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Software tools for musical performance

A methodological approach to uncover micro-agogics

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ABSTRACT

This article sets out a method of analysis for studying rhythmic flexibility in musical performance, with particular emphasis on the study of micro-agogics. With the help of the open-access software *Sonic Visualiser*, a practical example analysing a world-renowned performer, Pau Casals, and one of his most important audio recordings, the Cello Suites by J.S. Bach, is presented. The following paper examines the key points of performance analysis of micro-agogics in the interpretation of *Prélude* BWV 1007; an ideal work for this type of study as the prevailing notation is the repetition of semiquavers in 651 of the 654 notes. Five levels were analysed taking into account the compositional structure of the *Prélude*, levels that go from the duration of each note up to the duration of the bar. The small differences in timing that are produced between the notes of the same rhythmic value are the cornerstone of a *rubato* structure at different levels that make up the final resulting sound of this masterful performance. According to the results, Casals respects the written notation at the same time as producing a varied interpretation of the music by Bach.

Introduction

Over a century has passed since the introduction, diffusion and popularisation of recorded music as a format that enables a sound to endure in a lasting physical format. This important technological advance has created another element that may be studied in addition to the traditional musical score and other written texts. In recent decades, sound recordings have come to be considered important sources of knowledge and have started to be studied in depth, methodically and rigorously. Despite this research initially taking place in Anglo-Saxon countries, in the last ten years researchers and teams from all over the world, Spain included, have joined in. Different analysis techniques have been developed depending on the purpose of the research, which includes an area of knowledge known as "music performance studies", which is of great interest both to musicologists and performers, and encompasses both analysis of performance and also analysis for performance. An analysis covering these two facets would show how a particular player has played and recorded a work, and could also go a stage further by allowing another player wishing to emulate it to project this knowledge onto their own interpretation. This second musician could even go a stage further and use the performance as a starting point for their own. This type of practice comes under the category of "recordings-informed-performance", or RIP (Leech-Wilkinson, 2015), a term demarcating a variation on the well-known area of "historically-informed-performance" or HIP studies.

Along with other parameters of musical performance, these types of analysis are contributing to understanding how a particular eminent musician has approached their interpretation of the agogic nuances in a piece. Even though the most obvious characteristics may be clearly perceptible in a recording, there are a large number of minute nuances that usually go over the heads of most listeners, but which make all the difference to the end result. This aspect, which relates to the use of durations, could be called micro-agogics. Another factor to consider is the age-old difficulty in noting agogic nuances in the score in a minimally objectifiable way. Considering the essential role they play in the resulting sound in most cases, analysing the micro-agogics in a performance not only allows us to see data relating to durations starting with the shortest rhythmic value in the work, but also provides a commentary on these data in which the debate is as interesting as its conclusion.

This article summarises a method of analysis that aims to reveal how rhythmic flexibility is treated in performance and its projection onto another subsequent musical interpretation, which has been presented in detail in Saenz (2017b).

Analysis methodology

A complete and detailed system of analysis is outlined below to illustrate the commentary on the data with the most comprehensive understanding possible of the work and everything surrounding it from a semiological perspective. The interaction of four different analytical procedures is proposed in order to carry out comprehensive analysis of the rhythmic flexibility of the performance. Performance analysis should begin with the performer's ideas about musical interpretation, which leads us to the first step: a literature search. Any human interpretation of a work starts with the performer's style as its foundation. This is impossible to separate from the person's life story and is part of an evolution they undergo during their life as a performer. Whilst a truly holistic approach is a huge undertaking, it is possible to get to know the musician better by reading and studying biographies and other publications that provide information about them both as a musician and an individual. All this information helps the analyst to understand the performer in order to comprehend what they are listening to and find a reason why it is so. This is an approach akin to the performing arts when an actor or actress "gets into the role". Whenever a person's performance is studied, it should be remembered that any interpretation is imbued with its performer and the time in which it is performed, so getting as close as possible to their way of thinking is essential to understanding the subject being studied.

After this stage, the next two analytical procedures are conducted on the musical composition itself; these are a distributional and a harmonic analysis. For the structure, a distributional or paradigmatic analysis is ideal for this type of study. Visually very effective, the breakdown provided by the use of cells and their structural form makes the work easier to understand, as well as making clear its repeated and differential elements and the relationship between them. For the harmonic analysis, Roman numeral analysis is proposed instead of functional analysis, as it is more objective and leaves less room for interpretation by the analyst, although both methods can be complementary. These two analyses of the work can later be compared with the interpretative decisions to lengthen a note or series of notes for reasons of expression, such as to emphasise a harmonic shift or a structurally decisive moment in the composition.

The third stage is to analyse the recorded musical performance, in other words, the sound recording. The software Sonic Visualiser – an open source, free and user-friendly tool – is used to conduct a thorough study of the agogics as this analysis program can measure the duration of each note of a composition to the millisecond. Sonic Visualiser is designed to view, hear and analyse every detail of an audio file and allows a recording to be slowed by up to 12.5% without any other parameter of the sound such as the pitch, timbre or intensity being affected. Listening at such a slow speed gives rise to other analytical findings which, even if they are not related to agogics, should not be ignored as they can provide interesting information about the performance, such as the extension or projection of the sound of each note in the musical interpretation (Saenz, 2017c).

Multidisciplinary teams currently creating and sharing free plugins have developed applications specially designed to study the nuances of tempo by detecting the start of each note and inserting an onset, or sound marker. Together with the University of Alicante[1], Universitat Pompeu Fabra is one of two such Spanish universities to have created plugins for Sonic Visualiser. Specifically, Universitat Pompeu Fabra has shared the following applications developed by the Music Technology Group (MTG) on the Vamp Plugins[2] download site: HPCP - Harmonic Pitch Class Profile vamp plug-in[3], MELODIA - Melody Extraction vamp plug-in[4] and MIR.EDU[5].

In the case of bowed string instruments, it is not possible to automatically and exclusively detect the start of the note using a plugin as they currently lack the necessary precision. In some cases, the only option currently available is to mark the onsets semi-automatically, as recommended by Cook and Leech-Wilkinson (2009), and in most cases this has to be done completely manually. Plugins are, however, able to detect some key points, which can help to position a large number of onsets initially. From then on, manual corrections must be made in all cases. Applications may also record false markers, whilst others may be unmarked or displaced in relation to the real note change. To conduct a reliable analysis, all onsets must therefore be adjusted manually. The reason the applications currently available are unable to precisely detect the start of particularly problematic notes is mainly because the string does not vibrate fully from the moment the bow is drawn across it. In the case of a glissando, the analyst must decide when a note ends and the next one begins, so it seems unlikely that fully automatic detection will be achieved, although making predictions about technology is a fool's game considering the speed at which computer science is progressing.

With this in mind, an onset must be inserted at the start of each note. This manual positioning requires the analyst to invest a lot of time and a great deal of care to ensure the placement is precise and justified. This task should be conducted at 12.5% speed and with optimal listening conditions. Once all the markers have been positioned, a duration for each note that is accurate to the millisecond can be obtained. To broaden the scope of this information, the data can be exported to a data sheet to enable calculation of the totals, average durations by rhythmic value, differences between repetitions of the same musical material, and so on as required. By way of an example, in the analysis of Prélude BWV 1007 presented in Saenz (2017b, pp. 163-310), from which various examples will be cited in this article, of the 654 pieces of data obtained for the duration of each note, a total of 14,648 fields containing data had to be handled and subsequently interpreted, as far from being the con-

1 Plugins offered by the University of Alicante [consulted 2017]. Retrieved from http://grfia.dlsi.ua.es/cm/projects/drims/softwareVAMP.php

2 [consulted 5 August 2017]. Retrieved from http://www.vamp-plugins.org/download.html

3 [consulted 5 August 2017]. Retrieved from https://www.upf.edu/web/mtg/hpcp

4 [consulted 5 August 2017]. Retrieved from https://www.upf.edu/web/mtg/melodia

5 [consulted 5 August 2017]. Retrieved from https://github.com/MTG/miredu

clusion of the analysis in themselves, these data are simply the starting point for the analyst to begin their analysis.

A practical example: Prélude BWV 1007 performed by Pau Casals

Below is an example used to illustrate the method of analysis, with some of the results obtained from analysing Prélude BWV 1007 taken from the first of the six suites for cello by J.S. Bach and recorded in 1938 by the Catalan cellist Pau Casals. This recording is particularly significant as it was the first time the full six suites were recorded. Among other features of his particular sound and way of interpreting the music, Casals' particular use of rubato stands out. When interpreting rhythmic flexibility, Casals insisted on the need to seek a balance between the "natural rhythm" and the "rhythm on the score" in order to find "the sense of the timing in the space". By this he was referring to the performer's ability to apprehend the relationship between small units of time, and larger temporal units; groups of phrases and large structural features which make up a work (Blum, 2000).

In terms of literature analysis, publications by the following authors have been analysed in particular depth: Alavedra (1969 and 1975), Albet (1986), Baldock (1994), Ballester (2009), Blum (2000), Campbell (2004), Casals (1979), Corredor (1967 and 1975), García-Pérez (1983), Jean-Bernard (2009), Kahn (1977), Kaufman (2015), Kirk (1974), Lazo (2012), Llorens (2015), Mackie (2006), Reina (2009), Rubio (1979), Sibilin (2009), Tellez (2015), Vives (1966) and Zurita (2015) among others[6]. Information has been gathered from these sources on the aspects that provide the most important background to his performance style: his musical education and his role as a teacher (Saenz, 2017a). Other information has also been sought regarding Casals' relationship with Bach, the rediscovery of the suites and their dissemination, the historical context surrounding the recording of the work, as well as Casals' thoughts on issues of musical performance and specifically agogic nuances in interpretation.

In terms of a structural analysis of the work, it is a simple structure built on notation based around repetition. It is arpeggiated and in three voices, as can be seen in the way the composition unfolds and also in the final three-note chord. There are only two kinds of notation throughout the entire work: arpeggiated notation and another that is more melodic and directional. In most cases, the cells coincide with the bars[7]. In the Prélude there are only three rhythmic values: the quaver occurs twice, the semibreve at the end of the movement, and the recurring semiquaver, which is the rhythmic value used in the rest of the movement. This means that of the total 654 notes, 651 are semiquavers. The basis for the harmonic analysis was taken from Winold (2007a, pp.13-20 and 2007b, pp. 6-9).

In terms of the compositional structure of the work and bearing in mind the rhythmic recurrence discussed, we can observe 5 levels: level 1, note by note; level 2, created by group-

6 The information gathered from each of these is collected and commented upon in Saenz, 2017b.

7 The full distributional analysis and commentary on it can be found in Saenz, 2017b, pp.163-166.

ing two semiquavers; level 3, organised by beats; level 4, which groups together eight semiquavers; and level 5, which corresponds to the bar or cell. To transfer this information from an analysis of a performance to an analysis used for a performance, a graphic representation as per Cooper and Meyer (2007) has been used, applied exclusively to durations by using a horizontal line for long durations and a semicircle for short durations. The analysis headings described above have been used to transfer the data collected with Sonic Visualiser to the simplified score.

Below, a bar or cell from the Prélude is presented which has a high incidence of rhythmic flexibility. The part analysed is bar 7:

NOTE	BAR NOTE No.	DURATION	BEAT	2 SMQ. TOTAL	BEAT TOTAL	8 GROUP NOTE No.	8 GROUP TOTAL	BAR TOTAL
F#	1	0,213	1			1		
A	2	0,203	1	0,416		2		
D	3	0,201	1			3		
C#	4	0,178	1	0,379	0,795	4		
D	5	0,240	2			5		
A	6	0,186	2	0,426		6		
G	7	0,191	2			7		
A	8	0,209	2	0,4	0,826	8	1,621	
F#	9	0,291	3			1		
A	10	0,206	3	0,497		2		
G	11	0,149	3			3		
A	12	0,159	3	0,308	0,805	4		
D	13	0,208	4			5		
F#	14	0,243	4	0,451		6		
E	15	0,165	4			7		
D	16	0,281	4	0,446	0,897	8	1,702	3,323

Table 1: data relating to durations of the notes in bar 7.

Table 1 includes the following information: in column 1, the name of each note. In column 2, its position within the bar. In column 3, the duration of the note in level 1 taken directly from Sonic Visualiser. Column 4 shows the beat within which each note occurs. Column 5 is the sum of the group of two semiquavers or level 2, and column 6 refers to the duration of the beat or level 3. Column 7 places the notes in the two groups of eight notes the bar is comprised of, and column 8 shows the data relating to the grouping of these groups. The last, column 9, shows the total duration of the bar or level 5 in the last cell. Image 1 shows the notation of the same bar with the five levels represented by the graphic representation:

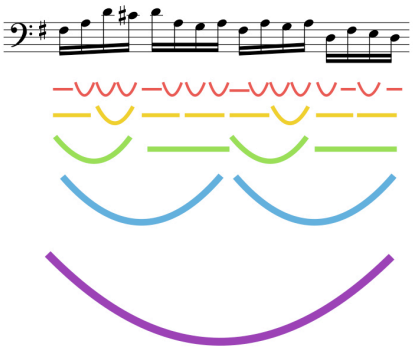

Image 1: bar 7 with the graphic representation of the levels.

This bar is a perfect example of employing micro-agogics in a performance; it shows continuous rhythmic flexibility as we can see by the fact that some of the ritardandi and accelerandi are strung together. To note this, the durations in column 3 must be looked at to the millisecond. In this way, level 1 has a melodic character belonging to cell B (bars 5 and 7). and shows convergence in the first three beats. As melodically important notes, the first notes of the three first beats stand out for being long, whilst in the fourth the notes No.14 F-sharp and No.16 D are notable.

A progressive four-note accelerando can be seen in the first beat, although the difference in increases between the four notes is not very large. Between No.6 A and No.9 F-sharp there is a progressive ritardando of four notes with a greater range between the notes that is therefore more evident. From this No.9 F-sharp to No.11 G, Casals again plays an accelerando in which he makes up the lost time, in this case with three notes and with more significant differences between them. From No.11 G, he again plays a four-note ritardando until No.14 F-sharp, executing the progressive and gradual decrease in speed in a regular fashion.

These fluctuations introduce different patterns in level 2, whilst in levels 3 and 4 we see convergence both in the interpretation of the beats and between the two halves of the bar. In level 3, the long-short pattern can be seen twice, a pattern that is not repeated in the other reason for cell B. Despite the prevalence of long values in level 2, the length of the bar is short overall. This bar reveals something very important about Casals' agogic control: despite all these fluctuations, there are converging patterns in levels 2, 3 and 4.

In Table 2, corresponding to bar 13, another example of micro-agogic mastery can be seen, where despite five accelerandi being played practically back to back with three-note ritardandi from the first to the last note, there is no significant difference in duration between the length of this beat and the others:

NOTE	BAR NOTE No.	DURATION	BEAT	2 SMQ. TOTAL	BEAT TOTAL	8 GROUP NOTE No.	8 GROUP TOTAL	BAR TOTAL
D#	1	0,365	1			1		
F#	2	0,188	1	0,553		2		
D#	3	0,165	1			3		
F#	4	0,166	1	0,331	0,884	4		
A	5	0,200	2			5		
F#	6	0,178	2	0,378		6		
A	7	0,172	2			7		
F#	8	0,198	2	0,37	0,748	8	1,632	
D#	9	0,235	3			1		
F#	10	0,188	3	0,423		2		
D#	11	0,175	3			3		
F#	12	0,179	3	0,354	0,777	4		
A	13	0,190	4			5		
F#	14	0,181	4	0,371		6		
A	15	0,182	4			7		
F#	16	0,188	4	0,37	0,741	8	1,518	3,15

Table 2: data relating to durations of the notes in bar 13.

In this case, there are repeated patterns in levels 1, 2 and 4 as can be seen in Image 2:

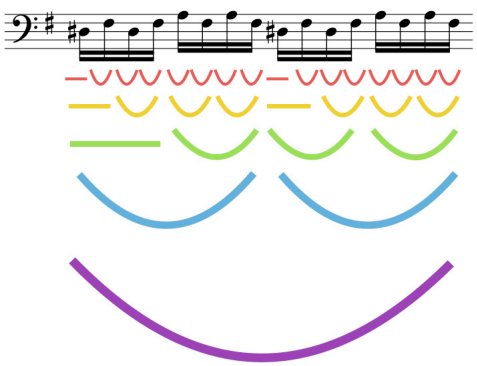

Image 2: bar 13 with graphic representation of the levels.

In the graphic representation of the levels, the almost complete symmetry between the two halves of the bar is notable in all levels except level 3, in which the long duration of the first note of the bar affects everything that comes after. Conversely, the third beat as a whole is not significantly longer than the second or fourth, so it is not a long beat. The equivalence between the durations of the notes should be noted, especially those that are not the first note of the beat.

In Table 2 an accelerando from the first note in the bar, which is also the longest, can be seen. This accelerando endures until No.3 D-sharp, whose duration is less than half that of the first note. After No.3 D-sharp, Casals plays a three-note ritardando until No.5 A, which is not as significant as the previous progressive increase in speed. From No.5 A, he goes back

to a three-note accelerando until No.7 A, and from here to a three-note ritardando until No.9 D-sharp. To this he once again links a three-note accelerando until No.11 D-sharp, and from here to another three-note ritardando until No.13 A. From the following note, No.14 F-sharp, he plays a final three-note ritardando to No.16 F-sharp, at which point the bar ends.

Conclusions

The analysis described in this paper has brought to light interesting information on the way in which Casals' performance employs rhythmic flexibility and which could subsequently be applied to another performance. In the Prélude, the aspect that particularly stands out is the way in which the regularity of the rhythmic values used by J.S. Bach in the score are interpreted freely by Casals, but without ever changing the composer's original notation. The data obtained using Sonic Visualiser and expanded into a data sheet have allowed us to see information that goes unnoticed in real time, but which is crucial to the recording of this performance having such historical importance. Deciding what should be done with each and every note is the kind of analysis that Casals used to conduct with his students (Blum, 2000, pp. 111-112), so it is safe to say that each duration reflected in the analysis was a conscious decision. Each of the five levels functions independently, even if there is some convergence. In short, we can say that the high number of agogic combinations employed by Casals shows the wealth of interpretations that are possible when playing Prélude, whilst still respecting what J.S. Bach wrote in the original score.

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