

# Performance motives: Analysis and comparison of performance timing repetitions using pattern matching and Formal Concept Analysis

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A method combining a pattern-matching approach with Formal Concept Analysis is used to explore repeated timing patterns in performance in order to analyze characteristics of performances and differences among them. Initial analysis of timing data from performances of Chopin's Etude Op. 10, No. 3 suggests that repetitions in timing patterns occur in several contexts: with motivic material identifiable in the score, with the same structural positions, in parts played very quickly, and not directly coinciding with any of the above. The paper explores the relation between these contexts and the roles of such repetitions in different performances of the same piece.

*Keywords:* music information retrieval; performance; pattern matching; repetition; motive

Investigations of performance often make primary reference to the score, using structural and other score-derived information to predict and explain performance features. Furthermore, averages of one or more groups of performances have been often regarded as representative. In this study, we concentrate on two aspects that are difficult to explore on these bases. We investigate the types of relationship between patterns of performance “features” and those in the score and their frequency, and similarities and differences among recorded performances of the same piece. We do so on the basis of recurrent expressive features that, we argue, have a “motivic” function in given performances. Motives (short repeated melodic, rhythmic, harmonic patterns) have long been recognized as important elements of

musical structure (Réti 1961). We develop this by exploring repeated patterns of expression originating in performance, which we term “performance motives.” Here we investigate repetitions of performance timing patterns in recorded performances of Chopin’s Etude Op. 10, No. 3 for piano.

The Etude is in ternary form: A—bars 0<sup>4</sup>-21<sup>2</sup>, B—bars 21<sup>3</sup>-61, A'—bars 62-77. Bars 1-5 are exactly repeated in bars 9-14, and bars 9-19 are exactly repeated in bars 62-72. Performances of this piece have been analyzed from a number of perspectives. For example, in Rink’s (2004) analysis of the Etude, recorded performances are studied, as are interpretative possibilities other than those heard within the recordings. Furthermore, Repp (1998) analyzed performances of bars 1-5 of the piece using principal component analysis and identified at least four dominating “independent ‘timing strategies’” that could be related to the melodic-rhythmic grouping structure of the music and local emphasis, and others that do not seem to represent an alternative structural interpretation of the music but rather an alternative “gestural shaping.” The timing patterns could be described as a weighted combination of these strategies and idiosyncratic variation, and a wide range of basic tempos and of degrees of tempo modulation were identified.

The aims of this paper are (1) to explore and characterize expression in performance through “performance motives” primarily by searching for repeated timing patterns in the individual performances and (2) to compare performances of the same piece using the identified motives.

## METHOD

The method has three stages: quarter-note beat-timing extraction, pattern matching, and lattice generation. Timing information from ten recorded performances of the Etude spanning 1933-2001 was collected and automatically corrected by manually tapping to the onsets of notes occurring on each eighth-note beat using Sonic Visualiser. A pattern-matching approach and Formal Concept Analysis (Ganter and Wille 1999) were used to identify repeated timing patterns using a tool developed in TurboDelphi™ for pair-wise comparisons of groups of quarter-note beats. It executes multiple analyses enabling concentration on different group sizes, degrees of similarity, and global comparison within and among performances. Formal Contexts were produced for each performance, and the Con Exp package produced line diagrams showing pairs of repetitions that can be linked to other repeating units. Following perceptual studies, a 60 ms threshold was used, below which two notes were deemed the same length (Moore 1997).

## RESULTS

The results indicate that there are differences between the performances in the number of repeated units, their repetitions, and tempo fluctuations. The extremes of the trends are Szekely (1987), with a very steady tempo and many repetitions, and Cortot (1933), with far fewer ones, while Ashkenazy (1967) is in-between. These are used as examples in the following discussion and are referred to by the performers' names.

### Repetition types

Repetitions in timing patterns were identified in several contexts.

*Type 1: Repeated timing patterns occurring with exact or varied motivic repetitions identifiable in the score and in the same structural positions*

This type can be predicted from previous literature (Friberg and Battel 2002). However, in the performances the size of the repeated units varies. For example, in the Cortot recording the pattern of bars  $1^2-2^2$  and  $2^4-4^2$  is repeated in bars  $9^2-10^2$  and  $10^4-12^2$ , encompassing a large proportion of the first phrase and its repeat. The span of similarity is shorter in the repetition at bars 62-66, occurring only in bars  $12^2-13^2$  and  $65^2-66^2$ . In Szekely's performance, however, bars  $9^1-10^4$  and  $62^1-63^4$  have the same patterns, whereas in Ashkenazy's there is even less coincidence between the repetitions identified in the score and the repeated timing patterns. For example, an exact repetition of bars  $2^4-3^4$  occurs at bars  $63^4-64^4$  but not in bars 9-13. In none of the performances do exact timing repetitions coincide with all repetitions identified in the score, suggesting that timing repetitions of units may be related to their position in the piece more generally and not solely to score-based motives. Varied repetitions identified in the score in some cases coincide with exact timing pattern repetitions. The units of varied repetition are relatively short. In some cases, varied repetitions identified in the score follow exact ones, and some or all share repetitions of the same timing pattern (for example, in bars  $18^1-18^4$ ,  $71^1-71^4$ , and  $72^1-72^4$  of the Cortot, and for the Ashkenazy in bars  $17^2-18^1$  and  $18^2-19^1$ ).

*Type 2: Repeated timing patterns occurring in the same structural positions but where different motivic material is identifiable in the score*

Theories of structural perception predict systematic timing variation at structural positions such as phrase ends or bar starts. Therefore, it could be expected that repeating structural patterns identifiable in the score would be

reflected in the timing patterns. The results indicate that such repetitions occur with devices like phrase-final lengthening or the emphasis of strong beats in the bar. For example, in the Cortot, the timing pattern of bars 10<sup>3</sup>-11<sup>2</sup> is repeated in bars 62<sup>3</sup>-63<sup>1</sup>; the beat location in the bar is the same but the locations in the opening theme are different.

*Type 3: Repeated timing patterns during passages of relatively quick tempo*

The B section has continuous eighth-notes and many performers play it much more quickly and steadily than the A sections (particularly bars 38-53). There are many timing repetitions here that may be considered distinct from those in the slower and rhythmically more varied A sections. For example, in the Szekely, the eighth-note lengths of bars 30<sup>1</sup>-34<sup>4</sup> are repeated in bars 34<sup>1</sup> and 38<sup>4</sup>. This coincides with the repetition of the whole four-bar phrase. For the Cortot, bars 46<sup>4</sup>-49<sup>1</sup> are repeated in bars 49<sup>4</sup>-52<sup>1</sup>, at a metrically equivalent position. Therefore, many repetitions in the B section coincide with motives or phrases identifiable in the score or occur in structurally similar areas.

*Type 4: Repeated timing patterns not related specifically to the above characteristics*

Some timing repetitions do not relate so specifically to any of the above characteristics. For example, in the Ashkenazy, the timing patterns of bars 71-74 are repeated in 59<sup>4</sup>-60<sup>3</sup>. Though these have different metrical positions, both occur during the two bars preceding the return of the opening theme: the first on a syncopated first beat and the second on the upbeat. The similarity in timing may reflect the similarity of the heard as opposed to written accent structure as well as the lead-in function of these bars. In the Cortot, the timing patterns of bars 16<sup>2</sup>-17<sup>1</sup> and 24<sup>4</sup>-25<sup>3</sup> are the same. Both precede either a climax (bar 16ff.) or the return of previous material (bar 24), the latter accentuated by a large pitch interval. In these cases, the local, direct relationships with the score are less obvious, and a combination of different factors may explain these repetitions of eighth-note beat timings.

### **Comparison among performances**

The timing repetitions identified in the lattices were compared to the score and categorized according to the types described above (Table 1).

The number of repeated units identified was greatest for Szekely and smallest for Cortot. The extent of repetition identified in the Szekely is not surprising as the overall eighth-note length contour is relatively flat. Further-

*Table 1.* Number of repetitions identified in each performance and proportion within each type identified before. Here, repeated sections of four eighth-notes or more are presented.

	<i>Type</i>	<i>Cortot 1933</i>	<i>Ashkenazy 1967</i>	<i>Szekely 1987</i>
Total number of repeats		77	49	118
% of repeats coinciding with:				
Repetition in score	1	42	6	14
Similar structural positions	2	21	28	37
<i>Total % of above</i>		62	35	52
Fast section (bars 38-53)	3	23	49	
None of the above	4	14	16	48

more, for this performance, the proportion of repeated timing units occurring with score-based repetitions is approximately the same as those that do not. This suggests that the timing patterns in this performance are primarily driven by a steady tempo in each of the sections, in what is the most metronomic of the performances. Cortot's and Ashkenazy's performances have far fewer exact timing repeats. The majority of Cortot's repetitions that coincide with the types mentioned above occur with exact and inexact repeats. For Ashkenazy, however, the majority of repetitions occur in structural areas that are similar in terms of either phrase or metrical position.

## DISCUSSION

This study of performances of Chopin's Etude, using a combination of a pattern-matching approach and Formal Concept Analysis, identified four types of repeated timing patterns. These coincide with a number of different characteristics of the notated music. The types seem to be related to a range of factors, including: (1) global characteristics of the performance such as the general tempo, (2) tempo within sections, (3) motivic material identifiable in the score, and (4) structural characteristics. Exact repetition does not always occur when repetition would be predicted from the notated music.

There are differences in the areas of timing repetitions: some have repetitions in most performances, others have repetitions in fewer performances, and yet others contain repetitions that are unique to one performance. It seems possible to characterize the timing features of the various performances in terms of patterns that play different roles in each interpretation. In Szekely's, the steady metronomic pulse dominates, and therefore, for the most part, any one repetition may not be salient. In Cortot's

and Ashkenazy's performances, in which the timing patterns are more varied, repetitions are rarer and signal different aspects of the music, some coinciding with specific score-based repetitions and some with more general functional positions. Cortot's repetitions coincide with those of themes, motives, and metrical properties of the music as notated, while Ashkenazy's also occur in areas of similar structural status. Cortot's repetitions therefore seem thematically, motivically, or metrically driven, whereas Ashkenazy's seem "architecturally" driven. These repetition types may form the basis of "performance motives" lending coherence to performances and may contribute to our perception thereof by emphasizing connections in the piece.

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