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Musical tension as a response to musical form[1]

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ABSTRACT

Musical tension is a complex phenomenon and its comprehensive description should generally include a variety of different approaches. In this study, our goal is to describe the musical tension as a response of a listener to formal patterns by combining perception tests with musical analysis. We hypothesize that the intensity of the perceived musical tension is proportional to the structural (or hierarchical) significance of the corresponding musical event. To ease comparisons of the tension curves obtained from the listening tests and score-based structural analyses, we present the principles of three new analytical methods: 1) Analysis of salient features of music, 2) Analysis of musical "energy", and 3) Reduction and averaging of tension curves. We hope that the results applying those methods will contribute to a better understanding of the formal structure of post-tonal music and the techniques of prolongation.

I. INTRODUCTION

Musical tension is a complex phenomenon and its comprehensive description should generally include a variety of different approaches. In this study, our goal is to describe the musical tension as a response of a listener to formal patterns by combining perception tests with musical analysis.

To the authors of this article, musical form is essentially a hierarchical phenomenon. The main idea behind this study is that perceived musical tension can be seen as being dependant on the hierarchical aspects of form. We hypothesize that the intensity of the perceived musical tension is proportional to the structural (or hierarchical) significance of the corresponding musical event. To ease comparisons of the tension curves obtained from the listening tests and score-based structural analyses, we propose three new analytical methods.

The first method, **analysis of salient features of music**, is based on the discrimination of the relative importance of different types of compound musical events (i.e. impulse and culmination) using analysis of the musical score and cognitive analysis (see Lock 2010). The method and analysis results in Lock (2010) were presented at the ICMPC11 in Seattle (USA) August 23–28, 2010, under the title „Tension design analysis as listening analysis strategy for contemporary music: Perception of tension in contemporary post-tonal orchestral music: a case study".

In the second method, **analysis of musical "energy"**, musical form is treated as a succession of small areas in which the energy of the music determined by rhythm, dynamics, texture, or register, is described with simple terms such as increase, decrease, or sustain (Kotta 2011).

For the third method, **reduction and averaging of tension curves**, listening test curves are reduced to "deeper level" curves as long as they can be compared with the outputs of other types of analysis as described above. Unlike mathematical or Fourier-based smoothing of curves, this method allows for a clearer visualization and structural differentiation of peaks and valleys. Consequently, this method offers improved opportunities to study the perceived musical tension as a response to musical form. In what follows, we describe only the principles of the aforementioned methods, we do not demonstrate their applicability in a specific musical composition entirely.[2]

II. ANALYSIS OF SALIENT FEATURES OF MUSIC

In this section we present a method of score-based cognitive-perceptual analysis of the salient features of post-tonal music. We believe that the form of a post-tonal work can be described as a succession of salient events of varying importance, rather than phrases or larger formal units typically used to describe traditional compositions. By observing the local contexts in which salient events occur, decisions can be made about their varying levels of importance.

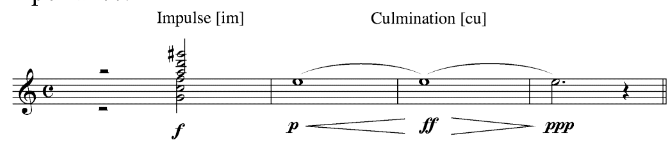

Figure 1. Examples of impulse [im] and culmination [cu].

First, an unprepared salient event may occur (a single tone, interval or chord with different dynamics or timbre, a characteristic motif, etc). We refer to such an event as **impulse [im]**. Second, such event may occur as a result of a previous development. In this case, we refer to it as **culmination [cu]** (see Figure 1). Third, the impulse may be followed by a substantial change in the course of musical development. We refer to such an event as **contrast [co]**. Finally, the contrast and culmination may coincide, in which case they constitute **contrast-culmination [cc]** (see Figure 2).

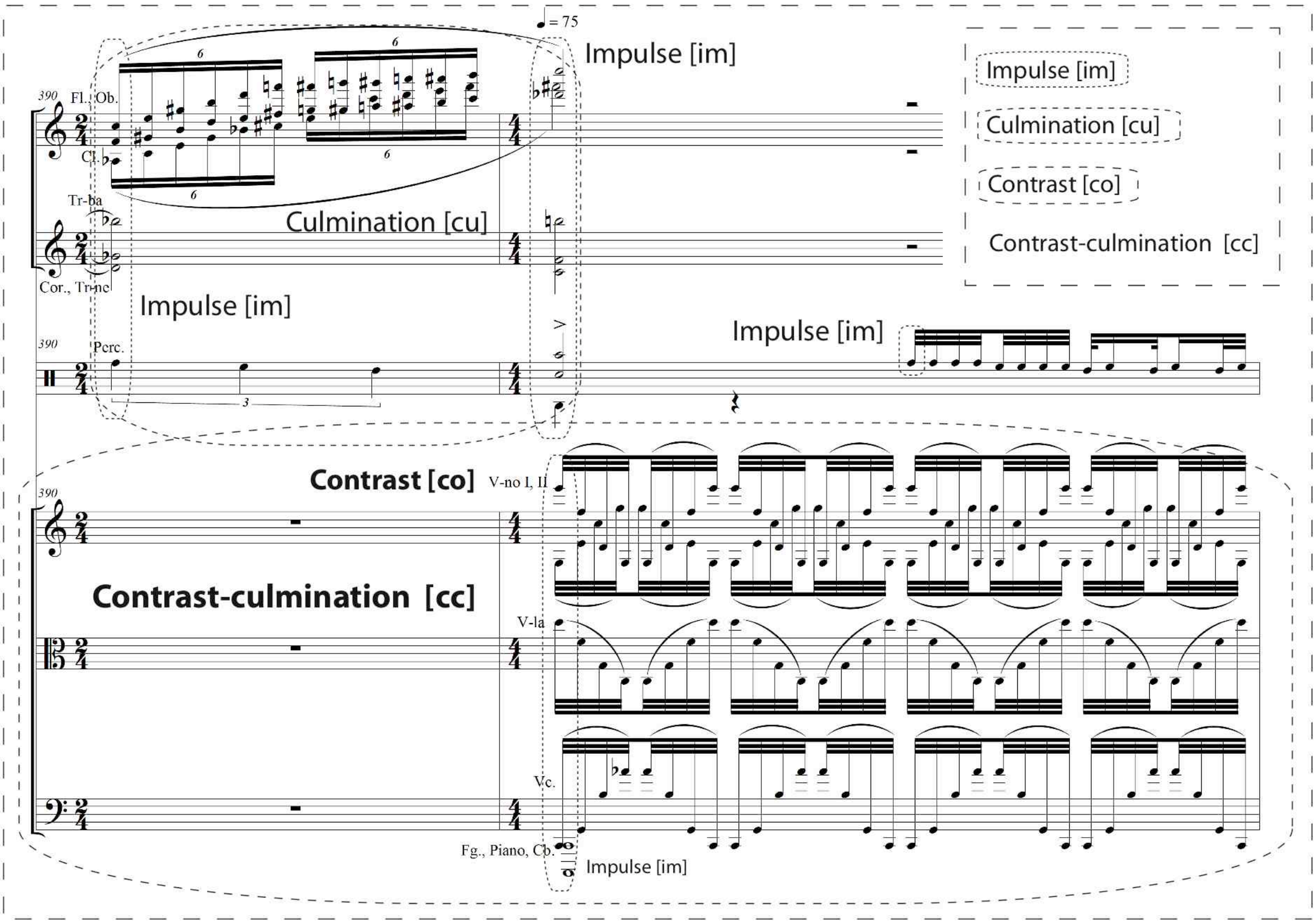

Figure 2. Example of impulse [im], culmination [cu], contrast [co], and contrast-culmination [cc] shown in Erkki-Sven Tüür's ensemble piece *Oxymoron* (2003) in bars 390–391.

The salient features are visualized on the linear time axis (x), and are given fixed values[3] on the vertical linear axis (y) (see Figure 3): impulse [im] = 10, culmination [cu] = 20, and contrast [co] = 30. The contrast-culmination [cc] can be expressed by two different values, 35 and 40, because the musical elements constituting the cc-s can coincide or follow each other in relatively short time but are to be considered as belonging to the event under observation. Measure numbers are included in the graphical representation. The graphical representation of such analysis can be realized as a bar or line diagram (see Figure 3) depending on purpose, i.e. the type of comparison with data obtained from other methods.

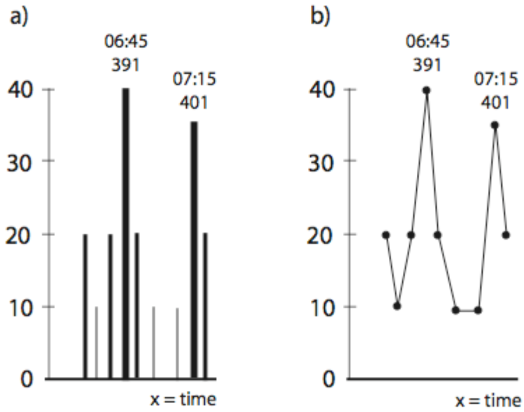

Figure 3. Two possibilities of graphical visualization of the same results of salient feature analysis of impulse [im], culmination [cu], contrast [co], and contrast-culmination [cc] shown in Erkki-Sven Tüür's ensemble piece *Oxymoron* (2003) around the bars 391 (see also Figure 2) and 401. Figure 3a is a bar diagram expressing the varying importance of particular events both in different heights on the y-axis and through the different boldness of columns (used in Lock 2010). Also the columns like the events itself stand alone, not being connected to each other and therefore not implying false connectivity (like in a line diagram, see Figure 3b). Figure 3b expresses the same results in a line diagram simply for the purpose of better comparitivity with line diagram of results of other methods. The time points for both cc's refer to the recording of that piece used for analysis (Tüür 2007).

III. ANALYSIS OF MUSICAL „ENERGY“

The musical process in the works of Erkki-Sven Tüür can be described as a series of **short formal sections** in which the emergence of **musical energy** in each carrier can be described by a single **qualitative state**. Such sections are referred to as **areas**. However, the separate carriers of an area may reveal simultaneously different qualitative states of energy (Figure 4).[4] For example, energy accumulation in dynamics can be accompanied by the energy persistence in the other carriers. In such a case, the area as a whole displays an energy accumulation (Figure 4a). Alternatively, the energy accumulation in register (e.g. rising melodic contour) can be accompanied by the energy loss in rhythm (e.g. shorter rhythmic values are progressively replaced by longer rhythmic values) whereas dynamics display no energy change. In such a case, the area as a whole reveals the energy persistence since the changes in register and rhythm mutually neutralize each other (Figure 4b). The latter case raises the question of the equivalence or compatibility of the different energy carriers which is discussed in more detail in Kotta (2011).

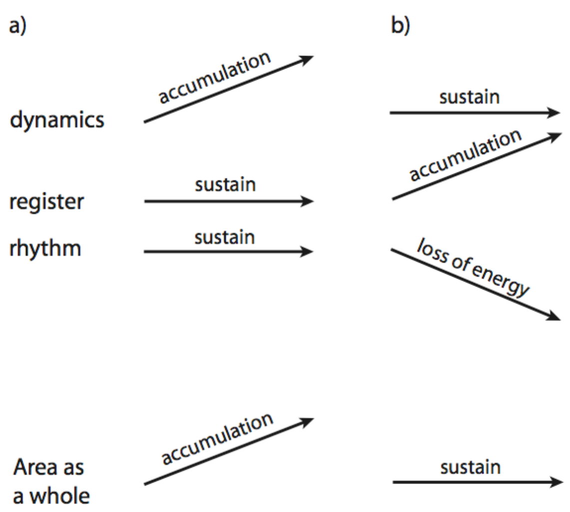

Figure 4. Area and its qualitative state of energy.

Points are places where the qualitative state of energy that characterize a certain carrier are replaced by another qualitative state (in the same carrier). Like areas, points can represent an energy accumulation, loss or sustain (or a tendency to move toward these qualitative states of energy). In order to determine the qualitative state of energy of a point, the energy value of the carriers of the preceding area need to be compared with the energy value of the carriers of the following area (Figure 5).

Next, we describe two possibilities out of many. If an area displays soft dynamics that begins to increase in the following area, and other carriers display no change, the point represents an energy accumulation (Figure 5a). Alternatively, an area may display some rhythmic activity which is then replaced by a longer or more sustained note(s) in the following area. At the same time, however, in terms of dynamics, piano in the preceding area is replaced by crescendo in the following area. The register displays no change. In such a case, the point represents the tendency to approach the energy persistence, since the loss of the rhythmic activity in the second area is offset by the energy accumulation in dynamics which was lacking in the first area, i.e. the energy value of both areas can be considered broadly equal (Figure 5b).

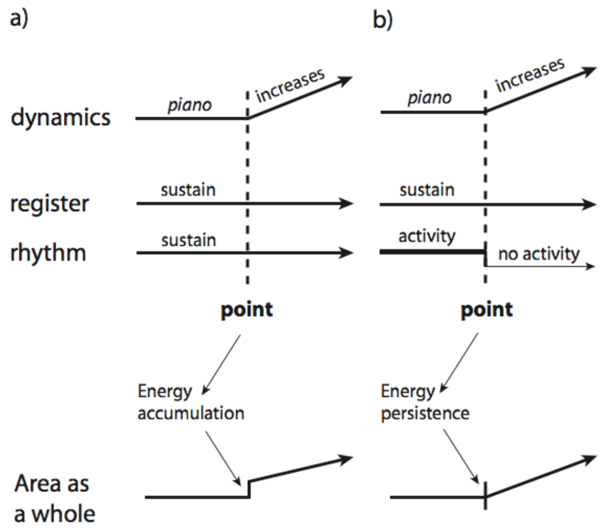

Figure 5. Point and its qualitative state of energy.

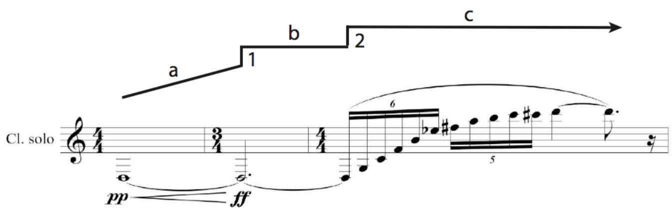

Figure 6. Erkki-Sven Tüürs Concerto for clarinet, violin and orchestra *Noēsis* measure 8–10 (solo clarinet part only).

Figure 6 features the opening gesture of Tüürs Concerto for clarinet, violin and orchestra *Noēsis*. The gesture can be divided into three areas which are referred to as a, b, and c respectively. Area a begins *pp* and shows an energy accumulation in dynamics and energy sustain in other carriers (pitch). Measure 8 represents the first point. Area b presents an energy accumulation, because the energy value of area as a whole is higher than the energy value of area a. The area b shows the sustained energy since it displays no change in all energy carriers. The beginning of measure 10 (measure 3 in Figure 6) coincides with the second point. It, too, represents an energy accumulation since the area c, in addition, includes the rhythmic activity which the area b was lacking. Finally, area c represents a tendency toward the energy persistence since the rising melodic contour, i.e. the energy accumulation in register, is balanced by the retardation of rhythm, i.e. the energy loss in rhythm – thus the opposing qualitative states of energy of the two carriers mutually neutralize each other.

Applying the method described above the music of Tüür can be redrawn as an "energy curve" which, can be compared with curves obtained from listening tests and other types of analysis.

IV. REDUCTION AND AVERAGING OF TENSION CURVES

In this section we introduce the basic principles of our method of reducing and averaging tension curves obtained from listening tests using a slider-controller for continuous data capture. The data for this section will be obtained in perception tests and are the basis for further analysis. The perception tests are based on listening to a complete work or a closed part of a piece. The participants are asked to "draw" the tensional development in real-time, using slider controllers following the primary sensations of tension. By moving the slider continuously and/or suddenly, or remain on the same level, if the tension does not change. They are also asked also to suspend the upper region of the slider until the most tensional events would take place in the last third of the section.

A. Reduction principles to analyze tension curves

Here we describe the principles of reduction of tension curves obtained from continuous slider-controller listening test data.[5] First we defined and graphically visualized basic terms such as **Highpoint**, **Lowpoint**, **High Reverse Point**, and **Low Reverse Point** (Figures 7–9). We then demonstrate how these points occur (i.e. how they can be derived from the tension curves) and what role they play in the reduction process (Figures 10–13). In Figure 13 we show how many reductions are needed in order to reach a level in which the reduced curves of different participants can be compared).

A point from which the curve starts to descend we call a **Highpoint**, hereinafter referred to as **HP** (Figure 7a). A point from which a curve starts to ascend we call a **Lowpoint**, hereinafter referred to as **LP** (Figure 7b).

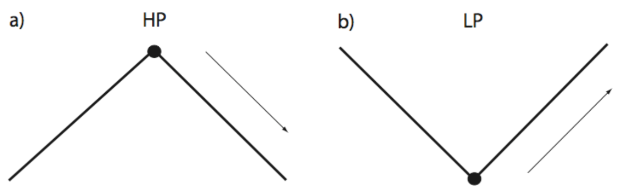

Figure 7. a) Highpoint (HP), b) Lowpoint (LP).

A highpoint which is directly followed by a lower highpoint we call a **High Reverse Point**, hereinafter referred to as **HRP** (Figure 8).

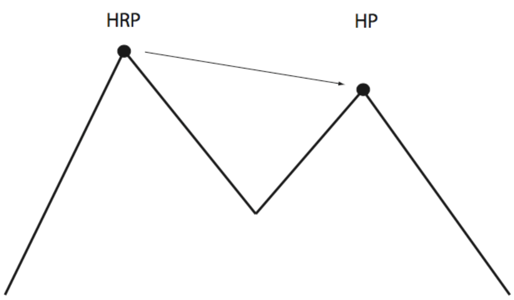

Figure 8. High Reverse Point (HRP) and the following Highpoint (HP).

A lowpoint which is directly followed by a higher lowpoint we call a **Low Reverse Point**, hereinafter referred to as **LRP** (Figure 9).[6]

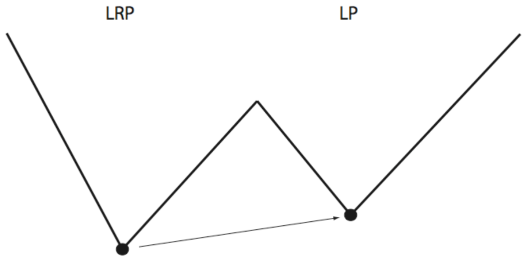

Figure 9. Low Reverse Point (LRP) and the following Lowpoint (LP).

The following examples (Figures 10–13) are hypothetical and fictive curves (read from left to right as a succession of points) in order to demonstrate possible instances which may occur in a reduction process. The Figure 10 represents a hypothetical raw curve (hereinafter referred to as curve A) and its first reduction (hereinafter referred to as curve B). In the process of reduction the high and low reverse points of the raw curve are connected with straight lines.

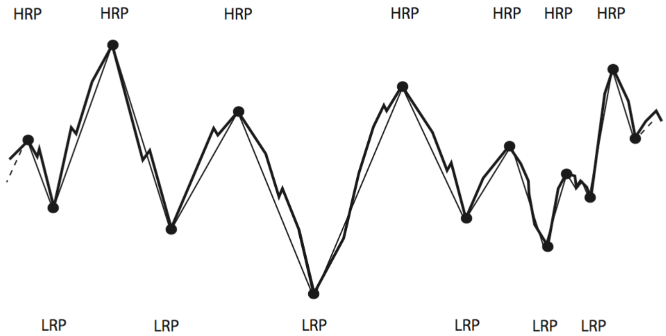

Figure 10. Hypothetical raw-data curve (curve A, thick black line) and its first reduction (curve B, thin black line).

Overlaps of curves and their reductions may occur, as when a curve displays HRPs and LRPs alternately following each other and shows a gradually increasing or decreasing value. Thus, instead of connecting a RP with the next closest RP, we connect it with a RP following the next closest RP. We refer to the points which are "ignored" in the process of reduction as evaded RPs (see the sixth RP in Figure 11).

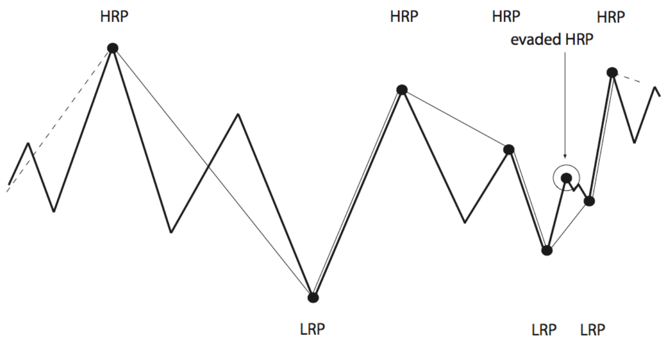

Figure 11. Thick black curve (curve B) and its reduction, thin grey curve (curve C). The figure shows three HRPs and three LRPs. By connecting the consecutive RPs the deeper level curve C emerges. The dashed lines before the first and after the last RP mark the hypothetical course of curve C.

Curve C includes points which cannot be categorized as HPs, LPs, HRPs, or LRPs. These points can be reduced out as shown in Figure 12.

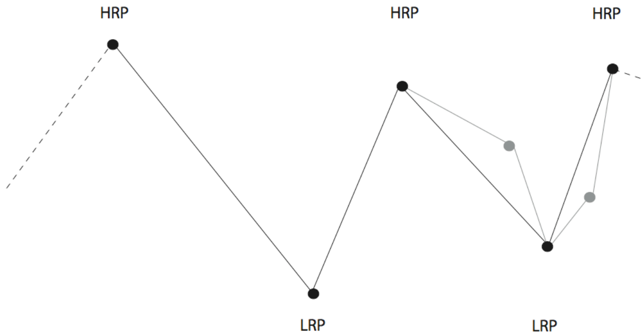

Figure 12. Curve C with points which are not understood as HPs, LPs, HRP-s or LRPs (points 4 and 6, marked with grey) are reduced out.

Analogously to curve A and B, curve C can be similarly reduced. We continued reducing curves until they show no more than three points within a fictive time window of one minute (counting from any point) (see Figure 13).

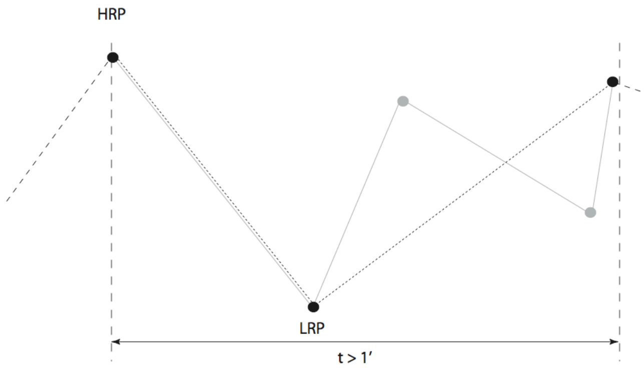

Figure 13. Curve C (grey thin line with partly grey dots) and E (dotted thin black line) within a one-minute time window. Curve C includes more than three points within one-minute time window. Curve E includes only three points within the one-minute time window and will be therefore the last reduction stage which we use in averaging the curves of all participants.

B. Averaging of intensity curves of multiple participants

The data of the reduced curves of selected participants[7] were collected and presented in a diagram with linear time axis (x) and the normalized tension level axis (y, maximum 100) (Figure 14). All points that occurred within 15 seconds were considered as belonging to the same time window. The first time window of 15 seconds began at the Tension Design Point (TDP)[8] 04:47.0 / 1 of the time axis (x) and the next window at the TDP 05:40.0 / 42 that immediately followed the first time window. The third time window began at the TDP 06:18.6 / 99 that immediately followed the end of the second time window etc. (see the grey areas and points in Figure 14). The time windows were converted to time points by averaging the time values of the points within the window under consideration (see the values of the time points next to the diagram of Figure 14).

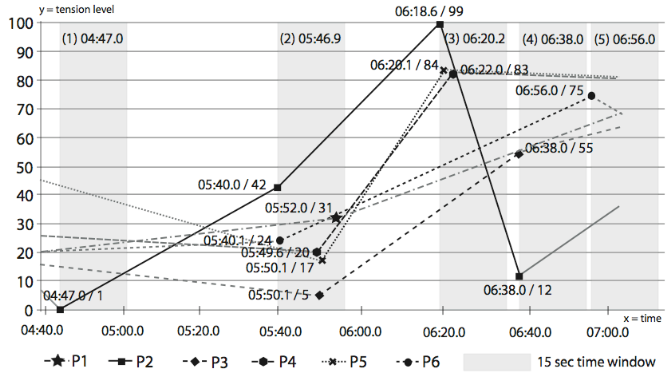

Figure 14. Fragment of the reduced perception test curves of Tüür's Fourth symphony (6 participants marked P1–P6 being distributed into 15 seconds time windows marked with grey areas each labeled with a number in brackets and the averaged time point values are shown in the top of each grey area.

Each time point has a tension value which is the arithmetical average of the tension values of the points making up 15 seconds time window (and which, in turn, is converted into the time point under consideration). However, in order to assess the actual value of a time point, the average reliability of the intensity value of the time point (hereinafter referred to as AR) has to be calculated according to the following equation: $AR = a \cdot n/x$. To calculate the AR of a time point we multiplied the average intensity value of that particular time point (a) with the ratio of the number of points making up the time window (n) and the total number of participants (x). If the time window under consideration includes only a single point we also applied this equation with n = 1 (see Figure 15). We considered the curve obtained from the calculated AR of the consecutive time points as the average of the intensity curves of all participants.

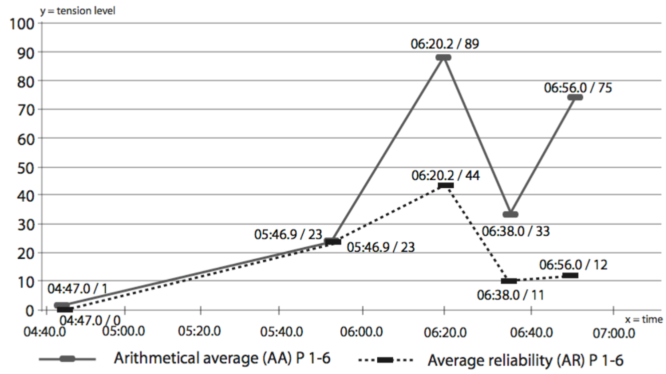

Figure 15. Fragment of the reduced perception test arithmetical average (hereinafter referred to as AA) and average reliability (AR) curves of Tüür's Fourth symphony (participants P 1–6). The grey colored upper curve represents the AA curve of TDP values whereas the fragmented black colored lower curve shows the AR curve of the TDP values.

The reduced and averaged curves are then compared with the graphical outputs of other analytical methods.

V. IMPLICATIONS

Through further research, we will compare the outputs of the three analytical methods described above with a traditional formal analysis of the works of post-tonal music. We are developing a method to explore optimal mappings between outputs of the analysis of form and the analysis of salient features of music, the analysis of musical "energy" and analytical outputs of the listening test participants along with their reductions. The authors of this study hope that the results applying the methods presented will contribute to a better understanding of the formal structure of post-tonal music and the techniques of prolongation.

ACKNOWLEDGMENT

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[1] This article is part of the forthcoming doctoral dissertation of Gerhard Lock at Estonian Academy of Music and Theatre Tallinn (Estonia) under supervision of ass. prof. Kerri Kotta (PhD). It develops further an earlier preliminary approach to analysis of tensional development of post-tonal music on the basis of listening tests and cognitive analysis called Tension Design (TD, Lock & Valk-Falk 2008, 2009).

[2] However, the methods presented here are especially developed for the analysis of the orchestral music of Estonian contemporary composer Erkki-Sven Tüür (b. 1959) and some selected examples are taken from his music as well.

[3] The events are given the values only to express their relative weight in integers. Therefore the numbers do not refer to the absolute values such as frequency, pitch, etc.

[4] An excerpt of a musical score and its analytical explanation is provided in Figure 6.

[5] using Max/MSP software written by Hans-Gunter Lock (Estonian Academy of Music and Theatre, Estonian Academy of Arts, Tallinn, Estonia). In 2011 the apparatus and software were refined enabling the use of up to 16 slider controllers and now called Tension Design Experimental Apparatus (TEDEA), see http://www.schoenberg.ee/tension-design/tension-design.html.

[6] The first reverse point of all participants is always a highpoint, because the first and starting point is the zeropoint (which allows only ascending movement of the slider controller).

[7] The following examples are based on perception tests in 2010 on Erkki-Sven Tüürs Fourth and Sixth symphonies in Estonian Academy of Music and Theatre. The study included musicians, artists and dancers with a blend of expert and non-expert knowledge of music.

[8] By Tension Design Point (TDP) we mean points in which both time and tension level dimensions make up an integral whole.