A COMPUTER-ASSISTED MUSICOLOGICAL APPROACH TO ANALYZE THE OCCURRENCE OF DOMENICO SCARLATTI MOTIFS ON BEETHOVEN'S PIANO SONATAS

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ABSTRACT

The similarity in compositions between Domenico Scarlatti and Beethoven has been discussed by musicologists for a long time, but apparently this perception has not been backed by quantitative analyses. In this article, we describe preliminary efforts to confirm the similarity quantitatively, by examining melodic motifs from Scarlatti keyboard sonatas that also appear in piano sonatas by Beethoven. The occurrence of these melodic motifs is much higher in Beethoven than in Mozart pieces, where the latter were used for comparison purposes. The results from the computer-assisted musicological framework proposed are consistent with historical evidence for the presence on Beethoven of the Scarlatti work.

1. INTRODUCTION

The music produced by Beethoven is frequently believed to contain traces from the legacy of Domenico Scarlatti. For instance, the supposed influence from Scarlatti was frequently mentioned by the Brazilian academic and composer Almeida Prado (1943-2010) to his students. Son to the renowned opera and sacred composer Alessandro Scarlatti, Domenico Scarlatti was a reference for the 18th century musical movement. His musical style is often seen as the first manifestation of the style that would prevail in the classical period. Though he was born in the same year as Bach and Handel, Scarlatti shows in his compositions musical innovations that the other two great composers did not explore systematically, e.g. bi-thematic movements, brusque changes of affects, generous usage of rests, repetitions. In fact, his developments in form and harmony are central to the subsequent stylistic developments, contrasting with the works of Bach and Handel, regarded as late Baroque. Scarlatti started composing his most important work, the 555 Sonatas, around 1740 when he was in his middle 50s. He was then an experienced composer, having worked for Queen Maria Casimira of Poland and Cardinal Ottobone in Rome, as well as in the Vatican as chapel mas-

ter. In 1721, Scarlatti went to Lisbon to work for the King of Portugal, D. Joao V, as music tutor of his young daughter Maria Barbara, who married Prince Fernando of Asturias in 1729 and became Queen of Spain in 1746. She brought Scarlatti to Madrid to compose exclusively for her, being herself a remarkable keyboard player. For her, Scarlatti could compose freely, using any compositional procedures that would conceive his prodigious musical inventiveness.

Being such prominent figure, Domenico Scarlatti was widely known in artistic circles where Beethoven could be acquainted with. However, there is no definitive evidence that Beethoven had access to Scarlatti's pieces. Such lack of evidence may not be surprising since no Scarlatti's handwritings have been found, not even a simple letter, or any music manuscripts written by his hands. There are only copies of his works. Scarlatti composed for Maria Barbara 492 of his 555 Sonatas, copied out for her use from 1752 to 1757. They were carefully written in a large format, widely spaced and decorated with colored inks [2]. That collection is now in Venice, called Venice collection. An additional Sonatas set, largely duplicating the Queen's series, were copied in the same period of the Venice collection, being now in Parma (known as Parma collection). Based on the Venice and Parma collections, another two manuscript sets of Scarlatti Sonatas were copied out by Abbe Santini, a collector of 18th century music. One set is in Munster and the other collection of 308 Sonatas were taken to Vienna in the second half of the 18th century, called Vienna I, divided in 7 volumes, from A to G. Another manuscript set was taken to Vienna probably by Giuseppe Scarlatti, Domenico's nephew, and M. L'Augier, a Viennese personality who was "intimately acquainted with Domenico Scarlatti" [1]. This would be the Vienna II collection, acquired by the Archduke Rudolph, a close friend, pupil and patron of Beethoven, on April 21, 1813, in an auction of Baron DuBeine's manuscript collection. DuBeine, who died in 1804, was another 18th century music collector. Significantly, the DuBeine auction happened one year before the unprecedented "Congress of Emperors" in Vienna, where Beethoven figured as the most prestigious composer and would present to a noble audience his 7th Symphony and the Battle of Vittoria with "extraordinary success" [6].

It is reasonable to assume that the Archduke Rudolph would not choose a large collection of one single composer without the knowledge or even consent of Beeth-

oven, known as a severe music tutor. Therefore, this suggests that Beethoven would have had some interest in Scarlatti. In this paper we describe the first attempts to confirm (or disprove) the possible relationship between Scarlatti and Beethoven in a quantitative manner. The analysis was performed by inspecting the melodic lines produced by both composers, in 38 Scarlatti sonatas and all Beethoven piano sonatas. For comparison purposes we also analyzed 17 piano sonatas of Mozart. From each melodic line, the intervals between consecutive pair of notes were taken and represented as a unidimensional signal. A collection of 199 motifs by Domenico Scarlatti – selected regarding their musicological importance – were searched through this signal in a strict manner, i.e., we look for exact interval matches.

2. METHODOLOGY

A set of motifs was extracted from D. Scarlatti piano sonatas, where each motif is represented according to the interval relationship between consecutive pitches. The approach to investigate the incidence of the 199 motifs extracted from D. Scarlatti compositions on Beethoven's and Mozarts piano sonatas is illustrated in Figure 1. Since Mozart's corpus is smaller than Beethoven's (32 piano Sonatas *versus* 17 piano Sonatas), we also analyzed the data with normalization, which is obtained through the ratio of Beethoven to Mozart corpus, regarding the number of notes in both corpora.

With the computational method presented in subsection 2.4, a search was performed for occurrences of the motifs in Beethoven and Mozart piano sonatas. A strategy for confirming the statistical relevance of the results is described in subsection 2.5. In order to identify the Beethoven sonatas that contained many Scarlatti motifs, a histogram of occurrences is presented. This rises important points regarding the historical relevance of these Sonatas. A complementary analysis was done in the time domain of the Sonatas. Since D. Scarlatti's adoption of compound meters is well recognized, a search for compound meters was done in Beethoven and Mozart Sonatas, by counting the number of measures for each time signature (e.g. 2/2, 4/4, 6/8 and so on) present in the considered works.

2.1 The *Corpus*

The *corpus* for this study comprises the 32 Beethoven's piano sonatas and the 17 Mozart's piano sonatas. They are encoded in the Humdrum file format and are available in a virtual library of musical scores [1]. Kern is a simple yet efficient data format, since it offers a good description of the musical events. Details on how this *corpus* is further split into melodic lines for analysis are given in (subsection 2.3).
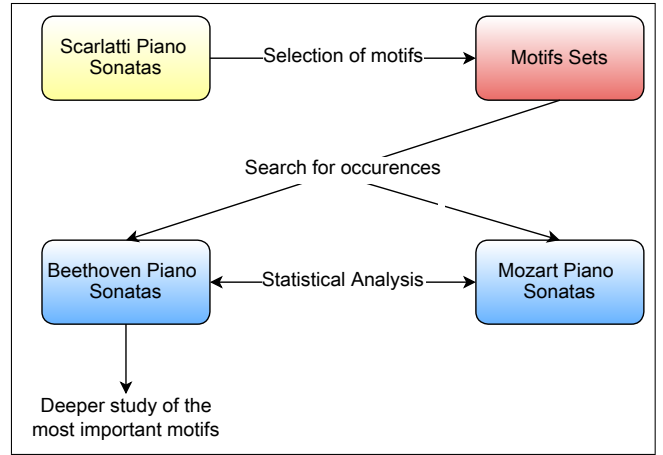
Figure 1: Overview of the proposed methodology: a set of intervalar motifs from D. Scarlatti are searched for in Beethoven and Mozart. From all motifs found, the most relevant are taken for deeper investigation under the musicological perspective.

Figure 2: Beethoven's Fifth Symphony opening motive. In this case, the motive keeps the pitch structure (the descending thirds, major and minor) and the rhythm structure (short-short-short-long).

2.2 Selecting Motifs from Scarlatti

Music motifs (also known as "motives") are referred to here as any recurring combination of pitches or note values that establish short patterns. They are essential in music composition, since composers tend to use them as compositional building blocks to construct musical phrases. Motives can be tonal, rhythmic or the combination of notes and rhythm. An illustrative example is the famous motif opening Beethoven's 5th Symphony (Figure 2), where only tonal motives were considered.

The process of selecting them from D. Scarlatti sonatas was to take each of the 38 Sonatas from Vienna II / I G collection and extract all relevant motifs found in them, which can be seen in two groups. One group gathers the motifs comprised by thirds, fifths and fourths as well as the major and minor scales. The other group picks the motifs that combine all sorts of intervals, and therefore they are structurally more irregular than the first group. For this analysis, 199 motives from D. Scarlatti Sonatas were considered.

2.3 Representing musical events

Each piece in the corpus was represented as a vector of notes, according to their respective MIDI note number. In order to have a representation that is invariant under transpositions, the relative interval between consecutive notes was used as the final vector to be analyzed. In addition, G and F clefs were considered as two different vectors for the
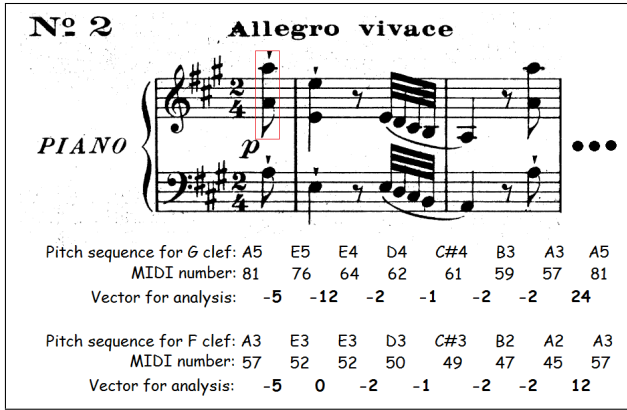
Figure 3: Sample measures of Beethoven's Piano Sonata no. 2 in A major - First Movement and the corresponding interval representation. Intervals with 0 semitones were eliminated (assuming that repetitive notes do not indicate significant information).

Figure 5: Number of appearances of the motifs in each of the 32 Beethovens sonatas.

same piece. For cases where more than one pitch occurs in the same beat, the higher note was selected to compose the vector. These steps are exemplified for the first metrics of Beethoven's Piano Sonata no. 2 in Figure 3. The query motives (i.e. the ones extracted from Scarlatti) are also represented according to the relative interval between consecutive pitches.

2.4 Finding the motifs

The approach to find melodic motifs occurrences is straightforward. The motif query is iteratively shifted and compared with the corresponding sequence of intervals of a vector from a specific sonata – by Beethoven or Mozart. The comparison is done note by note and, in a first analysis, only the motif for which all intervals coincide with those in the query is considered. Each iteration means to shift the query motif one position forward and realize a new comparison as illustrated in Figure 4.

2.5 Validation

The first approach we propose to validate our results considers randomness. We performed the same search – using the original 199 motifs selected from Scarlatti sonatas – but now, instead of using the original vector of notes from Beethoven and Mozart sonatas, we considered 'scrambled' versions of those vectors (respectively B' and M' as described in subsection 3.1). As expected, the number of occurrences in B' and M' are considerably lower than in B and M. By so doing, we intend to demonstrate that the motives were not found by chance and that the sonatas by Beethoven and Mozart were proven relevant to the analysis.

3. RESULTS AND DISCUSSION

3.1 Analysis of the 199 motifs

The search for the 199 motifs extracted from Scarlatti sonata led to 59 being found in Beethovens and Mozarts piano so-
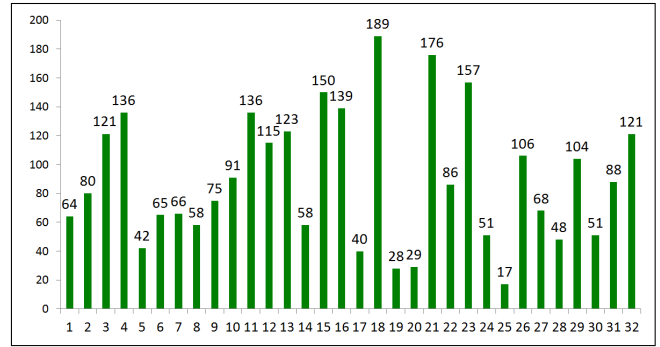
natas, from which only 5 motifs were found exclusively in Mozart's. The 54 motifs found on Beethoven's are significant, with 17 motifs being exclusively found in Beethoven. Furthermore, the appearance of 3 motifs indicates strong evidence of common elements of composition between Scarlatti and Beethoven. The first of the latter belongs to the group of motifs formed with thirds, fifths and fourths (K298E1/E2), while the other two belong to the group formed by any interval combination (K299A and K483A4). Discussion and more information about these three motives are provided in subsection 3.2. Figure 5 shows the frequency of appearance of the 59 motifs in each of Beethoven's sonatas. High incidence occurred for sonatas number 18, 21, and 23 (respectively opus 31 n.3, opus 53 and opus 57). The importance of opus 53 "Waldstein" and opus 57 "Appassionata" should be emphasized, for these Beethoven sonatas represent a turning point on piano composition, especially the Appassionata.

Table 1 displays the number of motifs detected in Beethoven's and Mozart's sonatas, and in their scrambled versions. The numbers in the first line indicate the absolute values, without normalizing to the number of notes in the corpus for each composer. The number of notes reflects a normalization factor of 2.3 for Beethoven, that is, the number of notes in Beethoven's corpus is 2.3 the number in Mozart's. With this normalization, the resulting numbers are given in the second line of Table 1, which confirms the higher incidence of motifs in Beethoven compared to Mozart. This can be further visualized with the graphical representation of the data in Table 1 in Figure 6, where the nodes indicate the composers (including their 'scrambled' counterparts, B' and M') and the edges reflect the relative number of incidences of the 199 motifs. The influence from Scarlatti on Beethoven is remarkable, as denoted by the similarity between composers given by the edge values.

In addition to considering the pitch domain as above, we also analyzed the use of compound meter, which was prevalent in Scarlattis work. The same pattern is also observed on Beethoven sonatas. Mozart, although having a number of compositions in 3/8 and 6/8 meters that is similar to the number found in Beethoven, does not employ either 9/8 or 12/8 meters in his sonatas. Still, Beethoven
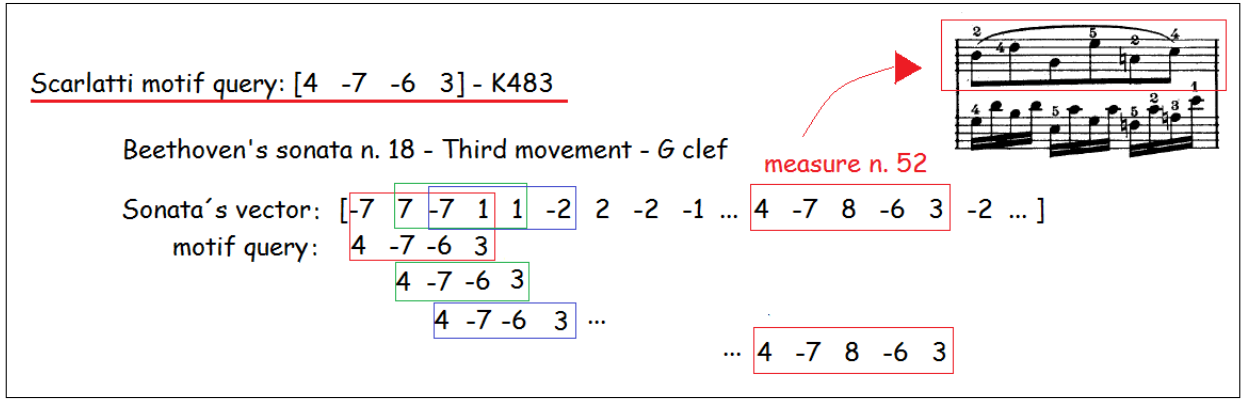
Figure 4: The algorithm to detect motives. For each motif found, the sonata and movement numbers were stored, as well as for which metric it happened.

Beethoven	Mozart	Beethoven'	Mozart'
2878	978	483	230
1252	978	210	230

Table 1: Number of motifs detected in Beethovens and Mozarts sonatas, where the first line corresponds to the actual numbers (non normalized) and the second line brings the normalized values according to the number of notes in the corpus for each author.
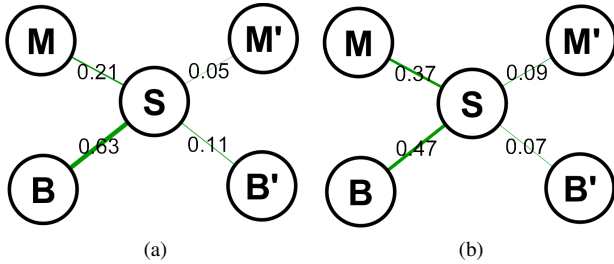

Figure 6: Graphical visualization of the relations between the number of motifs detected in Beethovens and Mozart' sonatas – (a) without and (b) with normalization. B' and M' attends for the 'scrambled' versions of vector notes by Beethoven and Mozart, respectively. A thicker edge suggests a stronger relationship between the pairs of composers. Note a higher similarity between Beethoven and Scarlatti, given by the numbers in the edges.

wrote about 500 measures using them (Figure 7). Moreover, the time signatures like 9/16, 12/16, 9/8 and 12/8 appear reasonably frequently in Beethoven but not at all in Mozart.

3.2 Most significant motifs

From the musicological point of view, strong evidence for the similarity between Scarlatti and Beethoven could be inferred by the appearance of three motifs, as follows.

A) K298E1/E2

Fast repeated notes are quite recurrent in Classical music, often used as a representation of comic affect. Even
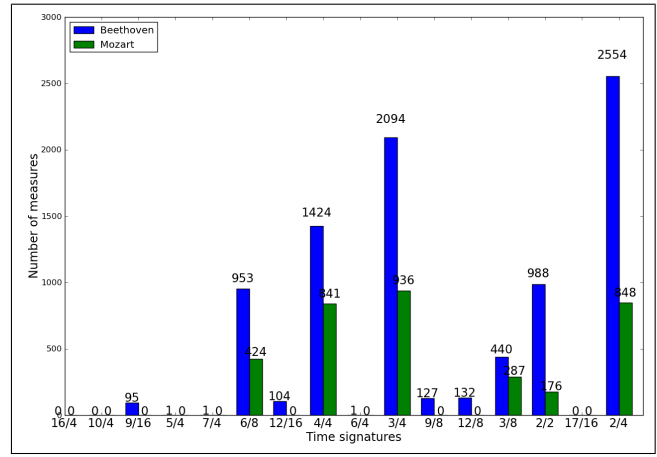

Figure 7: Frequency of time signatures in the sonatas by Beethoven and Mozart.

though arpeggios are widely used in Mozart's piano composition, the procedure of framing repeated notes on arpeggiated chords does not appear in his sonatas. In contrast, Scarlatti used this procedure widely, which is indeed characteristic of his musical style, as seen on bars 44 and 45 of K.298 in D major (E1 and E2 motifs) in Figure 8a.

Major chord arpeggios with repeated notes are found in three Beethoven piano sonatas, opus 31 n.3 4th movement, opus 78 2nd movement and opus 10 n.1 1st movement. In all three cases, the motifs appear syncopated, suggesting that Beethoven wanted to use a recurrent Scarlatti procedure in a different way. It is curious that this simple compositional procedure also used by Beethoven should not be found in Mozart's sonatas.

According to Rossini in his *Souvenirs Personels*, Beethoven would have said that "serious opera does not lie in the nature of the Italians. For the true drama, they know not enough of the science of music; and how should they acquire that in Italy? In opera buffa none can equal Italians. Your language and your temperament predestine you for it. Look at Cimarosa: how much superior the comic parts in his operas are to the rest! The same with Pergolesi" [5]. It suggests that what Beethoven would privilege in Italian
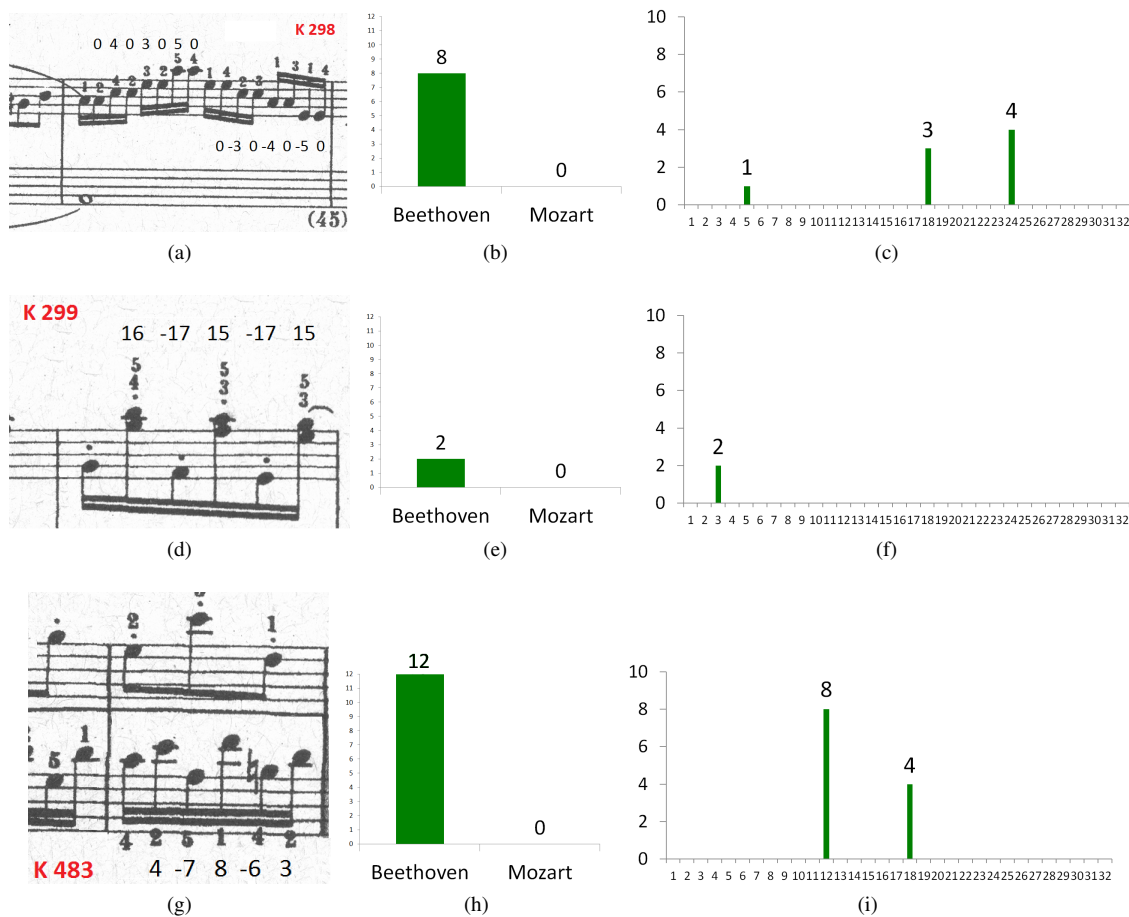
Figure 8: Illustration of the three relevant motifs described in this work. For each case, we show the passage in the score, the comparison between Beethoven and Mozart in terms of the number of occurrences, and the specification of Beethoven sonatas in which the motif was found.

music was its comic side. Scarlatti is undoubtedly a good source for Italian comic music on keyboard.

The 4th movement of opus 31 n.3 is a clear example of the comic affect coming from Italian music and it sounds somewhat an Italian tarantella. The 6/8 measure of this movement is also a very common Scarlatti procedure. On the second movement of Sonata opus 78, Beethoven's use of repeated note arpeggios follows the same affect of opus 31 n.1, however showing a more mature Beethoven as composer. Interestingly, the opus 78 was Beethoven's favorite sonata [4]. A timid appearance of K298 E2 motif on Beethoven's opus 10 n.1, regardless of its non-thematic use, still exhibits a happy affect in the cadence of E flat major, which contrasts with the c minor tonality of this Sonata.

B) K299A

The motif A of K.299 is another typical Scarlatti procedure, i.e., leaps that go beyond octaves. Mozart does not seem to use this kind of procedure as it would represent too much risk for the player. In fact, Mozart hardly uses intervals transcending an octave in his piano compositions. He is seldom audacious; in contrast to Scarlatti, his style lies mainly on simplicity and clearness. Beethoven, on the other hand, seems to have appreciated passages of Scarlatti sonatas where the player takes risk. It is suggestive

that Beethoven used the A motive of K.299 on the coda of the first movement of his opus 2 n.3 in C major in the same way Scarlatti uses it. Beethoven's opus 2. n3, dedicated to Joseph Haydn, pays tribute to his masters Haydn and Mozart. Would Scarlatti be among them?

C) K483A4

The 4th movement of Beethoven's opus 26 can be considered a typical influence from the Scarlatti style. A fragment of the harmonic sequence extract from K.483 (A4 motif) was found there in its strict form and basically the same way Scarlatti uses it, i.e., a harmonic progression on each of the 2 notes. In Mozart, generally, harmonic progressions go on groups of four 16th notes. This same A4 motif appears on Beethoven's opus 31 n.3, first movement, but in a different way. While in the opus 26 he uses it as harmonic progression, on opus 31 n.3 it is treated as thematic material.

4. FINAL REMARKS

In this paper, the relationship between Scarlatti and Beethoven was addressed quantitatively by analyzing melodic lines produced by these composers using a computational algorithm to identify common motives and use of com-

pound meters. In addition to identifying a frequent use of Scarlattis motifs in Beethovens sonatas, such use was much more frequent than in Mozarts sonatas employed for comparison. Three specific motifs typical of Scarlattis style were singled out and analyzed in detail, thus providing strong evidence for the influence from Scarlatti on Beethovens sonata.

These quantitative results corroborate the expectation from historians. For it is reasonable to suppose that someone in Vienna having a collection of Scarlatti sonatas manuscripts would look for Beethoven to share his preciosity with the great master. Since those manuscripts were in Vienna by the time Beethoven was living there and that all his Sonatas were written in Vienna, there is a real possibility of Beethoven to have had contact with Scarlattis sonatas analyzed here, namely the 38 sonatas from volume G of Vienna I collection, also found in Vienna II collection. Therefore, Beethoven might have utilized Scarlatti compositional procedures or ideas in his 32 Sonatas.

Because we consider the evidence above as insufficient for a proof of a possible influence from Scarlatti on Beethoven, we are already undertaking further research to include rhythmic analysis, and the use of different metrics to describe common music compositions procedures between Scarlatti and Mozart. For example, the correlation between their melodic lines reveals an interesting property that could be explored. Another important validation regarding the spectrum of pitch intervals is the incorporation of a threshold that allows the motifs to be detected even if some intervals do not match exactly. In this context, the Euclidean distance between motifs offers an alternative way to capture motifs with noise.

5. ACKNOWLEDGMENTS

6. REFERENCES

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