Comparative analysis of expressivity in recorded violin performances. Study of the Sonatas and Partitas for solo violin by J. S. Bach

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Abstract

Expressive performance characterization is traditionally based on the analysis of the main differences between performances, players, playing styles and emotional intentions. This work addresses the characterization of expressive violin performances by means of analysing audio recordings played by professional violinists. This study compares the performers' interpretations of a piece, a piece which might be considered the most important in violin history: "Sonatas and Partitas for solo Violin" by Bach. The importance is given by the relevance of their composer, J.S. Bach, as by the shining difficulty in its interpretation. In regard to the data we will work from real audio recordings. This allows the possibility of analysing the most accomplished performers, obtaining robust results by extrapolating the findings to different performers, and comparing their particular styles. In terms of audio descriptors, we will use state-of-the-art tools to extract them from the audio recordings. Thus, the work aims at finding some expressive behaviour using the audio descriptions extracted from the tools. One of the main results is the finding of a common behaviour at the end of phrases and in the repeated phrases.

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Chapter 1

1. Introduction

1.1 Expressive analysis

Expressive music performance characterization is traditionally based on the analysis of the main differences between performances, players, playing styles and emotional intentions.

We may ask why the study of Expressive music performance has interested so many researchers. Firstly, we should consider the influence that music has had and continues to have. In every part of the world throughout history, regardless of culture, people have always played and enjoyed music. We can consider music as a universal language used by humans: to express and convey emotions, feelings, and sensations. Assuming that some emotions are better expressed through music than through language, in effect, music may be considered more powerful than language itself.

People use music to express emotion: if such emotion did not exist, music would not interest people [2]. In other words, music without expressivity does not make sense. And it is not surprising that the study of expressivity in music began many years ago, even before computers could be used for such research.

The study of expressivity mainly focuses at present on classical music, paying special attention to the piano. The most contributing factor here is the ease with which a piano recital is captured, given that there are pianos equipped with MIDI. Another reason

could its importance in Western music for solo performances, chamber music and accompaniment, being also very popular as an aid for composing and rehearsal. Another important point is the pieces used in the expressive analysis of piano performances. The most common pieces are from specific composers such as Bach, Beethoven or Chopin [16]. These composers, among others, were selected because of the relevance and influence they have held since their own era (baroque, classical or romantic) up until our own time, without forgetting the coherence of their musical styles [2], [25].

In light of the current state of the art in terms of expressive performance analysis, we consider it appropriate to analyse the expressivity of the violin in particular, as one of the most representative instruments of the excitation-continuous group and, after the singing voice, one of the most articulate.

1.2 Why violin?

At instrument level, the piano is too often said to be the most important and complete instrument in the Western music. It comes as no surprise for that reason that the piano is the most studied one. The problem is that these precise, in-depth studies cannot be applied to other instruments, not even to the most representative of each family. These representative instruments are, for example, the oboe or flute among the woodwinds; the trombone or trumpet among the brass; and the violin among the string instruments. Moreover, the piano is usually played unaccompanied and, in few cases, with other instruments as in a duet, quartet or in an orchestra. On the other hand, the violin is as frequently played in small groups, like duets or quartets, as in bigger groups, like an orchestra. Furthermore, it is important to mention that the violin, in an orchestra, is the leading instrument. In addition to this pre-eminence of the violin with respect to the other instruments, it is also very rich in sound, and it has many expressive methods and

techniques such as vibrato (pitch variation), tremolo (amplitude variation), pizzicato (playing by plucking the strings), and spiccato (bouncing lightly the bow on the string at moderato speed, producing a series of sharply-articulated notes).

Taking into account all these issues, the importance of the violin remains clear, as likewise the need to study its expressive qualities from an analytical point of view.

Chapter 2

2. State of the art

2.1 Audio Descriptors

Audio description has become very relevant because it provides the user meaningful descriptors from audio signals. This concept applied to a piece of music can be seen as the implicit information that is related to this piece and that is represented in the piece itself. So, in the study of expressive music performance, different parameters related to the audio signal, such as loudness or tempo (among others), can be converted into relevant descriptors for studying an expressive music.

2.2 Tools for Audio Description

2.2.1 Melodic Transcription: Inter Onset Interval

First of all, it is necessary to know what an onset is. It refers to the beginning of a musical note or a sound event, in which the amplitude rises from zero to an initial peak. So Inter Onset Interval (IOI) is the time between the beginning (onset) of successive events or notes. The intervals between onsets do not include the duration of the events. Another important aspect that should be known is the melodic description, necessary for making the melodic transcription. This concept refers to the melodic aspects of the sound such as pitch or tonality, and they can be extracted by different techniques [28].

MAMIMelody

Musical Audio Mining (MAMI), developed at Ghent University [14], is a data-mining project for audio recognition that investigates ways of searching an audio archive as easily as you can search a text archive. Specifically, MAMIMelody (Figure 3) is an interactive transcription application made to show the behaviour of the melody transcription algorithm developed for the MAMI project. It can also be used in a context that allows the user to easily perform a melodic query and then get audible feedback about what was recognized. For the purposes of melody transcription, the recognized pitch events are fed into a synthesis module that regenerates the recognized melody for audible feedback [20].

2.2.2 Loudness

In music, loudness (based on dynamics) is the subjective quality of a sound that bears the primary psychological correlation to physical intensity. Frequently, loudness is confused with objective measures of sound intensity such as decibels. Moreover, this descriptor is affected by other parameters such as frequency and duration.

Loudness is often approximated by a power function with an exponent of 0.6 when plotted vs. sound pressure or 0.3 when plotted vs. sound intensity. More precise measures (such as equal-loudness contours) were later made showing how loudness grows more quickly (with a higher exponent) at low and high levels and less quickly (with a lower exponent) at medium levels. Loudness is measured in units of *sone* (unit of perceived loudness) and *phon* (unit of perceived loudness level

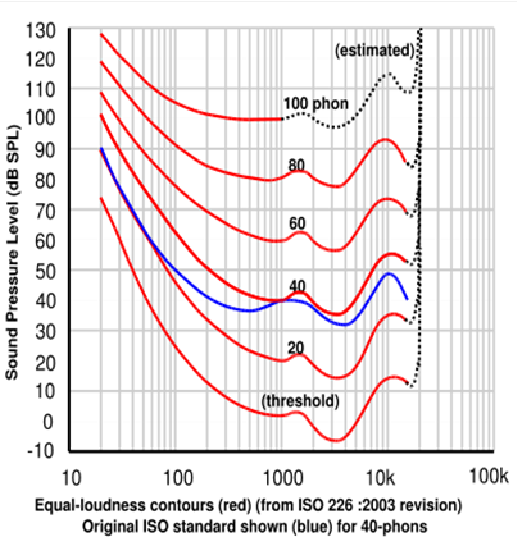


Figure 1. Equal-loudness contours

for pure tones).

Equal-loudness contours (Figure 1) were first measured by Fletcher and Munson using headphones (1933). In their study, listeners were presented with pure tones at various frequencies and over 10 dB increments in stimulus intensity. For each frequency and intensity, the listener was also presented with a reference tone at 1000 Hz. The reference tone was adjusted until it was perceived to be of the same loudness as the test tone.

MA Toolbox

The MA Toolbox [21] is a collection of matlab's functions for analysing music (audio) and computes similarities. One of its functionalities (ma_sone) calculates the sone (loudness sensation) and the total loudness of the audio. This function applies some auditory models to work out how strong the loudness sensation is per frequency band. The main parts are the outer-ear model, critical-band rate scale, spectral masking and sone. With all this information it is possible to obtain the loudness variation over time, as we can see in Figure 2.

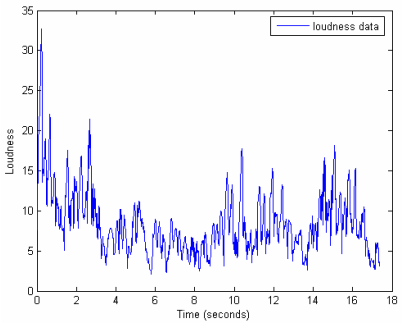


Figure 2. Loudness data's example

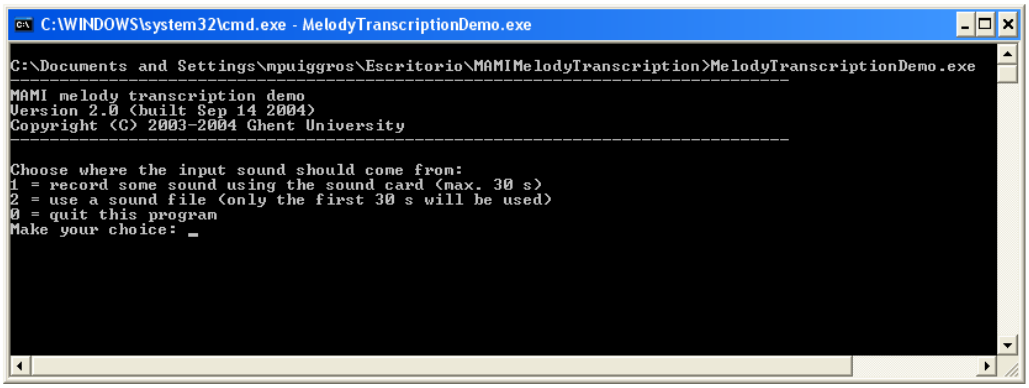


Figure 3. MAMIMelody's Program

2.2.3 Tempo

Tempo derives from the Latin *tempus* and in musical terminology it refers to the speed or pace in a given piece. Tempo is an essential aspect of sound, influencing the atmosphere and complexity of a piece.

The tempo is usually written at the start of a piece (Figure 4). Over time, this writing has been changing and in modern music is indicated in beats per minute (see section 0 BeatRoot). This indicates that a particular note value (for instance, in quarter notes) is specified as the beat, and the mark indicates the particular number of beats per minute that must be played. The greater the tempo is, the larger the number of beats played per minute, and so, the faster a piece must be played.

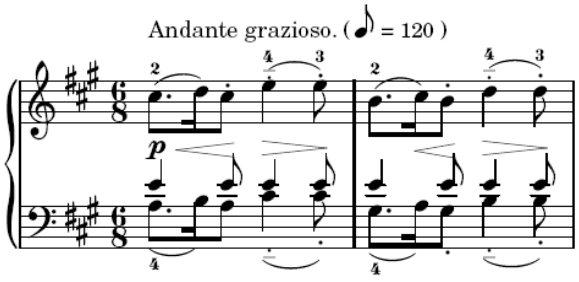


Figure 4. The beginning of Mozart's Sonata XI indicates the tempo as **"Andante grazioso"** and modern editor marks it as metronome **"♪=120"**.

BeatRoot

First of all, it should be noted that beats per minute (bpm) is a unit typically used as either a measure of tempo in music (as we said in previous section), or a measure of one's heart rate. A rate of 60 bpm means that one beat will occur every second (1 bpm is equivalent to 1/60 Hz).

BeatRoot is a musical beat tracking and visualisation system [6] (Figure 5). It estimates the tempo and the times of musical beats in expressively performed music. The data is processed off-line to identify the relevant rhythmic events. Also, the timing of these events is analysed to generate hypotheses of the tempo at different metrical levels.

Based on these tempo hypotheses, a multiple hypothesis search finds the sequence of beat times which has the most robust fit to the rhythmic events.

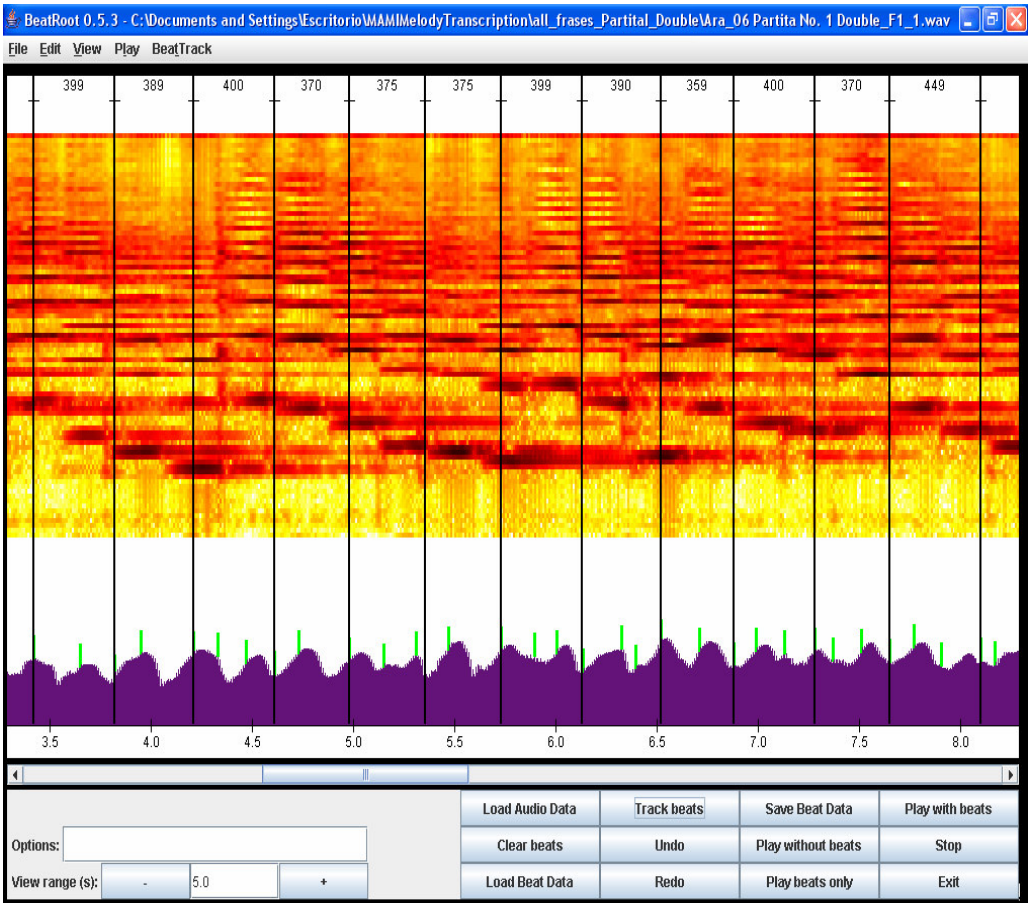


Figure 5. BeatRoot's Program [6]

Tempo's methods comparison

As the tempo is the most important descriptor, for that reason it has been the most studied. Much effort has been dedicated in the computer music community to the auto-immunization of the beat induction and tracking tasks: obtaining the basic tempo and the positions of individual beats in musical files or streams. We can thus find many different methods and implementations.

In order to compare some of the most important algorithms work has been done in evaluating the differences in the implementations. All of the algorithms are based on a frequent general scheme: a feature-list creation block that parses the audio data into a temporal series of features which suggest the predominant rhythmic information to the following pulse induction block. The characteristics can be onset features or signal features computed at a reduced sampling rate. Many algorithms also implement a beat tracking block. However, as the contest does not address the issues of tracking tempo changes and determining beat positions, the algorithms chosen either bypass this block or added a subsequent back-end for the reason of the contest. We will now move onto the methods used for making the comparison.

AlonsoACF and *AlonsoSP*

Both methods are based on the same front-end that extracts extraordinary accents, i.e., onsets of notes, by detecting abrupt changes in timbre, dynamics, or harmonic structure. The difference between the methods is found in the pulse induction block. The *AlonsoACF* system is based on the autocorrelation of the pulse signal, while the *AlonsoSP* system uses the spectral product.

DixonI, DixonT and *DixonACF*

They are both based on a simple energy-based onset detection followed by an IOI clustering method. *DixonI* algorithm chooses a tempo based on the "best" cluster, where the clusters are assigned by the number of IOIs that they contain, the amplitude of the equivalent notes, and the support of other clusters related by simple integer ratios. On the other hand, *DixonT* technique selects several prominent clusters as tempo theories, performs beat tracking based on these theories, and outputs the mean of the inter-beat intervals (IBI) from the best beat tracking solution as the final approximate of tempo. In contrast, *DixonACF* method splits the signal into 8 frequency

bands, and then softest, down samples and performs autocorrelation on each of the frequency bands. From each band, the 3 highest peaks (excluding the zero-lag peak) of the autocorrelation function are combined, and each is assessed as a possible tempo candidate, with the highest scoring peak determining the final tempo value.

Klapuri

The goal in this procedure is to account for slight energy changes that may occur in narrow frequency sub bands in addition to wide-band energy changes. Another algorithm's characteristic is the joint determination of three metrical levels (the Tatum, the beat and the measure) by means of probabilistic modelling of their relationships and temporal progression. Once computed the beats of the whole test excerpt, the tempo is calculated as the median of the IBIs of the excerpt's latter half.

Scheirer

Scheirer argued that pulse induction should be performed separately on the signal features computed on each of several frequency bands, and then combined, rather than on a single series containing the combined features. The output of the algorithm is a set of beat times rather than an overall tempo estimate, so it adds a small back-end to the code that outputs the state of the filterbank after the analysis of the complete sound file. Then the tempo is taken to be the resonance frequency of the filter with the highest instantaneous energy after the whole analysis. The choice of this particular back-end is based on the observation that this algorithm provides more reliable estimates after some processing of the sound file than at the beginning.

TzanetakisH, TzanetakisMS and *TzanetakisMM*

All the three methods are based on the wavelet front-end. The signal is segmented in time into 3 seconds analysis windows, with an overlap of 1.5 seconds. In every one, the signal is decomposed through wavelet transform into 5 octave-spaced frequency

bands, and the amplitude envelope is extracted in each band. Moreover, both of them use autocorrelation; nevertheless, they differ in some parts: the default method (TzanetakisMS) sums the diverse sub band amplitude envelopes and calculates an autocorrelation of the resulting sum. The maximum peak in the autocorrelation (tempo approximation) is calculated on every analysis window and the median of the tempo estimates is chosen as the final tempo. TzanetakisMM makes a independent tempo estimate for each band and each analysis window, and then it selects the median. TzanetakisH sums the subband amplitude envelopes, computes the autocorrelation of the resulting sum, selects several autocorrelation peaks and accumulates them in a histogram which summarises the peaks of all analysis windows. The tempo is finally set to the maximum peak of the histogram.

Uhle

This algorithm calculates the rates of metrical pulses on three levels (the tatum, the beat and the measure). The audio signal is segmented into features long-term segments. Amplitude envelopes are calculated by means of a smoothed Discrete Fourier Transform. Slope signals of the amplitude envelopes are computed using the relative difference function, and half-wave rectification. The slope signals are summed across all bands to produce an "accent signal". The autocorrelation function (ACF) is calculated for a non-overlapping 2.5 seconds segments inside each long-term segment. The Tatum period is approximate from the ACF by a periodicity detection procedure; and a second ACF is calculated on a larger time scale (7.5 seconds) to detect periodicities in the range of musical measures. A function representing periodicity saliences at integer multiples of the Tatum periods is computed and compared with a number of pre-defined metrical templates. The most highly correlated template establishes the value of the segment's tempo. Tempi are accumulated in a weighted histogram and the maximum yields the basic tempo of the piece.

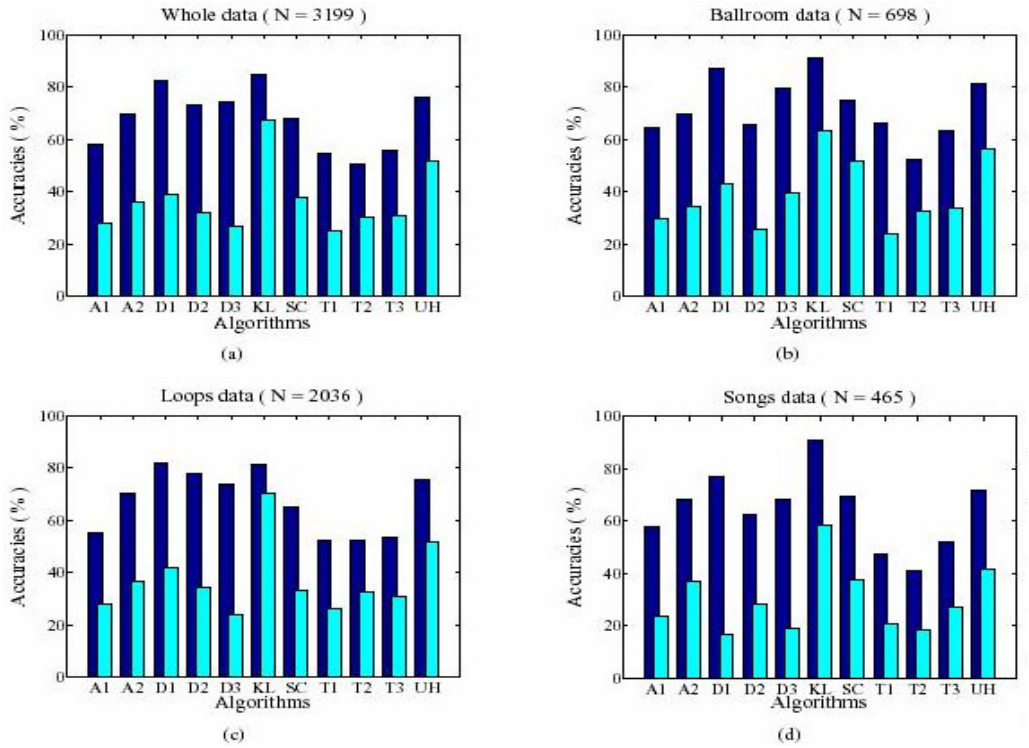


Figure 6. Accuracies 1 (light) and 2 (dark) on the whole data set –3(a)–, the Ballroom data set –3(b)–, the Loops data set –3(c)– and the Songs data set –3(d).

Once known all the methods used in the comparison it is possible show the results. Figure 6 shows the results for each algorithm: A1 is AlonsoACF, A2 is AlonsoSP, D1 is DixonACF, D2 is DixonI, D3 is DixonT, KL is Klapuri, SC is Scheirer, T1 is TzanetakisH, T2 is TzanetakisMM, T3 is TzanetakisMS and UH is Uhle. For each algorithm, accuracy 1 and 2 are given, in light and dark shadings, respectively, for the whole data set and each of the 3 subsets. Figure 7 illustrates the loss of accuracy for each algorithm when distortion was applied to the Songs data set as detailed above. Clearly, algorithms AlonsoACF, AlonsoSP, DixonI and DixonT

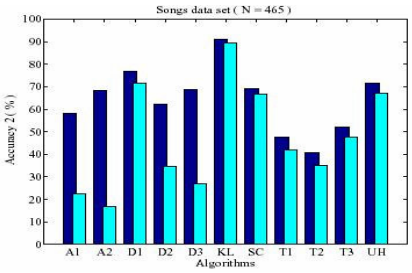


Figure 7. Effect of instance distortions on accuracy 2, dark

suffer more from distortions than other algorithms. And, from viewing these comparisons, it is possible to determine that measures accuracy 1 and 2 were the criteria used to determine the contest winner. As can be seen in Figure 6, the algorithm Klapuri outperformed the others with respect to these measures on all data sets: respectively 67.29% and 85.01% on the whole data set and f70.71%, 81.57%g, f63.18%, 90.97% gand f58.49%, 91.18% gon the Loops, Ballroom and Songs data sets, respectively. It was also the best algorithm in terms of noise robustness (Figure 7) [22].

2.3 Analysis of music expression from Audio and Score

As stated in the introduction, expressive performance characterization analyses differences in performances, performers, playing styles and emotional intentions [1].

In order to conduct an analysis of expression, it is important to narrow down the problem and to choose a musical style (related to the composer) and an instrument to be studied. Moreover, it is really important to understand the style chosen from a musicological point of view and also the acoustic characteristics of the instrument.

Within the most frequent styles analysed there are jazz, and classical music (the most common). At the same time, the studies of classical music are typically focused on a few composers such as Bach, Beethoven, Schumann or Chopin, composers that are representatives of either the baroque, the classical or romantic music periods [2]. Each of these historical music periods has it own expressive resources.

Another important factor to take into account in the expressiveness study is the instrument because each instrument has it own characteristics and mechanisms for

improving the expressivity of the piece. Perhaps one of the most frequently analysed classical instruments is the piano, for which studies will consider the pedalling, chord asynchronies, vertical asynchronies, and so forth. However, studies are also made of the voice, cello and violin [2]. Each of these instruments likewise possesses its own expressive elements, but there is a common one to be mentioned: the vibrato, a key expressive element used by the performers. In terms of signal processing, the vibrato is a frequency modulation. There is quite a bit of research work aimed at reproducing natural sounding vibrato in electronic synthesizers [3], while other studies focus on analysis in order to understand and modulate it [5].

The importance of this work is shown by the vibrato study on expressive performance. Thus, when violin performances are studied, this resource, the vibrato, should be taken into account.

As we have said before, expressive studies started many years ago and, along all this time, a large variety of techniques it have been used. For example, before computers and digital measurement devices were invented and easily available to everyone, researchers employed a vast range of mechanical and electrical measurement apparatus to capture all sorts of human or mechanical movements on musical instruments. In contrast to measuring music expression during performance through any kind of sensors placed in or around the performer or the instrument, other approach example is the computational extraction of expression from audio with an essential advantage that any type of recording may serve as a basis for investigation [2].

At the end of 19th century, the first studies were being conducted using specially equipped instruments. The subject of this work was about some basic exercises on the piano by Binet and Courtier (1895). Another original example is the Iowa Piano Camera, created by Henderson around 1936, which allowed for onset and offset times

and hammer speeds for each key to be captured on film; it could also capture the movement of both pedals. Studies carried out more recently incorporated modern technology to capture performances. For instance, Shaffer equipped the Bechstein grand piano tones with pairs of photocells, and the two pedals to capture essential expressive parameters from piano performances. The advantage of this method is that it does not affect the piano's playability [2].

Another approach to studying expressivity is to measure audio by hand: this involves manually analysing the recorded sound of musical performances by means of a standard sound editor. However, extracting the dynamics from audio parameters becomes more complicated, and moreseo if the extraction is made using polyphonic melodies. For instance, such parameters could be the detection of peak energy values, timing information or peak amplitudes (the last made by Gabrielsson in 1987) [2].

On the other hand, there exist several approaches for displaying extractions from audio data using automatic transcription systems, but these state of the art systems are not yet robust enough, depending on the complexity of the transcription. One such example is offered by the work carried out by Scheirer in 1997 incorporating score information into audio analysis algorithms [2]. One more computational extraction instance is the MATCH system (Music Alignment Tool CHest) carried out by Dixon and Widmer in 2005. This is an audio alignment method that detects optimal alignments between pairs of recordings. These pairs are used for transferring annotation from first recording to the corresponding times in the second [11].

Among these kinds of measurements, special mention should be made of the BeatRoot system, developed by Dixon in 2001 [2] and used in the context of expressive analysis. This system estimates the tempo and beat time from expressive music performances. This is significant for the reason that beat perception is a prerequisite to rhythm

perception, which in turn is a fundamental part of music perception and musical expression, and at the same time it implies the emotion [6], [7].

Having obtained the data, we then develop the structure of the model. The most common methods are through analysis by measurement and analysis by synthesis: the first one is based on deviation analysis from musical notation measured in recorded human performances. It tries to recognize and to describe a regular deviation pattern by means of a mathematical model, which relates score with expressive values. There exist many models addressed to specific expressive performance aspects as vibrato [26], or final retard and its relationship to human motion [27]. In contrast, we can find the model realized by Todd in 1992 that tries to make a global model, which assumes that a musical piece structure can be decomposed in a sequence of segments. The second, analysis by synthesis, takes into account the human perception and subjective factors. So real performances are analysed, and then the expert musicians intuition suggest hypothesis that are formalized as rules [2]. The most important system made in this category is the Director Musices: The KTH Performance Rules System developed by Bresin, Friberg and Sundberg between years 1991 and 2000 [8].

Other ways more recent to develop the model structure is using artificial intelligence as machine learning or case-based reasoning (CBR). The aim of machine learning is to discover complex dependencies on very large data sets, without any preliminary hypothesis. The problem lies in acceptance: rather than specific rules, when the results are general, accurate, and simple, they are accepted. One example of this is Widmer's work begun in 1995. An alternative approach is CBR based on the idea of solving new problems using similar previously solved problems. This process is similar to another observed in humans: the observation-imitation-experimentation [2]. One example is the SaxEx system for expressive performances in jazz ballads developed by Arcos and López de Mántaras in 1998 [9], [10].

All these methods try to explain and simulate expressive performances played in relation to rules extracted from musical performances using descriptors. At the same time, there exist works that combine descriptors (usually tempo and loudness) for making an expressive performance study. For example, one of them makes the comparison between six performers playing six Chopin pieces recordings using both descriptors.

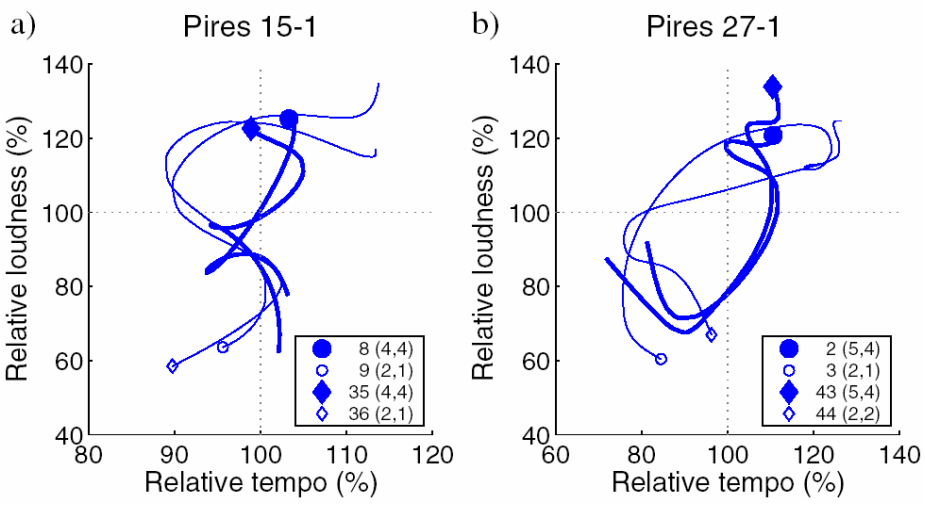


Figure 8. Tempo and loudness progression of a phrase from a Chopin's piece. Each line represents a phrase played by the same performer.

Their goal is to explore the expressive tempo-loudness phrase patterns and to determine inherent characteristics of individual performers and certain phrasesFigure 8. Figure 8 shows consecutive phrases played by Pires, with each figure representing one piece (op. 15 No. 1, op. 27 No. 1 respectively) [16].

In addition, another article introduces a method for displaying and analysing tempo and loudness variations as measured in expressive music performances. For this research, they use as much MIDI instruments as audio recordings from Schubert and Chopin

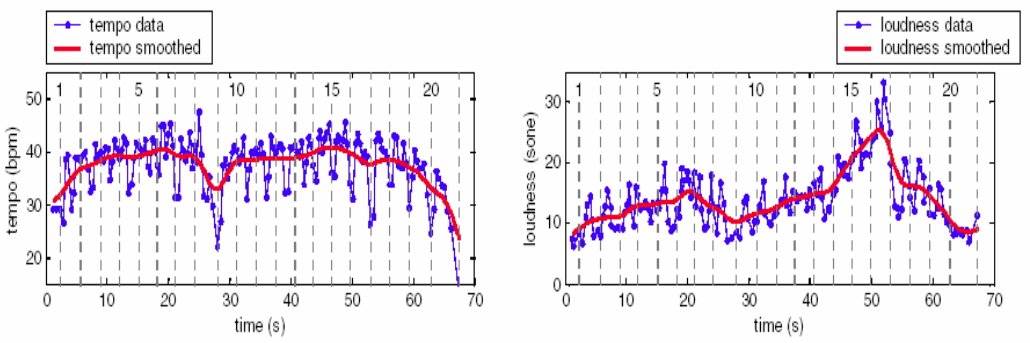


Figure 9. Representation of tempo and loudness curves from the same phrase played by the same pianist [19].

pieces for piano. Moreover, these pieces are played by two professional pianists: Maurizio Pollini and Alfred Brendel. Firstly, loudness and tempo are analysed independently (Figure 9) and then the expression trajectories are combined and analysed by means of smoothed data [19]. In (Figure 9) a red dot represents the music over time. For elaborating impression of time the trajectory of initial red dot decreases in size and fades over time. The more prominent bar circles indicate the beginning of a new phrase within the piece.

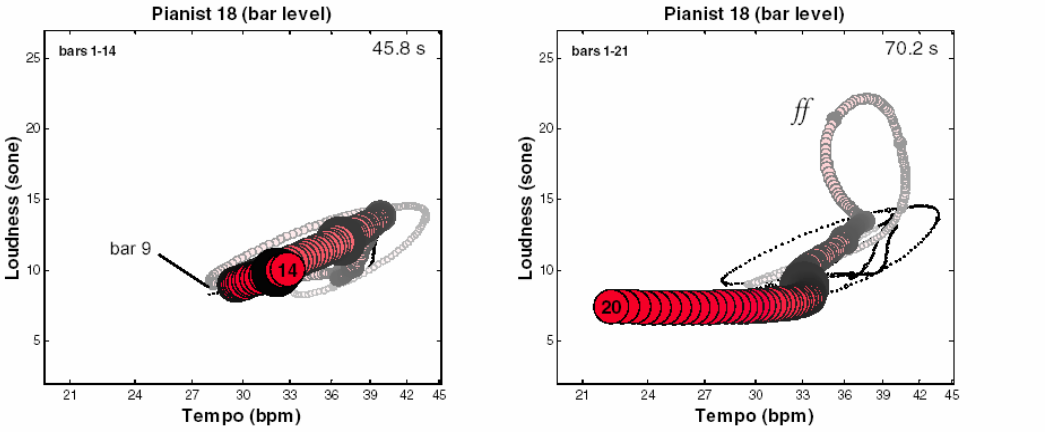


Figure 10. Loudness vs. tempo expression trajectories [19]

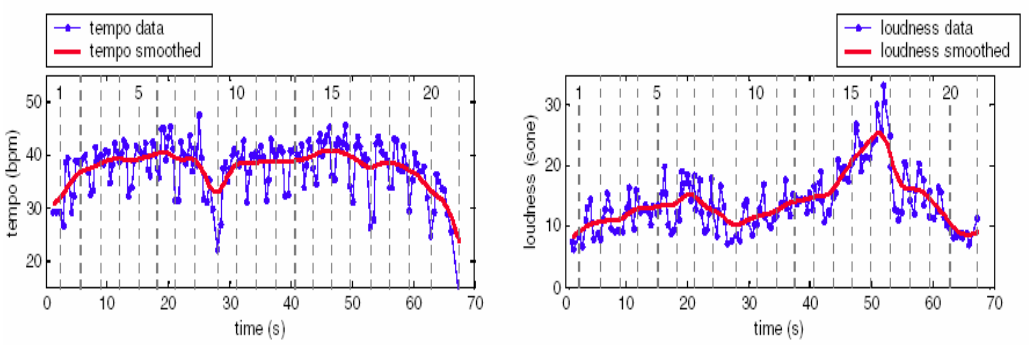


Figure 9. Representation of tempo and loudness curves from the same phrase played by the same pianist [19].

The main descriptors used in the studies are Inter Onset Interval, loudness, and tempo because these best describe the melody.

2.4 Discussion and thesis goals

There are many works that study the expressiveness of a melody. For this kind of study, the research generally focuses on one instrument because each one has its own way to play a melody with expression. Moreover, these studies are also focused on one era, one style and one composer (Chopin, Schumann, Bach) for the same reason, in order to specialise the expressiveness study.

Most of these studies have centred on classical piano music (for instance in Chopin's nocturnes, Bach's preludes or Schumann's *Träumerei*) [2], perhaps for the simple reason many consider the piano as one of the most complete and important instruments.

As we have said, while the piano is possibly the most widely studied instrument, these precise and in-depth studies do not apply to other instruments. Despite the nature of the interaction between instrument and performer, we could envisage a major division: excitation-instantaneous musical instruments, and excitation-continuous musical instruments. The first group, to which the piano belongs, the musician excites the instrument by means of instantaneous actions in the shape using impulsive hits or plucks. So, if the characteristics of the impulsive actions change, the shapes are modified. On the other hand, in the excitation-continuous instruments, the player makes the sound by continuously exciting the instrument. Hence, if we want to change the sound's characteristics, we will do it by means of modulating physical actions. The instruments belonging to this group are from wind to bowed instruments, including the voice. In spite of the magnitude of this group, and contrary to what happens with piano as we mentioned before, there is insufficient specialised studies analysing their expressiveness.

Given these facts, we have chosen the violin as the instrument to study, given being inside the excitation-continuous group and being also one of the most articulated one (together with the singing voice). At first, the analysis of violin expressivity can contribute to synthesize the violin in a more realistic way. After that, this study could be applicable to other instruments, in particular to other bowed string instruments.

In regard to the data, we will work from real audio recordings available. This allows the possibility of analysing the most accomplished performers, obtaining robust results by extrapolating the findings to different performers, and comparing their particular styles.

In terms of audio descriptors, we will use state-of-the-art tools to extract them from the audio as shown in this chapter. Thus, the work aims to find some expressive behaviour

using the audio descriptions extracted with these tools. As a main result we have identified a common behaviour at the end of phrases and in the repeated phrases.

Chapter 3

3. Musical Context

3.1 Introduction to baroque music

3.1.1 Introduction

Baroque music is an artistic movement and it describes the era of European classical music, which were compress between 1600 and 1750 approximately. This was preceded by the Renaissance and was followed by the Classical music epoch. The original meaning of “baroque” is “irregularly shaped pearl. Later the name comes applied also to music. Baroque music forms a major portion of the classical music canon. It is generally performed, studied and listened. During this period a lot of forms such as imitative counterpoint or diatonic tonality were developed. Moreover, the musical ornamentation, changes in musical notation, and advances in the way instruments were played also emerged. Baroque music increases in size and complexity in performances, as well as this style consolidated the opera as kind of musical performances. Many musical terms and concepts from this period are still in use.

3.1.2 Style and performance

Style and performance in baroque music contributes to Renaissance in use of polyphony and counterpoint. However, its use of these techniques differs from Renaissance music. On the other hand, in the Classical era, which followed the Baroque, the role of counterpoint was reduced and replaced by a homophonic texture. Moreover, baroque music also modulates frequently, but the modulation has less structural importance than classical music.

Baroque music often aims for a greater level of emotional intensity than Renaissance music, and a Baroque piece often uniformly represents a single particular emotion. Furthermore, baroque music employs a great deal of ornamentation, which was often improvised by the performer.

Another important point is that baroque sound is very rich and complex, but it can be said that there are two main characteristics in their performances: the transparent sonority and the incisive articulation [23].

Transparency

By transparent sonority should be necessary that tone was clear, it can not be confused into an atmospheric impression. We can see some examples as it says in [23] "*harpsichord tone, for instance, is acoustically more transparent than piano tone because its upper harmonics are more widely spaced. Rapid and heavy bow strokes yield less transparency than strokes of a moderate speed and pressure; rapid but light strokes yield less solidity. Heavy vibrato thickens the tone, whereas moderate vibrato colours it without endangering transparency. Simply too much volume may diminish the transparency by prolonging the confusing reverberation of a resonant hall*". In baroque music the ringing sonority is more appropriate than a strong and solid sonority.

Incisiveness

As it says in [23] "*by perceptive articulation it means using brusque accents and sharp attacks rather than explosive accents or massive attacks. A smooth cantabile may be reasonable, or an "etched détaché", or any requisite combination or modification of these; but very seldom a weighty "sforzando"* ". The violin characteristic is that it is really adapted to dynamic tone, but usually the bite serves better the baroque

articulation than the weight of the bow. In articulations case continuous legato is unattractive, because there are always the phrasings and the patterns which must divide. As in the legato continuous staccato is also unusual, because there are always the slight groupings which require some notes to be a little more different in duration or way to execution. The extremes are unpleasant as much the sound is too monotonous as it is too emphasized and stressed. In baroque music, a ponderous articulation can hardly be suitable; a lively articulation may be very suitable indeed.

While these are the principal features of the baroque performance, we will pay attention to the most important elements of this music: tempo and shape of the line.

Tempo

In baroque music there are obvious symmetries requiring corresponding regularity of tempo. It may be less obvious, but it is equally important, that there are subtleties within the symmetries, requiring sensitive and imaginative irregularities.

Baroque music is constructed with many cadences, many of which are transitory. Some are a little weightier in the progressions of the harmony and the movements of the bass: they do not permit rallentando, but they do require just sufficient recognition to acknowledge them with a momentary easing of the tempo. The listener, unconscious of this, feels nevertheless at ease, and does not get the monotonous sensation of being driven along with the depressing punctuality of a machine. The tempo is not arbitrary, nor is it ruthless either. The tempo is flexible. Yet other cadences are clearer still and require quite a perceptible rallentando, usually followed by an equally perceptible pause in the phrasing before the music takes up again in tempo. There will usually be something in the structure to account for any pronounced sense of cadence. For instance, a baroque allegro may often set out its opening metre in some shapely exposition, and make it evident both melodically and harmonically as this exposition

concludes. Unless the listener is presented here with perceptible rallentando, there is an effect of hurry even if it is not noticed as such. It is the same when preparing for the return of the primary material in more or less recapitulatory form (a repetition). This preparation must be heard to be endorsed by another sufficient although not excessive rallentando. In expressive playing, the performer should avoid numerous and exaggerated ritenutos, which are apt to cause the tempo to drag. Difficult as this is, it is nonetheless important, and so too the need for flexibility.

Shape of the line

In performing baroque music, the most important element after tempo is shaping the line. As it says in [23] "*melody, and the support of that melody by a bass-line which is itself a melody, and the linear imitation of melody whether by free or fugal counterpoint. All this goes to the texture of baroque music. Harmony, with its forward impulse, its tensions and its contrasting areas of tonality, generates the driving force behind the melody and the counterpoint. Rhythm enriches and diversifies the thematic material, and has its own serenity or urgency as the case may be*". There exist two steps in shaping the line: the first sustain the flow of a sound without crescendo and the second stage is the inflection of the sound with phrasing, dynamic, rhythmic, etc. which make possible divide it into patterns [23].

3.2 Introduction to the Violin

The violin (Figure 10) is a bowed string instrument that contains four strings tuned in perfect fifths. Surely violin is the most expressive and versatile string instrument because it has a large range of notes. It is the smallest member of the string instruments famaly, which also includes the viola, cello and bass, and it also has the highest pitch. The word "violin" comes from the Middle Latin *vitula*, meaning "stringed instrument".

The oldest knew violin had four strings and it was constructed in 1555 by Andrea Amati. The violins knew earlier, only had three strings, and the oldest existing violin is dated from 1560. The violin immediately became very popular, among both the public and the aristocracy.

Figure 10. Violin

Harmonics (also called overtones) are created by pressing the string, which produce the normal tone and a higher pitched note. Harmonics are indicated in a score by a little circle over the note (that determines the pitch of the harmony), and by diamond-shaped note heads. There are two types of harmonics: natural harmonics and non-natural harmonics.

Natural harmonics

Natural harmonics are played on an open string and this sound corresponds to the pitch, called the fundamental frequency. They occur at whole-number multiples of the fundamental, which is called the first harmonic. The second harmonic is the first overtone, the third harmonic is the second overtone, and so on. The sound of the second harmonic is the clearest of all, because it is a common node with all the succeeding even-numbered. In some cases, the composer calls for playing an open string for a particular effect, as decided by the musician for artistic reasons. Most composers use this technique, like Bach, with whom it is commonly used in the early works.

Non-natural harmonics

Non-natural harmonics are more difficult to execute than natural harmonics, as they implies both pressing the string and playing a harmonic on the pressed note. Using the "octave frame" (the distance between the first and fourth fingers) in any given position, it is possible to produce the fourth harmonic, two octaves above the pressed note. The position and pressure of the finger, as well as bow speed, are essential in producing the searched harmonic.

Using the harmonics previously described, the violin can obtain the compass from the G below the middle C to the highest note of the modern piano. Nevertheless, the top notes are frequently created by natural or non-natural harmonics.

The violin sound is produced by the physical characteristics of the arched shape and the depth of the wood. From the Baroque time, the violin has been one of the most important instruments in classical music for many reasons. One of them is its tone, which is notable above other instruments, making it suitable for playing a melody line, usually as a soloist. When it is played by a virtuous violinist, the violin is tremendously agile, and it is possible to perform difficult and rapid notes series. For that reasons frequently composers assign the melody to the first violins, while second violins play harmony spite the second can also play the melody in an octave lower than the first violins.

As we said before, the violin is the string instruments with highest range of tones. This fact implies it has a fantastic variety of harmonic colouring providing to the violin of a wide expressivity.

3.3 J.S. Bach biography and style

Johann Sebastian Bach (21 March 1685 O.S. – 28 July 1750 N.S.) was a German composer and organist. Bach drove the baroque to its higher and important point, he obtained the maturity of the baroque by means of his sacred works for choir, orchestra and solo instruments. Even though he was not the pioneer of new forms, he improved and enriched the current German style with a vigorous contrapuntal technique, a control of harmonic and motive scales organisation and the adaptation of foreign rhythms and textures (especially Italy and France). Bach's musical style comes from his extraordinary facility in contrapuntal invention and motive control, and his talent for improvisation at the keyboard. He wrote woven music of impressive sonority with a highest firmness because in his childhood he had an important and continuous contact with instruments, musicians and scores. During his teens and 20s, he demonstrated an increasing ability in the large-scale organisation of musical ideas, to apart from the improvement of the Buxtehudian model of improvisatory preludes and counterpoint of limited complexity. From now, it seems Bach has captivated for the Italians' dramatic style with clear melodic contours, with the rhythmic conciseness or with higher cohesion in the motive treatment.

There are numerous more specific features of Bach's style. The notation of baroque music was inclined to think that composers would transcribe only the basic framework, and that performers would make more beautiful this framework by inserting ornamental notes. Although this practice had significant modifications between the schools of European music, Bach was considered as an extremist because he notated with really details his melody, leaving few improvisations for performers. Bach's harmony is characteristic for using short tonicisation (particularly of the supertonic) with the objective to add colour to his textures.

Chapter 4

4. Music collection

4.1 Pieces: "Sonatas and Partitas for solo violin" from Bach

The Sonatas and Partitas for solo violin is a group of six works composed by Johann Sebastian Bach. It includes three sonatas and three partitas composed of dance-based movements such as sarabande, allemande, courante or bourrée, among others. For example, sarabande is a slow dance in triple metre with a feature that beats 2 and 3 of the measure are often tied, giving a distinctive rhythm of crotchet and minim in alternation. On the other hand, bourrée is a quick dance in double time that usually it is used in a suite as the allemande. This one, originally, formed the first movement of the suite. The last example, courante is a triple metre dances from the late Renaissance and the Baroque era.

Bach composed the "*Sonatas and Partitas for solo violin*" in 1720 but the original performer is unknown because the first manuscript was almost destroyed. However, some people think Bach might have done the first performance indicating that way his talent and ability as a violinist.

4.1.1 Discussion on the selection of the pieces

This repertory have been chosen by the fact that they are monophonic pieces without accompaniment which makes easier the analysis and extraction of audio parameters. These pieces have been played by many performers such as Ara Malikian, Arthur

Grumiaux, Sigiswald Kuijken, Shlomo Mintz, etc. According to [13], "*although this work was intended for violin, Bach himself transcribed portions for other instruments, and the entire set has been transcribed by others for guitar, viola, and cello"*. Moreover, the scores are available in MIDI format.

Additionally, this work from Bach was the first one written for a solo-violin, without bass continuo. That fact, combined with the enormous Bach's talent, contributed to the popularity of these Sonatas and Partitas, making these pieces fundamental to the violin pedagogy. This importance is a consequence of the music evolution and, overall, their virtuosic execution [24].

The last reason for this selection is the era, the baroque era. The Baroque period is very expressive but, at the same time, has clearer harmony than other periods, such as the Romantic. It is a significant fact because the harmony plays an important role in the expressive melody performances (using tensions and distensions).

4.1.2 Movement selection

The movement selected is the Double in B minor of Partita No.1 (Figure 11). The Double movement, in general, is an embellished variation of the previous movement. In this case, it is an embellished sarabande movement. Sarabande, as we have explained before, is a slow dance in triple metre. Apparently the dance became popular in the Spanish colonies before moving back across the Atlantic to Spain. Later, it became a traditional movement of the suite during the Baroque period. The Baroque sarabande is commonly a slow triple rather than the much faster Spanish original, consistent with the courtly European interpretation of many Latin dances. So, taking into account these characteristics, the Double movement was chosen for the following reasons:

- It is a short movement (34 compasses in two phrases) and it is important for the reason that it is the first studied movement and its length helps us to familiarize with the extracted audio descriptors and how they should be obtained. In addition, there is phrase repetition, which provides more material for comparison. And aside from comparing the execution of the phrase by the same performer, we can try to study the behaviour of different performers. It also shows the importance of the phrase repetitions in order to identify which manner of playing is the most common for developing the music.

- The other reason behind this selection is the tempo regularity of the movement. All notes of the melody are eight note except for two (a quarter note and a half note) located at the end of each phrase. This regularity facilitates the study of tempo because it is a little easier to detect the tempo fluctuations as well as the role of tempo in the expressivity; how it is used by each performer to transmit a specific feeling (depending on the musician) and build the melody trajectory.

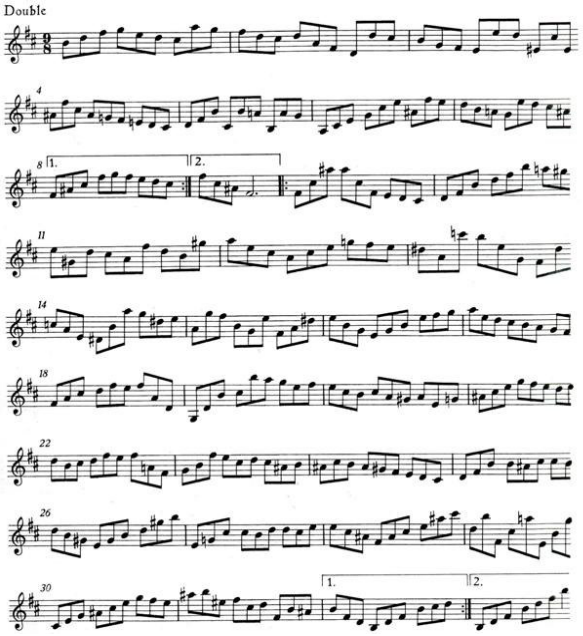


Figure 11. Double in B minor of Partita No.1

4.2 Recordings

Expressive studies carried out previously used different formats for studying musical expressiveness. The most common formats are the MIDI (for score representations)

and the wav (for audio recordings). Each has certain advantages and disadvantages: for example, with MIDI, descriptors like onsets and pitch are automatically found while for melodies it is really difficult to obtain good results from recordings (wav melodies). In contrast, with audio recordings better descriptors may be obtained relating to dynamics, articulation, vibrato, etc. Hence a better expressive description may be obtained.

Our recordings

In our case we have chosen recordings to analyse the movement because recordings are expressively richer than MIDI and they facilitate and improve the results obtained in the expressive research for performer comparison.

Performers were selected along the following criteria: first of all, we established that we need, at least, around 20 recordings in order to make the comparison and extract some behaviour from performers playing the Double movement. Second, these performers could not be amateurs because we need to obtain the best expressiveness references possible for making a good study. So we have chosen 20 recordings from 20 famous violinists: Ara Malikian, Arthur Grumiaux, Brian Brooks, Christian Tetzlaff, Garrett Fischbach, Itzhak Perlman, Jaap Schrder, Jacqueline Ross, James Ehnes, Jascha Heifetz, Josef Suk, Julia Fischer, Lucy van Dael, Mela Tenenbaum, Rachel Podger, Sergiu Luca, Shlomo Mintz, Sigiswald Kujken and Susanna Yoko Henkel[1]. It is possible to find the biography of these violinists in the Annex.

1 Biographical background for these violinists may be found in the Appendix.

Chapter 5

5. Audio Description for the Analysis of Expression

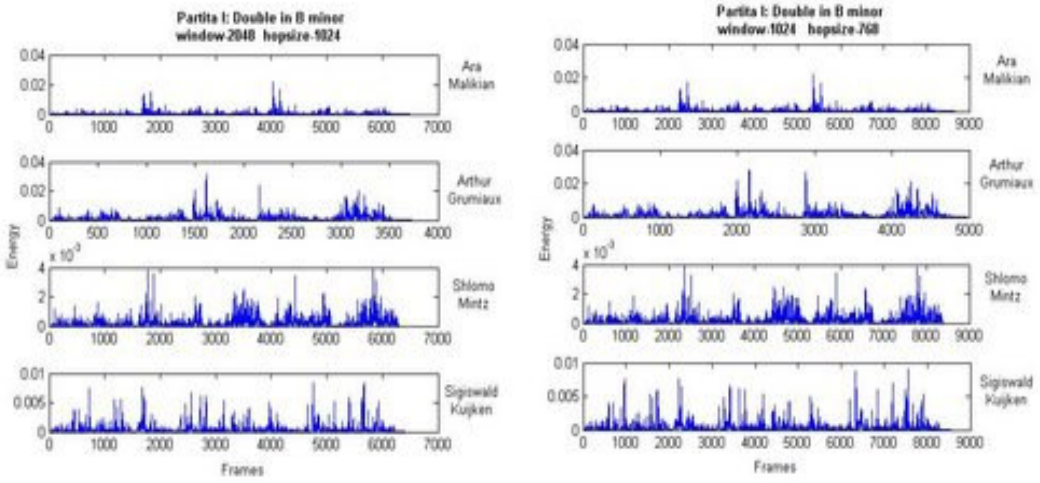
5.1 Intensity

In music, dynamics normally refers not only to the softness or loudness of a sound or note, but also to every aspect of the execution of a given piece, whether stylistic (staccato, legato etc.) or functional (speed). Loudness is the quality of a sound that bears the primary psychological correlation to its physical intensity (energy). There are two main types of dynamics: p or piano, meaning "softly" and f or forte, meaning "loudly" or "strong". Apart from these, many other, intermediate qualifying dynamics exist for expressing graduation such as mp (mezzo-piano), mf (mezzo-forte), etc. Moreover, changes in dynamics may be gradual, such as crescendo, or sudden, such as sforzando.

5.1.1 General Energy

In our initial approach we tried to identify this kind of dynamics by using a simple normalization of the energy in order to make an analysis comparing the different recordings. This meant calculating the general energy generated in a single movement. A movement of the Partita I: Double in B minor was the particular piece chosen. The analysis was made using various performers, namely, Ara Malikian, Arthur Grumiaux, Shlomo Mintz, and Sigiswald Kuijken. On this point, it should be noted that this was quite unsatisfactory, since loudness levels were very low. We tested different sets of window size and hop sizes, such as 1024 with a hop size of 256 (overlap of 25%), or

2048 with a hop size of 1024 (an overlap of 50%). Below are a pair of general energy examples (Figure 12 a) and b)).



a) Partita I: Double in B minor.
General energy window: 2048
Hopsize: 1024 (50%)

b) Partita I: Double in B minor.
General energy window: 1024
Hopsize: 256 (25%)

Figure 12. General Energy.

5.1.2 Note Violin Energy

As the overall energy proved insufficient, we also attempted to study the note energy. However, again the results were unsatisfactory. We will here explain how we calculated the violin note energy.

Firstly, we need to know if the violin note energy will allow us to identify the note's main part. Once the principal part is known, we are then able to calculate the energy. The theoretical violin

Figure 13. Theoretic Violin Envelope

envelope is shown in Figure 13. We can observe how the attack and decay parts in this envelope are very similar.

This effect must be caused by the way in which it is played, since the note played is long, sustained and sufficiently regular. In order to be able to compare the Theoretic Violin Envelope's sound with notes of the piece on which we have carried out our analysis on the original note. The result is shown in the Figure 14, from which we can observe how the ADSR envelope is quite similar to the original image (Figure 13).

While we know the theoretical envelope of any violin note, we must define the envelope for the violin notes from our chosen pieces, by studying several notes taken from these pieces. The notes found in our chosen pieces, namely, in a First Partita's movement, do not have this perfect envelope; they are more irregular than the sample note. One reason for this fact could be the fast execution of these notes or their position in the piece since after all a note in the middle of the melody is not the same as one that is played at the end.

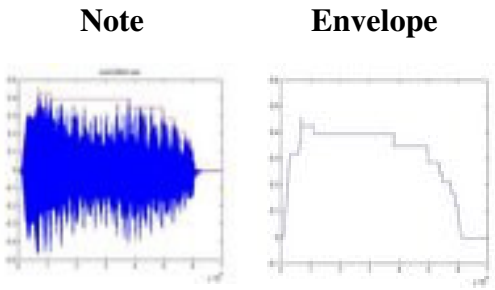


Figure 14. These figures represent the theoretical violin sound and envelope.

Here, in Figure 15, we show some examples of these notes and their envelopes.

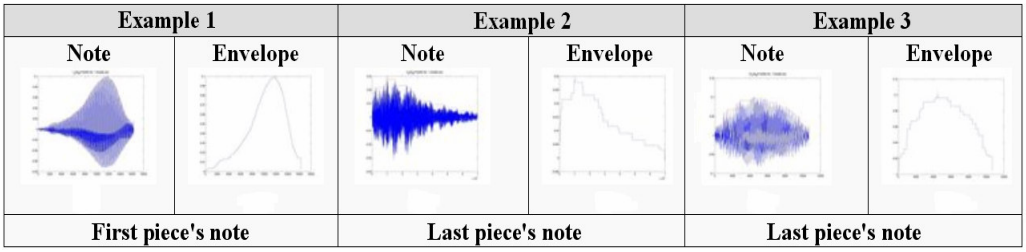


Figure 15. Partita I: Double in B minor - Notes

5.2 Melodic transcription

In order to study the energy of the pieces, we separated them into melodic phrases. Once the pieces were separated into phrases, we attempted to obtain the inter onset intervals (IOI) of all fragments using MAMIMelodyTranscription [14] for studying the energy of each note. We will later explain the results obtained with this tool by means of some experiments involving different performers.

MAMIMelodyTranscription's results

We conducted some experiments using four performers: Ara Malikian, Arthur Grumiaux, Sigiswald Kuijken, and Shlomo Mintz. In many cases the onset detection is very successful but there were some cases in need of some adjustments. The right diagram shows a good example of recognition:

*Added Notes = **AD*** *Deleted Notes = **DE*** *Total Notes = **TN***

***F1_1**: Phrase 1, first execution / **F1_2**: Phrase 1, second execution (repetition)*

***F2_1**: Phrase 2, first execution / **F2_2**: Phrase 2, second execution (repetition)*

1. Ara_06 Partita No. 1 Double_F2_1 - (Error ~ 6%, AD=11 / TN~216)
2. Ara_06 Partita No. 1 Double_F2_2 - (Error ~ 6%, AD=11, DE=4 / TN~214)
3. Arthur_06 Partita No. 1 Double_F1_1 - (Error ~ 1%, AD=1 / TN~72)
4. Arthur_06 Partita No. 1 Double_F1_2 - (Error ~ 3%, AD=1, DE=1 / TN~67)
5. Arthur_06 Partita No. 1 Double_F2 - (Error ~ 6%, AD=11, DE=3 / TN~220)
6. Shlomo_06 Partita No. 1 Double_F1_2 - (Error ~ 4%, AD=1, DE=2 / TN~67)
7. Shlomo_06 Partita No. 1 Double_F2_1 - (Error ~ 4%, AD=9, DE=2 / TN~216)
8. Shlomo_06 Partita No. 1 Double_F2_2 - (Error ~ 8%, AD=14, DE=4 / TN~214)
9. Sigiswald_06 Partita No. 1 Double_F1_1 - (Error ~ 7%, AD=5 / TN~72)

10. Sigiswald_06 Partita No. 1 Double_F1_2 - (Error ~ 13%, AD=7, DE=2 / TN~67)

11. Sigiswald_06 Partita No. 1 Double_F2_1 - (Error ~ 12%, AD=27 / TN~216)

12. Sigiswald_06 Partita No. 1 Double_F2_2 - (Error ~ 11%, AD=22, DE=2 / TN~216)

The most frequent errors were made in consecutively repeated notes as well as when the last note is the phrase's final note, when the player makes a vibrato. The vibrato effect is a hindrance to the recognition of the note.

Note: The worst onset detection with Sigiswald could be down to his interpretation. He almost plays notes as legato, so it is more difficult to detect the onsets.

5.3 Loudness

As we have said above, loudness in music is based on dynamics. It is the subjective quality of a sound that bears the primary psychological correlation to physical intensity. For that reason it is interesting for this study on expressivity, because expressive quality is a subjective parameter capable of being perceived by each person differently.

For the purposes of conducting this study, we used a toolbox, namely, MAToolbox (Measures for Audio Toolbox), in order to comprehend this parameter and then extract the sone (loudness sensation) descriptor.

5.3.1 Measures from the Audio Toolbox

This toolbox measures the strength in sones (loudness sensation) per frequency band. Using the MAToolbox we made some preliminary studies for viewing possible loudness trends and then used the measure in sones to make a more exhaustive study.

Some diagrams below (Figure 19) represent the loudness quality of a piece; in particular, they show the phrases of Double in B minor (the first or second repetition), as mentioned in Chapter 4 (Material used). The phrases represented in these figures are played by different performers, demonstrating different representations of a sound. The first window is a representation of a sound waveform while the others are the results of different auditory models of loudness. The FFT and Outer Ear models are not able to identify differences in loudness while the other models (Bark Scale, Masking, and Sone) do.

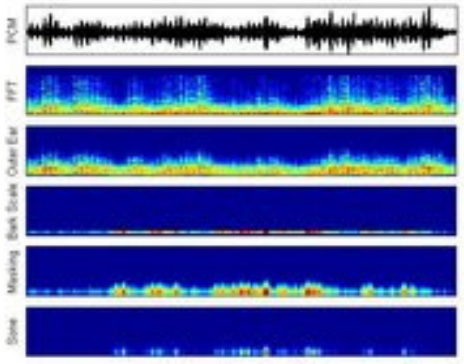


Figure 19. a) Ara Malikian F1_1

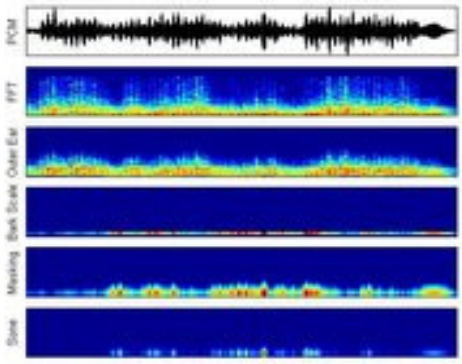


Figure 19. b) Ara Malikian F1_2

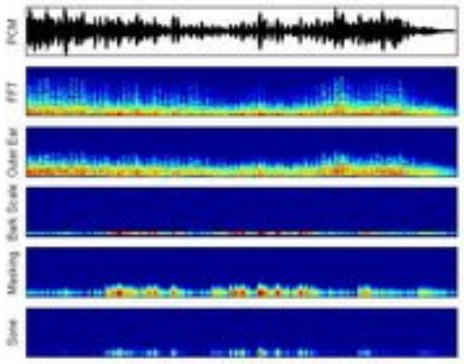


Figure 19. c) Shlomo Mintz F1_2

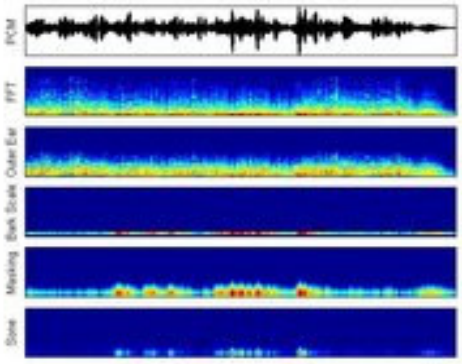


Figure 19. d) Sigiswald Kujken F1_2

Samples Figure 19 a) and b) are by the same performer, Ara Malikian, and are taken from the same phrase, but Figure 19 a) represents the first execution, while the Figure 19 b) represents the repetition of the phrase. In these we can see the loudness sensation is really similar unless we take into account the end of the phrase. The final is completely different because it is not exactly the same. The first execution (Figure 19 a)) ends with a short note followed by another note. On the other hand, the repetition (Figure 19 b)) ends with a long vibrato note that is not followed by another; instead, there is a little pause before a new phrase begins.

The following two figures (Figure 19 c) and d)) represent different performers with the same phrase; both are from the repeated performance (as we can see from the end). The particularity of these two figures lies in the difference of execution. The first (Figure 19 c)) is played as staccato, while Figure 19 d) is played as legato. We can thus see that in the Shlomo performance the most notably loud parts are more separated than in the Sigiswald performance.

The following two diagrams are taken from recordings (by Arthur Grumiaux) with the highest intensity. It is possible to see that the Bark Scale contains more red, as an indicator of intensity, compared to the other recordings. Moreover, the interpretation of the repetition of the phrase (Figure 21 b)) is more intense than the first execution (Figure 21 a)).

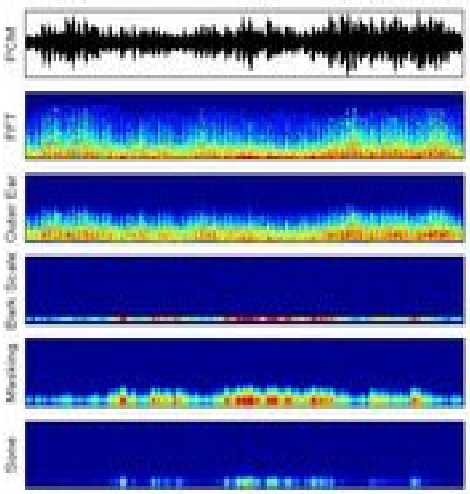


Figure 21. a) The highest intensity Arthur Grumiaux: First Repetition

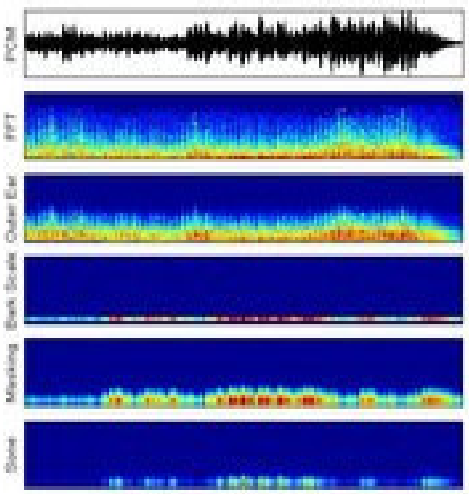


Figure 21. b) The highest intensity Arthur Grumiaux: Second Repetition

Spectrum Histogram

The Spectrum Histogram also summarizes the variations in the dynamics by counting, for each frequency band, how many times certain loudness levels are exceeded.

Depicted in this way, (Figure 22Figure 22) we can see which recording performer attains the greatest levels of loudness. We could therefore say that Ara Malikian (in the phrase repetition) attains the highest level, followed by the execution of the original phrase by the same performer. This may be attributed to the fact that the performer Ara Malikian uses the vibrato, a significant expressive feature.

Typically, for every performer, the phrase is louder in repetition than in its original execution, except in the case of Sigiswald Kuijken (of whom the opposite is true). That the phrase marks a lower loudness level in repetition may be owed to the technique used (this is the only one played with a baroque violin). In this way, music does not remain static, but it evolves into the next phrase.

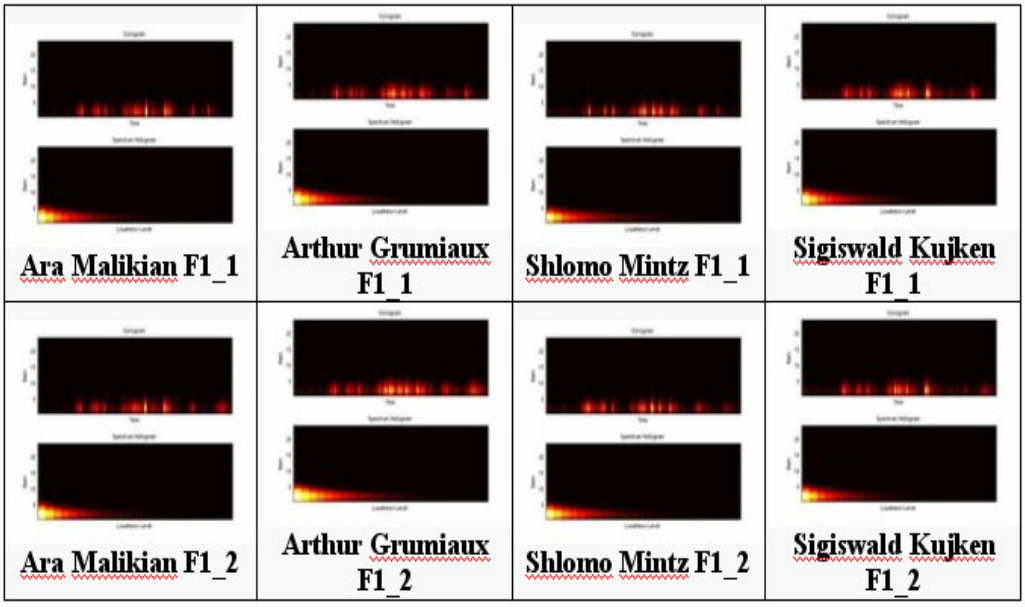


Figure 22. The variations in the dynamics

5.3.2 Piece's Loudness

For doing our study first we divided the movement into phrases. Once we had obtained all of the selected phrases from each performer, loudness was measured using the ma_sone function, which estimates how strong the loudness sensation (sone) is per frequency band. By means of this function we obtained the general phrase's loudness and then we smoothed this data in two ways: (a) by using the frame data average; and (b) by using a Gaussian window. Having obtained the overall loudness, we looked for the *climax* of each phrase to see if it occurs at more or less the same time with each performer. The *climax* is the highest point of a phrase (or melody) in the sense that the

music evolves toward this point (*climax*) and then, on attaining it, the music "returns" because the objective has already been found.

5.3.3 Loudness Descriptors

We have used three kinds of descriptors in relation to loudness (*Ntot, smooth and climax*). Although there are three descriptors, the first two are very similar because they contain the same data but *Ntot* is the original data, whereas *smooth* is the *smoothed* data from *Ntot*.

The *Ntot* loudness of the phrase: This descriptor shows how the loudness varies over time. As we have said above, the *smooth* represents the same as *Ntot* but with *smoothed* data. This *smooth* is obtained by means of two methods: the average and the Gaussian. In contrast, *climax* represents the maximum value of general loudness (for each phrase).

5.3.4 Graphics

Below are some examples of data obtained in the loudness process by means of graphics.

Frame Data Average:

The following examples are obtained using the average. This average is made using windowing. A window size is chosen, and then the phrases are parsed with this window and an average is got from each window, providing the *smoothed* data.

We can see in Figure 23 that the loudness analysis of the Double's original phrase differs between players and the order of interpretation. Naturally, each performer has an individual way of playing, with a particularly modular loudness, as we see from the

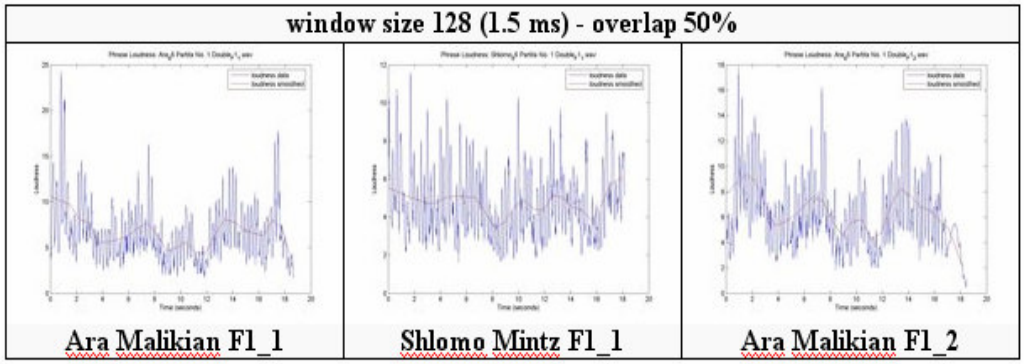


Figure 23. Frame Data Average: First phrase

figures by different performers. In figures "Ara Malikian F1_1" and "Shlomo Mintz F1_1", it is possible to see different execution between players, and that also the "Shlomo Mintz F1_1" interpretation marks a higher point of loudness than the "Ara Malikian F1_1" interpretation.

On the other hand, we can observe a substantial difference between different interpretations by the same person in relation to the same phrase, despite the fact that it always follows a kind of pattern. This difference depends on the order of execution: if it is the original execution or the repetition. Usually, if the repetition occurs at the beginning, then it tends to increase in loudness, as we can see in "Ara Malikian F1_1" versus "Ara Malikian F1_2".

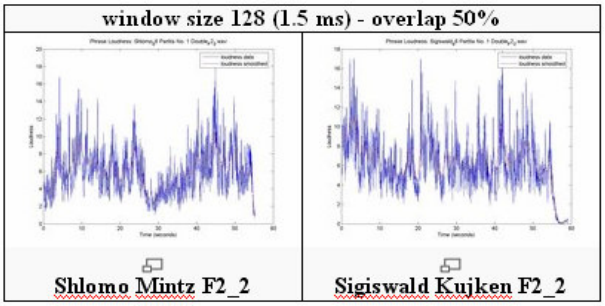


Figure 24. Frame Data Average: Second phrase

As with Figure 23, these graphics (Figure 24) have been obtained from the repetition of the Double movement's second phrase, and were analysed using a window size of 1.5 ms. with an overlapping of 50%. The problem is that, in this case, *smoothed* data is not smooth enough: it still reflects the overall loudness too much.

To solve the problem of Figure 24Figure 24 we increased the window size to 3 ms., providing data that is smooth enough. It follows the general loudness showing a clear trajectory interpretation (Figure 25).

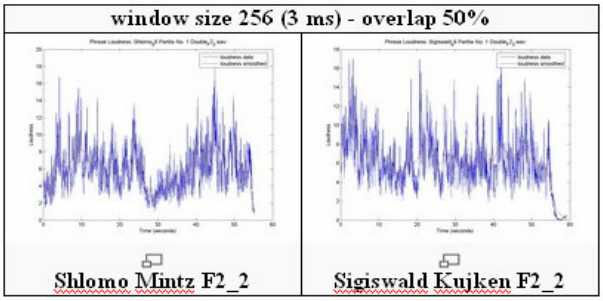


Figure 25. Frame Data Average: Second phrase

Frame Data Gaussian

The following examples are obtained using overlapping Gaussian windows. The process is similar to the average, but here each data window is multiplied by a Gaussian window (a window that has a distribution where the maximum number is 1 and it is situated in the middle of the number's array) and then divided by the sum of these Gaussian windows, thus providing the *smoothed* data.

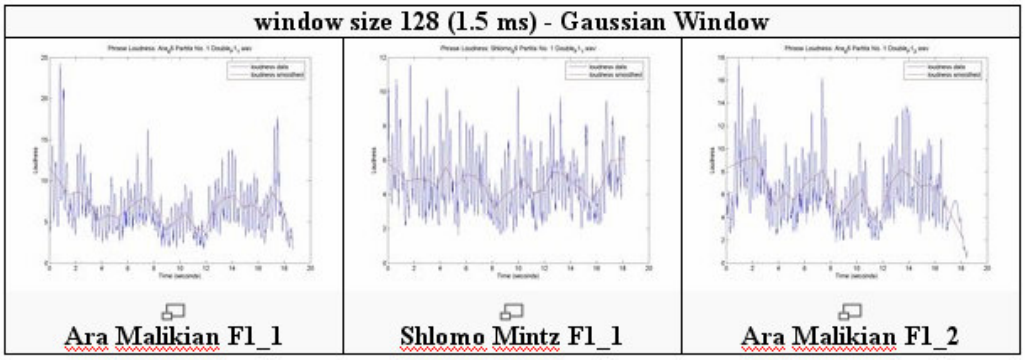


Figure 26. Frame Data Gaussian

As we can see in Figure 26, by overlapping the Gaussian windows, the results obtained are more or less the same as the previous case (using the average).

In spite of the similarity of the two methods, it should be necessary to study the differences between them for determining which has better application. For this reason, we will compare below the smooth loudness from average and Gaussian windows.

Frame Data Average vs. Frame Data Gaussian

Figure 27 shows the loudness of the first phrase in the initial execution taken from the Sigiswald Kuijken performance. At the same time, it shows the *smoothed* data using the average (left diagram) and Gaussian windows (right windows).

The main difference occurs in that the Gaussian method is more detailed than average. If we look at the first 4 seconds, we can see a difference in *smoothed* data: in the Gaussian windows, the *smoothed* data observes the overall loudness more than *smoothed* data carried out using the average. It is for this reason that we work with *smoothed* data carried out using the average.

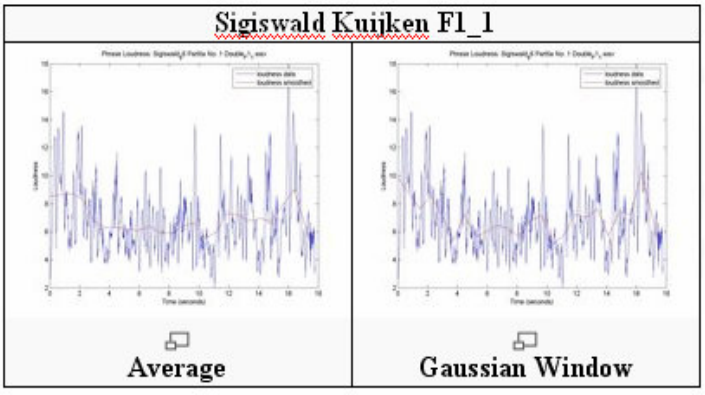
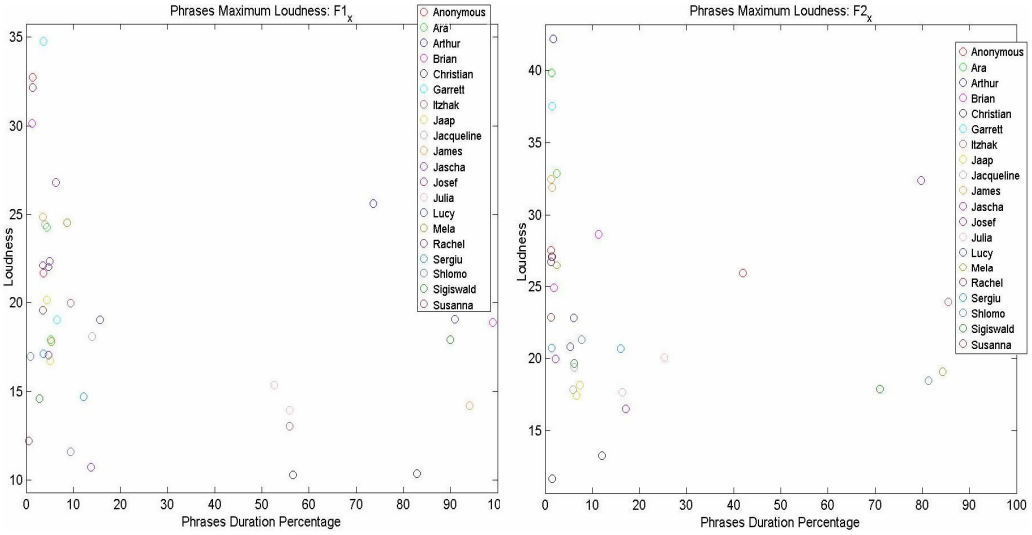


Figure 27. First phrases loudness

5.3.5 Climax

The *climax* study was done using phrases, so that we have a particular *climax* (climaxes) in a melody. In both phrases the *climax* is normally concentrated at the beginning of a phrase. It could be possible because it is necessary to gather enough energy for arriving to the phrase's end. Another important point to take into account is, in general, the second phrase (Figure 28 b)) has more energy than the original phrase (Figure 28 a)). It could be because the music has an evolution over time from the beginning until the end of a piece. So we could say that the *climax* of a piece is found at the beginning of the second phrase (around the first 20% of the phrase).

The following figure (Figure 28Figure 28) shows, in percentages, the correspondence between phrase climaxes.



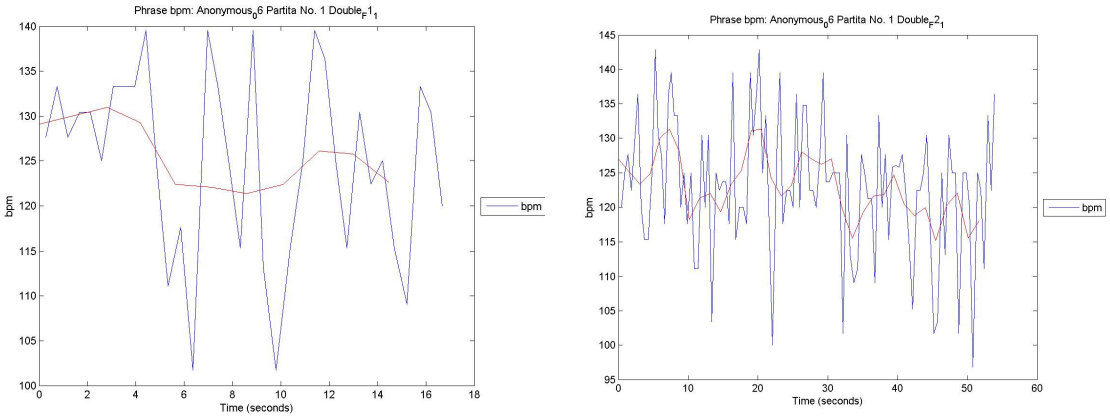
a) First Phrase **b)** Second Phrase

Figure 28. Phrase's climax:

5.4 Tempo

As we said before, refers to the speed or pace in a given piece. Also it is an extremely essential aspect of music, influencing the atmosphere and complexity of a piece. So, tempo is a typical descriptor for analysing the expressivity of a piece.

For the purposes of calculating tempo in our pieces, first it is necessary to determine the instantaneous beat. We have obtained it by means of the BeatRoot (An Interactive Beat Tracking and Visualisation System) developed by Simon Dixon [6]. Once we obtained the bpm (beats per minute) we related it with the time of the piece. As happened in the loudness, the bpm data should be *smoothed* for improved study. The next representations (Figure 29) show the bpm over time: the blue line representing the original data while the red line represents the *smoothed* data. The *smoothed*, as in the loudness case, has been obtained by the average and Gaussian method, and again the method selected for making the study is based on the average.

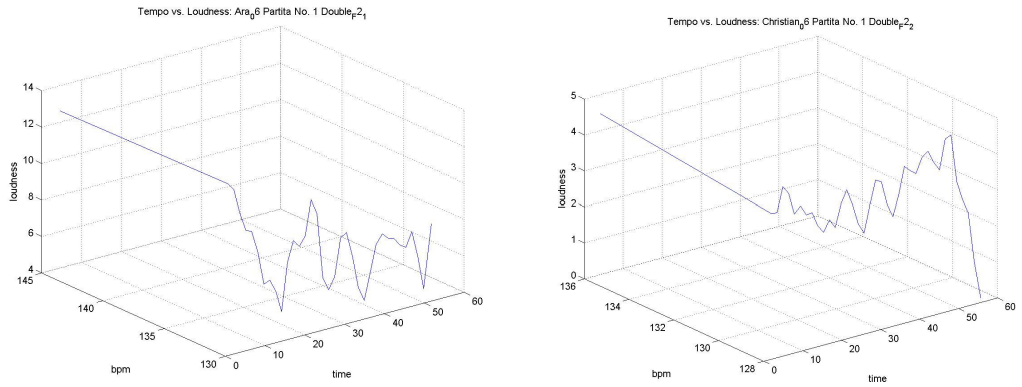


a) First Phrase, 1st repetition (1_1) **b)** Second Phrase, 2nd repetition (2_1)

Figure 29. Tempo's descriptor

5.5 Loudnes vs. Tempo

Lastly, we made a study combining the most important descriptors: loudness and tempo related with the time of the piece. As we can see in Figure 30 the loudness (y axes), the bpm (z axes) and time (x axes) are represented. In the Figure 30 a) we can see how the phrase starts with a specific loudness and tempo. Initially, loudness maintains the value while tempo decreases over time. Yet there comes a certain point where this trend changes, that is, to some extent, it is inverted. The tempo is more or less constant while the loudness fluctuates. On the other hand, Figure 30 b) behaves in the same way as Figure 30 a) except in the finale, because the a) figure in the finale significantly increases in loudness, whereas the b) figure at the end produces a total decrease in loudness. It is produced for the reason that the Figure 30 a) represents the first phrase and the first repetition and the original phrase cannot die since the piece continues, even as Figure 30 b) is the second phrase in its second repetition, where the piece ends, and where the music of itself dies.



a) Second Phrase 1st repetition (F2_1) **b)** Second Phrase 2nd repetition (F2_2)

Figure 30. Tempo vs Loudness

Chapter 6

6. Results and discussion

6.1 Introduction

In the previous chapter (Chapter 5), we have seen how graphics are created and interpreted. This is important since we use it to study the trends of the piece and how in each expression changes with performer. In the following sections (Loudness, Tempo, and Tempo vs. Loudness) we are going to show and discuss the results.

In the following sections, we will show some examples of the trends observed in Tempo, Loudness and in Tempo vs. Loudness. Each descriptor is represented in one phrase versus time, and each phrase is represented by one figure. The Double movement has two phrases with their own repetition, so we have the first original phrase (F1_1) with its own repetition (F1_2), and also a second original phrase (F2_1), also with its own repetition (F2_2).

6.2 Loudness

In loudness (Figure 31) if we compare each original phrase with each individual repetition (F1_1 vs. F1_2 and F2_1 vs. F2_2), we can observe certain trends:

- *F1_1 vs F1_2*

In general the loudness starts out at a high value and then gradually diminshes. The difference between the original phrase and the repetition comes at the end. The original interpretation (F1_1) ends in continuity, that is, the continuity of the same musical topic: the phrase does not come to an end, but remains rather open. On the other hand, the repetition (F1_2) ends the phrase, so that the loudness is lower. As for the performers, there is no similarity of interpretation between the original phrase and the phrase repeated.

- *F2_1 vs F2_2*

  In this case, the highest loudness (*climax*) is found at the beginning of the phrase. We can only talk about *climax* in this phrase because the *climax* is the highest loudness value of all pieces. Another important point to take into account is how each phrase ends. The original phrase, in general, ends with a slight increment in loudness, whereas in the repetition phrases it decays completely because this is the finale of the piece, so the music must finish. As in the case of the first phrase, there is no similarity between the original and the repetition.

If we compare the two phrases (F1_1/2 sv. F2_1/2), we should emphasize that the second one has a higher loudness level, it is because the piece is developed here. Another point to emphasize is a common factor between the phrases in repetition (F1_2 and F2_2) is that loudness tends to diminish on the last note because they are composed by, in both cases, a note with a longer duration than the other ones. The note duration is a dotted half-note (F1_2) and a quarter-note (F2_2) while all the other figures are eight-note.

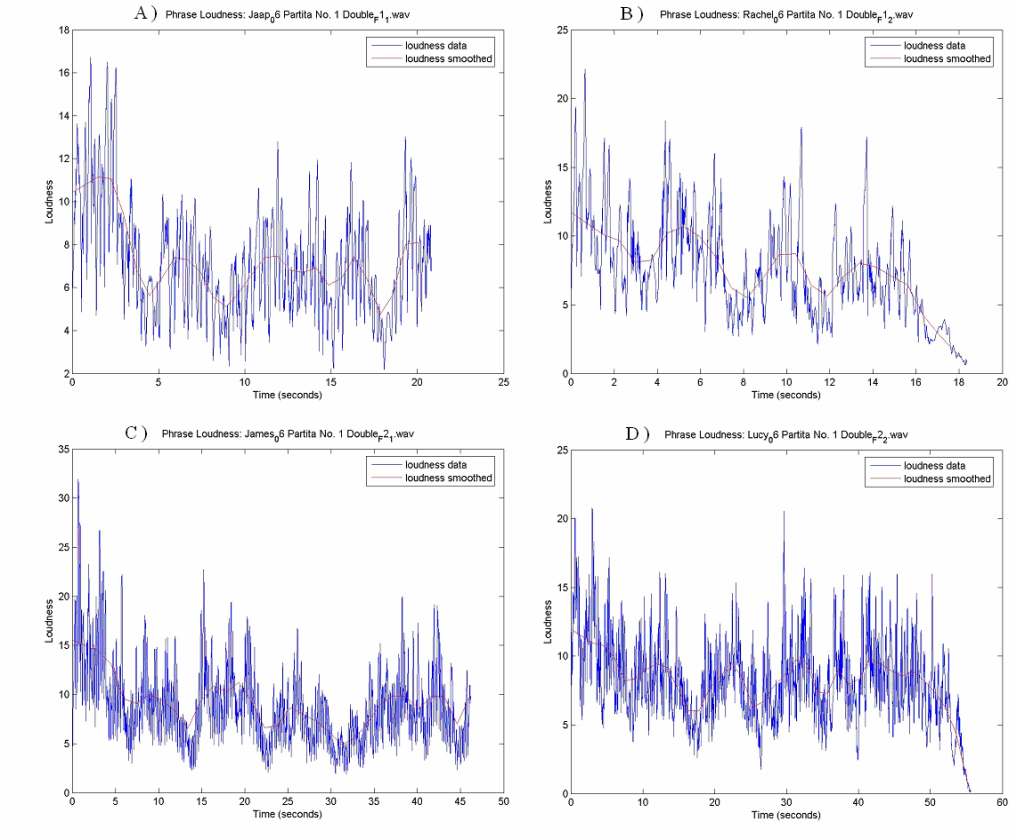


Figure 31. Loudness representation:

A) Jaap F1_1, **B)** Rachel F1_2, **C)** James F2_1, **D)** Lucy F2_2

6.3 Tempo

Few differences in tempo exist between phrases (Figure 32) – less so than in loudness – yet even so it is possible to mention some particular behaviour:

- *F1_1 vs F1_2*

  The most important fact is produced, almost always, in the phrase end because there exists a slight diminuendo, such as a preparation for the repetition (as in the original interpretation), the change of phrase (the first phrase repetition) or the end of movement (the second repetition).

- F2_1 vs F2_2

  The second phrase behaves in the same way as the first; it has no other relevant characteristic.

Comparing the two phrases, it is possible to see that no significant fluctuation is shown within each interpretation, although the interpretation varies between performers. This happens because there is no specific tempo indication for Double movement, so every performer adopts the tempo as they consider necessary. However, there must be a rule: tempo does not change within the movement by the same performer; moreover, we know that almost all notes are eight notes. This is because, typically, in the baroque period there are no changes of tempo made within the same movement; the tempo remains more or less constant.

Another important trend we may observe is that the repetitions of both phrases are performed at a slightly faster tempo or slightly slower than the original phrases. This arises for the simple reason that the repetition of the melody must in some way vary if it is to hold our attention.

This characteristic lack in tempo variations derives from the regularity of the piece. We have chosen a movement that is extremely regular to facilitate the initial analysis, so it

is natural there are no relevant changes of tempo that would make for an exhaustive study.

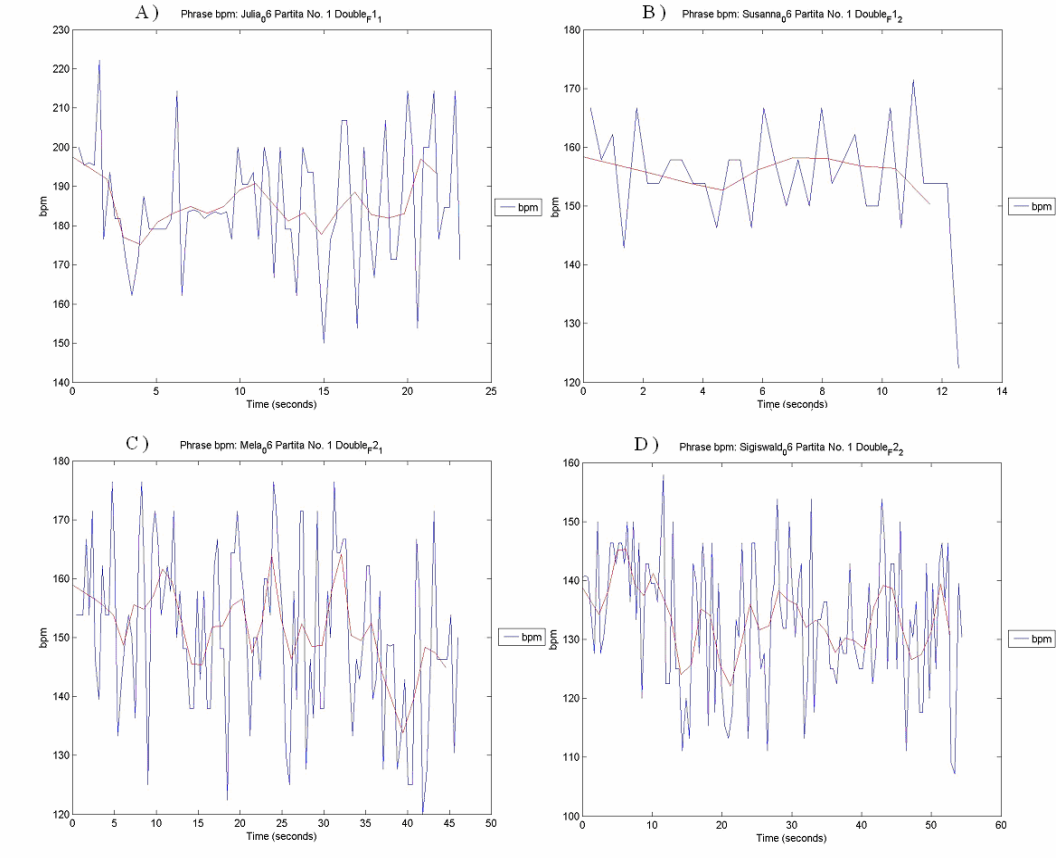


Figure 32. Tempo representation:

A) Jaap F1_1, **B)** Rachel F1_2, **C)** James F2_1, **D)** Lucy F2_2

6.4 Tempo vs. Loudness

Lastly, in this section, we can see the relation between both descriptors (loudness and tempo) and how they behave over time. In these figures is easy to observe how the

different performers have different ways of interpretation (Figure 33), and the different interpretations of the same melody by the same performer, i.e. Figure 34 shows the original phrase and the repetition.

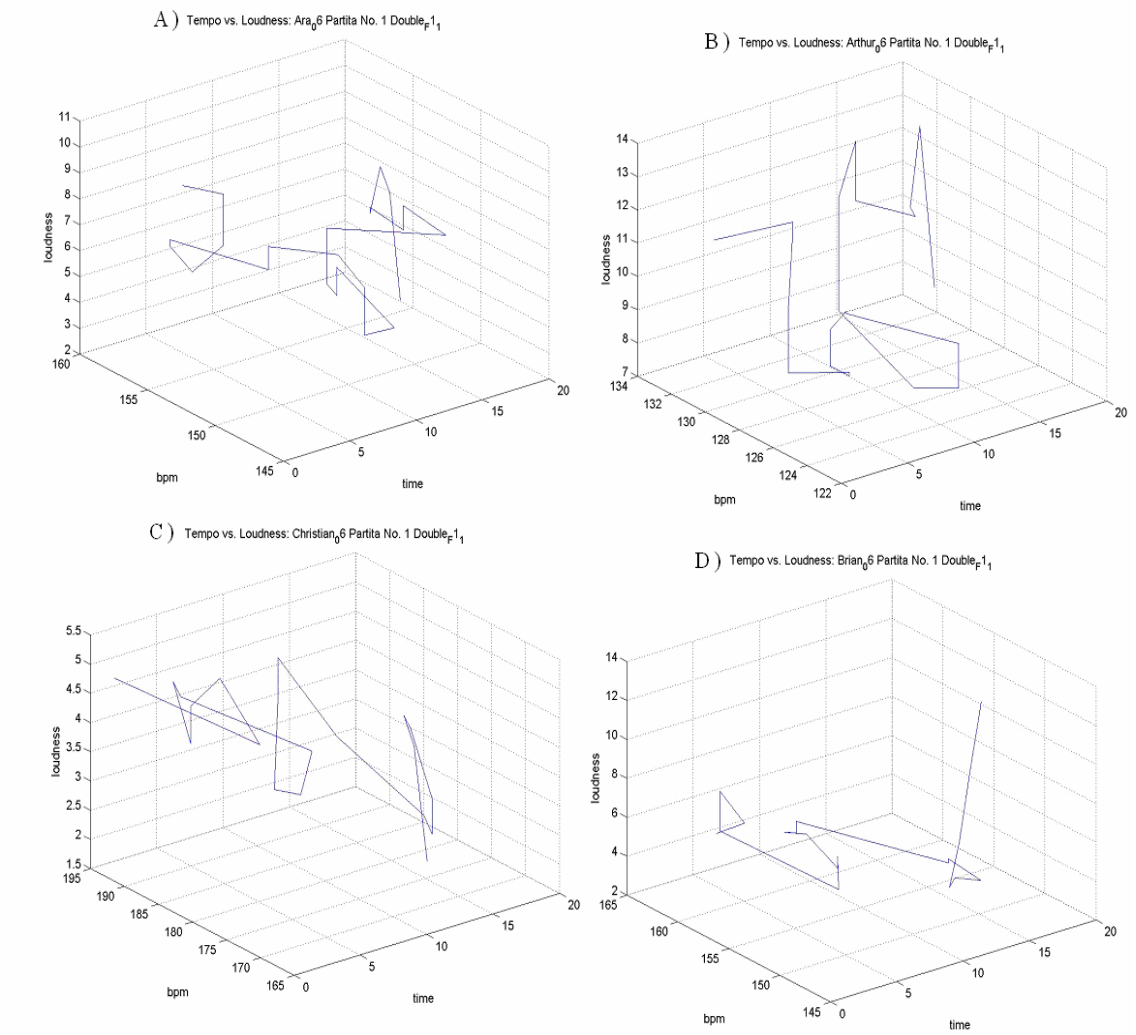


Figure 33. This graphics represent the first original phrase from 4 different performers: **A)** Ara, **B)** Arthur, **C)** Christian, **D)** Brian

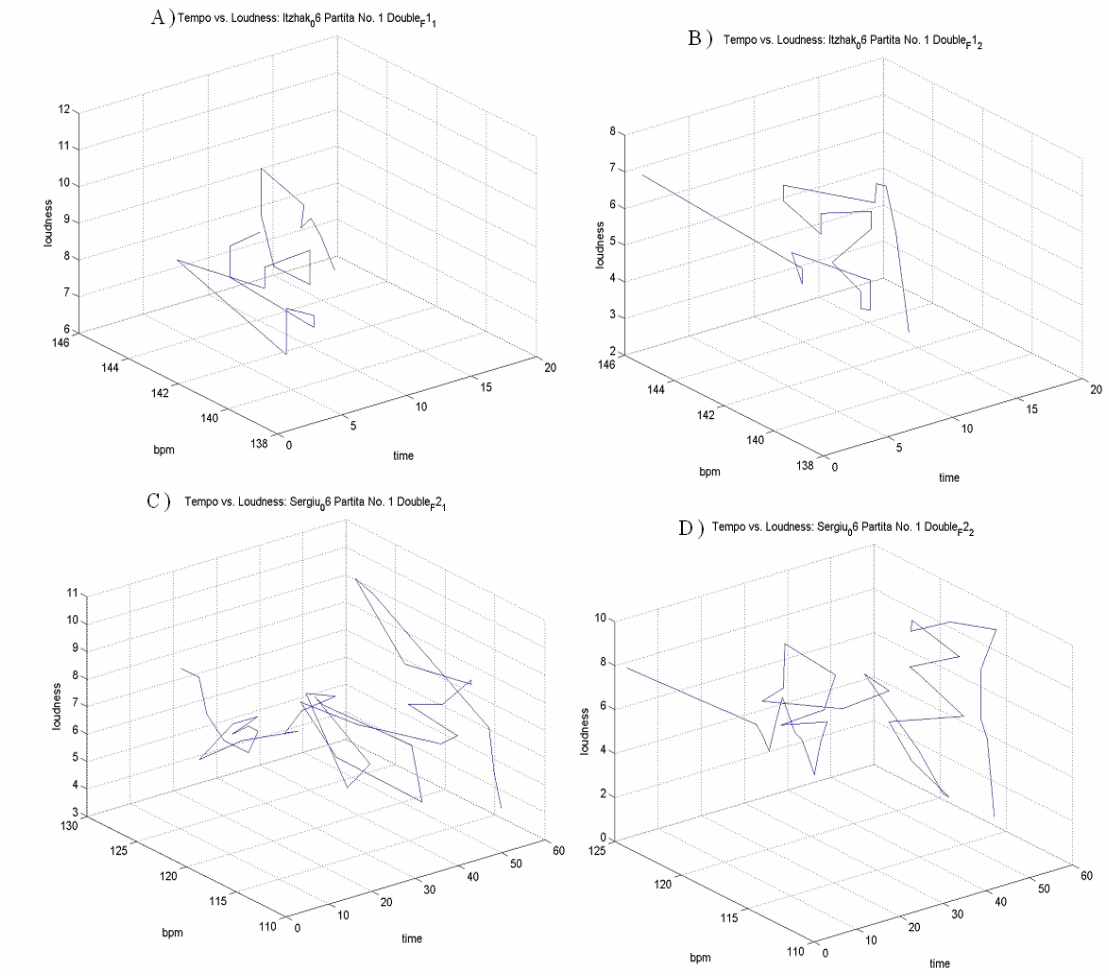


Figure 34. This graphics represent the different interpretation of a same melody (original vs. repetition) from a same performer.
A) Itzhak F1_1, **B)** Itzhak F1_2, **C)** Sergiu F2_1, **D)** Sergiu F2_2

Chapter 7

7. Conclusions and Future work

7.1 Conclusions

Throughout this project we have been able to analyse and observe some behaviour in the Sonatas and Partitas for solo violin by J. S. Bach. In spite of how little material is actually analysed, we have been able to observe significant points which affect most of the performers.

In this analysis we can see some specific and general behaviour occurring in the repetition of a phrase. It is possible to comment on some behaviour at repetition time: usually the repeated phrase tends to have a higher intensity than the original phrase and at the same time a slightly increase of the tempo for varying the melody. This is how it is possible to listen to it with the same attention without getting tiring of it.

Other interesting phenomena include the ritardando (in tempo) and diminuendo (in intensity level) found when the phrases end, as a consequence of the preparation for the next phrase. Music must “breathe” for the benefit of both our understanding and the melody.

And lastly, all these behavioural discoveries will serve towards simulating and reproducing greater expressiveness in computer generated music.

7.2 Future Work

The analysis carried out is limited in so far as that only one movement of a piece has been analysed. So, to conduct an exhaustive study, it would be necessary to analyse other movements by the same performers. That way, it may be possible to study the behaviour of each performer in a similar situation.

Another possible improvement would be to extend this study to include other pieces, creating an ampler vision of performers' interpretation, since playing baroque pieces is not the same as playing romantic pieces, for instance. Nevertheless, if these were compared, it would be possible to identify the characteristic behaviour of each performer. Moreover, once that behaviour was identified, it would be worthwhile applying machine-learning techniques for comparing performers and their expressivity based on real examples.

Finally, another potential future work would be to apply these studies to other instruments of the same family, the string family, such as the viola, violoncello or double bass. Being of the same family, the main characteristics would be very similar.

Chapter 8

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Chapter 9

9. Appendix

9.1 Performer's biography

9.1.1 Ara Malikian

Ara Malikian was born in Lebanon in 1968. He began studying the violin at a very early age with his father. His talent was recognized precociously despite the difficulties he encountered because of the war, forcing him even to study during long periods of time in air-raid shelters. He gave his first concert of significance at the age of 12 and when he was 14 a German conductor heard him and obtained a grant from the German government to study in the "Hochschule für Musik und Theater Hannover". At 15 he was the youngest pupil to be admitted in this prestigious centre for higher musical studies.

His musical and human restlessness have led him to deepen his relationship with his own Armenian roots and to assimilate the music of other cultures like those of the Middle East (Arab and Jewish), Central Europe (gipsy and Klezmer), Argentina (tango) and Spain (flamenco). All this is achieved within a personal language in which the rhythmic and emotional strength of these types of music go hand in hand with the virtuosity and expressiveness of the great European classical tradition.

With a wide-ranging repertoire, that includes the great majority of all the important pieces written for the violin (concerts with orchestra, sonatas and pieces with piano and chamber music) he has also premiered pieces from modern composers like Franco

Danatoni, Malcolm Lipkin, Luciano Chailly, Ladislav Kupkovich, Loris Tjeknavorian, Lawrence Roman and Yervand Yernakian. Malikian is also one of the few violinists that plays recitals for solo violin with programs featuring complete cycles of such significance as the “24 Caprices” of Paganini, the “6 Sonatas" of Eugène Ysaÿe and the “Sonatas and Partitas" of J.S. Bach. In his hands these pieces achieve a new musical dimension that makes us forget the enormous technical difficulties that they contain.

His extraordinary level and quality as a violinist have been recognised in many competitions of world-wide reputation, among which we can note the First Prizes obtained in the International Competitions “Felix Mendelssohn” (1987, Berlin, Germany) and “Pablo Sarasate” (1995, Pamplona, Spain) besides other prizes like those from the competitions “Niccolo Paganini” (Genoa, Italy), “Zino Francescatti” (Marseille, France), “Rodolfo Lipizer” (Gorizia, Italy), “Jeunesses Musicales” (Belgrade, Yugoslavia), “Rameau” (Le Mans, Francia), “International Artists Guild” (New York, USA), and the “International Music Competition of Japan”. In 1993 he received the “Prize for Artistic Devotion and Achievement” from the German Ministry of Culture.

9.1.2 Arthur Grumiaux

Grumiaux was born in Villers-Perwin, Belgium, in 1921, to a working-class family, and it was his grandfather who urged him to begin music studies at the age of 4. He trained on violin and piano with the Fernand Quintet at the Charleroi Conservatory, where he took first prize at the age of 11. The following year he advanced his studies by working with Alfred Dubois at the Royal Conservatory in Brussels, and also worked on counterpoint and fugue with Jean Absil. He received his first few major awards prior to reaching the age of 20; he took the Henry Vieuxtemps and François Prume prizes in 1939, and received the Prix de Virtuosité from the Belgian government in 1940. During this time he also studied composition privately in Paris with the

famous Romanian violinist Georges Enesco, Menuhin's teacher. His debuts were made in Belgium with the Brussels Philharmonic Orchestra playing Mendelssohn's concerto, and in Britain with the BBC Symphony Orchestra in 1945. Following his British debut, he advanced into Belgium academia when he was appointed professor of violin at the Royal Conservatory, where he had once studied. There, he emphasized the importance of phrasing, the quality of sound, and the high technical standards of artistry.

Grumiaux's playing has been included on over 30 recordings, nearly all under Philips, although his name is also seen on the labels of EMI, Belart and Music & Arts. The titles on these releases tend to be the compositions of Bach, Beethoven, Brahms, Mozart, and Schubert, and on occasion include works by Ravel and Debussy. One of his greatest joys in life was his partnership with the pianist Clara Haskil. On occasion, the two would switch instruments for a different perspective and relationship. Grumiaux was left with a professional and personal absence when she died from a fall at a train station, en route to a concert with him. In addition to his solo work, he has recorded Mozart quintets with the Grumiaux Ensemble, and various selections with the Grumiaux Trio, comprised of the Hungarian husband-wife duo Georges Janzer (viola) and Eva Czako (cello). His successful performance career led up to royal recognition, as in 1973, he was knighted baron by King Baudouin, for his services to music, thus, sharing the title with Paganini.

Despite a struggle with diabetes, he continued a rigorous schedule of recording and concert performances, primarily in Western Europe, until a sudden stroke in Brussels took his life in 1986. At the age of 65, Grumiaux left behind the memory of his elegant and solid musicianship.

9.1.3 Brian Brooks

Brian Brooks is accomplished as performer and teacher of both modern and baroque violin. He holds an impressive record of concerts and recordings as soloist and with leading ensembles and orchestras in the United Kingdom and worldwide.

A former student at the Royal Academy of Music in London, he later studied with, and was greatly influenced by, the legendary Polish violinist Szymon Goldberg. Having worked with such prestigious British period-instrument orchestras as the English Baroque Soloists, the London Classical Players, and the English Concert, Brian is currently the principal violinist of the Rochester-based ensemble The Publick Musick, whose orchestral concerts he directs and with whom he is often a featured soloist.

With a bachelor's degree with honours from the University of Cambridge, where he held a scholarship in mathematics, Brian is presently completing his doctoral dissertation in musicology at Cornell University.

9.1.4 Christian Tetzlaff

Christian Tetzlaff is internationally recognized as one of the most important violinists of his generation. The distinctive character of his artistry stems from an unassailable musical integrity and disciplined technique that enables him to brilliantly realize his expressive intentions, yielding highly individual, compelling interpretations. In honor of his artistic achievements, Musical America named Mr. Tetzlaff "Instrumentalist of the Year" in 2005.

From the outset of his career, Christian Tetzlaff has performed and recorded a broad spectrum of the repertoire, ranging from Bach's unaccompanied sonatas and partitas to 19th century masterworks by Mendelssohn, Beethoven, and Brahms; from 20th century concertos by Bartók, Berg, and Stravinsky to world premieres of contemporary works. Since his performances of the Schoenberg Violin Concerto that brought him to

international attention at age twenty-two - with Christoph von Dohnányi and The Cleveland Orchestra and with Sergiu Celibidache and the Munich Philharmonic.

Born in Hamburg in 1966 to a minister's family in which music occupied a central place, his three siblings are all professional musicians. He frequently performs with his sister Tanja, a cellist. He began playing the violin and piano at age six, but pursued a regular academic education while continuing his musical studies. He did not begin intensive study of the violin until making his concert debut playing the Beethoven Violin Concerto at the age of 14 and attributes the establishment of his musical outlook to his teacher at the conservatory in Lübeck, Uwe-Martin Haiberg, who placed equal stress on interpretation and technique. Mr. Tetzlaff came to the United States during the 1985-86 academic years to work with Walter Levine at the University of Cincinnati College-Conservatory of Music and also spent two summers at the Marlboro Music Festival in Vermont.

Christian Tetzlaff makes his home near Frankfurt with his wife, a clarinetist with the Frankfurt Opera, and their three children. He currently performs on a violin modeled after a Guarneri del Gesu made by the German violin maker, Peter Greiner.

9.1.5 Garrett Fischbach

Garrett Fischbach has been a member of the Metropolitan Opera Orchestra viola section since 1998, and was a member of the San Francisco Symphony from 1996-98, and the National Symphony in Washington, D.C. from 1995-96. He is also the first violinist of the Fischbach Quartet.

9.1.6 Itzhak Perlman

Perlman first became interested in the violin when he heard a classical music gperformance on the radio. He studied at the Academy of Music in Tel Aviv before

moving to the United States to study at the Juilliard School with Ivan Galamian and Dorothy DeLay. He made his debut at Carnegie Hall in 1963 and won the prestigious Leventritt Competition in 1964. Soon afterward he began to tour extensively. In addition to an extensive recording career, he has made occasional guest appearances on American television, starting in the 1970s on shows such as The Tonight Show and Sesame Street, as well as playing at a number of functions at the White House. In 1987, he joined the Israel Philharmonic Orchestra for their concerts in Warsaw and Budapest, as well as other Eastern bloc countries. He toured with the IPO in the spring of 1990 for their first-ever performance in the USSR, with concerts in Moscow and Leningrad, and toured with the IPO again in 1994, performing in China and India.

Perlman plays on the famous Soil Stradivarius violin, considered to be one of the finest violins made during Stradivari's "golden period". In 2003, Mr. Perlman was named the holder of the Dorothy Richard Starling Foundation Chair in Violin Studies at the Juilliard School, succeeding his teacher, Dorothy DeLay. Perlman also played during the entertainment portion of the White House State Dinner in honor on Her Majesty Queen Elizabeth II on May 7, 2007, in the East Room at the White House. [1]

Itzhak Perlman resides in New York City with his wife, Toby. In 1995, they founded the Perlman Music Program in Shelter Island, New York, offering gifted young string players a summer residential course in chamber music.

9.1.7 Jaap Schrder

Jaap Schrder has had a long and varied career as a violinist. His lifes work is a tapestry woven of the threads of all his achievements: chamber music, solo performances, conducting and teaching. He has travelled widely, sharing his expertise in the interpretation and performance of string music on authentic instruments from the baroque to the classical periods. The overall objective of his teaching and performing

continues to be the desire to cherish and transmit the unique French tradition of violin playing, well known for its emphasis on the art of bowing, lart de larchet, and on the cultivation of a highly articulate expressivity. His own studies at the cole Jacques Thibaud and with the Pasquier brothers, together with musicological studies in Paris and Amsterdam, have been of prime importance for his subsequent exploration of the baroque and classical techniques of playing. Jaap Schrders achievements include nearly 150 recordings for various labels. Jos van Immerseel, Stanley Hoogland, Christopher Hogwood and Lambert Orkis are among those who have performed with him. For many years he played in the Netherlands String Quartet, Esterhazy Quartet and Smithson Quartet. He was also orchestra leader and conductor of Concerto Amsterdam and the Academy of Ancient Music.

9.1.8 Jacqueline Ross

Jacqueline was born in New York and studied at the Juilliard School of Music where she was a scholarship student of Joseph Fuchs. On receiving the Bachelor and Master of Music Degrees, she continued advanced studies in Cologne with Sachko Gawriloff, later becoming his assistant, and in Amsterdam with the baroque specialist Lucy van Dael. She appeared as a soloist at the Venice Biennale and Darmstadt Contemporary Music Festival where she won the Kranichsteiner Prize. Following this she broadcast as a solo artist on all the major radio stations throughout Europe. Now living in the UK, Jacqueline is one of the very few soloists performing on both modern and baroque violin. She plays an exceptional and rare violin made by Andrea Amati in Cremona in 1570. The partnership has received high critical acclaim, most recently with the Violin Sonatas of JS Bach, all of which are being recorded for ASV.

9.1.9 James Ehnes

James Ehnes has rapidly established a pre-eminent reputation among concert violinists. He has performed with such renowned conductors as Vladimir Ashkenazy, Sir Andrew Davis, Charles Dutoit, Ivan Fischer, Lorin Maazel, Michael Gielen, Hans Graf, Miguel

Harth-Bedoya, Richard Hickox, Paavo Järvi, Andrew Litton, Zdenek Macal, Sir Charles Mackerras, David Robertson, Stanislaw Skrowaczewski, Christian Thielemann, Bramwell Tovey, and Bobby McFerrin, appearing with orchestras throughout Europe, Asia, the United States, and Canada. Recent engagements include appearances in Europe with the London Symphony Orchestra, the Philharmonia, the BBC Symphony Orchestra, the BBC Philharmonic, the Royal Scottish National Orchestra, the Royal Liverpool Philharmonic, the Ulster Orchestra, the Deutsche Kammerphilharmonie, the Orchestre de Lyon, the Czech Philharmonic Orchestra, the Budapest Festival Orchestra, and the Finnish Radio Orchestra, in Asia with the NHK Symphony Orchestra (Tokyo), the Malaysian Philharmonic and the Hong Kong Philharmonic, and in North America with the major orchestras of New York, Boston, Chicago, Philadelphia, Los Angeles, Detroit, Minnesota, St. Paul, Houston, Dallas, Seattle, Vancouver, Calgary, Winnipeg, Toronto, and Montreal.

Recitals have taken Mr. Ehnes to major cities around the world including London, Paris, Prague, Washington D.C., Tokyo, Osaka, Toronto, Montreal, and Vancouver. He has also appeared at major international festivals including Chicago's Ravinia Festival, the Marlboro Festival, the Seattle Chamber Music Festival, the Bravo! Vail Valley Music Festival, the Tokyo Summer Music Festival, the Bermuda Festival, the Montreux Festival, the Festival de la Chaise-Dieu, the Festival Côte St. André, the Moritzburg Festival, and the Festival of the White Nights. As a chamber musician, he often performs in trio with cellist Jan Vogler and pianist Louis Lortie and has collaborated with such artists as Leif Ove Andsnes and Yo-Yo Ma.

9.1.10 Jascha Heifetz

Heifetz was born into a Jewish family in Vilna, Lithuania, then a part of the Russian Empire. There is controversy over his birth year, which is sometimes placed a year or two earlier to 1899 or 1900. His father Ruvn Heifetz was a local violin teacher and served as the concertmaster of the Vilna Theatre Orchestra for one season before the

theatre closed down. Jascha took up the violin when three years old and his father was his first teacher. At five he started lessons with Ilya D. Malkin, a former pupil of Leopold Auer. He was a child prodigy, making his public debut at seven, in Kovno, now Kaunas, Lithuania playing the Violin Concerto in E minor by Mendelssohn. In 1910 he entered the St Petersburg conservatory to study under Leopold Auer. He played in Germany and Scandinavia at twelve meeting Fritz Kreisler for the first time in a Berlin private house together with other noted violinists in attendance. Heifetz visited much of Europe while still in his teens.

Heifetz had an immaculate technique and expressive vibrato. From time to time, his near-perfect technique and conservative stage demeanor caused some to accuse him of being overly mechanical, even cold. Virgil Thomson called Heifetz' style of playing "silk underwear music," a term he did not intend as a compliment. Even so, most critics agree he infused his playing with feeling and reverence for the composers' intentions. No one has ever surpassed the extremely high standard of technique that Heifetz set. His style of playing was highly influential in defining the way modern violinists approach the instrument. The vibrato is key to his style of playing. Heifetz possessed an exceptional vibrato, which complemented his extensive usage of portamento. Like Kreisler, he did not restrict vibrato to specific notes, heightening the emotional impact of his playing. Itzhak Perlman describes Heifetz's tone as "molten lava" because of its intensity. Because part of Heifetz's tonal makeup was from the strings he used, he was quite particular: throughout his entire career he used a silver wound gut g-string, plain gut d and a-strings, and a Goldbrokat steel e-string. Heifetz believed using gut strings rendered the tone of the player more "individual."

9.1.11 Josef Suk

Josef Suk (January 4, 1874 – May 29, 1935) was a Czech composer and violinist. He was born in Křečovice. He studied at Prague Conservatory from 1885 to 1892, where he was a pupil of Antonín Dvořák (he married Dvořák's daughter in 1898). He formed

the Czech Quartet with three of his fellow students — Suk played second violin with them for most of his life. From 1922 he taught at the Prague Conservatory where his pupils included Bohuslav Martinů and Rudolf Firkušný. He died in Benešov.

Suk's early works show the influence of Dvořák and Johannes Brahms, while later pieces use more extended harmonies to create a more personal and complex style. Unlike many of his countrymen, he made little use of Czech folk music. His best known works are probably the youthful Serenade for Strings (1892) and the symphony, Asrael (1906), a work written in response to the deaths of his wife and Dvořák. Other pieces include the Fairy Tale Suite (1900), the cycle of piano works Things Lived and Dreamed (1909), and the trilogy of symphonic poems A Summer's Tale (1909), The Ripening (1917) and Epilog (1929, for chorus and orchestra).

He won a silver medal at the Art Competitions during the Olympic Games of 1932 at Los Angeles with his work Into a New Life.

9.1.12 Julia Fischer

Julia Fischer, born in Munich, Germany, is of German-Slovakian parentage. Her mother came from the German minority in Slovakia and immigrated from Košice in Slovakia to the Federal Republic of Germany in 1972. Her German father moved in the same year from Eastern Saxony to West Germany. She has worked with internationally acclaimed conductors, such as Lorin Maazel, Christoph Eschenbach, Yakov Kreizberg, Yuri Temirkanov, Sir Neville Marriner, David Zinman, Jun Märkl, Ruben Gazarian, Marek Janowski, Herbert Blomstedt, Michael Tilson Thomas and with a variety of top German, American, British, Polish, French, Italian, Swiss, Dutch, Norwegian, Russian, Japanese, Czech and Slovakian orchestras. Julia Fischer has performed in most European countries, the United States, Brazil and Japan; in concerts broadcast on TV

and radio in every major European country, as well as on many US, Japanese and Australian radio stations.

In 2003 Julia Fischer – already for six years present in US concert halls at that time – appeared with the New York Philharmonic unter the baton of Lorin Maazel playing the Sibelius Violin concerto in New York's Lincoln Center as well as the Mendelssohn Violin concerto in Vail, CO. Her 2003 Carnegie Hall debut received standing ovations for her performance of Brahms Double concerto with Lorin Maazel, Han–Na Chang and the Bavarian Radio Symphony Orchestra. Fischer has been on orchestral tours with Sir Neville Marriner and the Academy of St. Martin in the Fields, Herbert Blomstedt and the Gewandhaus Orchestra, the Royal Philharmonic Orchestra and the Dresden Philharmonic. In fall 2004 the label PentaTone released Julia Fischer's first CD: Russian violin concertos with Yakov Kreizberg and the Russian National Orchestra. It received ravishing reviews, climbed into to the top five bestselling classical records in Germany within a few days and received an "Editor's Choice" from "Gramophone" in January 2005. Other recordings include the unaccompanied sonatas and partitas of J. S. Bach and the concertos of W. A. Mozart.

Among the most prestigious competitions that Julia Fischer has won are the International Yehudi Menuhin Violin Competition under Lord Yehudi Menuhin's supervision, where she won both the first prize and the special prize for best Bach solo work performance in 1995 and the Eighth Eurovision Competition for Young Instrumentalists in 1996, which was broadcast in 22 countries from Lisbon. In 1997 Julia Fischer was awarded the “Prix d‘Espoir” by the Foundation of European Industry. She recently had the opportunity to play Mozart's own violin in the room in which he was born at Salzburg to honor his 250th birthday.

9.1.13 Lucy van Dael

Lucy van Dael studied violin at the Royal Conservatory in The Hague. She began her career as a member of the Netherlands Chamber Orchestra under the direction of Szimon Goldberg, but soon became interested in the baroqueviolin. She therefore started a long collaboration with Gustav Leonhardt, Frans Brüggen, Ton Koopman (Musica da Camera), and the Kuyken brothers, becoming in the process one of the leading figures in the revival of authentic string playing. She has appeared with many ensembles and orchestras - among them the Leonhardt Consort, La Petite Bande and the Orchestra 18th Century - as violin or viola soloist.

Lucy van Dael is also increasing in demand as a conductor amongst orchestras worldwide. She was guest conductor of the European Union Baroque Orchestra, Concerto d'Amsterdam, the Irish Baroque Orchestra, Beethoven Akademie, Academia Montis Regalis, amongst others. A member of the faculty of the Amsterdam Conservatory, she is internationally sought after as a pedagogue, and has been visiting professor in Stanford, Berkeley, Basel, Melbourne, Oslo, Hamburg, Jakarta, as well as having given courses throughout the world.

Her extensive discography brought her several gramophone awards, like the Polish "Fryderyk'97", and the Dutch "Edison". It includes numerous recordings on a wide variety of labels, including : Emi, Sony, RCA, Philips, Telefunken, Harmonia Mundi, Archiv and Naxos: J.S.Bach's soloviolin sonatas.

9.1.14 Mela Tenenbaum

Mela Tenenbaum, an internationally acclaimed soloist, has toured extensively throughout the world. She has been concertmaster of Philharmonia Virtuosi since 1993, shortly after she emigrated to the United States from Kiev in the Ukraine. Equally at home as a violinist, violist and player of the rarely heard viola d'amore, she has appeared regularly with the orchestra as both soloist and chamber musician.

Born in Chernivitsi in the Ukraine (birthplace of a host of artistic and intellectual luminaries including cellist Emmanuel Feuermann, Stefan Zweig and many others), Ms. Tenenbaum received her master's degree in music from the Kiev State Conservatory and performed as resident soloist with the Kiev Chamber Orchestra and Kiev State Philharmonic from 1979 to 1989 when she emigrated to the U.S. with her family, shortly after the Chernobyl disaster. In addition, she was both concertmaster and frequent soloist with Perpetuum Mobile, an innovative chamber orchestra supported by the Ukrainian Union of Composers. Before leaving the Soviet Union, she premiered numerous works written for her by Russian and Ukrainian composers. In addition to her work with Philharmonia Virtuosi, she has been a featured soloist with the Seattle Chamber Music Festival, the Arkady Music Festival in Bar Harbor, ME., and the Indian River Festival in Canada, among others. She is a highly respected teacher of both youn students and professional musicians, who come from around the world to seek her tutelage.

Her recording activity has been extensive, including the complete Bach Sonatas and Partitas for Solo Violin as well as Bach's Sonatas for Violin and Keyboard which she recorded twice, once with piano and once with harpsichord. She has also undertaken the complete Mozart violin concertos as well as the Beethoven Concerto, and the complete Art of the Violin of Pietro Locatelli, Vivaldi's concertos for violin with two orchestras, and the works of Schubert for violin and orchestra. Her concertante recordings include numerous twentieth century works - by Ghedini, Klebanov and others. And she has recorded Brahms' and Beethoven's violin sonatas, along with a treasure-trove of infrequently encountered baroque masterpieces by Locatelli, Tartini and Leclair. She has also committed to disc four recitals of short pieces for violin or viola and piano, the sort of "lollipops" that great violinists turn into great art.

9.1.15 Rachel Podger

Rachel Podger is an English violinist specialising in the performance of baroque music. She often conducts baroque orchestras from the violin. She was born in England but educated at a German Steiner school. She returned to study first with Perry Hart, then at the Guildhall School of Music & Drama with David Takeno, Pauline Scott and Micaela Comberti. During her studies she co-founded baroque chamber groups The Palladian Ensemble and Florilegium, and worked with period instrument ensembles such as the New London Consort, and London Baroque.

She was first violin of the Gabrieli Consort and Players and later of The English Concert, c.1997-2002, touring extensively, often as soloist in Vivaldi's le quattro stagioni and grosso mogul concertos. In 2004 she began a guest directorship of The Orchestra of the Age of Enlightenment, opening with a tour in the USA with Bach's Brandenburg Concertos. She also works as a guest director with Arte dei Suonatori (Poland), Musica Angelica (USA) and Santa Fe Pro Musica (USA), and as soloist with The Academy of Ancient Music. She is a professor of baroque violin at the Guildhall School of Music & Drama.

9.1.16 Sergiu Luca

Sergiu Luca described in the Washington Post as a "a fiddler´s fiddler," is a concert personality who has enjoyed a worldwide career. He combines an unparalleled diversity of repertoire with inspired virtuosity as a soloist with orchestras and in annual recitals at major music centers around the world.

Soon after his debut with the Philadelphia Orchestra in 1965, he was chosen by Leonard Bernstein to play the Sibelius Violin Concerto with the New York Philharmonic for a special CBS television network tribute to the Finnish composer. He has subsequently performed with many of the world´s leading orchestras in Europe, Israel, Latin America, and the U.S., including the Cleveland, St. Louis, Pittsburgh,

Detroit, Houston, Baltimore, Atlanta, and National Symphony Orchestras and the Israel Philharmonic, New Philharmonia of London, and the Zurich Tonhall Orchestra.

Sergiu Luca´s many recordings attest to his sensitivity for varied styles and periods of music. He made a sensation with his recordings of the complete unaccompanied works of J.S. Bach, the first rendering on an original instrument. Subsequent recordings of music by Bartók, Schumann, Schubert, Mendelssohn, Tartini, Janacek, and William Bolcom, as well as orchestral recordings with Leonard Slatkin and the St. Louis Symphony and David Zinman and the Rochester Philharmonic, earned international acclaim. As a recitalist, Sergiu Luca has performed in Europe, Mexico, Japan, and throughout North America. He has collaborated with such keyboard artists as Emanuel Ax, Albert Fuller, Anne Epperson, Joseph Kalichstein, Peter Serkin, and Malcolm Bilson. He is the Dorothy Richard Starling Professor of Violin at the Shepherd School of Music.

9.1.17 Shlomo Mintz

Shlomo Mintz (born 1957 Moscow) is a highly regarded Israeli violin virtuoso, violist and conductor. Worldwide he is praised for his impeccable musicianship, stylistic versatility and commanding technique alike. Mr. Mintz regularly appears with leading orchestras and conductors and performs in recitals and chamber music concerts all around the world.

Shlomo Mintz began his career at age 11 as a soloist with the Israel Philharmonic Orchestra. Soon afterwards he was called on a week's notice by Zubin Mehta to play Paganini's first Violin Concerto with the orchestra when Itzhak Perlman fell ill. He made his Carnegie Hall debut at the age of sixteen in a concert with the Pittsburgh Symphony Orchestra that was presented under the auspices of Isaac Stern and the American-Israel Cultural Foundation, and subsequently began his studies with Dorothy

DeLay at the Juilliard School of Music in New York. He was Music Advisor of the Israel Chamber Orchestra from 1989 to 1993 and in March 1994 he was named Artistic Advisor and Principal Guest Conductor of the Maastricht Symphony Orchestra (The Netherlands). He led the orchestra in weeks of concerts during four seasons, including some as both conductor and violin soloist.

Shlomo Mintz is patron and one of the founders of the Keshet Eilon International Violin Mastercourse in Israel, an advanced-level summer programme for young talented violinists from all around the world in kibbutz Eilon, Israel, and gives master classes worldwide. He has been a member of the jury of several important international competitions, such as the Tchaikovsky Competition in Moscow (1993) and the Queen Elisabeth International Music Competition in Brussels (1993 and 2001). In October 2001 Mr. Mintz was President of the Jury of the International Henryk Wieniawski Competition for the Violin in Poznan, Poland.

He became the Artistic Director of the Sion-Valais International Music Festival, and the President of the Jury of the Sion-Valais International Violin Competition in Switzerland in 2002. In May 2006 Shlomo Mintz was granted a Honorary Doctoral Degree by the Ben-Gurion University of the Negev in Be'er Sheva, Israel.

9.1.18 Sigiswald Kujken

Sigiswald Kuijken was born in 1944 close to Brussels. The Belgian violinist, violist, and conductor Sigiswald Kuijken studied music at the Bruges and Brussels Conservatories, where he received a premier prix for the violin in 1964. He was seven when he first came into contact with the Renaissance instruments. Like his brother Wieland, he is self-taught on the viola da gamba. This early, and for the most part, intuitive contact with early music strongly influenced his playing of the Baroque

violin. In 1969 he began to re-establish the old technique of violin playing, without using a chin or a shoulder rest and without holding the instrument with the chin at all.

This technique has been adopted by many other players since then and was taught by Sigiswald Kuijken at The Hague Conservatory between 1971 and 1996. He continues to teach it at the Brussels Conservatory, where he has been professor since 1993. Between 1964 to 1972 he was a member of the Alarius Ensemble of Brussels, with whom he explored 17th and 18th-century music, and performance practice. With them and his brothers Wieland and Barthold, as well as with Robert Kohnen, Gustav Leonhardt and others, he has undertaken regular tours of Europe, the USA, Australia and Japan. He has also given countless solo recitals and has recorded most of Bach's chamber works and pieces for solo violin as well as music by Corelli, Vivaldi and Muffat.

In 1972 he formed the Baroque Ensemble La Petite Bande, with whom he has recorded music by Lully, Rameau, Bach, Händel, Gluck, Haydn, Mozart and many others. He also appears as guest conductor with many other Baroque ensembles, including the Orchestra of the Age of Enlightenment, whose inaugural concert he conducted at London's Queen Elisabeth Hall in June 1986. The Kuijken String Quartet, which was formed in 1986, specialises in the quartets of Haydn and Mozart and has appeared throughout Europe, Australia and the USA. Its current members are Sigiswald Kuijken, François Fernandez, Marleen Thiers and Wieland Kuijken. For string quintets, the group is joined by the leader of La Petite Bande, Ryo Terakado, on the first viola. Other ongoing chamber music projects include the Mozart sonatas and piano quartets with his brothers Barthold and Wieland, and Debussy programme featuring the whole of Kuijken family.

9.1.19 Susanna Yoko Henkel

Since Susanna Yoko Henkel held her first violin in her hands on her second birthday, she has never let go of the fervor for her instrument. In the meantime Susanna Yoko is playing on a violin built 1705 in Brescia/Italy by Giovanni Battista Rogerius, and the exhilaration of press as well as audience are causing them to go head over heels for the German-Japanese violinist. “Strad Magazine“ declares Susanna Yoko’s debut CD with works for solo violin as CD of the month, and appraises: „She makes a glorious sound – I can’t remember the last time I found myself swaying along to Bach so contentedly. Henkel plays with a disarming naturalness...“. The culture magazine „Applaus“ writes enthusiastically: „Seldom is solo violin presented so engrossing and intriguing as it is here“. The press praises her debut at the renowned Ansbacher Bachwochen: „Susanna Yoko Henkel presented a simply grandiose solo matinee“. Already during her studies in Munich with the great pedagogue Ana Chumachenco Susanna Yoko Henkel wins awards at international competitions (1997 Queen Elisabeth in Brussels, Dong-A in Seoul, 1999 Mozart-Competition in Salzburg). To follow are first prizes at the German Music Competition in Berlin, the Competition “Tibor Varga“ in Sion/Switzerland and the International Violin Competition in Markneukirchen. Susana Yoko performs regularly with top-ranking orchestras as a soloist (i.a. Berlin Radio Broadcasting Orchestra, Symphony Orchestra Mozarteum Salzburg, Stuttgart Chamber Orchestra, German Chamber Academy Neuss, Orchestra of Beethovenhalle Bonn, Symphony Orchestra Aachen, mdr-Symphony Orchestra Leipzig, National Orchestra Frankfurt/Oder, Südwestfunk Radio Broadcasting Orchestra, National Orchestra Mainz, Philharmonic Orchestra Duisburg, Puchon Philharmonic Orchestra Seoul, European Union Chamber Orchestra, Waterbury Symphony Orchestra, Florida West Coast Symphony Orchestra) and is invited to renowned festivals such as the Ansbacher Bachwochen, Ludwigsburg Schlossfestspiele, the Rhinegau-Musik-Festival, and the concerts in Châtelet Paris. 2003 Susanna Yoko is selected as soloist for the highly regarded „Toyota Classics“ tour and appears with the Mendelssohn violin concerto in Malaysia, Brunei, Indonesia and in the Philippines.

9.2 Additional Figures

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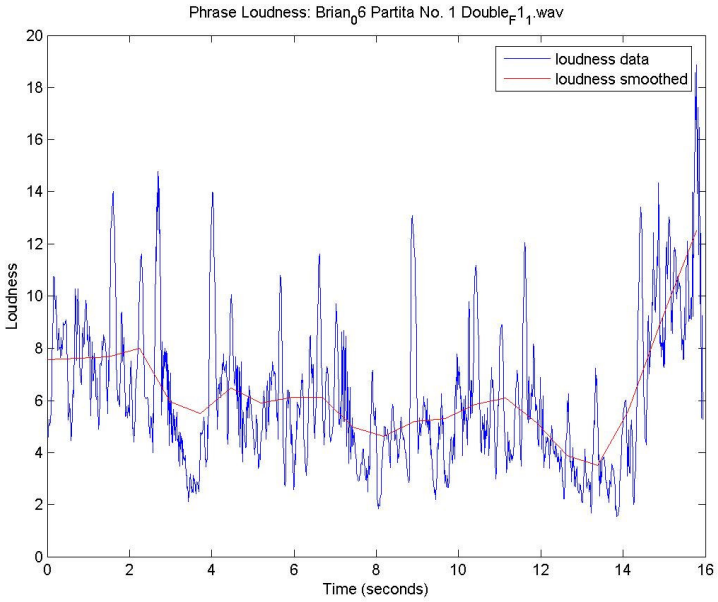

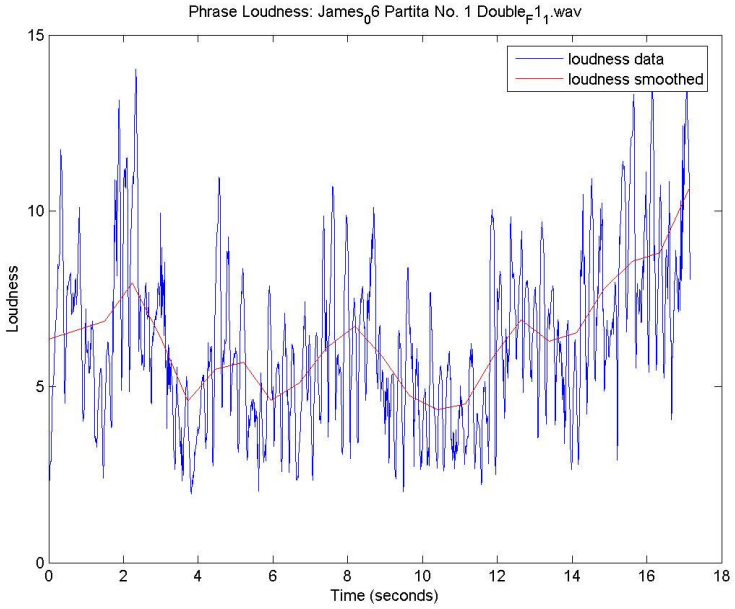

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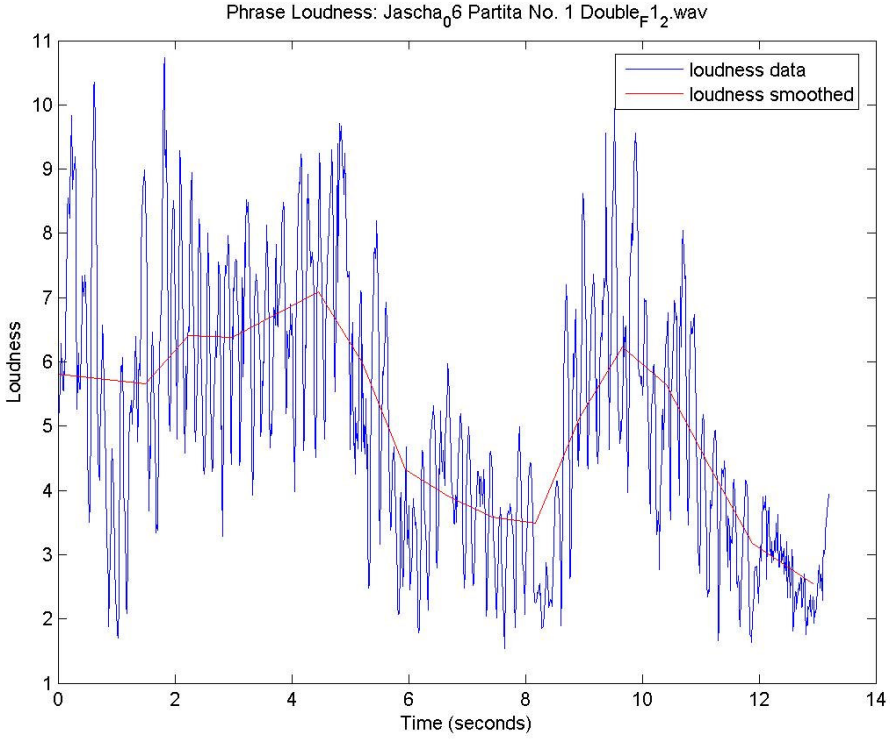

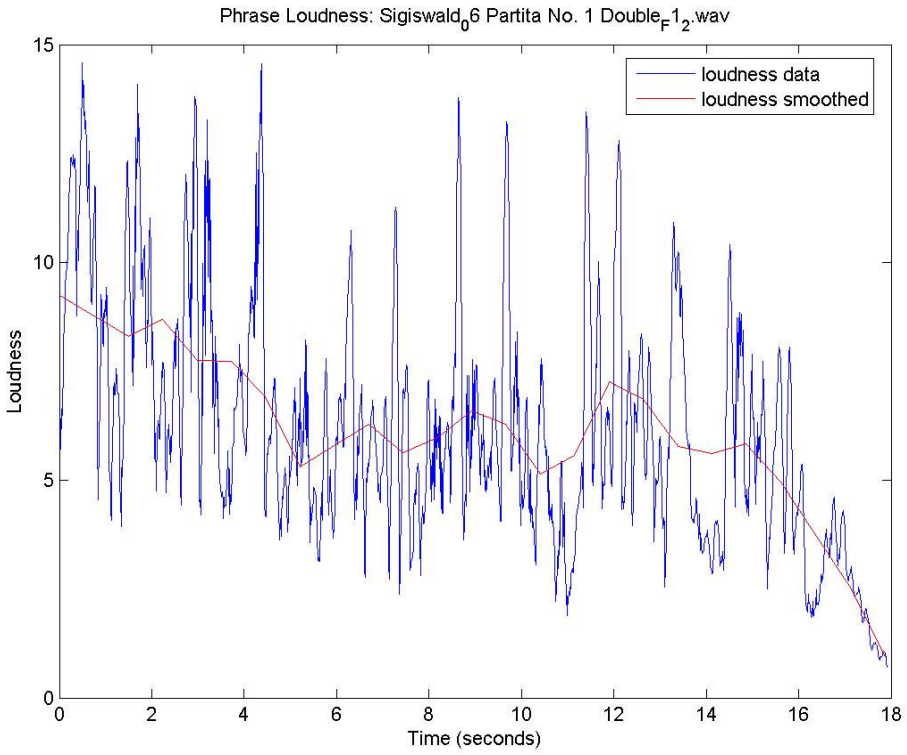

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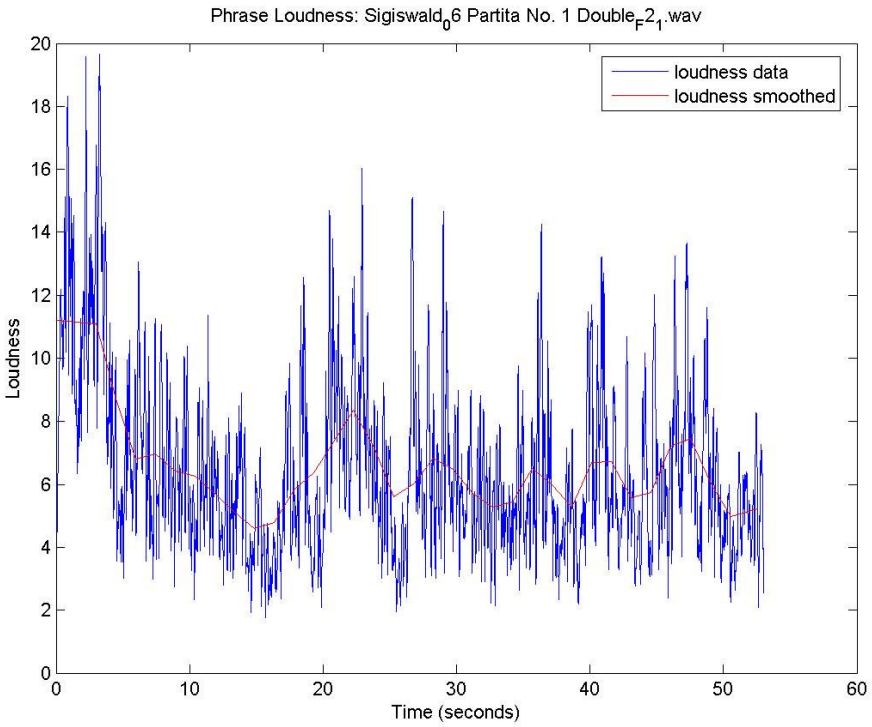

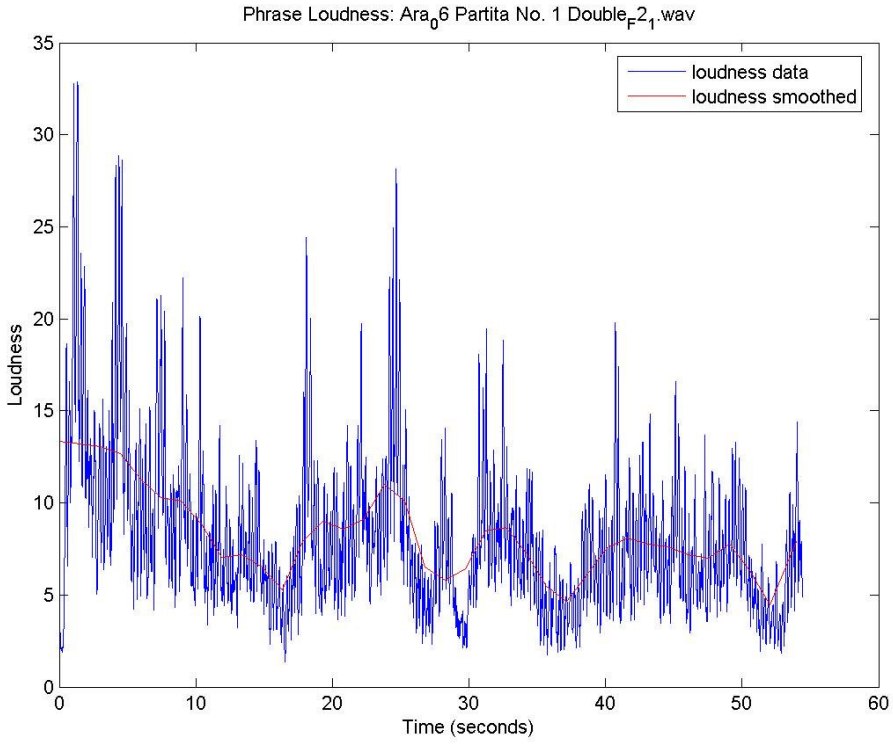

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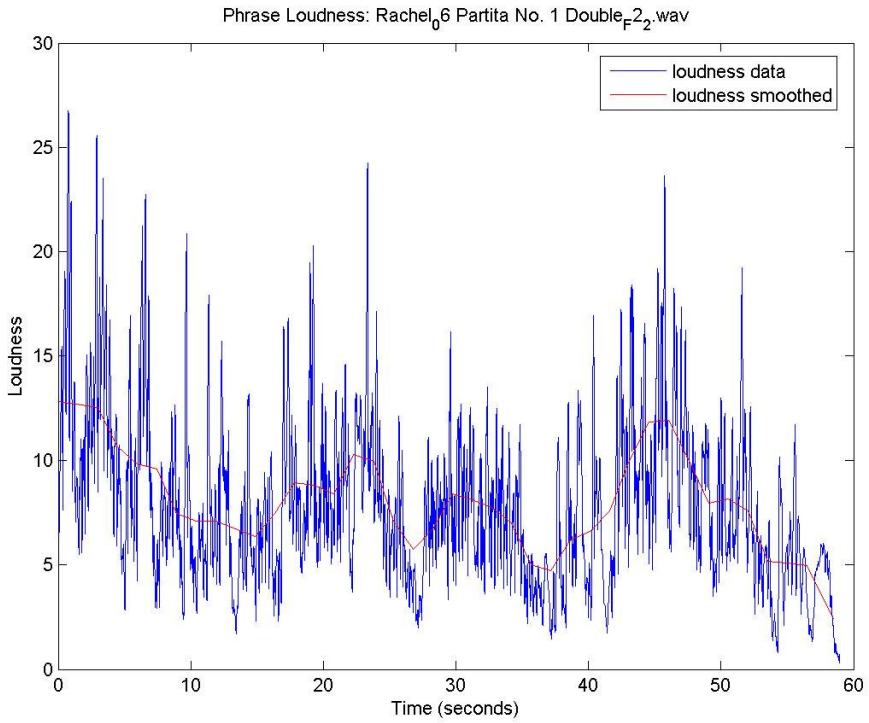

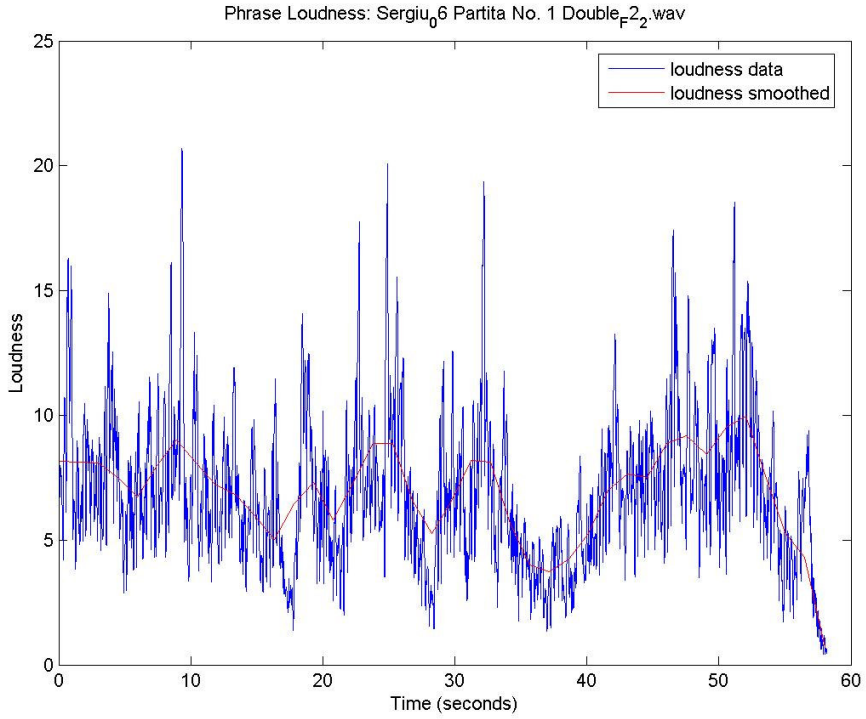

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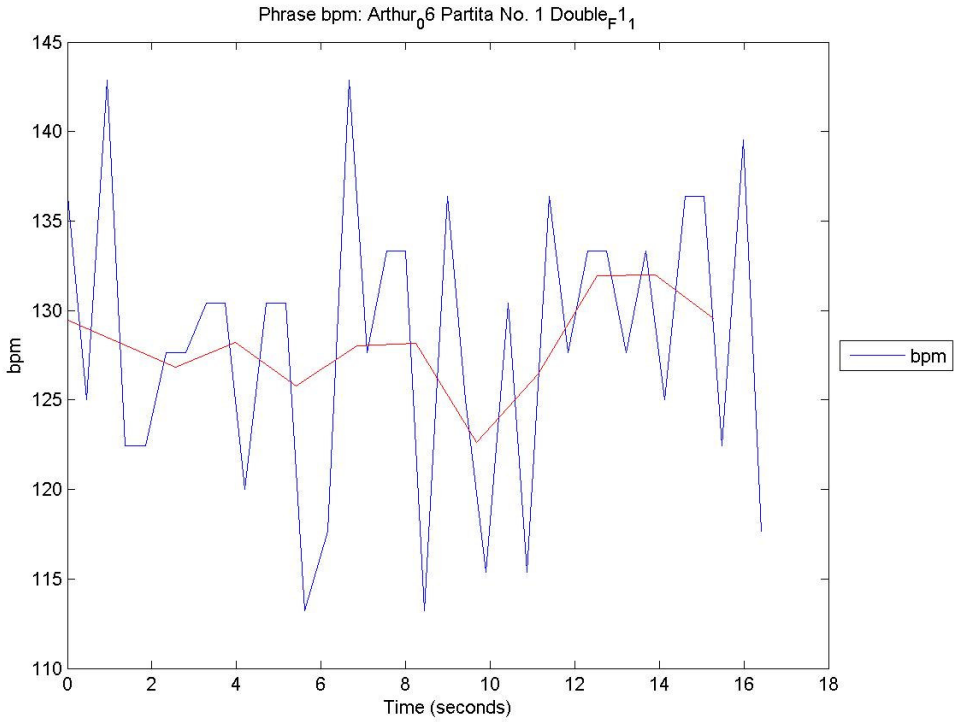

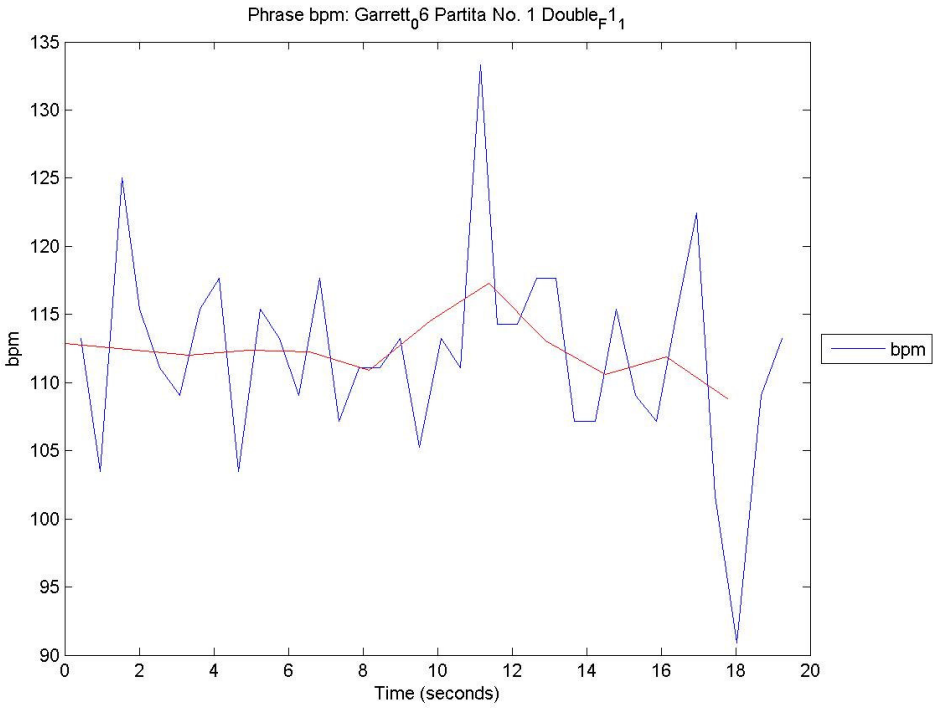

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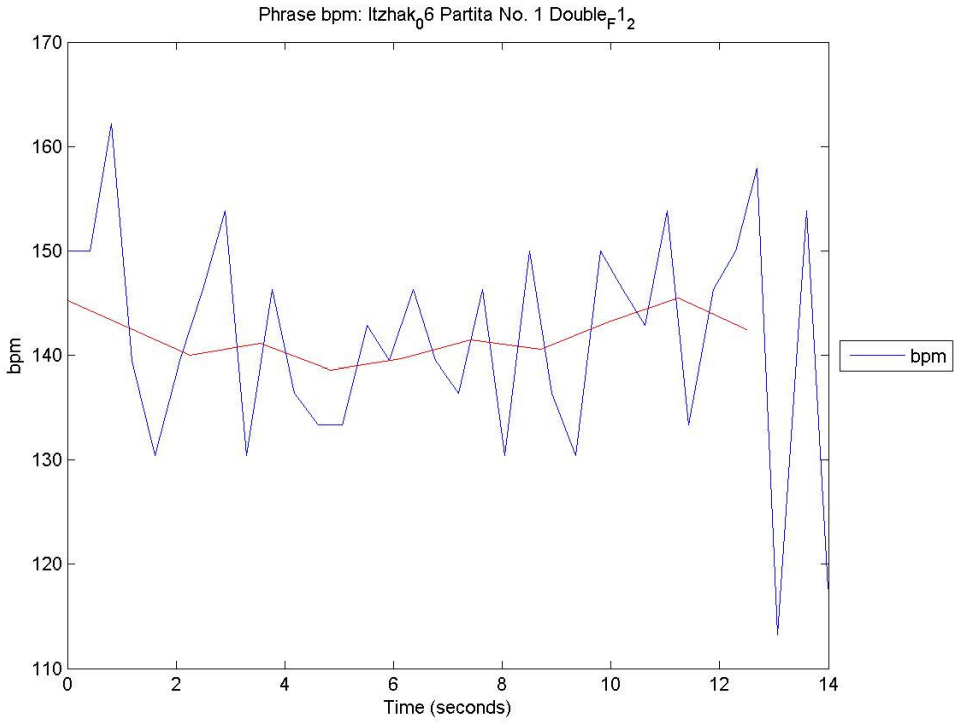

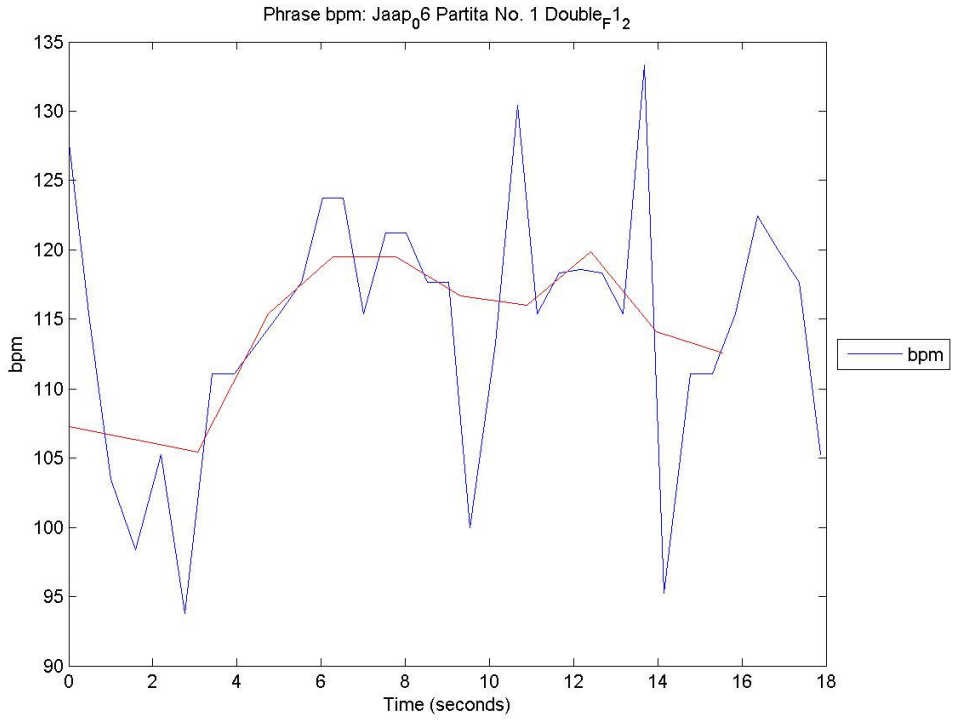

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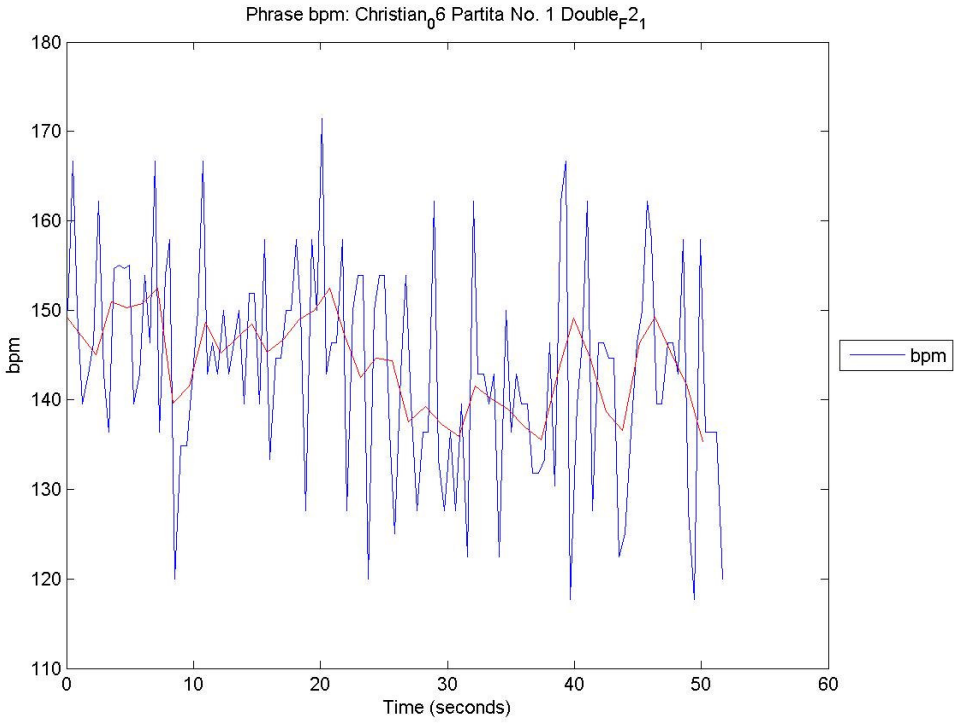

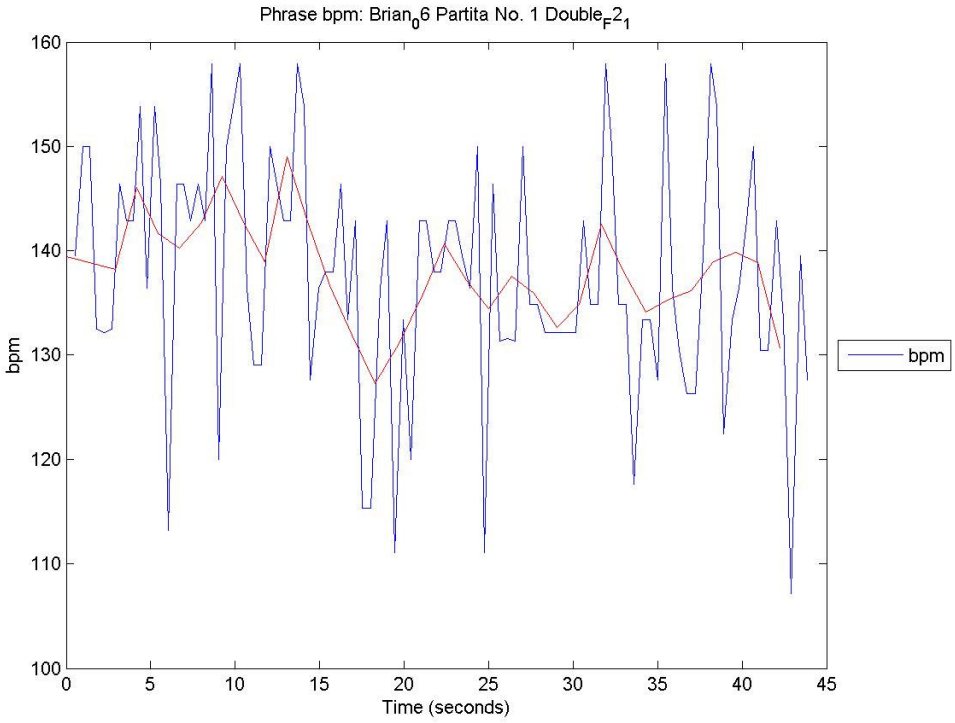

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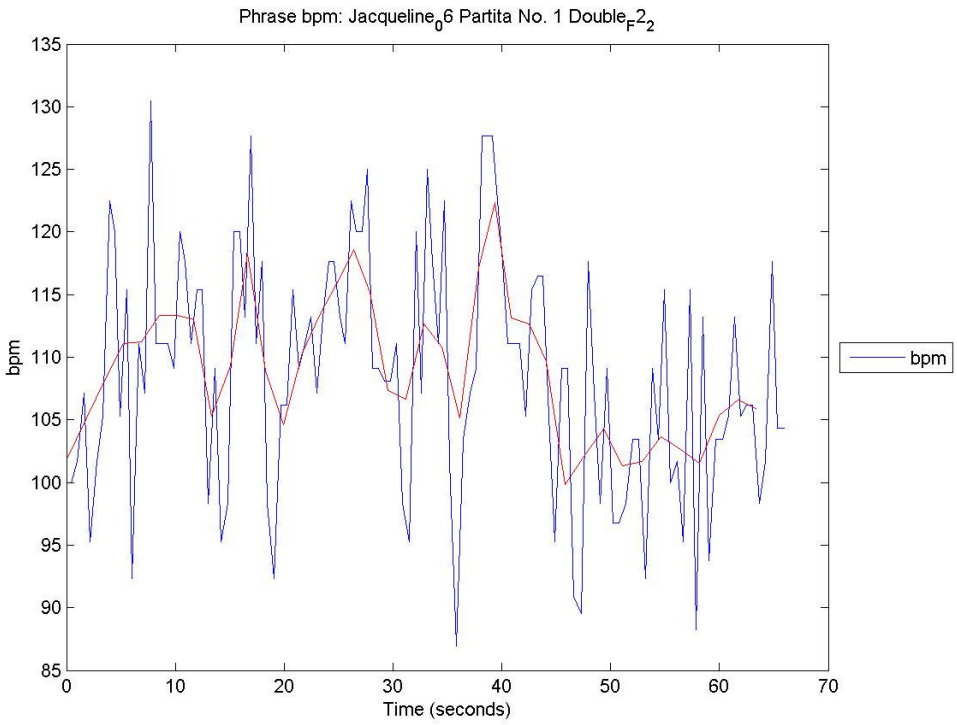

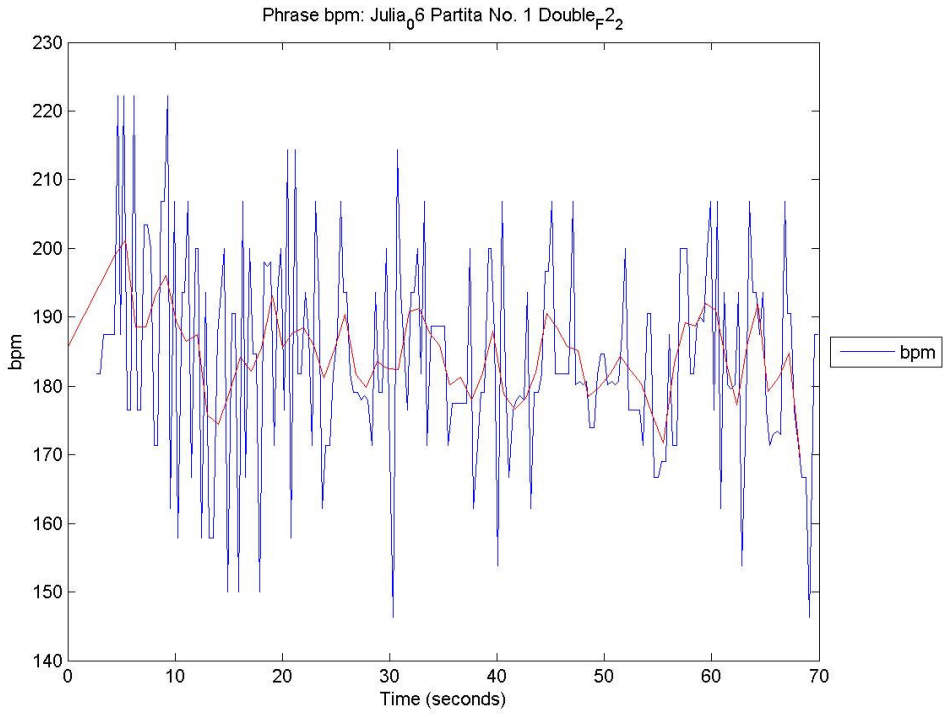

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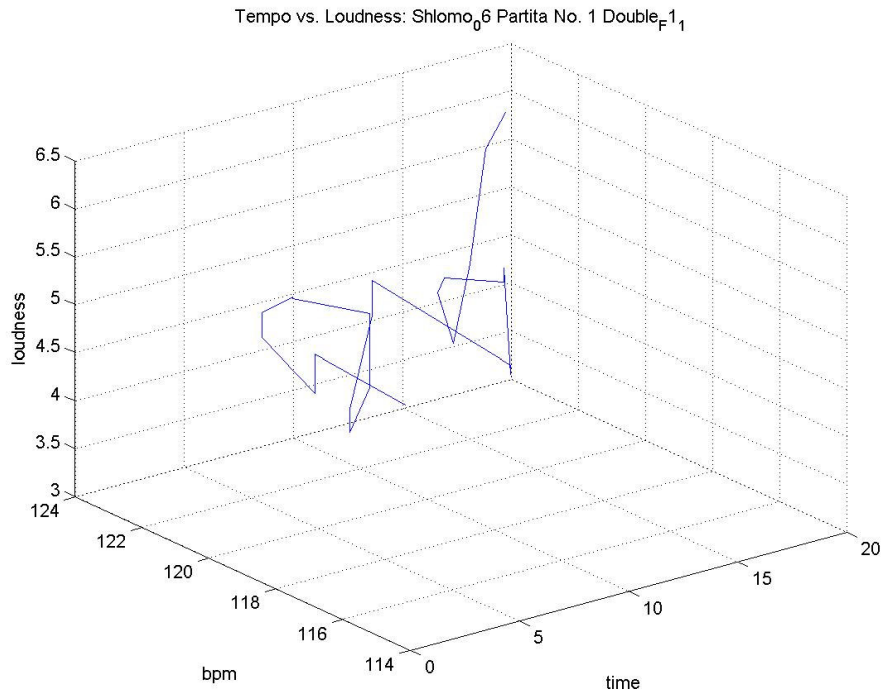

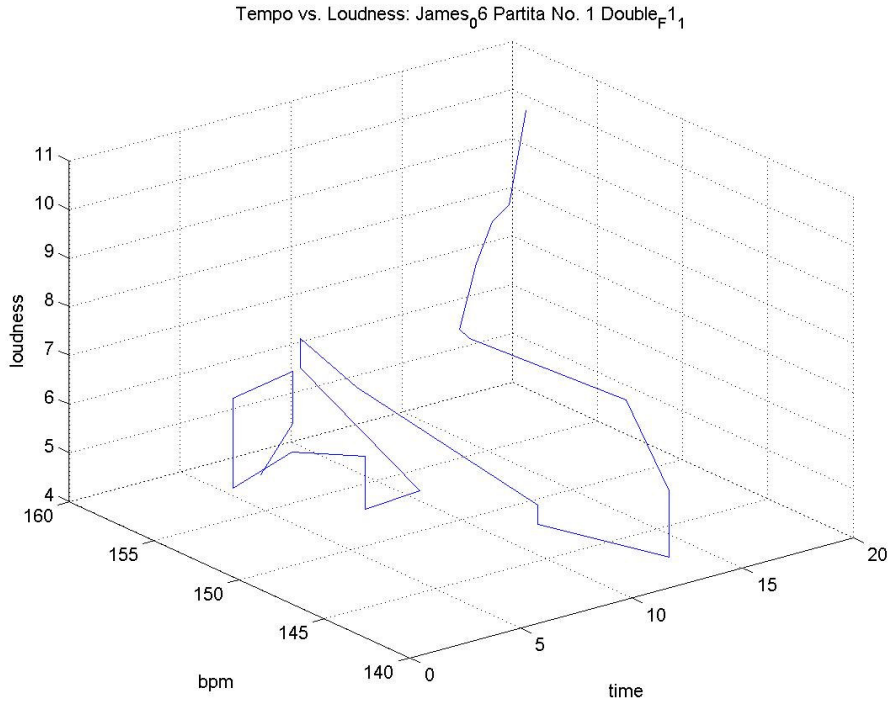

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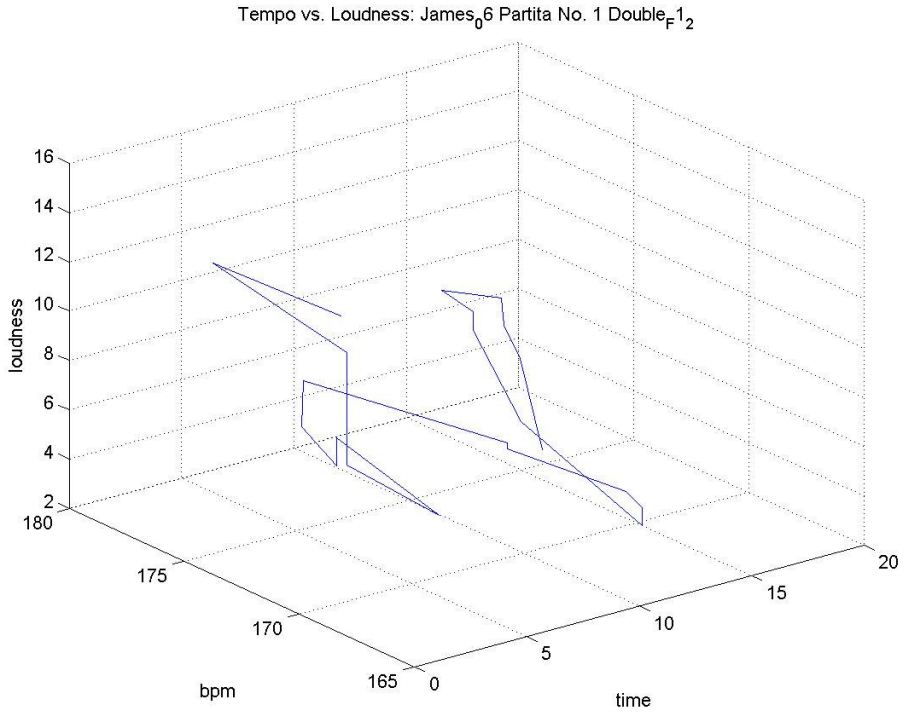

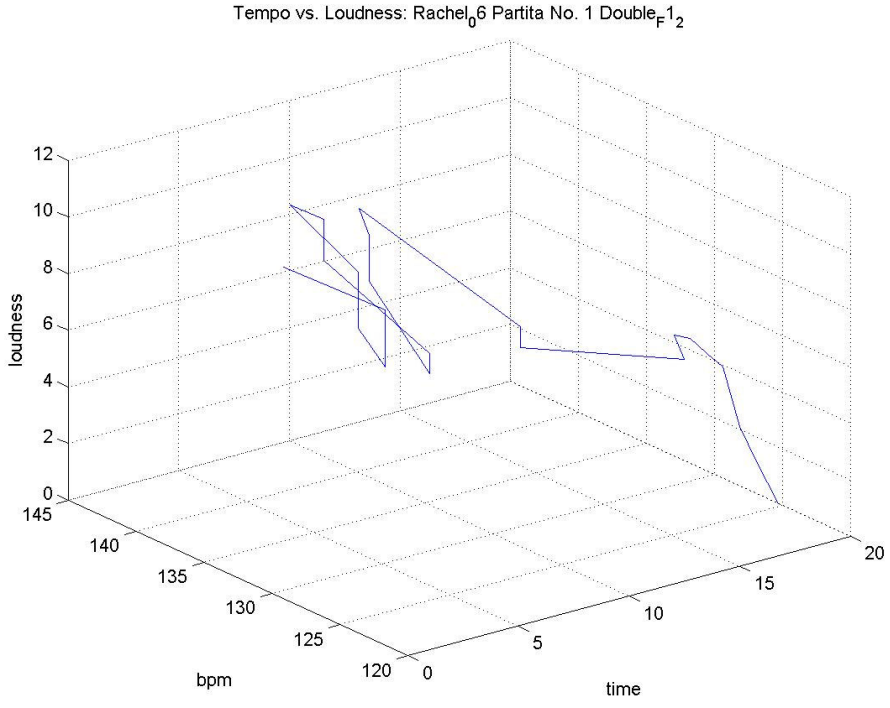

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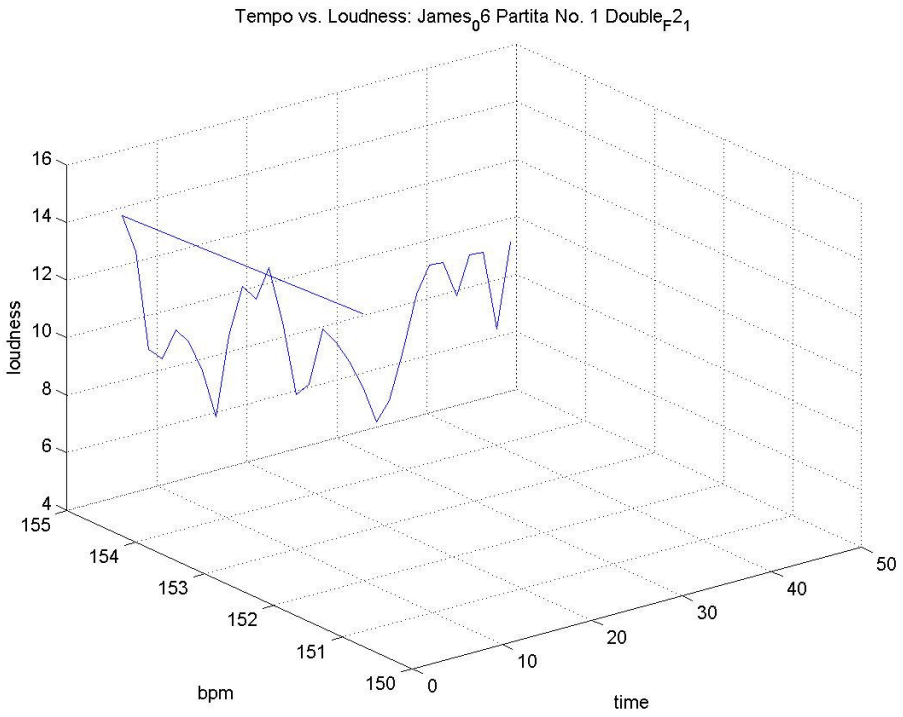

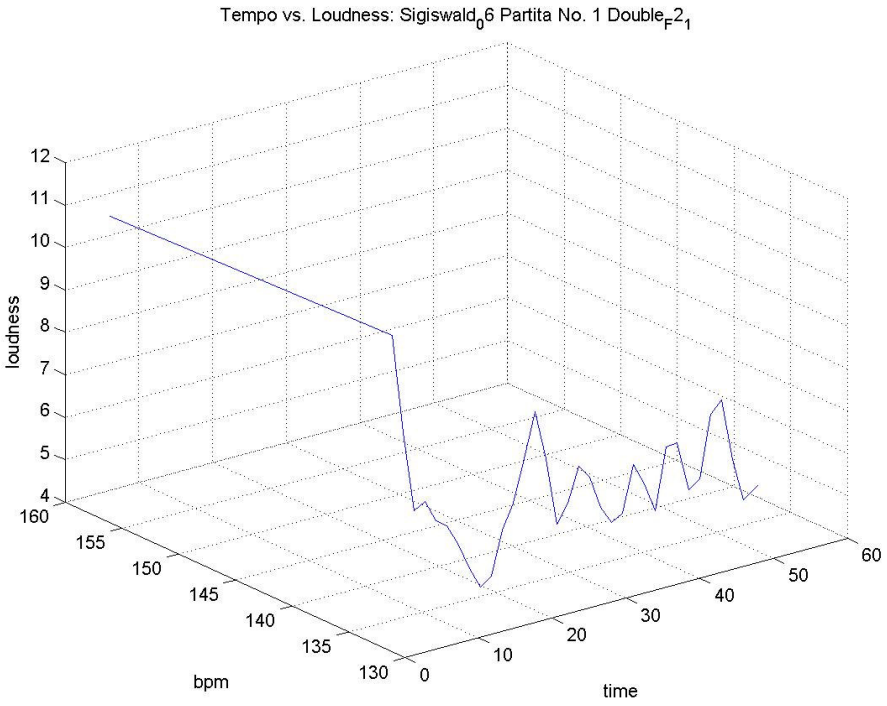

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