

The change in Beethoven's music composition: Is there a role of his mental distress?

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Received 18 February 2022, Accepted 8 June 2022

Abstract – *Background:* During his life, Beethoven faced a lot of personal problems and diseases that could lead to a prolonged period of serious mental disorder. The aim of this work is to study the link between the distribution of pitch frequencies observed in 101 movements of 32 sonatas and four periods of his compositional style. *Methods:* The 32 sonatas for piano were chosen because they were composed during the three periods usually considered to reflect Beethoven's career. A hierarchical generalized additive model was performed to regress the frequency of pitches with Musical Instrument Digital Interface (MIDI) pitches, periods of composition, degrees, rests, and length of the sonata's movements. *Results:* The median frequency of pitches was higher during Beethoven's time of mental distress. This period appeared as transitory between the bright Promethean period and the fullness of the final Ethereal period. This change in the expression of Beethoven's creativity could well have played the role of a self-therapy. *Conclusion:* From this singular account of Beethoven's history of mental problems and his way of dealing with them, it could be concluded that the stimulation of their musical creativity could be beneficial for psychiatrically patients with mental health issues. It also suggests that some mechanisms such as the application of hysteresis to cognitive function at a time of mental distress, may indicate new research avenues in the treatment of mental diseases.

Keywords: Art therapy, Creative illness, Generalized additive model, Mental distress, Music therapy, Psychosis

Introduction

Beethoven (1770–1827) greatly influenced the evolution of Western music in its transition from Classicism to Romanticism as did Monteverdi, Bach and Mozart respectively for opera, baroque or classicism [1, 2]. It is usual to distinguish three musical periods related to Beethoven's compositions as described by de Lenz [3]. The changes were initiated by new artistic orientations that Beethoven wished to take or personal problems he had to overcome. Firstly, his "musical youth" spanned from 1792 to 1801 during which he composed his first symphony and first piano concerto, as well as his first six string quartets and 17 piano sonatas. During the year 1802, he became conscious of the gradual and definitive deafness and its consequences on his career of interpreter and pianist virtuoso as described in the Heiligenstadt will. Therefore, he chose to invest in full-time composition as he was determined to bring a new breadth to the music of his time. This was the Promethean or Heroic period which lasted until 1814. This period included major pieces of music such as symphonies Nos. 3 ("Heroic Symphony"), 5, and 6, the concertos Nos. 4 and 5

("The Emperor"), the quartets Nos. 7 to 11 and the piano sonatas Nos. 16 to 18 and Nos. 21 to 26. The last so-called final Ethereal period, from 1814 to 1827, saw the composition and creation of more spiritual works, the best known being the Ninth Symphony and its "Ode to Joy". He also composed his last six piano sonatas Nos. 27 to 32 between 1814 and 1822.

Among the personal problems that Beethoven faced, were many diseases the most documented of which was his deafness with no specific cause clearly identified [4–7]. Although there were no devices to assess hearing loss, the progressive stages of Beethoven's deafness and his feeling can be gleaned from his correspondence. Since his deafness developed gradually, some authors have sought a link with the harmonic profile of his works, expecting the treble pitches to be used less frequently over the years, while others found no difference [8–10]. Beethoven is also known for his strong personality. This temperament led him to encounter and overcome difficult situations. Some events in his life may have contributed to the development of a "creative illness" in the form of psychosis as suggested by Bower [11]. This author shows that Beethoven's psychological symptoms settled down fully from 1815 and disappeared around 1820, a period representing the first part of

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Table 1. Characteristics of the four periods of composition.

Musical periods	Youth	Promethean	Ethereal		<i>p</i> -value
			Period of mental distress	Final Ethereal	
Year of composition	1792–1801	1802–1813	1814–1819	1820–1827	
Nos. of sonatas	1–15, 19, 20	16–18, 21–26	27–29	30–32	
Number of sonatas/	17	9	3	3	
Number of movements	58	26	10	7	
Frequency of pitches occurrence (beats):					
Sum	80 461	44 790	20 964	9553	
Median (IQR ^a)	5.75 (22.8)	8 (28)	11.9 (37.2)	10.5 (23.5)	<0.001
95% CI Median ^b	5.00–6.33	6.92–9	9.75–14.9	8.5–12	
Pitch range (MIDI notation)	26–91	26–101	24–101	24–99	
Number of pitches per movement:					
Median (IQR ^a)	1856 (1663)	2730 (2108)	3218 (3267)	2708 (2409)	<0.001
Number of rests per movement:					
Median (IQR ^a)	197.5 (180)	269.5 (280)	337.5 (297)	187 (125)	<0.001
Number of measures per movement:					
Median (IQR ^a)	150 (111)	194 (167)	216 (232)	162 (74)	<0.001

^a Interquartile range.

^b 95% confidence interval.

the Ethereal style. The link between psychosis or other mental illnesses and artistic creativity has been the subject of many studies [12]. Clinical or neuroscience studies have not proven causality even when creativity was shown to be characterize patients with dementia, schizophrenia, bipolarity, depression or psychosis [13–17]. In the point of view of a musicologist, Beethoven faced a severe existential crisis during this same period with a paroxysm during the years 1817 and 1818. It was particularly linked to the legal war he was engaged in with the mother of his nephew to obtain guardianship [18].

The aim of this work is to study the link between the distribution of pitch frequencies observed in 101 movements of 32 sonatas and four periods of Beethoven’s compositional style. One of these periods corresponded to a difficult time in the life of the composer.

Materials and methods

Correspondence between sonatas and compositional styles

Pieces of music chosen were composed using a single instrument and throughout the life of the composer. Thus, the piano sonatas are relevant as they were composed during most of Beethoven’s musical career, between 1794 and 1822 [19]. In addition, the piano was an instrument with a wide range of six octaves to six octaves and a half in the pre-romantic era. The 32 piano sonatas were selected and allocated into four periods according to their year of composition (Tab. 1).

The three periods usually retained by musicologists were maintained: Youth, Promethean and Ethereal. The last Ethereal period was further divided into two subperiods: a period of mental distress from 1814 to 1819 which corresponds to that described by Bower and a final Ethereal period that extends between 1820 and 1827 [11]. The period of

mental distress includes the sonatas Nos. 27 to 29 composed respectively in 1814, 1816 and 1818 before those of the final Ethereal period (sonatas Nos. 30 to 32).

Outcome

To analyse the change in composition style, I studied the frequency of occurrence of pitches in 101 movements of the 32 sonatas using absolute enharmonic pitch histograms. These show the frequencies of pitches occurrence in the Musical Instrument Digital Interface (MIDI) system, from pitch 24 (C1) to 101 (F7) for a given movement, taking into account the duration of each pitch (Fig. 1).

For example, in the andante of the “*Appassionata*”, sonata No. 23 in F minor, the pitch A1b gets a frequency of five beats corresponding to four quarter pitches, an eighth for 0.5 and two sixteenth for 0.25 each.

The absolute enharmonic pitch histograms were downloaded from the KernScores website, a library of virtual musical scores in the Humdrum Kern data format. This format gives the frequency of pitch occurrence using MIDI system. I used the international musical notation to correspond with the MIDI system. Of the 101 histograms corresponding to the movements of the 32 sonatas, only the fourth movement of sonata No. 21 was not available. All the pitches for a given movement without aggregating on the octave, were chosen to get unfolded pitch histograms. This led to a total of 155 768 pitch occurrences. Their distribution according to the four periods is depicted in Table 1.

Studied factors

The degrees and accidental pitches have been introduced into the model. I classified each pitch in degree, I (tonic) to VII (leading-tone), according to the primary tonality of each movement, without taking modulations

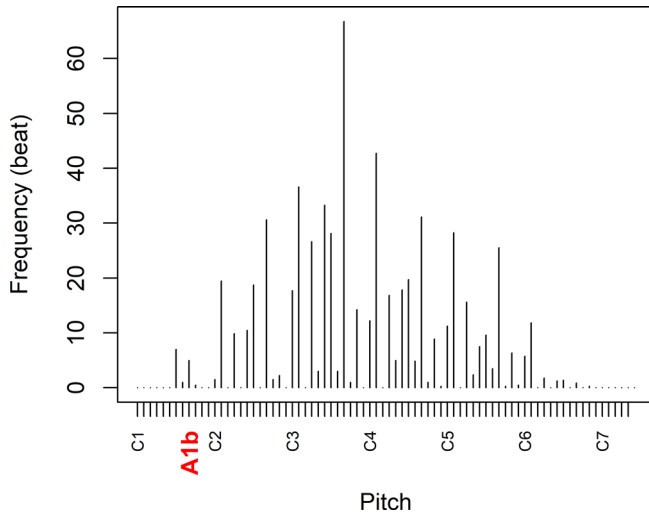


Figure 1. Unfolded pitch histogram of the andante of sonata No. 23, the so called “Appassionata”.

into account. The remaining pitches were considered as accidentals.

In addition to periods and degrees for each movement, the number of measures, the number of rests, and the total number of pitches were obtained from the KernScores site data.

Statistical analysis

The statistical unit for the analysis was the frequencies of occurrence of pitches. They were described with studied factors for each sonata movement and compared according to the four periods with usual statistics, median and interquartile range.

The median frequency of pitches occurrence of each period was compared using their 95% confidence intervals according to Carpenter and Bithell [20]. A Kruskal–Wallis test was used to determine the median per period of composition.

To regress the frequency of pitches occurrence with the four periods of compositional style, I performed a hierarchical (or multilevel) generalized additive model that consisted of two stages. The first-stage of the model comprised the movements reflecting the periods of composition, number of rests in a movement, and length of the musical piece that is to say the total number of pitches per movement. The MIDI number of pitches and degrees constituted the second-stage. Figure 2 depicts the main variables of the two stages for pitches and periods. This kind of hierarchical generalized additive model was chosen because it allows gains in the accuracy of predictive estimates of the pitch frequencies according to the periods of composition, a pitch frequency is not linearly correlated to MIDI pitch number.

The general model was written as follows:

$$y = \alpha + s(x, \text{“tp”}) + s(x, f, \text{“fs”}) + s(f, \text{“re”}),$$

where α is an intercept term.

As the frequency of pitches occurrence y was not normally distributed, a normalization using a logarithmic transformation was performed.

Pitches were included in the model with their MIDI number from 24 for C1 to 101 for F7. Pitches in MIDI number were considered as a semi-quantitative covariate as they corresponded to sounds with progressive frequencies h in Hertz (Hz) from low to treble pitches.

Number of rests and length of the movement were also considered as semi-quantitative covariates x . Periods and degrees were included as factors f in the model and considered as a group-level smoothing. As the frequency occurrence of pitches might vary according to the periods of composition, modelling also tested interactions between covariates x in one hand and periods and degrees on the other hand.

The models were fitted by controlling for the covariates x and f by a spline s with the mgcv package; s was the spline function with two types of smoothers: thin plate regression splines (“tp”) and random effects (“re”).

The choice of the final model was based on the Akaike information criteria, adjustment of predicted data according to observed data and Gaussian quantiles plots.

To help interpret the results, four pitches groups were not included in the model. These were based on the median and quartiles of the pitch frequency distribution observed in the 101 movements of the 32 sonatas: 24 (32.7 Hz) to 43 (98 Hz) and 44 (103 Hz) to 62 (293 Hz) were considered as extremely low and low-intermediate, those between 63 (311 Hz) and 81 (880 Hz) intermediate and from 82 (932 Hz) upwards as treble.

All analysis were performed with R 3.6.1.

Results

The median of the frequency of pitches occurrence of sonata movements increased from the youth period to the period of mental distress and decreased in the final Ethereal period. The median with a lower limit of 9.75 was significantly higher for the period of mental distress than the upper limit for the Promethean and the youth periods, respectively 6.33 and 9, but not significantly higher from that of the final Ethereal period. The median lower limit of the final Ethereal was higher than the upper limit median of the youth period, respectively 8.5 and 6.33 (Tab. 1).

The number of pitches, rests and measures per movement increased during the first three periods, with a maximum observed during the period of mental distress.

Irrespective of the musical period, the most frequently used pitches were the accidental pitches, the tonic and the dominant taking into account the primary tonality. The frequency of accidental pitch occurrence was higher during the final Ethereal period than in the other periods. On the contrary, the tonic and the dominant were less represented. There was an intermediate frequency of degrees and accidental pitches occurrence for the period of mental distress between the Youth and Promethean periods on

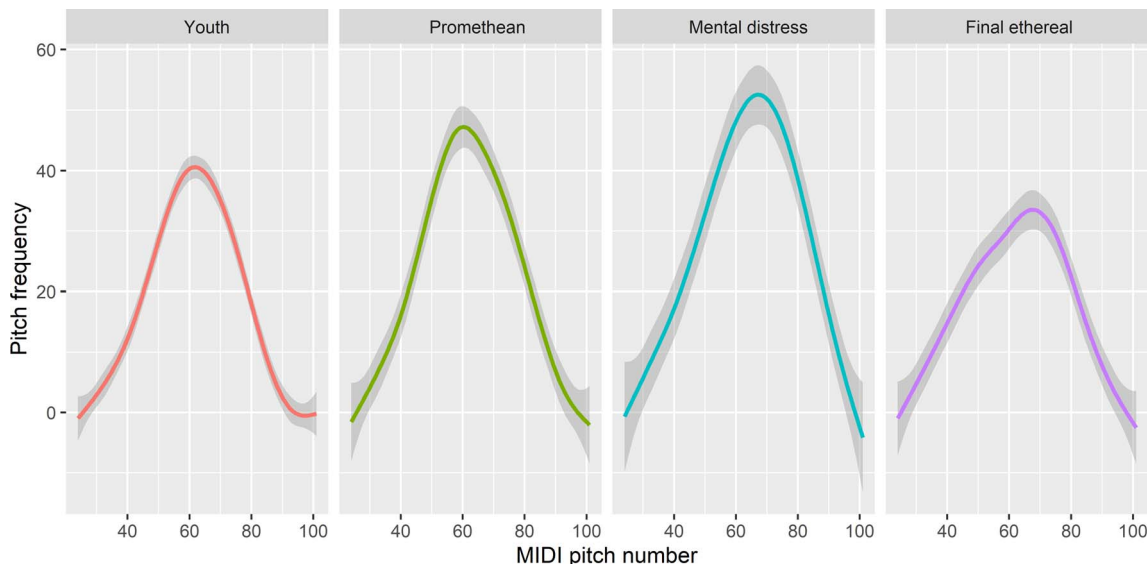


Figure 2. Two stages of the hierarchical model used to study the link between pitches frequencies with periods of composition.

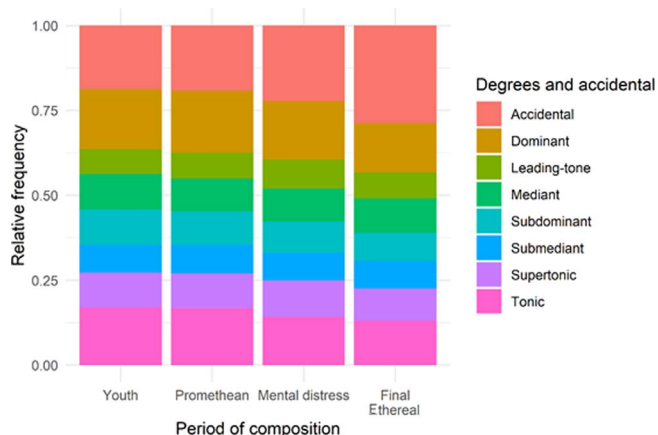


Figure 3. Relative occurrence frequencies of degrees and accidental pitches within each period of composition.

one hand, and the final Ethereal period in the other hand (Fig. 3).

The model predicted frequencies of extremely low register occurrence, 28 (E1, 41.2 Hz) to 42 (F2#, 92.5 Hz), higher during the final Ethereal period than in other periods. The Youth and Promethean periods had higher frequency of occurrence for the low intermediate pitches MIDI 54 (F3#, 174.6 Hz) to 60 (C4, 261.6 Hz) while the final Ethereal and the mental distress periods had higher frequencies of occurrence for the intermediate and treble MIDI pitches 78 (F5#, 740 Hz) to 95 (B6, 1976 Hz) (Fig. 4).

Discussion

The period of mental distress appeared as transitory between the first two periods and the last period of composition. Indeed, it had the same extremely low register occur-

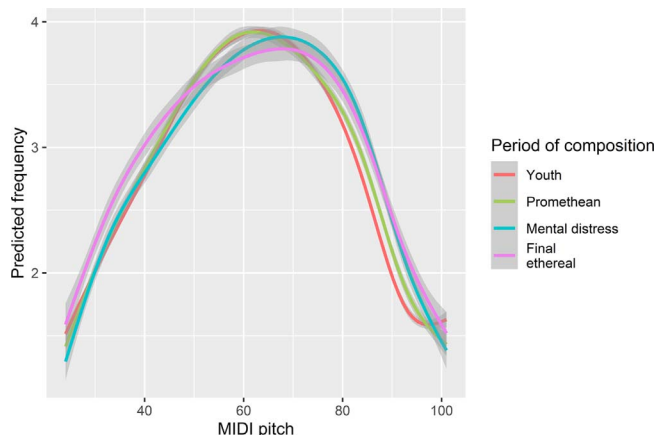


Figure 4. Frequencies of the pitches occurrence and their 95% confidence interval predicted by the model according to their MIDI classification and the four periods of composition.

rence frequency than the Youth and Promethean periods and the same intermediate and treble pitches occurrence frequency than the final Ethereal period (Fig. 4). The period of mental distress was a particular compositional moment in Beethoven’s life. I suppose he reacted exceptionally to his failed love affair, deafness, death or exile of his protectors and finally the more harrowing battle for custody of his nephew after his brother’s death. Beethoven found a new balance due to an impressive ability to endure the profound upheavals in his life, whether they concern his state of health or his emotional environment. He then understood how to transcend these obstacles and to develop his style of composition.

The period of mental distress could be part of a creative process as described by Ellenberger’s metaphorical models [21, 22]. This phenomenon has been observed in other artists and studied through Zausner’s work [23]. This author makes an analogy with Chaos theory first applied

to the evolutionary changes of thermodynamic or biological systems. Applied to the cognitive functioning of an artist, the disease could have played the role of a catalyst leading to a change in the composition style. Among four categories of bifurcations, the second corresponds to a chronic illness that occurs when the artist has reached a certain maturity. It changes the current creative style to another as it has been interpreted for Durer, Michelangelo, Goya, and Monet. For Beethoven and as testified in the famous Heiligenstadt's will in 1802, the awareness of his deafness led him to devote himself entirely to composition by adopting a new musical period the so called Heroic or Promethean. Similarly, Beethoven's severe existential crisis could have induced a new change in his composition occurring during the period of mental distress which made the transition from the Promethean period to the final Ethereal period as this work suggests.

The period of mental distress could be one in the evolution of schizophrenia. The disease can evolve through multiple states according to Bleuler [24]. Nevertheless, it is difficult to label the difficulties that Beethoven endured as schizophrenia because it was not described at this time. However, it is from witnesses and letters describing Beethoven that the symptoms could be identified and grouped into a syndrome that matches with schizophrenia. Moreover, a diagnosis is often made after a long period of observation during which the psychiatrist has met and listened to his patient (so-called "parole-être"). This information is not available for Beethoven. Some authors have interpreted this period of mental distress as a possible prolonged and transitory psychotic episode in Beethoven's life [11, 25], others proposed another diagnosis as bipolar disorder [26, 27]. Nevertheless, it remains difficult to describe Beethoven's distress during this period according to the DSM-5 classification despite numerous testimonies and correspondences [28]. It is more the long euthymic phases or a cyclothymic temperament that would favour creativity rather than the full-blown disease [29–31]. Did Beethoven have such a profile at a given point in his life? According to some authors, Beethoven exhibited depressive episodes more frequently than moments of exaltation with a flight of ideas [32]. Beethoven's personality had several extremes: suspicion, paranoia, egocentric, impulsive, insensitive, impolite, perfectionist . . . However, none of these manifestations were related to a proven mental disease, rather they reflect the behaviour of artists generally unwilling to follow rules or standards. Beethoven said about himself "I'm hot blooded, it's my fault" and Cherubini said Beethoven "was always abrupt". The cyclothymic aspect in Beethoven's personality is reflected in some works, the first movement of the string quartet No. 6 "*La Malinconia*", largo of the piano sonata No. 3. His temperament faced with disturbing life events could have led to a creative illness and a form of psychosis translated in a transitional style of music during the period of mental distress preceding the final Ethereal period.

Other causes could also be examined. Among them, Beethoven had a family history of alcoholism and violence with his father. He presumably died from decompensated

alcoholic cirrhosis with chronic pancreatitis as revealed by his autopsy. Onset of liver disease occurred in 1821 to reach the terminal state of alcoholic cirrhosis and encephalopathy, the so-called Gayet-Wernicke disease expressed by neurological symptoms which could have cognitive dysfunctions [33]. Therefore, it could have influenced Beethoven's late composition during the final Ethereal period. It is nevertheless difficult to think that a composer suffering from an encephalopathy could have written his greatest work for piano, the Diabelli variations, at this stage of the disease when his cognitive abilities would have been affected.

The change observed during the period of mental distress could also be related to the progression of deafness. Between 1798 and 1801, Beethoven was in denial of his deafness before accepting the disability and switching to full-time composition to enter the Promethean period. During the period of mental distress, deafness was already well established and Beethoven had no doubt about its irreversibility even if he looked for tools to improve his hearing (hammerklavier, amplifying tools). It can reasonably be assumed that deafness did not influence Beethoven's composition during this period. Saccenti *et al.* grouped the string quartets over three periods during which Beethoven's deafness worsened until it became complete. Results from this work showed a more frequent use of the pitches <1568 Hz at an advanced stage of his deafness and the treble pitches increased in frequency for the last quartets published in 1825 and 1826, between three and six years after the composition of the three last sonatas for piano [9]. This work is partly in accordance with these findings as a higher frequency of pitches >1047 Hz occur during the mental distress and final Ethereal periods. Liston *et al.* assumed that Beethoven's hearing loss started in the high frequency range, between 2500 and 5000 Hz and that therefore the corresponding pitches would be less frequent. The authors did not show a decrease in the use of treble sounds over time when the nine symphonies were composed. They supported an increased use of low and medium pitches in Beethoven's later compositions [10]. This work confirms these results for the mental distress and final Ethereal periods. The influence of deafness on the style of composition remains controversial as Beethoven had probably a well developed "inner" hearing.

This work has limits, mainly concerning the link between pitch frequency and period of composition. I did not include in the model potential confounding variables arising from the theory of analysis like formal principles, tying notes, rubato, legato . . . However, these variables could link with periods of composition, but not with pitch frequencies, that did not make them confounding factors. Nevertheless, it would be interesting to look at the broad characteristics of the evolution of the 32 sonatas throughout the periods of composition. Until Sonata opus 22, Beethoven's sonatas met the classical formal structure of the 18th century (under influence of Mozart and Haydn influence) even if they showed already innovative elements (op. 13 was a first step towards the symphony of the Promethean period). From the opus 26, sonatas became more audacious. Opus 27 consisted in a stylistic standardisation

of the movement and opus 31 in a new approach of the sonata genre. Opus 53 and 57 are typical of the Promethean period with their dramatization. During the period of mental distress, Beethoven seemed to make opus 101 a unique example of experimental sonata, and opus 106 could be considered to make the synthesis of Beethoven's musical experience and innovations. Opus 106 is the closest sonata of the last three where Beethoven seemed to regain his confidence [34]. It is admitted that encouraged by the composition of the sonata opus 106 in 1818, the so-called "Hammerklavier", Beethoven drew his creative strength for the great projects like *Missa solemnis* or the *Ninth symphony* from 1820.

Changes in pitch frequencies of Beethoven's sonatas could also be influenced by other musicians. During his Youth period, Beethoven was influenced by Mozart and Haydn more for his first three sonatas, the first movement of the 17th sonata or the scherzo of the 18th. His sonatas were a source of inspiration source for a number of romantic composers as Mendelssohn (third movement of Beethoven's sonata number 6) or Schumann (Third movement of Beethoven's sonata number 11) [34]. It remains difficult to study the potential confounding effects of the influence of other musicians on the link between change in pitch frequencies and period of composition.

The choice of the three musical periods used were based on the commonly acknowledged Lenz classification [3]. The three-dimensional partition is used by other authors before and after him. Despite her controversy, this classification keeps the evolution of the main moments of Beethoven composition. The year 1802 marked a turning-point between Youth and Promethean periods when Beethoven choose to become a full-time composer as shown in the Heiligenstadt's will. What is less clear is the crucial year between Promethean and final Ethereal periods. Year 1814 was chosen as sonatas op. 90 and op. 101 were timely and stylistically close. In addition, the seven first as well as the last five sonatas composed between 1794–1798 and 1815–1822, respectively seem consistent with the Promethean and the final Ethereal periods.

Conclusions

The period of mental distress made the transition between a bright state, the Promethean period and a state of fullness, the final Ethereal period. This change in composition period could be explained by a new orientation of Beethoven's creativity which could have played the role as self-therapy. The therapeutic virtues of art, especially through creativity and music, have been shown in several studies in various pathologies, including schizophrenia and schizophrenic disorders [35–37]. The beneficial effects of music should be considered to balance the deleterious effects of infection control measures in order to prevent the onset or worsening of mental disorders in the population, in particular those already weakened by mental diseases [37, 38]. From a curative point of view and throughout the singular story of Beethoven, providing healthcare by stimulating musical

creativity could benefit mentally frail patient [39, 40]. Understanding the ability of hysteresis applied to cognition functioning in a vulnerable state represents ways of therapy research in mental and degenerative illnesses.

Nomenclature of abbreviations

Hz	Hertz
IQR	Interquartile range
MIDI	Musical Instrument Digital Interface

Conflict of interest

Jean-François Jusot certifies that he has no financial conflict of interest in connection with this article. The author reports the following conflict of interest: Jean-François Jusot is Editorial Board member in *Life Sciences-Medicine of 4open* by EDP Sciences. This manuscript contains original material that has not previously been published.

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Cite this article as: Jusot J-F 2022. The change in Beethoven’s music composition: Is there a role of his mental distress?. 4open, 5, 13.