ . 6	1 2	5 3 2	5 2
5 2	1 2	5 1 2	5̣ 6̣	1 . 6̣	1 6̣

Here are some 3-part cadences to 6 and 2 (tracks 79 and 80):

5 6	1̇ 2̇	3 .
3 2	5 6	1 2
1 6̣	3 2	5̣ 6̣

Pitch p2 - Here are the intervals in relation to pitch p2:

P2 to p3	Bright minor 2nd - 137 cents
P2 to s3	Dark major 2nd - 173 cents
P2 to s5/4	Bright major 3rd - 420 or 428 cents
P2 to p5	Tritone or very bright 4th – 552 cents
P2 to 6	Dark 5th – 663 cents
P2 to 7	Bright minor 6th – 831 cents
P2 to s1	Bright major 6th – 915 cents
P2 to p1	Major 7 - 1089 cents
P2 to s2	Very bright major 7th – 1147 cents

Much as in *pelog*, p2 doesn't have enough gravity to feel like a tonal center to me. No matter how I mix up pitches, it wants to go to p1, s1, p3, s3, or 7.

Pitch p3 - Here are the intervals in relation to pitch p3:

P3 to s3	Very dark minor 2nd - 36 cents
P3 to s5/4	Dark minor 3rd - 283 or 291 cents
P3 to p5	Bright major 3rd - 415 cents
P3 to 6	Bright 4th – 526 cents
P3 to 7	Dark 5th – 694 cents
P3 to s1	Dark minor 6th – 778 cents
P3 to p1	Very bright major 6th – 952 cents
P3 to s2	Minor 7 - 1010 cents
P3 to p2	Dark major 7th – 1076 cents

We can use *pelog,* and swap out p1 with s1. All examples from the *pelog* 3 section above work in this fashion. If we swap p2 with s2, we get the following mode (tracks 81/82): p3, 4, p5, 6, 7, s1, s2.

All examples from the *pelog* 3 section work with this mode as well. In fact, all examples from *pelog* 7, 6, and 1 work. This is basically an alternative form of *pelog*. Here are a few examples to show how this would sound (tracks 83/84):

6 3 4 5 7 6 6 . 5 6 . 7

2 1 $\dot{7}$ 1 2 3 3 2 1 1 2 3

6 5 5 6

3 3 3 3

$\dot{7}$ 1 1 1

Pitch s3 - Here are the intervals in relation to pitch s3:

S3 to s5/4	Bright major 2nd or dark minor 3rd – 247 or 255 cents
S3 to p5	Dark major 3rd – 379 cents
S3 to 6	Dark 4th - 490 cents
S3 to 7	Tritone or dark 5th – 658 cents
S3 to s1	Very bright 5th – 742 cents
S3 to p1	Bright major 6th – 916 cents
S3 to s2	Dark minor 7 – 974 cents
S3 to p2	Bright minor 7 - 1040 cents
S3 to p3	Very bright major 7th – 1177 cents

I feel that s3 is so close to p3 that there is no significant harmonic difference to talk about. We can swap out p3 with s3 with the scales and cadences mentioned for p3 for a subtle variant.

Pitch s5 - Here are the intervals in relation to s5 (4):

S5 to p5	Minor 2nd feel - 132 cents
S5 to 6	"Bright" major 2nd - 243 cents
S5 to 7	Major 3rd – 411 cents
S5 to s1	4th - 495 cents
S5 to p1	"Dark" 5th - 669 cents
S5 to s2	"Bright" 5th - 727 cents
S5 to p2	Minor 6th - 793 cents
S5 to p3	"Bright" major 6th - 930 cents
S5 to s3	Super flat minor 7th - 966 cents

We can swap out s1 with p1, and all examples from the *slendro* 5 *Pathet Sanga* section will work.

Here are some 2-part cadences to 5 and 2 (tracks 85 and 86):

3 . 2 3 5 3 . 2 . 2 2

6 1 5 1 2 1 6 5 1 6 5

Here are some 3-part cadences to 5 and 2 (tracks 87 and 88):

6 i̇ ż	3 5	i̇ ż	i̇ ż
3 . 5	1 2	6 5	6 5
1 . 2	6̣ 5̣	3 5	3 2

Adding 7 to *slendro* makes a major scale with a very flat 7th or very sharp 6th (depending on the gamelan, and your ears that day). Here is a very nice 3-part cadence resulting from that addition (Tracks 89 and 90):

3 2
1 7
6 5̣

Pitch p5 - Here are the intervals in relation to p5:

P5 to 6	Minor 2nd - 111 cents
P5 to 7	Dark minor 3rd - 279 cents
P5 to s1	Dark major 3rd - 363 cents
P5 to p1	Bright 4th - 537 cents
P5 to s2	Tritone - 595 cents
P5 to p2	Dark 5th - 661 cents
P5 to p3	Minor 6th - 798 cents
P5 to s3	Dark major or neutral 6th - 834 cents
P5 to s5/4	Minor 7th – 1081 or 1089 cents

Even when adding more pitches to the mix, I have the same reservations as before about using p5 as a tonic. The fifth is simply not strong enough to have the gravity needed to really feel like home.

Pivoting between laras - We can use the very strong proximity of 4 and s5, and the strong proximity of p3 and s3 on most gamelans to act as a pivot between *laras*. Play the following *gatra* in *pelog* (tracks 91 and 92):

3 5 6 5

1 2 3 3

Now play the same *gatra,* but play the first two beats in *slendro*. By doing this, we are using the similar pitches (s5 and p5, s3 and p3, tumbuk 6) to pivot between *laras*. Here are two examples of *gatra* that can switch from *slendro* to *pelog* and back on the second beat (tracks 93 and 94):

p3 p5 6 s5 s3 s5 6 p5 6 p5 s3 s3 6 s5 p3 p3

p1 p2 s3 s3 s1 s2 p3 p3 p3 p2 s1 6̇ s3 s2 p1 6̇

Something that should be noted about mixing *pathet* is that it is difficult to switch between the instruments. One should always consider the logistics of how the piece will be performed when writing in this fashion. It is best to attempt never to have a performer playing more than one line of material. I highly recommend segregating parts so that individual players can stay on one instrument without switching *laras*. This can get cumbersome when writing 3-part harmonies, but will ultimately be easier for players used to performing traditional material.

It also poses challenges for instruments performing *garapan* (plural of *garap),* which are melodic elaborations based on *lagu* (melody) either presented in the *balungan*, or implied by the piece as a whole. An understanding of the limitations of instruments performing *garap* should be considered. For example, there are 2 pelog *genders* in a set

of instruments. One has pitch 7, and no pitch 1. The second *gender* is the opposite; it has pitch 1 and no pitch 7. Neither have pitch 4. Thorough consideration of *garap* to be used should be made, and noted for the performers if necessary.

DENOUEMENT

So that's it. Looking beyond the traditional approaches allowed me to see other methods that could be utilized in the composition of music for Javanese gamelan. Through an understanding of the tradition and a deeper study of tunings and scales, I have presented a method that—although a radical departure from the traditional heterophonic nature of the music—can be used to generate new music utilizing vertical harmonic properties. When we make friends with our fuzzy intervals, they don't sound so threatening, or brash, or out of tune. They sound like the voice of the gamelan making the fuzzy intervals. When we let any gamelan be itself, we can let it sing these parts with its own *embat* - its own fuzzy intervals. It isn't necessary to create specialized instruments, as the general idea will still be retained, even if the accent changes.

The next step in elaborating and testing this approach is to compose pieces that use 3-part vertical harmony in *slendro, pelog,* and mixed *laras*. A series of pieces using traditional short forms that stay focused on each tonal center should be composed as well. Figuring out solutions for *garapan* through these compositions will help produce materials and methods that can be applied to future works. Finally, finding ways to get the pieces played and recorded on other gamelans would be greatly beneficial, as that is where the system will truly be tested.

It also seems vital to update the work of Surjodiningrat. Gamelan is a living music that is constantly changing and evolving, and, as previously mentioned, many gamelans measured by Surjodiningrat are not gamelans that would be used for new music. I think it would be incredibly beneficial to measure the tunings of gamelans currently in active use around the globe with the same methods Surjodiningrat used.

Suhirdjan recently passed away. He was one of the best modern builders of central Javanese gamelan, and his instruments have spread across the globe. It would be prudent to measure and document those instruments and their tunings before they go too far out of use or lose their tuning.

I hope others will find this to be a functional tool and aid in the composition of pieces for gamelan. If we keep in mind that each gamelan will have its own personality quirks when it comes to tuning, there is the possibility of utilizing vertical harmonic ideas in composing for the instruments. We don't have to be afraid of different tunings causing massive changes to the quality of a piece, if we are aware of where the significant changes occur, and allow the character of the instruments to enhance our compositional practice.

GLOSSARY

Balungan – is a skeletal melody that provides a frame for other instruments to build their parts from.

Bubaran – traditional form comprised of 8 beats per *gongan,* with *kenongan* every 2 beats.

Circled beat – beat where gong *ageng* is played.

Demung – lowest pitched member of the *saron* family that normally plays the *balungan*.

Dot above or below scale number – indicates an octave above or below the middle register. 2 dots represent 2 octaves.

Ellipsis above, open end up – beat where the *kempul* is struck.

Ellipsis above, open end down – beat where the *kenong* is struck.

Ellipsis above and below – beat where gong *suwuk* is played.

Embat – interval. It can also refer to the intervallic relationships of an entire set of instruments.

Gamelan – a set of instruments mostly made up of pitched keyed metallophones and gongs. Sometimes the word *gamelan* is used to refer to the type of music played upon the instruments, although a more accurate word to use when referring to the music is *karawitan*.

Garap – melodic elaboration phrases played over the balungan. Phrases are determined by the *balungan*, *pathet*, and other factors.

Gatra – grouping of beats within a *gongan*. Normally, there are 4 beats in a *gatra,* with the strong beats being the second and fourth.

Gerong – male choir. Typically singing in unison.

Gong ageng – largest gong. Used to signify the end of full cycles of the *balungan* in the piece.

Gong suwukan or Gong Suwuk – large pitched gongs lower than *kempul* that mark the end of a grouping of *kenongan*.

Gongan – entire phrase leading up to a gong stroke.

Irama – concept of tempo in central Javanese music. *Irama* determines the general speed at which the *balungan* is moving, and how much space instruments performing *garapan* must fill.

Kempul – hanging low-pitched gongs that help mark the colotomic structure of the piece.

Kenong – large pot gong with a sharp attack that helps mark the colotomic structure of the piece. The phrases of the *balungan* between points where the kenong are struck are called *kenongan*.

Kenongan – subdivisions of a *gongan* phrase that lead to *kenong* strokes.

Kepatihan – system of cipher notation used for central Javanese gamelan.

Ladrang – traditional form comprised of 32 beats per *gongan,* with *kenongan* every 8 beats.

Lancaran – traditional form comprised of 16 beats per *gongan,* with *kenongan* every 4 beats.

Laras – scale. Central Javanese gamelan use two *laras; pelog* and *slendro*.

Lagu – melody.

Line(s) above pitches – indicates a subdivision of a beat in a *gatra*.

Pathet – simply defined as mode. Pathet is also related to time of day or stage of life. If we look at the slendro pathet, *Nem* is the morning and infancy, *Sanga is* midday and middle age, *Manyura* is evening and old age. *Pathet* helps to define how any elaboration in a piece is handled.

Peking – also known as *saron panerus* - highest pitched member of the *saron* family, which plays simple elaborations of the *balungan*. For example, the *peking* often doubles the pitch of the *balungan*, playing eight beats to a gatra instead of four.

Pelog – heptatonic scale represented in Kepatihan as 1,2,3,4,5,6, and 7.

Period – used to indicate a beat where no pitch is struck.

Rebab – two stringed bowed instrument that leads instruments playing *garap*.

Saron – family of metallophones with a sharp attack and relatively quick decay.

Saron Barung – middle register of the *saron* family, and is almost always referred to as *saron*. It normally plays the *balungan*.

Seleh – any strong beat. This could be a beat with a gong stroke, *kenong* stroke, or even the second or last beat of any *gatra*.

Slendro – pentatonic scale represented in Kepatihan as 1, 2, 3, 5, and 6. All intervals land somewhere between a major second and a minor third.

Slenthem – a metallophone characterized by its soft attack and long sustain. It normally plays the *balungan* with members of the *saron* family.

APPENDIX 1 – A Quick Javanese Gamelan Primer

The following provides basic information to help a reader uninitiated in Javanese gamelan to understand the material presented.

KEPATIHAN

Although originally an oral tradition, Javanese gamelan also uses a form of cipher notation called *Kepatihan*. There are two tunings in a full gamelan set. *Slendro* is a pentatonic scale represented in *Kepatihan* as 1,2,3,5, and 6. *Pelog* is a heptatonic scale represented in *Kepatihan* as 1,2,3,4,5,6, and 7. A dot below the scale number means that the pitch is in the octave below the central octave on any given instrument. Two dots below the scale number means two octaves below the central octave. A dot above denotes that it is in the octave above the central octave. Two dots above means two octaves above the central octave.

The concept of *pathet* is most simply explained as the idea of mode in Javanese music. This is an oversimplification of the overall concept, but it will work for this exploration. *Pathet* found in *pelog* break the scale down to 5-note modes.

A period is used to denote a rest. This is a bit of a misnomer, as the previous pitch rings through the period of the rest. However, the action of the player is to *not* sound a new note in that place, so it has been commonly taught as a rest.

Most commonly, phrases are grouped into 4-beat sections known as a *gatra*. The strong beats of a *gatra* are the second and fourth, with the fourth being the strongest. Gamelan is an end-weighted music. Phrases and elaborations all go to the last beat. This is echoed throughout the structure of pieces, with the final gong being the strongest point of the entire piece.

One can consider one beat in a *gatra* to be a quarter note in duration. If there is a line over the top of the notes indicates a subdivision of a beat. Subdivisions of the quarter note are written between the pitches, and can be tied to the quarter beat on either side. For example, the following two *gatra* are the same, although the line ties the middle beat differently.

6̄5̄3 2 1

6̄5̄3̄ 2 1

In my experience, most people are currently using the first of these examples. This clearly shows the duration of the pitches under the line. We know that pitches under the line only last an 8th of the *gatra*. The second example helps emphasize the end-weighted nature of the phrasing, but the second beat under the line lasts a 4th of the *gatra*. Further subdivisions add lines. For example, here is how one would notate an 8th note followed by two 16th notes:

6̄5̄3̄2 . 1

A dotted 8th feel can be created by adding a rest as the first beat of the 16th note subdivision:

6̄.5̄3̄ 2 1

INSTRUMENTATION

Instruments of a gamelan can be broken down into three categories; colotomic, *balungan*, and *garapan*. These categories describe their role in the music. Unless otherwise noted,

they are all a type of metallophone made most commonly of bronze or iron. American made gamelans like the ones built by Daniel Schmidt, Lou Harrison, and Bill Colvig are often made of aluminum.

Balungan instruments play the central melody of the piece. The most common *balungan* instruments are the lower-pitched instruments in the *saron* family, *saron demung* and *saron barung*. Informally, they are known as *demung* and *saron*. They have a sharp attack and relatively quick decay. The *balungan* is also commonly played by the *slenthem*, which is a lower-pitched instrument with a soft attack and long sustain.

Colotomic instruments are used to indicate key structural points within a piece of music. *Balungan* phrases can be broken into *gatra*, and are then marked by *kenong* and *kempul*. *Kenong* are large pitched kettle gongs that have a sharp attack, and *kempul* are medium sized pitched hanging gongs. Large gongs mark whole phrases. How these markers are spaced help to determine the form of the piece.

Notation for *kenong* and *kempul* are ellipses with the open end up for *kempul,* and open end down for *kenong* placed over the beat of the *gatra* where they take place. Gongs are marked as ellipses above and below to indicate gong *suwukan* (large pitched gongs, commonly abbreviated to gong *suwuk*), or a full circle around the final note to indicate gong *ageng* (great gong – largest and lowest pitched gong in the set).

Gatra with *kenong* marked: 6 5 3 $\overset{\frown}{2}$

Same *gatra* with *kempul* marked: 6 $\underset{\smile}{5}$ 3 2

Same *gatra* marked to indicate gong *suwuk*: 6 5 3 $\underset{\frown}{\overset{\frown}{2}}$

Same *gatra* marked to indicate gong *ageng*: 6 5 3 

There are a few short traditional forms that are helpful to know about, and help clarify the role of colotomic instruments. *Bubaran* is a form with 8 beats to a *gongan* with *kenong* at end of every *gatra*, and *kempul* on second beat of every *gatra*, except the first (this is left silent in deference to the greatness that is the gong). Every *gatra* has two beats. *Lancaran* has 16 beat *gongans* with 4 beats per *gatra*. It has the same *kenong* / *kempul* structure as *bubaran*.

Here are samples of *bubaran* and *lancaran* form showing the *balungan* and the colotomy:

Bubaran: 6 1 6 5 6 5 3 2

Lancaran: 3561 6535 1653 6532

GARAPAN

Garapan instruments utilize the *balungan* and other melodic material to determine elaboration patterns to play. I will not go into a thorough discussion of these instruments, or techniques. Samples included with this study will not use them. Examples of *garapan* can be heard on included recordings of pieces in Appendices 2 and 4.

APPENDIX 2 – Score for "Clear Day, Shimmering Water" (Track 95)

Clear Day, Shimmering Water – For just tuned gamelan, laras slendro
Derived from "Chance Resonance"

Let all balungan pitches ring.

A

[: 5 1 5 i . . 5 1 5 i . . 5 1 5 i ..
. . 5 1 5 i 5 1 5 1 5 i 5 1 5 (1) :] X 5

Last time: 5 6 5 (3) go to B

On second and fourth time, Saron plays:

5 1 5 i . . 5 1 5 i . . 5 1 5 i
. 561 5 5165651 1 1 151 1 1 1515

. . 5 1 5 i 5 1 5 1 5 i 5 1 5 (1)
1 6 123 2 3 235 1 2 653 .565321

B

[: 6 3 6 3 . . 6 3 6 3 . . 6 3 6 3
. . 6 3 6 3 6 3 6 3 6 3 6 3 6 3 (3) :] X4

Last time: 6 5 3 (2) Go to C

On second and third time Demung plays the following imbal (rests may be filled with preceding note):

6 3 6 3 . . 6 3 6 3 . . 6 3 6 3

3 3 3 3 3 3 3 3 6 3 6 3 6 6 6 6 6 6 6 6 3 6 3 3 6 6 3 3 6 6 3 3
2 5 2 5 . 5 2 5 5 . 5 5 . 1 1 . 1 5 5 1 5 . 5 2 5 . 5 5 5 5 5 5

. . 6 3 6 3 6 3 6 3 6 3 6 3 6 (3)

3 3 5 5 6 6 3 3 5 5 5 5 2 2 2 2 2 2 2 2 2 2 2 2 5 5 5 5 3 3 3 3
5 5 6 6 1 1 5 5 2 6 6 6 3 1 3 3 3 1 3 1 3 3 3 1 3 3 6 6 2 5 5 2

C

[: 6 2 6 2 . . 6 2 6 2 . . 6 2 6 2

. . 6 2 6 2 6 2 6 2 6 2 6 2 6 (2) :] X 4

Last time: 5 3 2 (1) slow to Irama II, go to D

On Second and third time, bonang imbal (2356), play to 6 on kempul, 2 to kenong and gong. Saron and Demung play the following:

6 2 6 2 . . 6 2 6 2 . . 6 2 6 2

. 256 2 6i65356 6 6 532 2 26532

. . 6 2 6 2 6 2 6 2 6 2 6 (2)

123 3 . 2321612 5 6 1216 5321312

D

[: 5 1 5 1 6 3 6 3 6 2 6 2 5 1 5 (1) :]

_____

Stephen Parris - October 2013

APPENDIX 3 – Score for "Devil Box" (Track 96)

Devil Box – Laras Pelog
for Lydia Martín

to be played on saron (preferably just tuned) with no muting, except where it seems reasonable for the character of the piece. It was written using a saron from the gift gamelan being built for Mills College by Daniel Schmidt and Mills students.

Tempo = 240 b.p.m. (approx.)

Marked repeats can be taken up to 4 times at player's discretion. Entire form (excluding finale) can be repeated at player's discretion.

Dynamics can change at repeats, but one repetition should be relatively loud. If resultant tones are not occurring, you are doing it wrong.

.

Saron – [: 7545 7545 7545 7545 (i)545 i545 i545 i545 :]

Slenthem – $\frac{\dot{7}}{4}$ $\frac{\dot{7}}{4}$ $\frac{\dot{i}}{5}$ $\frac{\dot{i}}{5}$

[: 6545 6545 6545 6545 (i)545 i545 i545 i545 :]

$\frac{6}{4}$ $\frac{6}{4}$ $\frac{\dot{i}}{5}$ $\frac{\dot{i}}{5}$

[: 7646 7646 7646 7646 (i)545 i545 i545 i545 :]

$\frac{7}{4}$ $\frac{7}{4}$ $\frac{\dot{i}}{5}$ $\frac{\dot{i}}{5}$

[: 2424 2424 2424 2424 (3)434 3434 3434 3434 :]

$\frac{4}{2}$ $\frac{4}{2}$ $\frac{4}{2}$ $\frac{4}{2}$

[: 7474 7474 7474 7474 (6)464 6464 6464 6464 :]

$\frac{7}{4}$ $\frac{7}{4}$ $\frac{6}{4}$ $\frac{6}{4}$

[: 7474 7474 7474 7474 (7)575 7575 7575 7575 :]

$\frac{7}{4}$ $\frac{7}{4}$ $\frac{7}{5}$ $\frac{7}{5}$

[: i4i4 i4i4 i4i4 i4i4 (i)5i5 i5i5 i5i5 i5i5 :]

$\frac{i}{4}$ $\frac{i}{4}$ $\frac{i}{5}$ $\frac{i}{5}$

last time:

i 6 4 6 i 6 4 6 i 6 4 6 i 6 4 6

$\frac{i}{6}$ $\frac{i}{6}$

i 6 i 6 i 6 i 6 i 6 i 6 i 6 i 6 (.) $\overline{757}$

$\frac{i}{6}$ $\frac{i}{6}$

Rall. . . . . .

_____

Stephen Parris – February 2014

APPENDIX 4 – Score for "In Light of a Proper Solution, an Unjust and Excessive Response" (Track 97)

In Light of a Proper Solution, an Unjust and Excessive Response
laras slendro and pelog

A: Sarons and gong only (rubato – pause between gatra)

Sl: 5 2i3 . 5 2 123 2 i 2 3 2 3 3 . 3.i 2 216 21612

Pl: .56 7 65.76 . 576 .77665575 4 7 67.i7 6 3 6 3 5

. 2 1 2 . 2 1 3 2 . 1 2 3 1 2 3 2 . 2 3 2 2 3 3

. 54565 . 5456576 5676655 77665544 . 456 5 456455

B: Buka sarons. Demungs on beat 2 and 4. Slenthems on beat 4. Demungs, slenthems, and peking split between pelog and Slendro.

Sl: . . . . i 5 3 2 . . . . 1 2 1 3

Pl: 7 5 7 5 . . . . 7 5 7 5 4 5 6 7

P5 S5 P5 S3 P5 6 P5

[: 3 3 3 3 i 5 3 2 3 3 3 3 1 2 1 3 Bonang imbal Pl: 2367

[: 7 5 7 5 4 7 6 5 7 5 7 5 4 6 5 7 Gong Sl. 1

P5 S5 P5 S3 P5 6 P5

3 3 3 3 i 5 3 2 3 3 3 3 1 2 1 3 Bonang imbal Pl: 2367

7 5 7 5 4 7 6 5 7 5 7 5 4 6 5 7

6 6 6 6 6 6 6

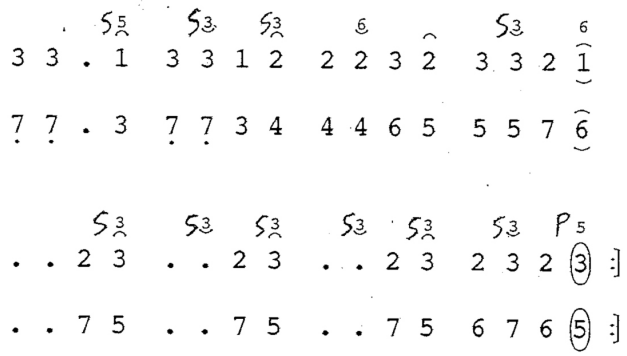
2 2 3 2 . . 3 2 3 i 3 2 . . . Bonang imbal Pl: 2356

6 6 5 6 . . 5 6 7 6 7 6 . . . Gong Sl. 2

6 6 6 6 6 6 6 6

2 2 3 2 . . 3 2 1 i 1 2 . . . Bonang imbal Pl: 2356

6 6 5 6 . . 5 6 7 6 7 6 . . .



Bonang imbal Pl: 2367

Gong Sl. 1

Bonang imbal Pl: 2367

Demung imbal for section B:

3.6.3.6. .5.7.7.7	i.i.6.3. .4.5.5.5	3.6.3.6. .5.7.5.7	i.3.i.6. .4.6.5.7
3.6.3.6. .5.7.7.7	i.i.6.3. .4.5.5.5	3.6.3.6. .5.7.5.7	i.3.i.6. .4.6.5.7
1.121.12 .ḍ...ḍ..	1.123.2. .ḍ...5.6	3.i.i.i. .7.6.7.6	2.1.2.1. .ḍ.ḍ.ḍ.ḍ
1.121.12 .ḍ...ḍ..	1.123.2. .ḍ...5.6	3.i.i.i. .7.6.7.6	2.1.2.1. .ḍ.ḍ.ḍ.ḍ
3.6.1.1. .2.7.2.3	1.1.2.2. .7.7.4.4	2.5.3.3. .4.4.2.5	3.3.2.1. .5.5.7.ḍ
3.6.3.6. .5.5.5.5	3.6.3.6. .5.5.5.5	3.6.3.6. .5.5.5.5	3.5.3.6. .6.7.5.5

Stephen Parris - Sept. 2014

APPENDIX 5 – Tunings of all gamelans measured, and intervals of interest.

Gamelan Tunings in cents - Slendro

name	Schmidt Gamelan	Mardiswara	Lokananta	Swarahardja	Nagalima	Kanjutmesem	Manisrengga	Lipurtambaneng	Konservatori Karawitan 1	Landung	Gam. GPH Tedjakusuma	Surak	Rarasrem	Sadadpengasih	Hardjawinangun
Location	Berkeley	Solo	Solo	Solo	Solo	Solo	Solo	Solo	Solo	Jogja	Jogja	Jogja	Jogja	Jogja	Solo
Pitch 6 in Hz	480	536	521	508	503	503	493	484	479	476	476	476	472	475	471
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
cents	231	243	249	257	232	235	240	251	236	242	234	250	230	248	244
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
cents	267	255	230	214	245	241	246	234	254	247	260	248	248	234	235
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
cents	204	234	259	255	232	238	250	254	225	248	228	239	238	250	250
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
cents	231	237	240	226	252	251	235	216	229	219	235	226	231	226	240
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
cents	267	242	244	254	244	259	244	246	256	275	267	255	259	248	256
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Stretch in cents	0	11	22	6	5	24	15	1	0	31	24	18	6	6	25

Intervals of interest

1 to 5	702	726	729	695	729	730	731	704	708	714	723	713	717	710	725
6 to 2	498	479	484	480	496	510	479	462	485	494	502	481	490	474	496
6 to 3	702	713	743	735	728	748	729	716	710	742	730	720	728	724	746
1 to 3	435	471	499	481	484	489	485	470	454	467	463	465	469	476	490
2 to 5	471	489	489	469	477	479	496	488	479	495	488	487	486	484	485

Pantjasona	Hardjanagara	Madumurti	Kodokogorek Kyahi Keboganggang	Udanriris	Tunggul	Konservatori Karawitan Gamelan 2	Konservatori Karawitan Gamelan 3	Gam. GPH Hangabehi	Pengawesari	Pusparana	Madukentir	Pretjet	Si Thomas	Udan Mas	Si Darius	AVERAGE
Jogja	Jogja	Jogja	Jogja	Solo	Jogja	Solo	Solo	Jogja	Jogja	Jogja	Jogja	Solo	Seattle	Berkeley	Oakland	AVERAGE
472	465	466	468	466	461	464	461	453	453	454	452	437	482	472	465	476
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
248	244	243	253	260	228	244	242	237	233	258	242	256	240	245	231	243
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
260	244	258	247	240	244	259	245	254	258	242	256	220	261	248	267	247
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
226	238	233	221	228	249	245	240	234	251	228	228	258	238	236	231	238
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
221	217	224	228	236	238	228	244	236	235	230	237	240	240	228	204	232
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
251	257	258	262	258	264	247	232	252	256	242	250	240	231	244	267	252
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	0	16	11	22	23	23	3	13	33	0	13	14	10	1	0	13.25

707	699	715	696	704	731	732	729	724	744	700	721	718	739	712	702	717.566667
472	474	482	490	494	502	475	476	488	491	472	487	480	471	472	471	484.533333
698	712	715	711	722	751	720	716	722	742	700	715	738	709	708	702	723.1
447	455	457	449	464	487	473	484	470	486	458	465	498	478	464	435	471.1
486	482	491	468	468	493	504	485	488	509	470	484	478	499	484	498	485.033333

Gamelan Tunings in cents - Pelog

name	Schmidt Gamelan	Mardiswara	Konservatori Karawitan 1	Hardjaswara	Kanjutmesem	Konservatori Karawitan Gamelan 2	Kadukmanis	Kantiilbelik	Radio Republik Indonesia	Landung	Siratmada	Semangigel	Gam. GPH Tedjakusuma	Manguahardja
Location	Berkeley	Solo	Solo	Solo	Solo	solo	Solo	Jogja	Solo	Jogja	jogja	Solo	Jogja	Solo
Pitch 6 in Hz	480	478	481	468	470	453	464	465	467	462	454	449	444	435
high 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
cents	182	273	240	217	245	234	256	272	280	281	236	256	268	298
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
cents	204	169	194	196	172	232	174	149	136	161	170	187	164	170
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
cents	112	112	115	103	114	87	132	120	127	112	135	116	88	102
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
cents	119	95	128	113	139	120	100	145	111	150	110	106	132	109
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
cents	267	308	272	281	272	270	316	267	321	278	292	301	284	309
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
cents	151	121	147	155	140	136	111	131	161	144	129	129	141	140
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
cents	165	130	121	135	141	113	143	125	81	103	134	122	117	127
low 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Stretch in cents	0	8	17	0	23	-8	32	9	17	29	6	17	-6	55

Intervals of interest

1 to 5	702	654	668	684	692	639	670	668	674	675	665	658	674	685
2 to 5	537	524	547	549	551	526	527	543	593	572	531	536	557	558
2 to 6	649	636	662	652	665	613	659	663	720	684	666	652	645	660
3 to 6	498	515	515	497	525	477	548	532	559	540	537	523	504	520
3 to 7	702	684	709	693	697	709	722	681	695	701	707	710	668	690
3 to 5	386	403	400	394	411	390	416	412	432	428	402	407	416	418

madukusuma	Radio Republik Indonesia	Pandji	Pantjasona	Hardjamulja	Konservatori Karawitan gamelan 3	Udanarum	Guntursari	Nagawilaga	Gunturmadu	Telegatmunjar	Si Thomas	Udan Mas	Si Madeleine	AVERAGE
Jogja	Jogja	Jogja	Jogja	Jogja	Solo	Solo	Jogja	Jogja	Jogja	Jogja	Seattle	Berkeley	Oakland	**AVERAGE**
437	435	429	432	430	432	411	335	331	304	425	482	476	465	**439**
1	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
280	260	306	248	261	256	255	308	291	340	260	186	223	231	**259**
7	7	7	7	7	7	7	7	7	7	7	7	7	7	**7**
141	148	158	161	161	124	176	149	170	132	179	203	144	173	**168**
6	6	6	6	6	6	6	6	6	6	6	6	6	6	**6**
106	102	87	95	100	142	108	101	124	94	99	109	155	94	**110**
5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
136	132	132	127	124	193	165	90	87	131	131	122	104	99	**123**
4	4	4	4	4	4	4	4	4	4	4	4	4	4	**4**
302	309	251	297	310	267	249	315	288	334	281	281	300	336	**291**
3	3	3	3	3	3	3	3	3	3	3	3	3	3	**3**
129	130	190	129	131	105	124	129	177	105	152	148	143	128	**138**
2	2	2	2	2	2	2	2	2	2	2	2	2	2	**2**
121	122	104	152	122	119	140	124	79	77	98	156	137	139	**123**
1	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
15	3	28	9	9	6	17	16	16	13	0	5	6	0	**13**

														Average
688	693	677	705	687	684	678	658	631	647	662	707	684	702	675.392857
567	571	573	553	565	565	538	534	552	570	564	551	547	563	552.285714
673	673	660	648	665	707	646	635	676	664	663	660	702	657	662.678571
544	543	470	519	534	602	522	506	499	559	511	512	559	529	524.964286
685	691	628	680	695	726	698	655	669	691	690	715	703	702	692.714286
438	441	383	424	434	460	414	405	375	465	412	403	404	435	414.571429

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