Letters

The Importance of Silence in Music Information Retrieval

We would like to report some research results regarding the importance of taking rests into account in the stylistic analysis and classification of music.

In music, rests—gaps in the flow of notes—play an essential role, demarcating phrases and allowing a performer (whether human, bird, or whale) to indicate the syntactical endings necessary for clear communication, verbal or otherwise. In order to analyze the rules of formal grammars in natural language, computer languages, or data structures (such as music), parsing or syntax analysis methods have been developed. These methods are based on the symbols that constitute such languages. In the case of our research, symbols (the notes) are transformed into MIDI information, but when the score is transformed into MIDI, critically, silences are not encoded (that is, they are neglected for the pitch transition analysis), even when there is a precise symbol for a rest in the musical notation. Locating these silences for analytical purposes therefore requires indirect methods.

The examples considered here are drawn from Renaissance motets, written in a sophisticated imitative contrapuntal style that was subject to clear rules codified by leading theorists of the time such as Vicentino (1555) and Zarlino (1573). (For later codifications of Renaissance style, see for example, Fux, 1725, Jeppesen, 1931, Rubio, 1972, and Mann, 1987.) In these treatises, as was understood in vocal music of this period, a normal phrase length was related to the ability of a singer to complete a phase without taking a breath, subject to the text's syntax. More generally, how the use of these breaths in classical musical composition contribute to a sense of what a musical phrase is and how it is perceived by a listener has been the subject of a recent dissertation by Neta Spiro (2007); a broad Schenkerian theorization can be found in Rothstein (1989).

The research reported here is part of a project exploring the use of statistical and mathematical methods to analyze early Western classical music (Formal Methods in Musicology, https://formal-methods-in-musicology.webnode.com). Here we focus on several polyphonic *cantus firmus* motets by the English Tudor composer John Sheppard (c.1515–1558), using the methodology outlined in a previous book chapter (Padilla et al. 2017). The first test work was *Christi Virgo Dilectissima* in six voices (for a modern edition, see Wulstan, 1978), for which the original tenor partbook is lost and for which there are three modern completions (compositions of the missing voice) by three different musicologists, as well as a fourth that aggregates an optimal version (Williamson et al. 2019). We wanted to determine which of these completions is stylistically closest to Sheppard's five surviving voices for this motet.

Part of the methodological contribution made here consists in modifying the routines of the program being used to analyze the scores. The work was done in MATLAB, with the MIDI Toolbox 1.1 library, which was developed by Tuomas Eerola and Petri Toiviainen (Eerola and Toiviainen 2016). With this library it is possible to read, process, and modify MIDI information from a given score.

In MIDI Toolbox 1.1, the functions *ivdist1.m* and *pcdist2.m* respectively count the interval distance and the transition from one note to the other, even if there is a rest between them. (We slightly modified the first of these functions for the sake of implementation, but the end result was actually the same.) For this study, that was counterintuitive, because for this repertoire it is normal to consider the rules of phrase structure as applying only to consecutive notes that have no silences in between. In order to produce a better result, we needed to modify the program to avoid encoding the interval between notes on either side of a rest. (Source code for our modification is available at https://github.com/Mateo92/FMM/tree/master.)

In order to implement this modification, it was necessary to first identify where a silence is, using the information that the MIDI matrix provides. This was done by noting that if the onset time in seconds of one note plus its duration time is smaller than the next note onset time, there has to be a rest between them. A conditional statement was implemented inside the loop of both functions. It is important to specify that for this study, duration weighting was not considered, so the function only adds 1 to its count every time there is certain interval or certain transition. What the new conditional statement does is to subtract 1 every time it finds that the previous interval or transition counted was between two notes that have a rest in between.

A particular case from a further study (Knights, Rodríguez, and Padilla Forthcoming) is next examined, using the same statistical interpretation as above. Figures 1 and 2 show two different analyses of the pieces by Sheppard, *Libera nos* (first setting, in seven voices) and *Christi Virgo Dilectissima* (for modern editions, see Wulstan, 1978). The first (Figure 1) is obtained using the functions as they originally are in the MIDI Toolbox library, and the second (Figure 2) using the modified functions that take into

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Figure 1. Sheppard's Libera nos *and* Christi Virgo Dilectissima*, PCA-SVM analysis using the original functions.*

Figure 2. Sheppard's Libera nos *and* Christi Virgo Dilectissima*, PCA-SVM analysis using the modified functions.*

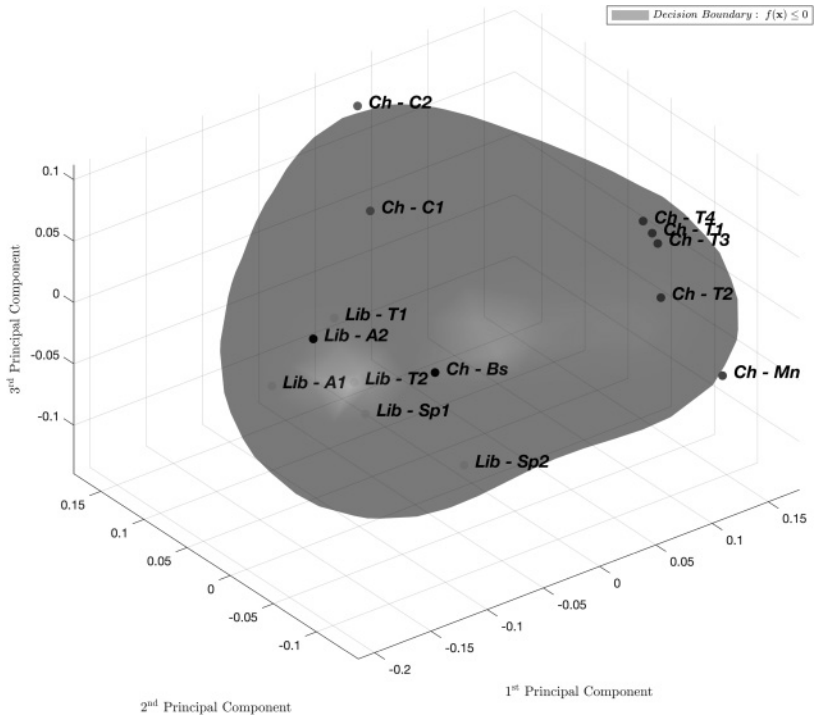


Figure 1

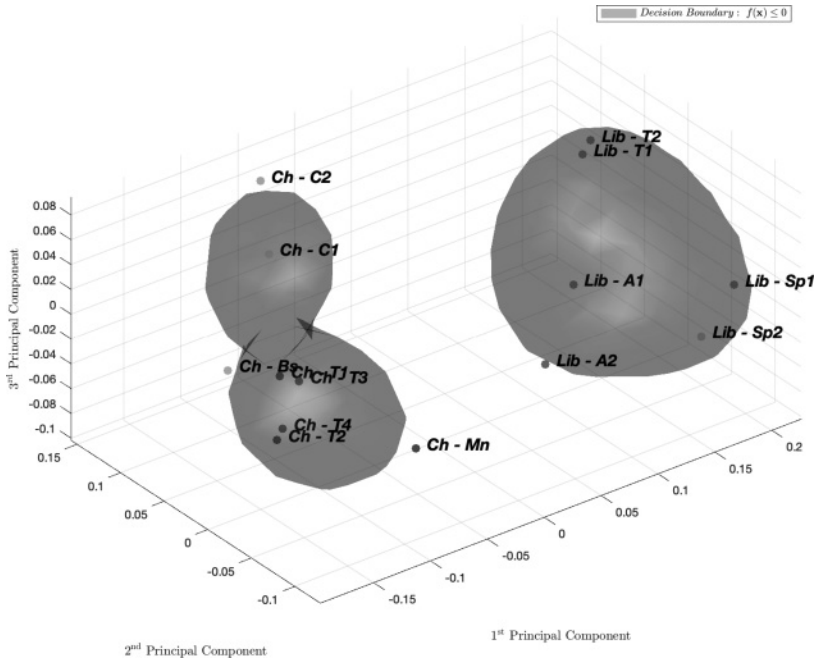


Figure 2

Figure 3. Sheppard's Libera nos *and* Christi Virgo Dilectissima*, dendrogram analysis using the original functions.*

Figure 4. Sheppard's Libera nos *and* Christi Virgo Dilectissima*, dendrogram analysis using the modified functions.*

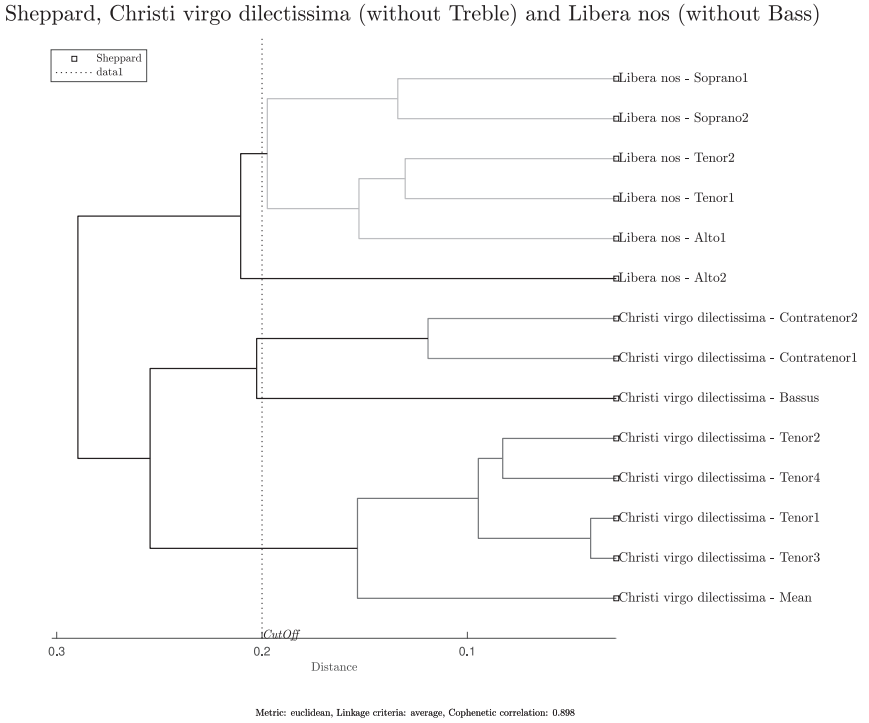


Figure 3

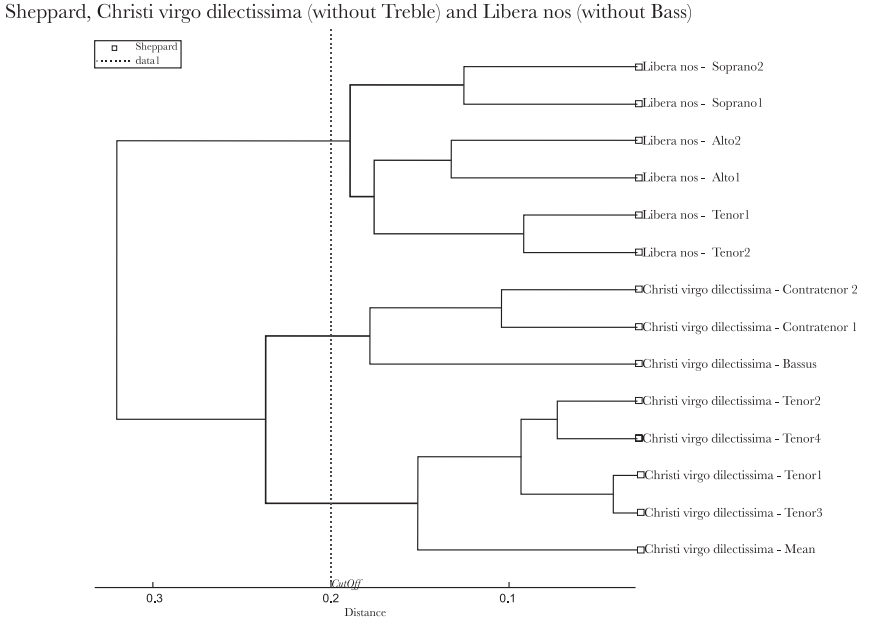
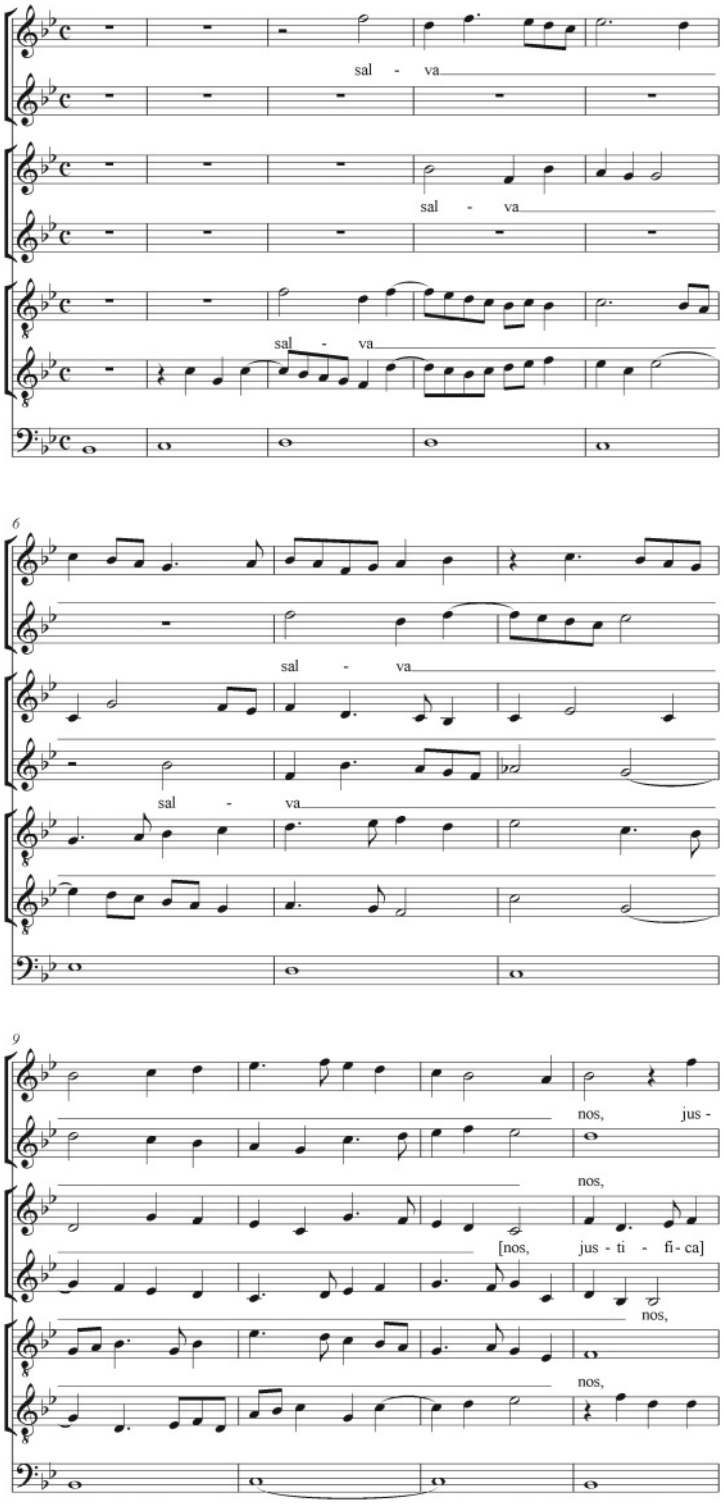


Figure 4

Figure 5. First twelve bars of Libera nos *by John Sheppard.*



account the rests. In both cases the predetermined long-note plainchant *cantus firmus* (in the bass of *Libera nos* and the treble of *Christi Virgo Dilectissima*) has been omitted in order to consider only the composer's own polyphonic lines.

We can see how the revised method, which considers silences and thus properly defines the vocal phrases, better classifies the statistical differentiation between pieces. It also produces a better classification of the polyphonic voices, which is more clearly shown in the dendrograms (see Figures 3 and 4).

In the dendrograms it is shown that the voices from *Libera nos* are better classified using the modified functions; particularly, the alto voices are arranged in the same branch. This is important, as the music was composed using pairs of closely related imitative points by voice (see Figure 5 for bars 1–12, about a quarter of the complete piece, our edition).

In conclusion, programs like the MIDI Toolbox are invaluable for creating sophisticated data analyses of music from scores, but it is essential that their precise functionality is understood before the validity of their results can achieve a high level of confidence. In the case of music like High Renaissance motets, which are created using imitative vocal phrases of relatively short length (Knights, Padilla, and Rodríguez 2019), it is essential that intervals not be counted where they cross a rest. The methods outlined here ensure that musical melodies can be well defined, in order to make accurate statistical classifications of musical style in this repertoire, and indeed others from the pre-Classical period. This confirms something that every performer knows: Rests matter.

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Mateo Tonatiuh Rodríguez is affiliated with the Science Faculty of Universidad Nacional Autónoma de México and with Escuela Superior de Música, Instituto Nacional de Bellas Artes y Literatura; Francis Knights is affiliated with Fitzwilliam College, University of Cambridge; Pablo Padilla is affiliated with Instituto de Investigaciones en Matemáticas Aplicadas y en Sistemas Universidad Nacional Autónoma de México; and Dan Tidhar is affiliated with Wolfson College, University of Cambridge.

Mateo Tonatiuh Rodríguez
Mexico City, Mexico
mateotonatiuh@ciencias.unam.mx

Francis Knights
Cambridge, UK
fk240@cam.ac.uk

Pablo Padilla
Mexico City, Mexico
pabpad@gmail.com

Dan Tidhar
Cambridge, UK
dut20@cam.ac.uk

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