Analysis of the Simultaneity, Voice/layer Balance, and Rhythmic Phrasing in Works for Guitar by Rodrigo, Brouwer, and Villa-Lobos

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ABSTRACT

The paper analyzes different right-hand guitar techniques, such as the use of block chords, the balance between independent musical voices and layers, and global rhythmic control. Three well-known musical excerpts were chosen from the twentieth-century repertoire for guitar and were played in three different renditions: the beginning of Rodrigo's *Entre Olivares*, Brouwer's *Étude II* and a phrase from Villa-Lobos's *Étude 8*. The audio was recorded by means of an acoustic guitar with hexaphonic pickups, and data extraction was programmed in Max. Finer timing adjustments—down to 1 ms—were made manually. At this scale, we found that block chords are rarely played simultaneously; for the description of this quasi-simultaneity, we introduced the concepts of spread interval and spread pattern. The excerpts were analyzed also on the note/chord level and in terms of general rhythmic phrasing. Using these combined parameters enabled us to explore the technical difficulties and expressive choices in each rendition.

1. INTRODUCTION

There is no novelty or merit in saying that the guitar is able to deliver more than one sound at the same time. However, taken in isolation, this fact is unable to reveal the real possibilities the instrument offers for exploring harmony, counterpoint, and other types of polyphony. The most straightforward approach, the playing of 3- to 6-note chords, arpeggiated or not, may easily be found in a large variety of methods of teaching/learning, well known to every beginner. Counterpoint writing and performing is much more challenging, and everyone minimally acquainted with keyboard technique will soon discover the drawbacks of such an exploration on the guitar, mainly when playing three or more voices. We refer to another type of polyphony as a "counterpoint of layers" in order to differentiate it from the regular, baroque-like counterpoint, in which every voice has a similar status. This type is also very common on guitar, leading to bass-melody-chords textures, which present their own demands for players. Extended techniques also bring into play new possibilities, such as new sound typologies and percussive resources.

The guitar affords two distinguishing features: the first is the set of six strings, with its tuning and its spatial distribution over the fretboard. The second, not completely independent from the first, is that the right and left hands have quite distinct functions in producing sound. Typically, the left hand is responsible for changing the length (tuning) of the strings while the right hand supplies the initial conditions and the energy to the vibrations, both factors being directly linked to sound quality. Most of the characteristic guitar sound comes from these features.

Musical scores give precise indications for fingering: the letters *p* (thumb, from the Spanish *pulgar*), *i* (index), *m* (middle) and *a* (ring or annulary) are used for the right hand fingers. Numbers 1 to 4 are used for the left hand fingers; numbers 1 to 6 inside a circle indicate the string, moving from high to low strings; and a zero indicates an open string.

Until now, systematic approaches to playing polyphony on the guitar have not been very common. The piano has a richer literature, owing to the manufacture of the Disklavier by Yamaha since 1987, in different models and degrees of precision [1, 2]. Loïc Reboursière and his group have issued related works for guitar in Belgium [3] with hexaphonic pickups, although they are not currently concerned with simultaneity and polyphony. The experimental setup used in the present analysis has already been described in 2013 [4]: hardware items, software, algorithms for extraction of note onsets, offsets, and amplitudes. Briefly, we developed a real-time procedure for the detection of onsets, amplitudes, and offsets, using an adaptive comparator of peak and RMS signals, which uses 11 parameters for each string, and works within an error margin of 10 ms. In this previous study, we focused on a specific right-hand technique that is difficult to master, the tremolo, in which we showed that regularity was never really achieved for all the parameters analyzed. We now tackle a broader variety of techniques: block chords, voic-ing control, legato, and rhythmic phrasing. In this way, we are able to compare not only technical capacities, but also the musical interpretations the musicians offer in the chosen excerpts.

The excerpts come from twentieth-century guitar literature that is very well known by both professionals and amateurs. The first excerpt, the beginning of Rodrigo's *Entre Olivares* [5], which is devoted to block chords, is a techni-

cal challenge for every player; thus, it is a good example for looking at how simultaneously the four notes in each chord are played, along with observations about voice balance, pulse and time keeping, and silence between chords. The following excerpt, the second study in the first series of Brouwer's *Études Simples* [6] for guitar, written as a "coral" (choir) , gives the opportunity to observe voice conduction, the general dynamic curve and also the way chords are extinguished. The last musical excerpt, bars 16 to 27 from Villa-Lobos's *Étude 8* [7] for guitar, has the typical bass-melody-chords texture wherein some rhythmic flexibility is expected. In this case, the variations found in both rhythmic and layer phrasing arise mainly from individual expressive options.

For each excerpt, we have chosen three different renditions played by seven different guitarists: two of them are graduate students, and the remaining five are advanced undergraduate students from our music school. The guitarists were asked to play every excerpt as it is, the only limits being their technical expertise and musical intentions. The fingering used by both hands was kept the same for each of the excerpts. We identify each piece by two capital letters (JR for Rodrigo, LB for Brouwer and VL for Villa-Lobos), followed by a number from 1 to 3. Thus, LB2 indicates the second rendition of the second study from Leo Brouwer [1] .

2. PLAYING BLOCK CHORDS IN RODRIGO'S *ENTRE OLIVARES* (1956)

The first recording sessions made about three years ago, using a hexaphonic pickup for the guitar, had already shown that simultaneity could not be taken for granted in chord playing; thus, it deserved more detailed attention. The plan for a controlled experiment focusing on the perception of block chords was aborted owing to the large number of variables: number and register of notes, types of attack, dynamic levels, shape of dynamic envelopes, harmony, use of open strings, etc. Furthermore, how perception is influenced by the individual capacity of resolving independent notes inside a chord introduces further difficulties. However, the revision of related topics in the psychoacoustical literature revealed some important elements to be analyzed in this technique, mainly the concepts of temporal resolution [8, 9], perception of the precedence of stimuli [10, 11], stream segregation [12], and masking [13].

Rodrigo excerpt can be seen in Figure 1. Before delving into some of the technical and interpretative aspects, we should note that the number of combinations for the right-hand fingers in attacking a 4-note chord—simultaneously or quasi—are considerable: total synchronicity (1 possibility), total asynchronicity (24), one 2-note synchronicity (36), 2 times 2-note synchronicities (6), 3-note synchronicity (6). Because of this amazing quantity, the predominance of any pattern will probably not be a coincidence; rather, it would indicate a well-incorporated way of handling this technique. In the present case, our analysis has a time resolution of 1 ms, meaning that notes inside this interval are considered synchronous. In the following text, the delay between the first and last note played in each chord is called a "spread interval", and a "spread pattern" is one of the 73 possible combinations just described. Although these choices are neither consciously made nor easily distinguished by listening, for they all fall within the 30-ms, quasi-simultaneous threshold described by Shirado and Yanagida [11], they nevertheless are influenced by the degree of technical expertise of the players, and they do influence the sonorities of both chords and phrases. In the excerpt, strings 6 to 3 are used and are played by the right hand fingers *p, i, m*, and *a*. Figure 2 shows a typical spread pattern.

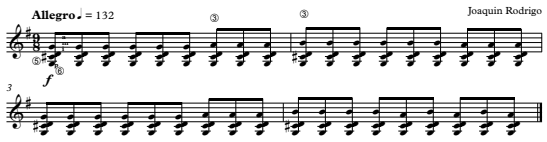

Figure 1. Initial bars of Rodrigo's *Entre Olivares* (from Ediciones Musicales Madrid, 1958).

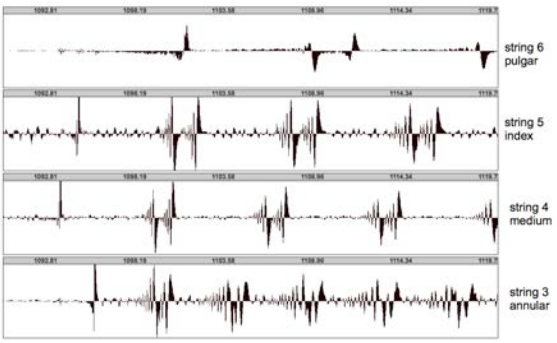

Figure 2. Waveforms of the notes of a chord played in rendition JR1. The window size is 30 ms. Note the spread pattern, *m, i, a, p*. The spread interval of this chord is 7 ms.

Figure 3 displays the amplitudes for the separate strings (voices) for each rendition. (In this and in the next section we will use the mixed-choir terms for voices: soprano, alto, tenor, and bass.) The average pulse for each example can be seen in Table 1. JR1 shows the most regular amplitude pattern, not only in the relative balance among the strings, but also in the expression of the pulse, with a peak at every three chords. JR3, although the only one played according to the demanded tempo, shows very irregular amplitude curves, and a noticeably weaker dynamic global level in the tenor line (on the fifth string). Its audio track has more noise than the others: for example, it seems that the finger scratches the string during a great deal of the preparation phase, occasionally making difficult the task of identifying the onset and offset points. Rendition JR2 shows some regularity on the dynamic control but, in general, the playing is softer than that of the others (note that the score specifies *forte* at the start).

Table 1 and Table 2 show additional features related to the performance of block chords: mean values for pulse,

[1] Recordings of these examples may be requested to the authors at www.musica.ufmg.br/sfreire.

spread intervals, gaps between chords and the duration/IOI proportions, and spread patterns, as well as the proportion of chords with simultaneous notes. With the spread pattern indicated by the letters *p, i, m, a*, when two letters come together, as in *im, p, a*, this means that the index and middle fingers attacked simultaneously (inside the 1 ms threshold). In the analyzed examples, it is possible to note the prominence of the index and middle fingers taking first place for the majority of the attacks. Although this may seem natural—given that these fingers are in the middle position and would thus be more adequate for guiding the fast movement required by the piece—we need more data to generalize this statement.

Renditon	Pulse (BPM)	Gap (ms)	Duration /IOI (%)
JR1	124.5	127	78
JR2	124.5	130	81
JR3	132	126	83

Table 1. Data extracted from the three renditions of the beginning of Rodrigo's *Entre Olivares*. The values for pulse, gap, and duration/IOI are mean values for the whole excerpt.

Renditon	Spread interval (ms)	Prominent patterns	Chords with 2 or more sync. notes
JR1	8 ± 2	*im a p* (38%) 1st finger *i* or *m* (100%)	40 (%)
JR2	5 ± 3	1st finger *i* or *m* (70%)	50 (%)
JR3	18 ± 8	*i m a p* (43%) 1st fing. *m* (57%)	30 (%)

Table 2. Block chord features from three renditions of the beginning of Rodrigo's *Entre Olivares*. The values for spread intervals are mean values.

We also measured the gaps between two successive chords, in both absolute and relative terms. This will not be called "legato index", owing to the occurrence of transient offsets, a quite common feature in the fast playing of block chords. The effective duration is the time interval of the free vibrations; the rest of the IOI (inter-onset interval) is occupied by the preparation phase: stopping and re-attacking the notes.

This analysis points out the different technical challenges present in this excerpt: fast pulse, balance between the 4 notes in each chord, dynamic level, metric expression, and technical coherence in the spread interval and patterns. None of the renditions showed a high level of behavior in all these features. Besides the fact that the players are not really professionals, they had less than a month to prepare, whereas proper preparation takes much longer. Professional guitarist Scott Tennant observed in an interview about this excerpt, "It took the better part of the year to work that out to tempo" [14]. Abel Carlevaro also dedicates the sixth chapter of his guitar method to this technique [15].

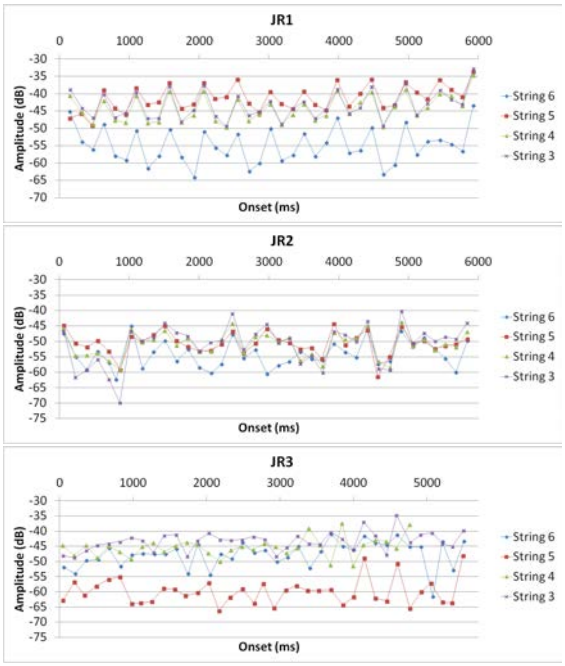

Figure 3. Amplitude curves for each string in (a) JR1, (b) JR2, and (c) JR3.

2.1 Offset-onset Interval on Guitar

An extremely smooth legato is not practically achievable on guitar. With the exception of the vibrato or bending within the limits of two frets, all other note transitions present, in different degrees, some kind of transient. These transitions are glissandos, hammering-on or pulling-off the strings (called legato in the guitar literature), changing the pitch on the same or in different strings, and repetition of notes. Some features of legato playing will be discussed in the next section. Here, we concentrate on the simplest situation: re-attacking a note on the same string. Informal experiments with one of the main types of right finger articulation (free stroke without planting, trying to play legato as much as possible) shows that there is always an unintended gap between the notes; in other words, before a new note is attacked, the string stops vibrating for a time just before the onset transient. This pause is necessary to reshape the initial conditions of the next vibration, which, in the case of the plucked string, comes from the initial transverse displacement of the string [9].

The duration of this gap varies between 18 and 50 ms. In practical terms, these preliminary results show that the preparation of a new legato note must always be fast, and the musician must simultaneously avoid perceptible offset transients, regardless of the actual pulse. This fact may contribute to the common notion among guitarists that is more difficult to play legato in slow movements than in faster ones. (In fact, psychoacoustical factors also come into play because guitar notes have quite a fast decay.) In the excerpt under examination, we can note that the aver-

age duration of the gaps is about 128 ms, a value much higher than the ones found in the situation of a 1-note free stroke. As we can be quite sure that each re-attack in these renditions is made as fast as possible, it is not difficult to imagine that the preparation of a 4-note chord is much more complex than that of a single note.

3. VOICING CONTROL IN BROUWER'S *ÉTUDE II* (1973)

Jim Ferguson, in the preface to Tanenbaum's book [16] on Brouwer's studies, says, "Brouwer's 20 'simple studies' have come to enjoy an important position in the guitar repertoire for a number of reasons. Since they concentrate on the lower position fingerboard region, they are accessible to students. At the same time, their high degree of musicality has made them suitable for concert programming. And because they comprise an extraordinary array of contemporary compositional practices—including pop rhythmic and tonal elements—they are as relevant as they are ingenious." As indicated by the subtitle, second study (Figure 4) is conceived as a choir, and one of the main concerns of the players must be to bring out the individual voices. Bass and tenor voices are played by the thumb (*p*), alto by the index (*i*) and soprano by the medium finger (*m*). Figure 5 shows the amplitude curves for each voice.

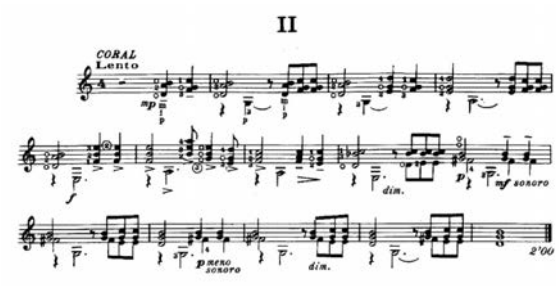

Figure 4. Brouwer's *Étude II*, from *Études Simples pour guitar* (1ere Série), Max Eschig, 1973. Note the lack of a bar line between measures 8 and 9.

For this study, the LB1 rendition shows the less nuanced amplitude curves. The soprano line is the most prominent throughout the performance, whereas the remaining voices present very similar amplitude curves. In LB2, the dynamic curves are more accentuated, following the marks in the score. In bars 8-11, the bass line exhibits a more independent curve, playing a crescendo till the indication *p meno sonoro*. LB3 also reveals accentuated curves, but they are more independent than those in LB2. Also here, the soprano is the most detached voice.

Tempo is also a concern here. Tanenbaum [16] comments on the duration given in this score, stating "in his Berkeley master class, Brouwer demonstrated a relatively fast tempo for this study, and he said that the timings for the set are generally wrong." The total duration and mean BPM value of each rendition is given in Table 3. Additional data concerning spread intervals and patterns for the 3-note block chords are also shown in this table. In the present case, the block chords are played with three fingers, and the total number of possible combinations is 13. The player of LB3 seems to perform the chords in a very consistent and planned way. A prominent spread pattern is present, with the largest spread interval of the group and a low number of simultaneous notes. The more prominent soprano line is correlated with the spread pattern, being the first to be attacked in more than 80% of the chords. Rendition LB1, the longest one, also has a quite consistent spread pattern, with the thumb preferred as the last finger to attack in each chord. LB2 shows no prominent pattern, but there is a considerable proportion of simultaneous notes.

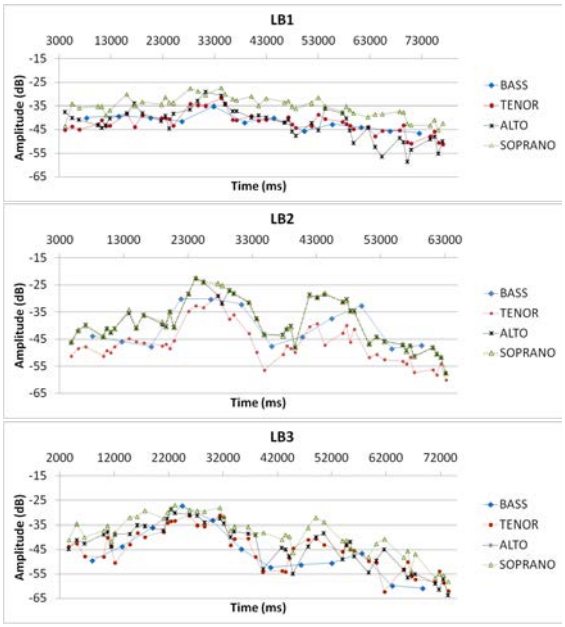

Figure 5. Amplitude curves for each voice in examples (a) LB1, (b) LB2 and (c) LB3.

Renditon	LB1	LB2	LB3
Total duration (s)	78.5	59	73.5
Pulse (BPM)	41	51	43
Spread interval (ms)	9 ± 4	5 ± 3	11 ± 6
Prominent patterns	*i, m, p* (41%) *m, i, p* (35%)	none	*m, i, p* (83%)
Chords with 2 sync. notes (%)	9	33	6.5

Table 3. Data extracted from three renditions of Brouwer's *Étude II*. Pulse and spread interval are mean values.

The control of dynamic levels is usually closely connected with the control of timbre. Although this feature is one of the most important in the expressive intentions of the performers, we have not yet developed tools for this task. The mixing of the individual tracks sounds quite different from the global acoustical impression owing to the lack of resonance from the guitar body. The use of the centroid/f0 ratio may be helpful in determining the relative brightness of the notes, but the overall sound quality analysis continues to remain an open issue.

In this Brouwer excerpt, we did not discuss the gap be-

tween chords because of the bass line, which is attacked in different moments and remains sounding over the chords, thus helping the legato expression. Another feature that contribute to the overall sound quality of the choral texture on the guitar is the chord offset. Extinguishing a note can be accomplished several ways on the guitar. Besides the natural decay of the vibrations, actions of the right or left hand can be involved, sometimes in combination. The right hand preparation for a new attack has already been discussed in the last section. In addition to that, the preparation of a new note (by the stopping or releasing of one string with a left-hand finger) may cause the offset, sometimes with an undesirable, though hardly avoidable, transient. Commonly, the simultaneous extinguishment of multiple notes does not happen exactly at the same instant, being highly dependent on the fingering of both hands. The possible combinations of all these factors provide a set of typical sonorities to the offset of chords, which, in its turn, poses additional technical challenges for a balanced voice leading.

4. LAYERING AND RHYTHMIC PHRASING IN VILLA-LOBOS'S *ÉTUDE 8* (1928/1953)

4.1 Beat Determination

The excerpt chosen from Villa-Lobos can be seen in Figure 6. It shows a typical guitar texture, consisting of a melody accompanied by a bass line and an intermediate layer with chords, arpeggiated or played as a block. Its rhythmic structure is quite straightforward: each 2/4 bar in the chosen interval (bars 16-25) has one of these two basic patterns: 1 𝅘𝅥𝅯+ 2 𝅘𝅥𝅰+ 2 𝅘𝅥𝅯, or 4 𝅘𝅥𝅰+ 2 𝅘𝅥𝅯. Nevertheless, we observe, in practice, not only that block chords may be played with some spread (as seen in the previous sections) but also that the bass and melody notes are not commonly simultaneous. Therefore, it is necessary to explain and justify the chosen methods for analyzing the layers and for the rhythmic phrasing of this excerpt.

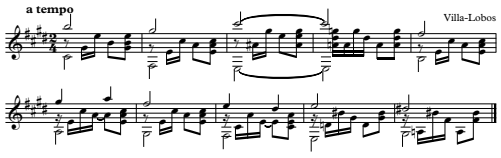

Figure 6. Bars 16-27 from Villa-Lobos *Étude 8* (from Max Eschig, 1953).

The amplitude of a block chord was calculated by adding the RMS values for each of its notes, regardless of possible mask-ing or loudness corrections. This was done even if the chord was clearly arpeggiated. Although this value may not be strictly correlated to the perceived intensity, it cer-tainly is to the player's intention. The highest pitch played in the chord was chosen as its rhythmic activity, a choice—derived from a common-sense hypothesis among guitarists—that was confirmed by the analysis. For the bass-melody attack, the timing of the high pitched note also showed itself as the best choice for analyzing the rhythmic phrasing. Two of the players performed these bass-melody bichords as two non-simultaneous events (the average delay is about 188 ms for VL2 and 80 ms for VL3); even in this case, the beat tracking showed that this situation is better interpreted as an anticipation of the bass note, and not as a delayed melodic line.

4.2 Rhythmic Phrasing and Layering

Figure 7 shows the IOIs present in each rendition. It is quite easy to visualize two different regions, one related to the eighth notes played (above 400 ms) and the lower related to the sixteenth notes. VL1 and VL2 make a noticeable decelerando in bar 19 (corresponding to the fourth peak in the graphic). In VL2 we also find a kind of fermata on the first chord of bar 19 (16th value in the graphic), followed by three fast sixteenth notes. In all the renditions, consistent accelerando and decelerando can be found in every sequence of four sixteenth notes. VL3 is the slowest rendition, with a medium value of 53 BPM. The other two are played around 60 BPM. VL2 shows a sharper contrast between the theoretical ratio of 50% between sixteenth and eighth notes. This is not only graphically visible but also is expressed by the global average. While this ratio is about 37% for VL2, it is 46% for VL1 and 47% for VL3.

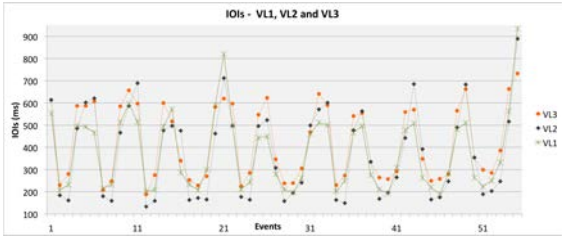

Figure 7. Inter-onset intervals in the three renditions of the Villa-Lobos excerpt.

Another point of interest is the balance among the different layers present in this excerpt, shown in Figure 8. The more undulating pattern of the chord curve rises from the changing of density in this layer: one event can be either a single note or a 3-note chord. Nonetheless, we can see that the curve is not split in two clearly distinct regions. In all examples, the bass line is played with amplitudes considerably lower than that of the melody. In VL1, the bass is even softer than the middle layer. It is possible also to note higher values for the chords amplitudes in bars where the melody is not being played. The loudest melodic point is repeated in two of the samples, but the player of VL3 has chosen a different moment.

5. FINAL REMARKS

The limited number of renditions for each of the musical excerpts does not allow for any statistical inference; nevertheless, they illustrate the typical technical and expressive capacities of guitar players. Based on the previous discussion, it is easy to figure out how schematic a musical score is, when compared to the sonic richness of any of its performances. Investigating a combination of low-level

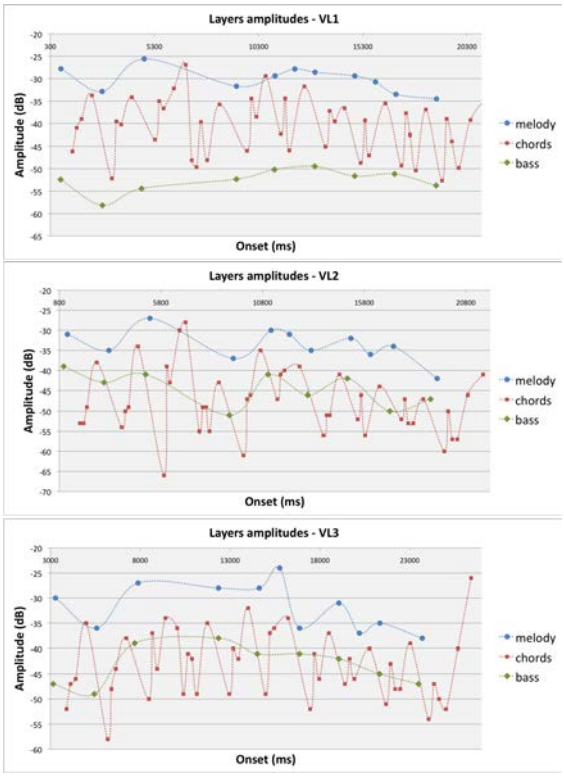

Figure 8. Amplitude curves in each layer—melody, chords, bass—in renditions (a) VL1, (b) VL2 and (c) VL3.

(onsets, offsets, amplitudes, transients) and medium-level features (pulse, rhythmic phrase, dynamic curves, legato index, prominence of spread patterns) reveals many characteristics about the performance of the chosen musical excerpts.

The setup developed for these experiments was meant to work in real time because of the many possibilities it offers for interactive situations (besides the low-level descriptors already described, medium-level descriptors related to pitch sets and rhythmic activity are being implemented). It has also been very helpful in the non real-time analyses of performances that have been done since its implementation.

Our next step for this project is to incorporate a second guitar with the same resources (this time with RMC rather than the LR Baggs pickups used here); this will permit more extensive research on sound quality, as well as duet analysis and evaluation of how instrument-specific the already implemented algorithms are. Because most of the player's gestures happen during the preparation phase of a note just before the actual sound production, further steps should also be taken towards multimodal analytical environments.

Acknowledgments

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