

# Preliminary Knowledge Extraction from Beethoven's Sonatas: from Musical Referential Patterns to Emotional Normative Ratings

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**Abstract**—The piano sonatas of Beethoven represent part of the Intangible Cultural Heritage. The aims of this research were to further explore this intangibility by placing emphasis on defining emotional normative ratings for the “Waldstein” (Op. 53) and “Tempest” (Op. 31) Sonatas of Beethoven. To this end, a musicological analysis was conducted on these particular sonatas and referential patterns in these works of Beethoven were defined. Appropriate interactive questionnaires were designed in order to create a statistical normative rating that describes the emotional status when an individual listens to these musical excerpts. Based on these ratings, it is possible for emotional annotations for these same referential patterns to be created and integrated into the music score.

**Keywords**—Emotional annotations, intangible cultural heritage, musicological analysis, normative ratings.

## I. INTRODUCTION

DURING the last few centuries, many analysts, philosophers and researchers [4], [6], [14], [17], in their attempts to interpret music, have dealt with the morphological analysis of music by taking into account different aspects and methods of music theory. For example, Schenker [17] claims that the analysis of any musical form is based on the tonic triad, something that has been accepted by most researchers in the music world. Accordingly, the work of many analysts [9], [15], [18] was based on this and it was used to analyze the composition techniques of Beethoven's Sonatas for piano.

Many other researchers [8], [11] have taken a different approach and dealt with the analysis of human response to music because humans experience and feel what they hear. For example, they have studied the individual's subjective response to music based on factors such as familiarity and personality [11], [19], whereas others have studied the criteria

on which music evokes emotions [8]. Researchers have found that emotions change rapidly during listening to music and so have often assessed emotional states using dimensional models [16], [20], in which typical dimensions are valence and arousal levels. Valence represents the perception of emotions as being either positive or negative and appears to be related to the presence of consonant or dissonant chords [5]. Arousal level indicates the degree of intensity of an emotion. Even if it seems to be independent of consonance or dissonance, it is strongly connected with loudness and musical expectation [7]. Violation of an expected chord usually increases emotional arousal, whereas the realization of that expectation lowers emotional arousal [1], [2], [10], [12], [13].

Taking together the aforementioned for the interpretation of music, the present study aimed firstly, at the musicological analysis of some specific excerpts from Beethoven's “Waldstein” and “Tempest” Sonatas (Section II) and secondly at the definition of emotional normative ratings for these Sonatas through an interactive online questionnaire (Section III). This research aimed to serve two purposes:

- The building of a database of musical pieces, each labelled with a specific emotional rating in terms of valence and arousal. The emotional classification of these musical measures circumvents the limitation of there being only a few well-characterized affective auditory stimuli sets available to researchers, most of which are of short duration. Following this classification, these musical excerpts would then be fed into a game-like Human Computer Interaction application that would aim to help users to understand and handle affective states and transitions in the music and enable them to work towards a more enhanced artistic performance.
- The identified emotional labels of the musical excerpts would afterwards be transformed into emotional annotations describing the affective space of the performer while s/he performs the given music score. These annotations would be provided as input in an “augmented music score” (a visualization module inserted into the game) to facilitate access to the knowledge of the composer, both gestural and emotional.

## II. MUSICOLOGICAL ANALYSIS OF THE “WALDSTEIN” AND “TEMPEST” SONATAS

Narrative is the instrument of human thought since it is the narrative mode that best conveys human intentions and actions. People experience what they hear, which are the

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structures of a piece. These structures are necessary to transmit ideas that process their own internal structure. For the researcher, the study of musical narrativity is absolutely necessary as is that of musical motifs.

Narrative, as already stated, is a basic way of working of the human mind. The narrative-generative process unfolds as a gradual expansion or composing out of achronic fundamental structure, so that is why it is very important to include it in order to analyze the “Waldstein” and “Tempest” Sonatas of Beethoven.

#### A. The Waldstein Sonata

In the “Waldstein” Sonata, no. 21 in C major, Op. 53, in the first movement, Beethoven narrates a melody which sticks in the human brain because he uses certain repeated motifs, such as repeated notes at a fast tempo, or ascending scales that lead to a peak, or cadenzas that drop and end the phrase. Also, for the performer, it is vital to focus on the fingering used (though there are no specific fingers used), so as to realize how the composer achieves his goal to get the melody to where he wants it.

To be more specific, in bars 23 – 30 (see Fig. 1) which is a passage of an ascending chromatic scale and descending arpeggio, different fingering sequences are used and it can be seen that the point is to reach elevated sentimental status. Although there are downward movements, the aim is to go up (the participation of left hand with the ascending arpeggio, makes it clearer).



Fig. 1 Some indicative musical bars (24-27) from the “Waldstein” Sonata

In bars 35 – 40, on the other hand, broken chords with descending movement predominate. This is a continuous gesture that can be deployed on the piano in a single-minded way which enables the performers to make music by moving the wrist up and down slightly. The performer can also express feelings such as happiness or anger.

In bars 50 – 58 the arpeggio movements enable the performer’s hand to be moved in a freer, more relaxed way like dancing gracefully on the piano. The fingering used is almost the same in all arpeggios - 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> or 4<sup>th</sup> finger (right hand).

Some bars before the movement ends, in 282 – 283, a cadenza is the indication/sign of the phrase coming to completion. The use of all fingers and the continuous alternation of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> fingers, make the melody more powerful and gives the impression of something that is reaching its conclusion.

#### B. The Tempest Sonata

In the “Tempest” Sonata, no. 17 in D minor, Op. 31, No.2, in the 2<sup>nd</sup> – 5<sup>th</sup> bars, there is the repetition of intervals of a second with the use of 1<sup>st</sup> and 3<sup>rd</sup> fingers, with the fingering changing when the note is repeated. These intervals when played continuously form a kind of obsession, which figuratively prepares the storm that follows in musical terms of analysis, that is to say the breakout of several melodies. Moreover, this stable motif gives the listeners the opportunity to become familiar with specific sounds or melody lines, so as to identify them later on. Also, the repetitive movements give the feeling of intense sentiment and the satisfaction of composing in a simple way, with something new, taking into account the interval of a 2<sup>nd</sup> and the alternation of only two fingers.

Bars 8 – 17 (see Fig. 2) include repetitive intervals but now not only 2<sup>nds</sup> but also 3<sup>rds</sup>, 4<sup>ths</sup>, 5<sup>ths</sup> and so on. The 5<sup>th</sup> finger here is extremely important since it gives the impulse for the descending movement of the hand. The “molto energetico” notification implies this tendency for powerful fingers and characteristic movement of downwards and upwards positioning of the wrist.



Fig. 2 Some indicative musical bars (8-17) from the “Tempest” Sonata

Bars 19 – 20 and 97 – 102, depict a chromatic ascending scale where alternative fingering sequences are used, mainly 1<sup>st</sup>, 3<sup>rd</sup> and 2<sup>nd</sup> finger. Bars 21 – 24 have a looser style, a freer one, since this is what the arpeggio implies. When playing arpeggios the hands are dancing gracefully on the piano and the wrist turns right, in order to go upwards (to the notes of higher pitch) whereas it turns left in order to go downwards (to the notes of lower pitch). In correspondence with this, on the piano performers are taught to do the same and imitate the ascending/descending arpeggio. Due to the fact that they experience “freedom” of score interpretation and performing, the result can be either similar in each case, or very different, with new sounds being created.

### III. THE PROPOSED APPROACH

An interactive online questionnaire was designed to create the required statistical normative rating that describes the emotional status when an individual listens to specific musical excerpts. Stimuli consisted of musical parts taken from two Sonatas of Beethoven, the “Waldstein” and the “Tempest”. Subjects were 36 volunteers recruited through online calls to

participate in this study.

The participants rated their emotional responses (valence and arousal) to each musical excerpt using a 9-point Self-Assessment Manikin (SAM) scale, and a pictorial rating system developed by Lang in the 1980s [3] to obtain self-assessments of emotions experienced (Figs. 3 and 4).

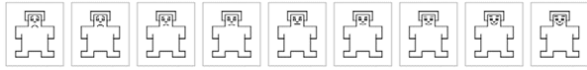


Fig. 3 The 9-point SAM scale for Valence (1 for displeasure and 9 for pleasure)



Fig. 4 The 9-point SAM scale for Arousal (1 for little or no arousal and 9 for very strong arousal)

The entries submitted by the subjects were statistically analyzed using SPSS software. Every participant had to answer all of the 22 questions asked. Since there is no objective physical unit of measurement to compare against self-reported emotional experience, the evaluation has the mean and the standard deviation of all subjects' responses as reference.

Apart from the first and second statistical moments of the ratings, there was an effort to identify the causality between the subsequent ratings. Specifically, since most subjects listened to the stimuli in succession, an emotional causality could be anticipated across the experiment. This could happen because the musical excerpt that was played previously could potentially affect the listener's emotional response to the current one, by following the composer's intention that is expressed through the realized compositional structure. This transition from one musical part to the other might also enhance a learning effect; musical patterns introduced to the subject in one particular musical part, might result in a smaller violation of expectation. According to the literature, the realization of this expectation could be depicted with a lower arousal rating.

#### IV. RESULTS

TABLE I

RATINGS OF THE STIMULI FROM BEETHOVEN'S SONATA NO. 21 (WALDSTEIN)

Musical meters	Emotional state	Mean	Musicological analysis
8-30	Valence	6.28	Elevating a bit the sentimental status ( <i>it should have been more, since it's the beginning of the piece</i> )
	Arousal	5.92	
34-41	Valence	5.14	Rather neutral status due to static rhythm
	Arousal	3.94	
50-58	Valence	5.61	Feeling more relaxed, graceful, dream-like
	Arousal	5.11	
74-81	Valence	6.08	Repetitive motif, not particularly interesting ( <i>it should have been lower</i> )
	Arousal	5.53	
130-142	Valence	5.22	Arpeggios give the sense of repetition, rather neutral feelings
	Arousal	5.61	
282-287	Valence	5.86	Powerful motif, leading to the end ( <i>anxiety should have been caused</i> )
	Arousal	5.14	

The musicological analysis of the specific bars from Beethoven's "Waldstein" Sonata that was described in Section II is summarized in Table I (last column), as well as the corresponding means of valence and arousal. The results of the emotional analysis of the "Waldstein" Sonata are shown in Figs. 5 and 6.

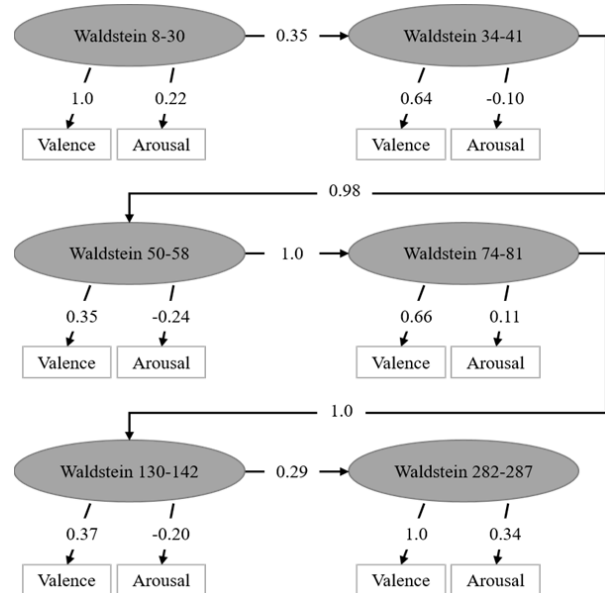
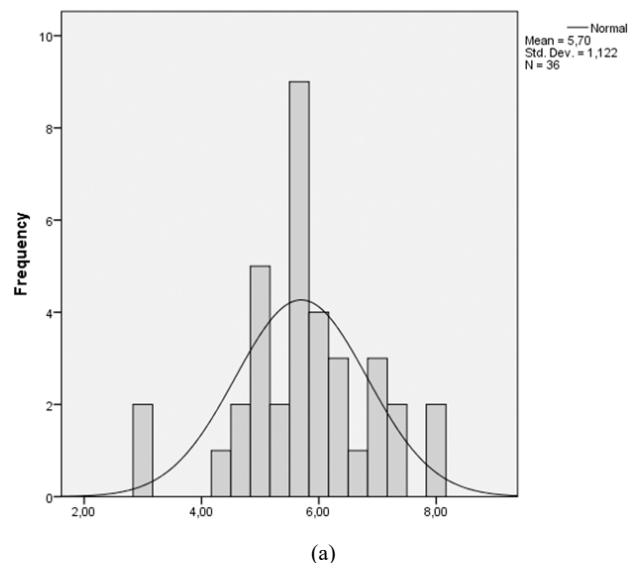


Fig. 5 The corresponding causality diagram



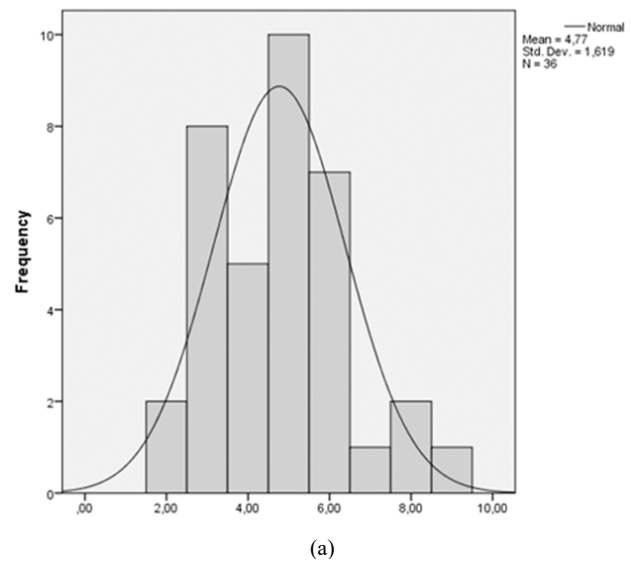
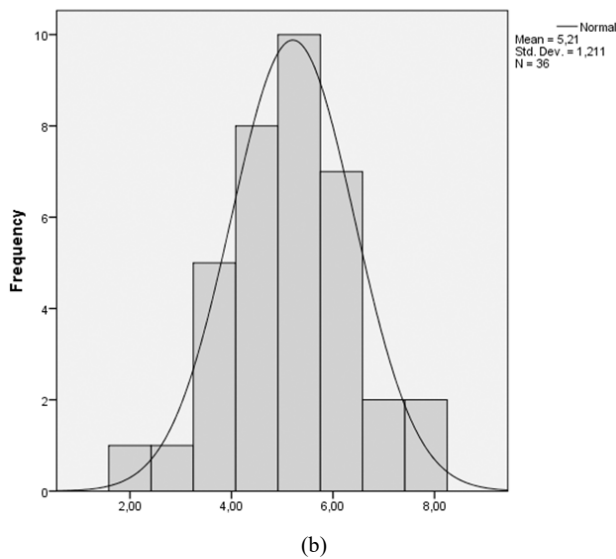


Fig. 6 Ratings of Valence (a) and Arousal (b) for Beethoven's "Waldstein" Sonata

TABLE II  
RATINGS OF THE STIMULI FROM BEETHOVEN'S SONATA NO. 17 (TEMPEST)

Musical meters	Emotional state	Mean	Musicological analysis
1-21	Valence	4.64	Sweet, rather flat motif, reactions completely justified
	Arousal	4.31	
22-42	Valence	4.67	Loose situation (maybe lower)
	Arousal	5.00	
59-62	Valence	5.14	Static rhythm, rather indifferent motif (reactions completely justified)
	Arousal	4.44	
79-93	Valence	4.97	Motivation diminishes again due to neutral motif/rhythm
	Arousal	3.50	
97-102	Valence	4.42	Largo and pp reduce the motivation, however it is a strong passage covering a wide pitch range? on the piano
	Arousal	2.83	

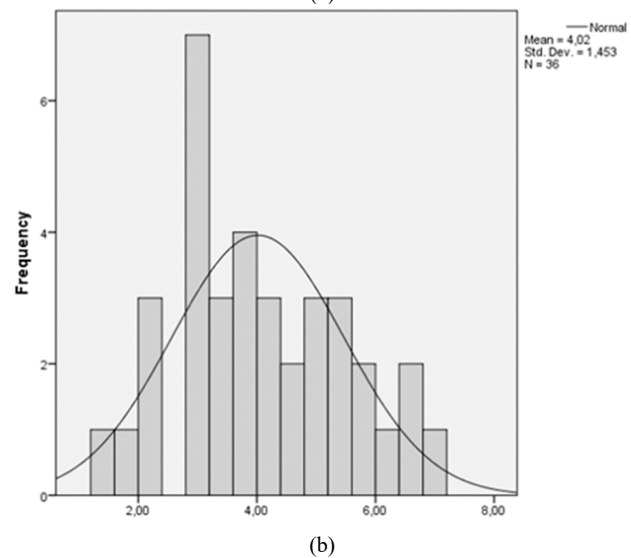


Fig. 8 Ratings of Valence (a) and Arousal (b) for Beethoven's "Tempest" Sonata

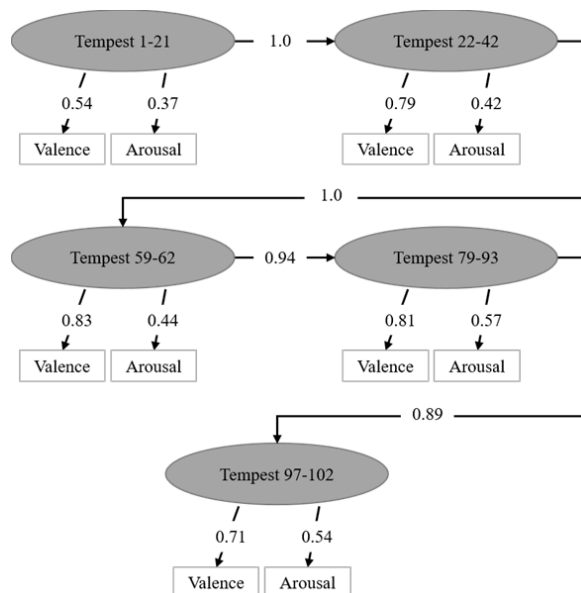


Fig. 7 The corresponding causality diagram

Similarly, the musicological analysis of Beethoven's "Tempest" Sonata is depicted in Table II along with the means of valence and arousal; and the results of the emotional analysis of this Sonata are shown in Figs. 7 and 8.

#### V. ANALYSIS OF THE RESULTS

Overall, subjects seemed quite hesitant about using the extreme scores on the 9-point scale (i.e. values 1 and 9). The ratings of arousal and valence were distributed across the remaining range of scores. However, only the distribution of arousal for the "Waldstein" Sonata fits the normal distribution and differs a lot from the corresponding one for the "Tempest" Sonata (Figs. 6 and 8 respectively). Since these musical measurements were presented to the subjects after a significant number of other auditory stimuli ("Waldstein" Sonata), there is a slight chance that the low arousal scores

were due to the lack of excitement that the participants may have felt at the time.

It is also remarkable that the musical bars 34 – 41 are the only auditory stimuli from the “Waldstein” Sonata associated with such a low arousal rating (Mean = 3.94). As mentioned in the musicological analysis, the continuous hand movements (gestures) in that musical excerpt can be deployed in a monotonous way. This monotony could be interpreted as a natural musical expectation, which is linked with a low arousal level, according to the literature [1], [2], [10], [12], [13].

In terms of the causality relationship between subsequent ratings, the results presented in Figs. 5 and 7, support the hypothesis that the emotional state reached due to the musical excerpts played previously affects and serves as an emotional memory which influences the emotional response to the current musical excerpt. More specifically, these results are based on an operational model that hypothesizes that a causality relationship exists between subsequent ratings. Each construct or latent variable, in this operational model, is constituted by two observable dimensions: valence and arousal. The operational model was estimated using the Structural Equation Modelling (SEM) methodology. All figures that are attached to the arrows linking two variables in the model refer to standardized coefficients. The levels and the signs of the standardized coefficients indicate the weight and the direction of the causality effect. The fit statistics that are attached to the results presented in Fig. 5 are as follows: Chi-square = 112.357; df = 49;  $p = 0.000$ ; Normed Chi-square = 2.293; GFI = 0.618; NFI = 0.390; CFI = 0.464, RMSEA = 0.192.

Similarly, the fit statistics that are attached to the results presented in Fig. 7 are as follows: Chi-square = 81.062; df = 31;  $p = 0.000$ ; Normed Chi-square = 2.615; GFI = 0.712; NFI = 0.595; CFI = 0.678, RMSEA = 0.215. These figures indicate that most fit statistics do not pass the appropriate critical levels. This is due to the fact that the sample sizes are rather small. However, considering that the Normed Chi-square ratios are much less than the critical level of 5, it is believed that the results in Figs. 5 and 7 may be used for inferences.

## VI. CONCLUSION, LIMITATIONS AND FUTURE WORK

All in all, the findings from the two causality operational models may be summarized as follows. Firstly, there is a causality relationship between successive emotional states, as can be deduced from the significant standardized coefficients between constructs. For example, in Fig. 7 (“Tempest”), it can be seen that in general the influence of emotions decreases as the transition from one measurement to another occurs: “1-21” → “22-42”: 1, “22-42” → “59-62”: 1, “59-62” → “79-93”: 0.94, “79-93” → “97-107”: 0.89. However, this decreasing influence is not seen in Fig. 5 (“Waldstein”), because the value of each link between successive constructs fluctuates in accordance with the emotional state measure.

Secondly, the weight of each dimension in determining a construct is indicated by the value of its standardized coefficient. For example, in Fig. 7 (“Tempest”), it can be seen

in the link “79-93” → “97-107”: 0.89. The weights for “79-93” are valence = 0.81 and arousal = 0.57; and the weights for “97-107” are valence = 0.71 and arousal = 0.54. These results indicate that valence drive emotions more in both “79-93” and “97-107”. Similarly, the influence of each dimension may be traced moving down the causality hierarchy.

Finally, in terms of the outcomes of this study and future work, an increase in the sample size should be considered a priority. This is due to the limitations that were mentioned above in that most fit statistics do not pass the appropriate critical levels. Thus, the next steps to be taken, in order to fulfill the purpose of the present study, will be to create a database of musical pieces, along with their emotional normative ratings and then to integrate these into an “augmented music score” through which the performer will learn to handle his/her affective states and transitions, as well as to having access to the composer’s knowledge, both gestural and emotional, leading to more authentic musical performance.

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