CHAPTER 1

INTRODUCTION

1.1 Introduction

The writing of this work explores the arts and sciences in describing piano performance. In the analysis of multiple pianists' recordings of the Sonata No.1 in C (Op.1) by Johannes Brahms (1833-1897), comparisons were made using the parameter in *Time* and its relationship in artistic musical impression. As music is the logic of science behind the veil of human expression (Seashore, 1936), this project demonstrates systematic inter and intra deviations of pianists' timing and their inferences are made on musical expression. This study could perhaps improve both piano performance practice and pedagogy. Ten recordings of pianists were chosen from performances by Martin Jones (British), Grigory Sokolov (Russian), Krystian Zimerman (Polish), Andreas Boyde (German), Peter Rosel (German), Kamerhan Turan (Turkish), Idil Biret (Turkish), Sergey Schepkin (American), Eugene List (American) and Julius Katchen (American).

1.2 History

Increasingly throughout the 20^{th} century, descriptions of musical performances contained emerging new theories in the multidisciplinary sciences.

Difficult to define, the musical framework, a two-way communicative channel between composer-performer involved equally an effective interpretation of a compelling musical idea deeply embedded in its conception (composition). Transmission of explicit messages in the form of musical scores into implicit meaning in expressed performances often resulted in an array of different performances in the same scores with multiple emotive response in listeners (Barucha, 1999).

Methodologies describing varieties in implied musical intentions both by performer-listener transcribed through multidimensional perceptual analysis were simply known as scientific measurements in quantitative deviations (Seashore, 1936; Palmer, 1996). Multidimensional studies analyzing musical expression utilized methods from the sciences, humanities and the arts, but there were no nomenclatures describing musical emotions till today (Gabrielsson & Juslin, 2002).

In 1938, Carl Emil Seashore from the Iowa University, USA published a book on the Psychology of Music. He suggested that music could be explained through scientific methodology. Seashore focussed on 19 principles (Seashore, 1936), of relevance to this dissertation is the 3rd principle regarding timing in temporal spaces, which stated that

> *The psychological equivalents or correlates of the characteristic sound are pitch loudness, time and timbre that have subsets in harmony, volume, rhythm and tone qualities. Thought, feeling, action and memory are descriptions and they are all classified as four large areas of Tonal, Dynamics, Temporal and the Qualitatives in music.* (p.22)

Then later, in the 5th scientific principle he outlines the importance of deviation from any strict modal.

> *The medium of musical art lies primarily in artistic deviation from the fixed and regular; such as rigid pitch, uniform intensity, fixed rhythm, pure tone and perfect harmony and quantitative measurement of performance may be expressed in terms of adherence to the fixed and so called true or deviation from it in each of the four groups of musical attributes*.(p.22)

The 8th principle dwells on the experimentation with music.

> *All measurements may be represented graphically in what we have called the musical pattern score which symbolizes the language of scientific measurement in the score that has musical meaning…it is economical and natural*.(p.22)

As direct musical measurements are obtainable through plotting of graphs, inferences regarding a musical idea from them are indirect methods. *Deviations* in Temporal Spaces are difficult to quantify due to the syntactical nature of musical discourse (Ramsay, 1982). This dissertation attempts to accurately describe the interpretation of emotion through statistical analysis.

1.3 Systematic Musicology: definitions

For aims of refining new knowledge in theories of music, the study of various systems that functioned in music were often borrowed from other disciplines (Carlsen, 1982).

Systematic Musicology is multidisciplinary in nature, analyzes complex phenomena in music and its related dimensions through methods borrowed from psychology, physiology, neuro-cognitive sciences, physics, mathematics and computing technologies (Parncutt, 2007). There are many symposiums regarding Systematic Musicology presenting amazing numbers of projects comprising experimental music research in this new field.

Pianists' expressive timing were systematically reproduced artificially through use of modern computing technologies (pDM) (De Poli & Zanon, 2003). These expressions or quantitated " *Systematic Deviations* " from musical notations were essential when comparing music performances through their *Time* in perceptual structure (Clarke, 1993; Desain & Honing, 1994; Repp, 2000; Friberg, Colombo, Fryden & Sundberg, 2000; Bresin, Friberg & Sundberg, 2006). Perpetually measurable, *Deviation* from the rigid standard explains human expressions and enhance knowledge to the better understanding of musical performances.

1.4 Research Objectives

In this project, 10 pianists’ recordings were analyzed for temporal deviations which were translated into emotional expressions, quantified as indexes of emotional measurement (EI, Emotion Index). This repertoire was chosen from the world wide web because of its compatibility and convenience with Audacity ™ (version 1.2.3).
The large data collections from the web were necessary to meet requirements in the support for important statistical analysis.

In the art of listening, timing in music could give evidence to new interpretation. This study was aimed to postulate a hypothesis regarding temporal treatments to structure and its effect in affective measure. The study of structure in musical emotional expression were guided from theories and experimentation behind music perception and this was applied to demonstrate differences in pianists’ timings.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The Sonata No.1 in C (Op.1) composed by Johannes Brahms (1833-1897) was one of his earliest piano works presented in the autumn of year 1853. Ten recordings of pianists were analysed for new knowledge in finding interpretations that could contribute to the betterment of performative and pedagogic arts in piano.

2.1.1 The Brahmsian Piano Performance Practice

Brahms was a prolific pianist with a singing touch (Adler & Strunk, 1933) that attracted listeners to his imaginative art. With both hands stretching from high to low registers on one piano, this Sonata, on reflection could be transformed into an arrangement for orchestra. The application of principal themes wandering from one voice to another in an increasingly chromatic contrapuntal complex were trademarks of this composer (Adler & Strunk, 1933). The interlacing of melody strata with different rhythmic identities in a mixture of themes and its fragmentations in the Development section of the sonata was a place to showcase a composer's skill and creativity. Even though technical in nature, musical devices like elisions, augmentations and diminutions were neither mechanical nor soulless (Walker, 1899) but had emotive underlinings.

Regarding tempo, it was reported that Brahms did not expect strict adherence to tempo, rather advising *"Do it as you like but make it beautiful"* (Sherman, 1997, p.474).
In other words, Brahms advise suggests that deviation of tempi is expected in finding one's character in the beautiful performance of a composition.

2.1.2 The Sonata No.1 in C (op.1) by Johannes Brahms (1833-1897)

Robert Schumann (1810-1856) the German composer recommended the publishing of the Sonata's First Edition of 40 pages to Breitkopf and Hartel in year 1853 after discovering the prodigy in Johannes Brahms.

Johannes Brahms performed it at the Leipzig Gewandhaus (Townhall) on the 17^{th} of December, 1853. Dedicated to Joseph Joachim (1831-1907), a violinist and pedagogue (Pulver, 1925), Brahms's greatest friend in music and life were historically marked through their letters, correspondences and concert tours together (Ebert, 1991).
Composed in early 1853 at age 20, the sonata is a 4 movement classical form.

The study here focusses on the first movement which is 270 bars long in the Peters Edition Publication (Sonata Scores: Peters Edition, see *Appendix A*, pp.93-103).

2.1.3 The Explicit Musical Expression, a performing Science and Art

The *Performance Cycle* depicted in Figure 2.0 simplifies artistic representations of musical expeditions. Three important categories in the communication of explicit musical expression from *Score* (Chapter 2.1.3.1), *Listener's Perceptual Experience* (Chapter 2.1.3.2) and *Expressive Performance* (Chapter 2.1.3.3) are explained in the following.

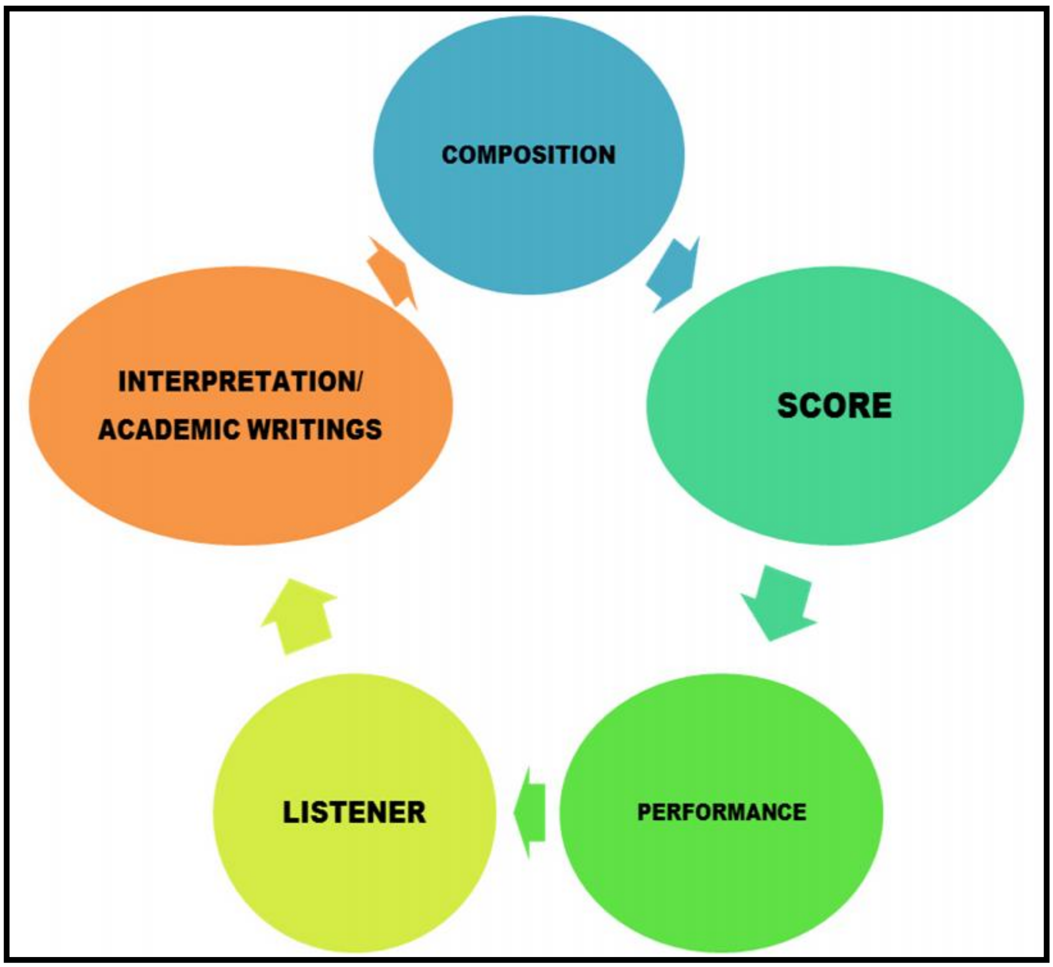


Figure 2.0 The Performance Cycle

2.1.3.1 A Composer's Message

At the initiated state, Symbols encoded in Scores were transferred and decoded by performers (Kendall & Caterette, 1990) and listeners (Gabrielsson, 1999).

The Composer's message, a refined work of art embedded deep in history is represented as events in the course of time. With modern developments in analysis of form and structure, multiple interpretations resulted in an array of beautiful performances.

Said to be one of the finest expressions of emotions (Meyer, 1956; Corrigall & Schellenberg, 2013), effective music cannot be composed, performed or appreciated without the influence of emotions (affect). Emotions embedded in musical scores were said to be the expressive intent of composers (Bhatara et al., 2011) and while performers' expressions were explicitly motivated to listeners' experience (Repp, 1995a; Palmer, 1996; Shoda & Adachi, 2012), their meanings were vaguely decipherable (Schellenberg, Stalinski & Marks, 2014).

For performers, an ideal interpretation for each musical work and its performance goal were important for the clarification in the composer's message (Palmer, 1996).

This communication of expression can be difficult to describe as transformed musical states from performer to listener required highly organised structure processing (Kendall & Caterette, 1990). Powerful expressions created by unexpected and unconventional devices often produced differences between individuals and these characteristics resulted in varied listening experiences (Slodoba, 2000). Structural representations of music in the mind of performers encoded as adjectives of emotions can then be perceived by listeners (Hevner, 1935/1936; Schubert, 1999; Gabrielsson, 1999).

In Juslin (1997) and Juslin & Madison (1999), listener's made inferences on performer's expressions through *Timing* and reliably interpreted performer expressive intentions through experimental studies (Bhatara et al., 2011; De Poli, 2013).

The hypothetical existence of a non-verbal encoding-decoding communication between performer-listener explained the unseen performer intentions through expressive deviations. These deviations, expressed as musical emotions were experiences in *Time* with dynamic representations often prescribed as aesthetic beauties in music (Juslin, 2013).

In describing music, performers' expressions (Cognitivism) through interpretations of musical structure (Meyer, 1956; Schmuckler, 1989; Butler, 1992) and empirical studies in listeners' perceived or elicited emotions (Emotivism) were two sides of the same story. Skills and abilities in interpreting composer's messages were crucial for performers as artists in practise. The first implied *Interpretation,* is cognitive in analysis as mental represent of musical structure and form may influenced feelings for meaningful expressive characterization in a performance (Repp, 2000).

The hypothesis of identifying performer intentions described as *deviations* is quantifiable with proper application tools.

2.1.3.2 Listener's Perceptual Experience

2.1.3.2a The Cognitive and Emotive in Music Expressions

There are two large thoughts (Cognitivisme / Emotivisme) in describing the same meaning in music. Music is capable of representing emotion but not the feeling of it as it contained structures (Meyer, 1956; Bhatara et al., 2011; Juslin, 2013), where perceptions of musical structure is well cognizant in humans. When sad music is heard or performed, sadness is recognized but not experienced at all (Schellenberg, 2010).

The cognitivist theorist, Leonard B. Meyer hypothesized in his book, "*Emotion and Meaning in Music*," said that "*the nature of music perception followed patterns with principles on continuation which may contain weakening of shapes to end in completion and closure*",(p.160) They reflect intramusical meaning that may not be referential to any emotional absolute.

For the elicitation and arousal of emotions, listener's actually feel emotions rendered by music. The emotional contagion is proven with experiments in the Valence and Arousal Spaces with the aid of theories in physiology and psychology.

Juslin (2013) graded intensities in Arousal domains, where in (*barely noticeable*), (*pronounced*) and (*light,long termed*), Arousal in emotional colours were termed as *Preference*, *Real Emotion* and *Mood*.

Research in these 2 areas of Cognitivism and Emotivism in music is very challenging where one is evidential in form and structure, the other being abstract, beautiful and ethereal.

2.1.3.2b The 'Gestalt' Principle in Music

Tenney & Polansky (1980) defined Temporal 'Gestalt' Units as network of sounds in simultaneous or successive tones that contained hierarchies of motives, phrases, sections and movements in temporal spaces. In this framework, perceptual boundaries depended on nature of sounds and sound configurations that occurred within and between time spans. An analogue of fusion and fission in Quantum Physics was used to describe forms of temporality. In the reaction vessel of musical spaces, small units imposed on one another to form simultaneous combinations. In successive tones, coherent units chained into extended sequences, their extensions lead to groupings, formed longer segments or phrases. Alternation and Repetition were ideas of patterning events in music (Serafine, 1984). Cook (1990) translated Arnold Shoenberg's definition of 'Gestalt' from *Composing with 12-tones* as,

> *After music has ran its course in Time, the finality of it is a whole set of ideas, form, content being timeless in entity, communicates between performer-listener either in succession or together marks a contribution to how it was as a whole*.(p.220)

Musical attributes in the form of timing, affect, melody contour, phrase, segment etc. were series of perceptual transformations in this 'Gestalt' frame when music was heard as more than in all of these combined. However, this was sensible if a trained listener concentrated on the idea. Combinations of horizontal and vertical elements in both repetitive and differentiated phrases were described as "Gestalt" experiences by (Bharucha, 2006).

Small units of melodic contours were note to note pitch changes or sequence of pitches weaved into voices together in different combinations as music progressed in time where notably, higher pitches within a melody were played louder than lower pitches at phrase endpoints. Repp (1998) mentioned the limits of expressive parameters in the piano, a percussive instrument where variations in Timing, Dynamics and Articulation were only allowed in temporal spaces (Palmer, 1996). Horizontal timing (successive tone onsets), vertical timing (asynchronies among tones in chords), vertical dynamics (intensities of individual tones with chords) were very difficult to conceptualise, though Horizontal dynamics (peak intensities of successive tones) could be measured. Articulation (degree of separation or overlap of successive tones) especially in pedalling were complicated (Repp, 1994). Measurements in the study of acoustic piano recordings were therefore limited to horizontal timing and dynamics (Repp, 1998).

2.1.3.3 Expressive Intensions of Performer as a Study of Expressions in Music

2.1.3.3a Basic emotions

As early as 1893, listeners were asked to write down words that described their reaction to pieces of music (Gilman, 1893). Affective measurements were well documented in (Hevner, 1936) with elements of emotional adjectives systematically grouped into several clusters. Musical structures like melodic rise and fall, rhythm, modes (Hevner, 1935) and associated tensions were described in words. Faster moving tones were associated to happiness, excitement and slower tempos indicated adjectives in sorrow, serene, dreamy but dignified (Schubert, 1999). The same music, described in multitude of words with interpersonal variations became a statistical problem (Asmus, 2009).

From (Fig.2.1 & Table 2.0), eight clusters in Hevner's adjectives of emotion (Hevner, 1936) were mapped into the 2 Dimensional Valence_Arousal (VA_AR) Emotion Space (Schubert, 1999) by use of listener's subjective response in continuous listening tasks.

Table 2.0
Hevner's adjectives in Schubert's 2D Modal

Cluster 1	2	3	**4**	**5**	**6**	7	8
Schubert,E. \ Hevner,K.	(negative valence) High AR	(mixed valence) Low AR	(positive valence) Low AR	(positive valence) Intermediate AR	(positive valence) High AR	(central valence) High AR	Undefined VA_AR
Awe	Dark	Dreamy	**Lyrical**	**Delicate**	**Bright**	Agitated	Emphatic
Dignified	Depressing	Longing	**Leisurely**	**Fanciful**	**Cheerful**	Dramatic	Exalting
Sacred	**Frustrated**	Plaintive	**Satisfying**	**Graceful**	**Gay**	Exciting	Majestic
Serious	Gloomy	Pleading	**Serene**	**Humorous**	**Happy**	Exhilarating	Robust
Solemn	Heavy	Sentimental	**Tranquil**	**Light**	**Joyous**	Passionate	Vigorous
Spiritual	Melancholy		Quiet	Playful	Merry	Impetous	
Lofty	Pathetic		Soothing	Quaint		Restless	
Inspiring	Sad			Whimsical		Sensational	

From Table 2.0, (Schubert, 1999) described the measuring of emotion continuously in time by tracking 2 dimensions in the Valence_Arousal (VA_AR) Emotion Space and clustered the adjectives in groups 4,5,6 (darker circle) which generated positive valences in graded Arousal (AR) levels. Figure (2.1) illustrates Hevner's adjectives mapped together with the 2 dimensional emotional space chart.

Figure 2.1 Hevner's adjectives mapped into the 2D Emotional Space
from (Schubert,E., 1999)

Perceptions to temporal dynamics of emotion was analysed using a single dimension of performance in measurement, *Emotionality* which suggested or communicated musically relevant emotions in continuous timed response (Lucas, Schubert & Halpern, 2010).

Figure 2.2 Mean Emotionality Response Time Series for Beethoven(B) Mozart(M) and Tchaikovsky(T*)* *from*
(Lucas, Schubert & Halpern, 2010)

Figure (2.3) illustrates the Russell Circumplex Model of Affect (Russell, 1980) which conceptualized emotional feelings by dimensionalling similarities to differences in circular order. The bipolar grid from (pleasure-displeasure) contained elements of valence to energy (Arousal-Sleepiness). This spatial circle in 4 quadrants varying from 0 to 360 degrees also delineated on subjective metaphoric adjectives in music.

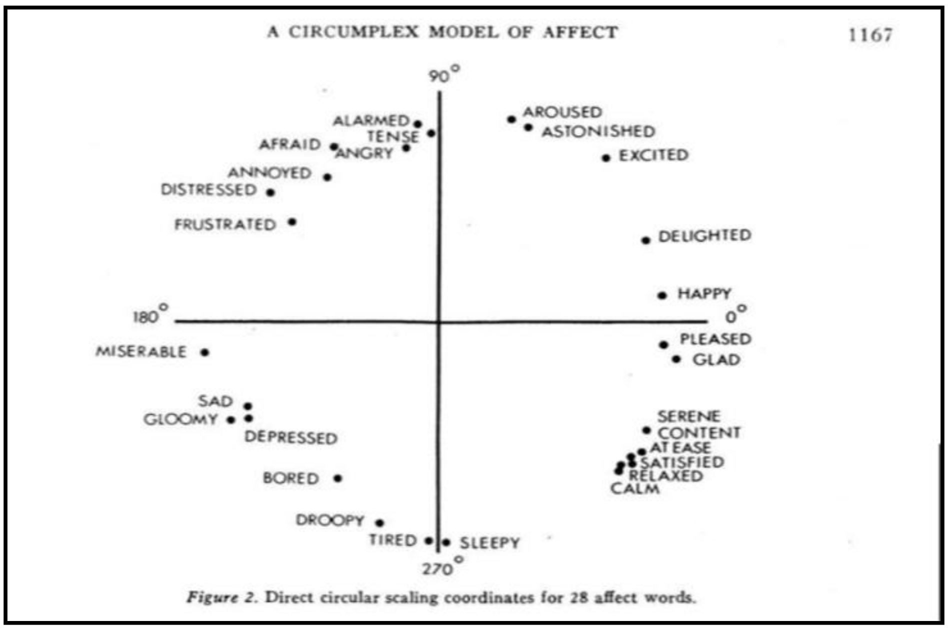


Figure 2.3 The Russell Circumplex model of Emotion, *from* (Russell, 1980)

Modelled after this Russell Circumplex, emotion contagion in continued subjective fluctuation from pleasure (positive) to displeasure (negative) in Valence (*x-axis*) versus High and Low Arousal (*y-axis*) in this 2-Dimensional (VA_AR) Affective Space is complimented with a 3rd dimension in Kinematics, which is discussed in the following chapter.

2.1.3.3b Dimensional Approach : Valence_Arousal (VA_AR) and Kinematics Energy (KE) (Affective and Sensorial Spaces)

Affect (*latin:Affectus*) had meanings larger than just emotional experiences.

Referred to both states of mind and body-related feelings expressed physiognomically, measurements in Affective Spaces (Schubert, 1999/2004) were defined in 2dimensions (4 quadrants) as Valence (VA, at the *x-axis*) and Arousal (AR, at the *y-axis*). Valence (VA) formed subjective evaluations of changing valencies from positive to negative (*x-axis*) and the Arousal (AR) domains moved along the (*y-axis)*from High (positive) to Low(negative) (Fig:2.4). Happy and sad valencies were studied in music recognition (Hevner, 1935/1936; Schubert, 1999/2004/2011; Hunter, Schellenberg & Shimmack, 2008; Hunter & Schellenberg, 2010).

Measurements of physiological Arousal (AR) in facial expressions (Electromyography EMG) required participation from both auditory and visual domains. These experiments involved activations of the *corrugator supercilli* (eyebrow) and *zygomaticus major* (cheek) muscles which were important in the rendering of 'extramusical' aesthetics (Barucha, 2006; Chapados & Levitin, 2008; Vines et al., 2011). Intensities (Arousal) can be presented as graded physiological correlates measured in skin conductance, electrodermal activities (EDA), finger temperature, oxygenated hemoglobin (neuroactivity), respiratory (RR) and (HR) heart rate (physiology). Scholars noted the augmentation of musical emotional response when combined listeners' visual and auditory fields were more receptive to modularities in multivalencies (mixed emotions), arousal (intensities) and kinematics (movement) (Vines et al., 2011).

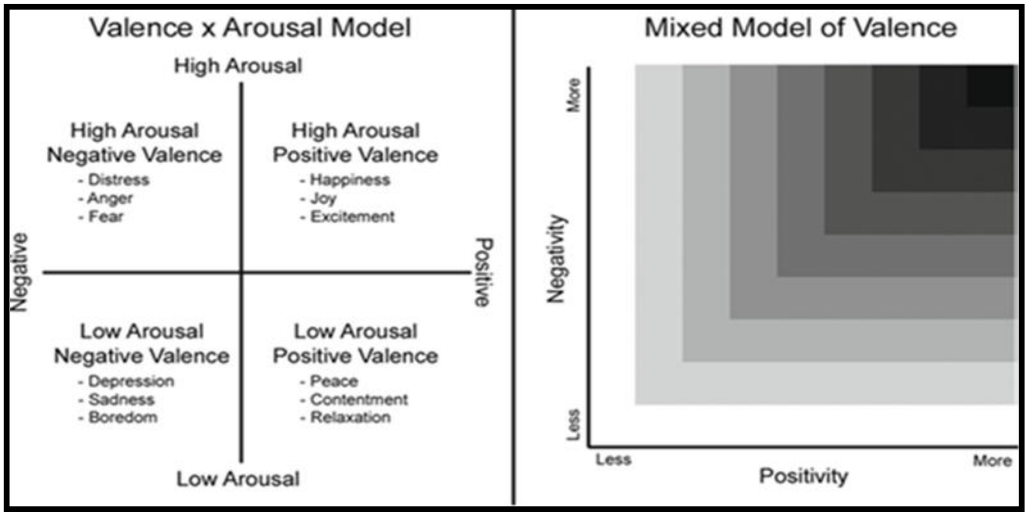
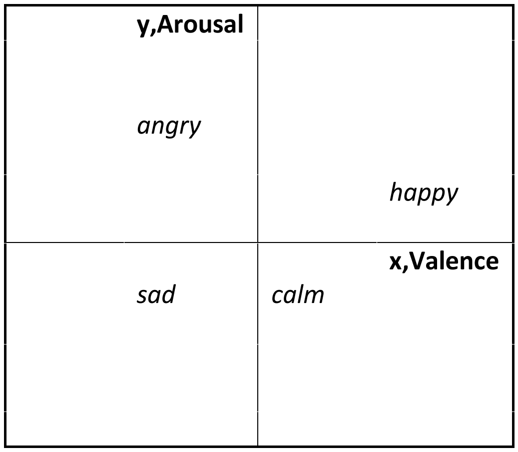


Figure 2.4 Valence Arousal 2 Dimension Affective Emotion Space & Mixed Model of Valence *from* (Hunter&Schellenberg, 2010)

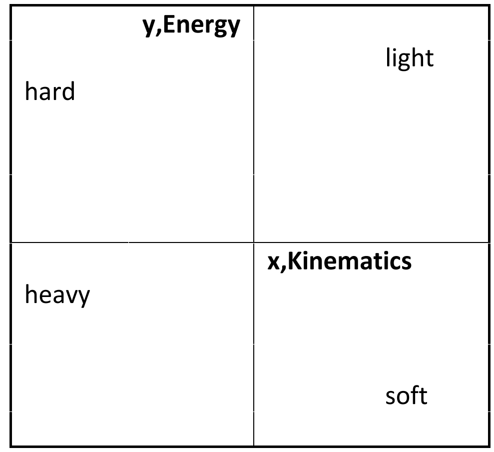
The 2 Dimension (2D) Affective model was limited in its presentations of complete emotions. Due to the nature of interpretation and varied performing styles, functions of the entire range of musical features were not fully represented within this model of emotion (Schubert, 2004).

Organizations of mixed valence in arrays of increasing colour intensities were displayed in (Hunter & Schellenberg, 2010). Listening to music elicited mixed feelings and this was greater when affective cues of conflicting mental representations of both happy and sad music were applied (Hunter, Schellenberg & Shimmack, 2008/2010).

Hunter, Schellenberg & Griffith (2011) hypothesized that mood congruence influenced happy and sad emotions in music, thus resulted in ambiguous mixed-valence (Fig.2.4).



VA_AR Affective Space



Kinematics Energy Sensorial Space

Figure 2.5 VA_AR (Affective) and Kinematics Energy (Sensorial) Spaces *from* (De Poli,2003)

Modelled by Bayesian methods, Affective and Sensorial expressive intentions in music performance were classified as adjectives in positions corresponding to their perceptual spaces (De Poli, 2003; Cannaza et al., 2004; Mion & De Poli, 2004; Mion & De Poli, 2007a & b). The following opposites in adjectives from Affective and Sensorial Spaces combined to form Friction, Elasticity and Inertia.

	x-axis	**y-axis**
Affective Spaces	{High Valence /Happy }	[High Arousal/Angry]
	{Low Valence/Sad }	[Low Arousal /Calm]
Sensorial Spaces	{High Kinematics/Light }	[High energy/Hard]
	{Low Kinematics/Heavy}	[Low energy/Soft]

Combined Spaces	Hard-Heavy-Angry	FRICTION
	Light-Happy	ELASTICITY
	Calm-Soft-Sad	INERTIA

Indirect mathematical mapping of behavior from force to velocity resulted in 3 descriptors of Friction, Elasticity and Inertia. The resistive movements in opposite adjectives like Friction (hard/heavy/angry), Elasticity (light/happy) and Inertia (calm/soft/sad) explained perceptual metaphoric tension (Mion & De Poli, 2007a & b). Canazza et al. (2004) described tempo in three categorical rates like slow (heavy), moderate (soft) and rapid (bright,light). Apart from VA_AR, secondary dimensions in the form of Potency (roughness), Tension (loudness) and Energy (spectral flux) contributing to affective qualities in music were evidenced in real music recordings (Cannaza & De Poli, 2014).

Listener's affective response were predicted from psychoacoustic properties of sound in (Coutinho & Cangelosi, 2009). Here, a 3-Dimensional model of continuous bipolar rating scale with *Pleasantness-Unpleasantness* (categorial space) together with *Rest-Activation* and physiological *Tension-Relaxation* were recommended .

In (Kawakami et al., 2013) the 2D Affective Space (pleasant-unpleasant,direct-vicarous) differentiated emotions perceived or felt. The latest model with 2 Dimensional approach hypothesized ambivalent emotions in sad music and compared emotive to cognitive responses to music.

2.1.3.3c Music in Multidimensional Spaces with emphasis on Emotions and Time (Affective and Temporal Spaces)

Figure (2.6) explains the multifaceted dominance of Music in almost every part of human existence. Time (Temporal Space) and Emotions (Affect Space) occupy multidimensional spaces. The music cognition scientist, Aristoxenus (364-304BCE) suggested that on the study of music, both 'musician and the mind of the listener' were a priority.

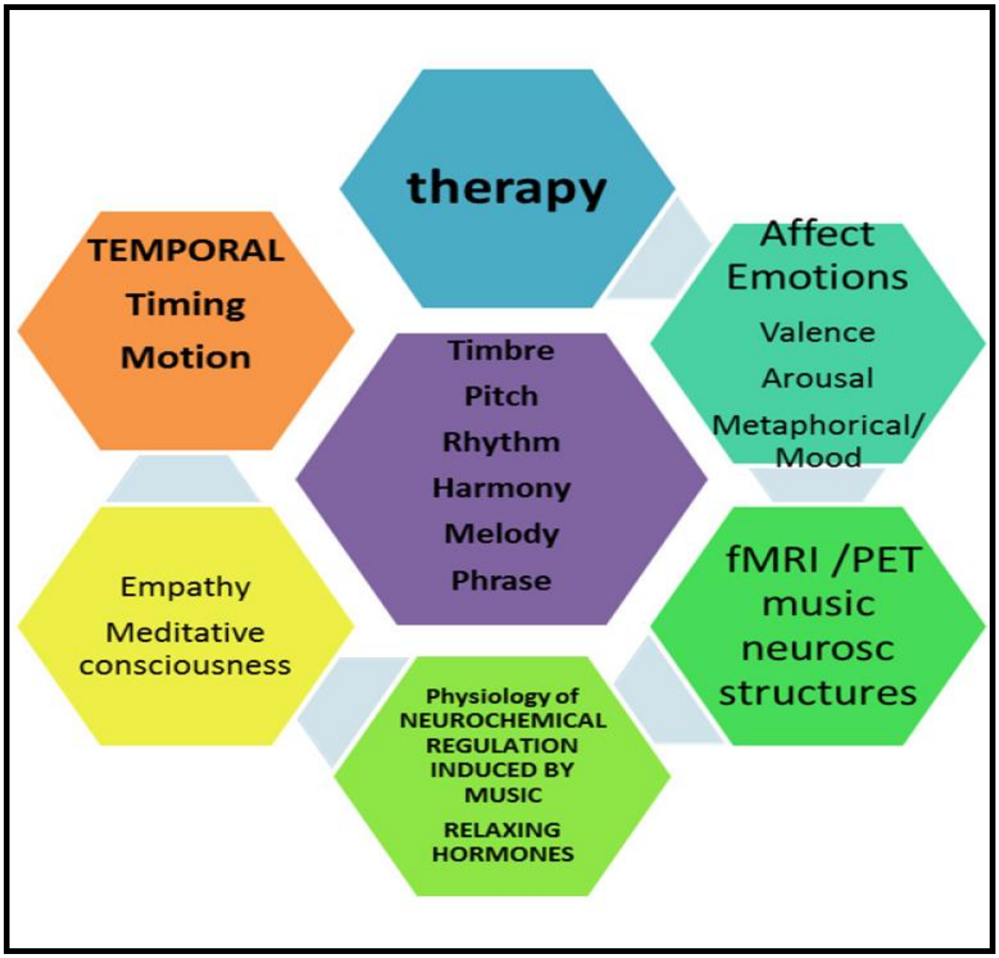


Figure 2.6 Music in Multidimensional Spaces

The multidimensionality of music were classified as three broad categories of recognized motion (*temporal*), affective (*emotion*) and structural (*cognitive)* in music experiences (Barucha, 2006). Affect has a broader connotation to emotion with extended non verbal or auditory features in the form of facial expressions and signified language. Vines, Nuzzo & Levitin (2005) explored *temporal* experiments by analyzing continuous musical tension as movements of kinetic energy (affective velocities) in time. In this study, listening patterns of musical tension-relaxation through conduits of affective structure contained musical emotions in sinusoidal waves of accelerated-tensing / decelerated-relaxing change. They formed undulating peaks and valleys that contained affective velocitical energies. Piano key velocities were defined as physical and mechanical manifestations of amplitude (Bhatara et al., 2011).

Music cognition-applied neurosciences employed the used high end functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography (PET) in their analysis of human brain scans when induced by music. Brain changes through activation of neurobiological markers of timing in music were observed in multiple brain regions (Wiener et al., 2010) during *Time* perception tasks. The malfunction of these structures in the brain induced by agonists (excitatory drugs) and antagonists (inhibitory drugs) of dopaminergic pathways confirmed their *temporal* influence (Wittmann, 2007a &b/2009; Carrion, 2010; Wittman et al., 2011). The neuroconnection between *Emotions* and visceral processes to *Time* perceptions were shown in a direct link between the Insular Cortex to the Interoceptive system within neural mechanisms (Craig, 2009). The Insular, through *temporal* integrated networks were reported to produce a series of *Emotional* (anterior insula) moments in *Time* (posterior insula) (Cauda et al., 2011).

Hevner (1936) and Hunter, Schellenberg & Shimmack (2008/2010) proved that listener's emotional responses typically paralleled emotions portrayed in music. Listeners recognized that faster moving tones produced happiness in contrary to slower moving tones, sadness. The mixed emotions of opposites in both sad and happy music were thought to be psychological forces of motivation in human beings (Juslin, 2013).

In emphatic response, the physio-biochemical release of relaxing hormone, *Prolactin* is correlated to sad acoustic features (Huron, 2011). In contrary to *Cortisol* in stressed response (Koelsch, 2012), soothing music lowered levels of this hormone. The regulation of relaxing hormones and physiological evidence in music-induced neuroimages (Levitin, 2007:Chap6, p190; Chanda & Levitin, 2013) proved that musical gifts evolved through neuromusical structures in man. Therefore, therapeutic interventions through this understanding may be the way forward.

Emotions in music were explored by using variations of psychological subjective judgements over a timed series physiological data. These two covaried significantly with tests in physiological heart rates, blood pressure, facial electromyography and electrodermal activities, EDA in (Krumhansl, 1997). The study was similar in (Chapados & Levitin, 2008) when electrodermal activity (EDA) were strongest in dimensions of affect with added visual modes, demonstrated the multimodular effects of music.

2.1.3.3d Continuous measurement of subject reactions during performance

This chapter describes the various methods used to observe emotions in real time performances. Described as expressive geometries of motion in body representations, both kinematics and visual sensories were important in conveying musical emotions (Vines et al., 2011). In (Nusseck & Wanderley, 2009) the study of expressive kinematics utilised both expression and timing in music. Changes in melody contours and valence were observed when continuous monitoring of musically induced emotions were done in timed series (Schubert, 2004/2011).

Emotions in continuous expectancies of tension- relaxation were monitored in a live concert using measurements of multicomponents in subjective feelings (VA_AR), facial EMG and peripheral arousal through skin conductance (Egermann et al., 2013).

For live performances, real-timed information transfer of structure (phrasings) and perceived tensions (VA_AR) in judgements revealed a perceptual structure in expression (Vines et al., 2006).

Pianoforte expression had been validated with experiments using multiple affective psycho-physiological measurements in valence arousal (VA_AR) evaluations, responses in heart / respiratory rates, movement studies of arms and index of postural angle (kinematics). In (Nakahara et al., 2010), higher expressitivities were demonstrated by the piano performances with subjects on higher valence-arousal (VA_AR) emotional scales. The expressive climate had higher readings in the physiological data where correlations from bodily functions (temporal movements) to expressions in music were favourable.

Figure 2.7 The experimental set-up for piano expression *from* (Nakahara et al., 2010)

Affective intentions in the Artistic were compared to Deadpan and Exaggerated interpretations in one pianist (Shoda & Adachi, 2011) by the measure of postural head-waist angle, θ. Artistic liberation (deviations) from fixed forms could be controlled in any expressive performance when these variables were allowed within their aesthetic permissions. The preferred *Artistic* rendition differed from *Deadpan* and the *Exaggerated*. This experiment highlighted musical structural contrasts to temporal projections in body movements.

Figure 2.8 A pianist's postural angle, θ *from* (Shoda & Adachi, 2011)

2.1.3.3e The Study of Time

Time perception depended on important combinations in sensory modalities like attention, memory, arousal and emotional states (Wittman & Van Wassehove, 2009). Humans required all these points to perceive time. The mental construct of time required active estimates inside the brain (classic internal clock models) and outside of it (multiple factors) that linked human emotion (Geoffard & Luchini, 2010; Droit-Volet, 2013).

In (Buhusi & Meck, 2009), psychological time is represented by multiple clocks where duration is dependent on the intrinsic (emotions) and extrinsic (rhythm of others). Experimental results suggested that the brain continuously processed represents of durations through multiple timing events within different temporal envelopes. From Einstein's theory on Relativity (Schild, 1959), time intervals were registered differently by independent moving clocks. Judging time in different temporal spaces therefore can be unreliable in humans with these inherently moving clocks.

Time perception depended on the intricate interplay of several brain neuro-structures that processed different timing durations (Craig, 2009; Weiner et al., 2010; Cauda et al., 2011). The consequence of excitatory and inhibitory drugs on time perception tasks controlled at dopaminergic pathways in the brain's limbic system confirmed their temporal connections (Wittman, 2007a & b/2009; Carion, 2010; Wittman et.al., 2011).

Duration is the fundamental time percept as it required the measure of time that passed by (Van Wassenhove, 2009). The influence of emotions on the perception of duration was studied in (Angrilli et al., 1997; Droit-Volet&Gil, 2009). Within the framework of the classic internal clock models, (Angrilli et al., 1997; Droit-Volet&Gil, 2009; Wittmann & Van Wassenhove, 2009) found that negative Arousal (AR) increased estimates of duration by accelerating internal clock speed. The distance of time in duration was overestimated in research subjects when a study of pictures with negative arousing emotional faces were compared to neutral ones (Droit-Volet & Gil, 2009).

Explained as stresses in the Arousal (AR) phenomena that increased or decreased internal clock rates, duration can be overestimated or underestimated. The underlying physiological activation induced by emotional stimuli in Arousal (AR) confirmed the influence of emotions on time perception.

Studies on the structure of time could be approached differently in qualitative and quantitative methods. Descriptive qualitatives had the advantage of anecdotal characters colouring the variety of time's multiphenomenal qualities. Quantitative methods required formal instruction as data quantified must be consistently reproducible and verified in repeats (Saniga, 2000).

2.1.3.3f Analysis of Time by empirical measurements

Full performances were measured in *Time* and (*score-time*) being timing of smaller units/subunits (De Poli, 2003) was described in many studies of pianists' recordings (Repp, 1993/1994/1995a&b/1997a&b/1998/2000; Bresin, Friberg & Sundberg, 2003; Serra et al., 2013). In expressive timing, deviations in microstructures within these units and subunits contributed to the majority of expression (Repp, 1998). The creation of artificial music performances were quite impossible for humans as deviations were always present (Seashore, 1935; Palmer, 1996) even in the most mechanical of performances.

In the conveying and clarification of composer's intentions, performers usually enlightened the musical structure with added personal interpretation. The musical message was further enriched with possible technicalities in the instrument of choice manipulated with physical properties in notes. With accentuated notes in skillful *agogics*, duration was modified within a phrase. Music played after or before the beat in *Tempo Rubato* (Palmer, 1996) and *Ritardandi* (Repp, 1993/1995a/1997b) described as lengthening or shortening of phrases at structural boundaries, modified duration. Represents of duration were measured as the relative IOI (Inter-Onset Interval), when time difference between the next event and the actual was divided by the symbolic (score) duration (Repp, 1993).

IOIs (InterOnset Intervals) are timing microstructures described as temporal intervals between successive tone onsets, measured in % deviations from the mean IOI (Repp, 1995b/1998; Palmer, 1996).

In the analysis of expressive timing, IOIs were normalized to fixed nominal note in a function of metrical score position (Repp, 1993/1995a & b). Tempo modulations were contributed by unequal intervals between successive tone onsets, thus differentiated performances as overall expression in the one and same score (Repp, 1998). IOIs cumulated in continuous modulations of local tempo (Repp, 1995b) together with the micropauses (Margulis, 2007) between them were applied in many studies. Aesthetic performances by experts were differentiated to conventional performances in students (Repp, 1995a & b/1998) by change in IOIs. The experience of expert pianists featured new and bolder interpretations than the nominal standard by students in these studies (Repp, 1997).

Time and emotion were correlated in (Bhatara et al., 2011) where models of mechanical to graded expressive versions of piano performances were applied with note onsets (IOI). The experiments quantified *physical* (acoustic) parameters in music performance (timing) with note onsets (IOI) and mapped them to *psychological* representation of music emotion.

Shapes of irregularities on time in Erik Satie’s “Vexations” were presented using IOI and Lyapunov models to describe states of human consciousness (alert, drowsy, trance) in (Kopiez, Bangert, Goebl & Altenmuller, 2003). These studies challenged the tolerance of human circadian rhythms on their psychomotoric stabilities with the performing of piano for 28 hours.

2.1.3.3g Mathematical model

Expressive timing were represented in temporal dimensions in the form of rhythm, meter and structure in tempo and timing (Honing, 2001). Mathematically explained, tempo deviations could be expressed as time shifts associated accentuations or contrasts termed as rubato (robbed time), accelerando (increasing speed) and ritardando (slowing down). Palmer (1996) defined *Rubato* as the slowing down of tempo in phrase lengthening at final endpoints. Categorical decisions in faster moving tones were determined as less expressive in (Repp, 1995b). As Tempo is the change of rate over a fragment of music, Timing is the combination of tempo and overall time shifts described as positions in a phrase in performance, score or global tempo in temporal dimensions.

The paradigms in imitation experiments (Clarke, 1993; Repp, 2000) were created to test perceptual effects of structural transformation in inverted performances when compared to normal performances. In these studies, transformed performance with time dislocations created shifts between structure and expression thus confirming the cognitive relationship between structure and expression.

Other scholars have characterized expressive piano performance with expressive timing models in the form of Time Span Reduction (TSR) which determined the parallel in musical structure linked to timing (Todd, 1985). Tempi modulation were described as linear change in the velocity of musical motion over time.

Power function mechanics explained the inversion of dynamics (crescendo/decrescendo) to expression (rubato/stress/contrast) in music (Todd, 1992; Windsor & Clarke, 1997). Todd (1992) proposed an inverse relationship between performance timing and dynamics.

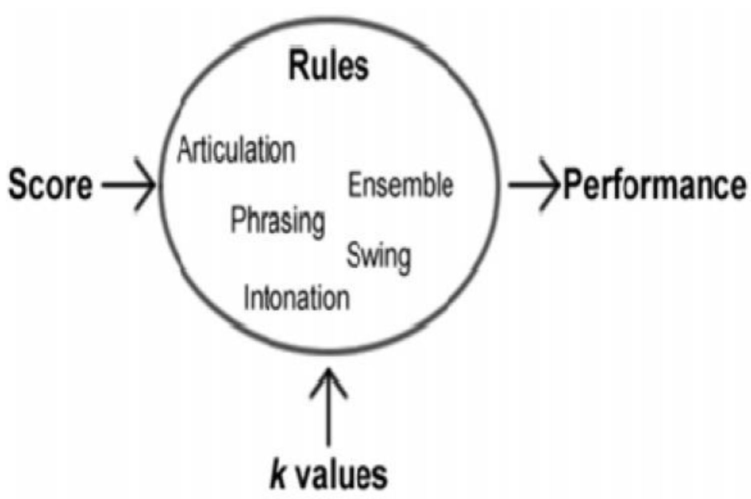
From theories in elementary mechanics, Tempo is an inverse of velocity (duration of time) measured as metrical distance and kinetic energies (acceleration and deceleration). Tempo and its function in structure depended on variables in metrical distance over time, its group lengths phrased by crescendo and decrescendo had boundaries that could carry over to new phases in time.

These models of timing generated from the same mechanics had limitations in their function when supersitions of timing components in fixed single mechanism resulted in ambiguous data collection. Valence_Arousal (VA_AR) predictions were evaluated with computer models of Music Emotion Recognition (MER) Dimensions and Fuzzy Logics (Yang & Chen, 2011).These mathematical models had their problems in defining emotions due to the fine granularity of nature in emotions.

2.1.3.3h Kungliga Tekniska Hogskolan (KTH) Rule System

Research groups in Kungliga Tekniska Hogskolan(KTH), Sweden developed many computerized programmes relating music performances over many years (Friberg, Colombo, Fryden & Sundberg, 2000; Friberg, Bresin & Sundberg, 2006).

The pDM (Director Musices) paradigm could mimic human performances through creation of it artificially through applied 'analysis by synthesis' methods. Musical articulations, phrasing, sound levels, inter onset intervals, tempo and contributors of expressive cues in multiple deviations were applied using a weighted musical input factor, k where sets of rules were combined to create or study musical performances.



Experiments with k factors of emotional expression were further improved with the involvement of 2-Dimensional Valence Arousal (VA_AR) models (Friberg, 2006) and a new Performance Space, P (De Poli & Zanon, 2003). This model of expression compared human to synthetic and "dead-pan" performances.

Piano performances by famous artists were recognised by machine learning techniques in these modern computer algorithms. Rules explaining musical and psychoacoustic principles in deviations that mimic human-like performance thus could improve learning and teaching strategies (Widmer & Zanon, 2003).

Musical deviations with particular emphasis on timing were studied to see how it affected musical expressions. In (Bresin, Friberg & Sundberg, 2003), deviations from nominal IOI of pianists performing a Mozart's Piano Sonata were approximated with metaperformances with pDM. Cue profiles of different emotion were systematically arranged as percentages of IOI deviations. Combinations of emotionally different performances produced from same scores explained the relationship between the structure in time to emotions (Bresin & Friberg, 2000).

2.1.4 Conclusion

Most scholars deliberated on evaluative judgements in valence-arousal (VA_AR) paralled physiology experimentations in their quest of finding the emotional core in music. This 2-3 dimensional model had itself limits to the measure and representations of musical emotions. Difficult to quantity, it was uncertain whether humans perceptually evaluate the accuracy of emotional judgements when selecting datas with the 2 Dimensional Emotion Space (2DES) models of affect (VA_AR). The search of situation predictors to affect different persons the same way or varying different emotions in the same piece of music were complicated.

Emotional reactions to music had high intra and inter-individual variance that explained different expectations in different listeners. Differences of emotional perceptions in music with subjectivities in personal variance could result in diversed data collection.
The ambiguities in adjectives of musical expression cannot be statistically quantified when different set of words meant the same musically.

In most literatures, descriptions of performer intentions through expressive deviations from the score, parameterised in time contained perceptual structure. Emotive and Cognitive concepts in music contained varied theories. Mathematical models like Fuzzy logic and MER systems (MATLAB) in emotion perceptions observed in (Yang & Chen, 2011) were also not without issues in evaluative subjectivities.The study plan was to focus on a systematizing methodology that could test consistencies in exact mathematical deductions, eliminating ambiguous statistical difficulties.

2.1.5 Analysis of deviations in recorded human performances

Epstein's (1985) article on tempo relations in cross cultural studies encouraged more performance analysis (Latham, 2005). Feinberg (2014) in his article on the "Composer and Performer" in his rememberance of the teacher and reknowned pianist of the Moscow Conservatory of Music, Alexander B. Goldenweiser (1875-1961) mentioned the importance of studying recordings of piano performances. Goldenweiser said that

> *it was equally interesting and instructive to compare recordings and analyse significant differences between composer's markings of tempo and dynamics with the interpretation of different performers,*

therefore, rudiments in pianoforte performance and pedagogy required listening and comparing different performances. This stressed the importance of education and search for new interpretation should the performer prepare to sparkle their teachers or the concert world at large.

Recordings of the Brahms Sonata No.1 in C (Op.1) by Martin Jones was described by (Hansen, 2013) in his project of real-time listening guides. In this study, Hansen studied the sonata's timing performance in Martin Jones which he hypothesized generated expression differences.

The comparison studies in 10 pianists aims to deliver clues to excellent performances through temporal deviations.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Ten recordings of the Piano Sonata No.1 in C (op.1) by Johannes Brahms (1833-1897) were selected from the world wide web, converted into MP3 formats with a speed of 128 Kbps, saved into files, identified and segmented with Audacity ™ (version 1.2.3).

Audacity ™ (version 1.2.3) source code is available under the (GPL) General Public License of the Free Software Foundation. It is a program that controls digital audio waveforms by recording and importing sound files by using MP3. Audacity operates on Windows (98 / XP) with most computers. This multitasking program can record, edit, split and mix music with the aid of a time indicator (Oetzmann & Mazzoni, 1989).

Ten recordings of the Brahms Piano Sonata No.1 in C (Op.1, 1st movement) from Martin Jones (British), Grigory Sokolov (Russian), Krystian Zimerman (Polish), Andreas Boyde (German), Peter Rosel (German), Kamerhan Turan (Turkish), Idil Biret (Turkish), Sergey Schepkin (American), Eugene List (American) and Julius Katchen (American) were arranged according to Total Time measured in seconds, down to 3 decimal points.

Table (3.0) and Appendix C below is a summary of 10 concertizing pianists in the analysis of recordings.

Table 3.0
Data on 10 Pianists

PIANIST	AGE	NATIONALITY
Martin Jones (Reference)	b1940	British
Grigory Sokolov	b1950	Russian
Krystian Zimerman	b1956	Polish
Andreas Boyde	b1967	German
Peter Rosel	b1945	German
Kamerhan Turan	b1965	Turkish
Idil Biret	b1941	Turkish
Sergey Schepkin	b1962	American (Russian origins)
Eugene List	(1918-1985)	American (Russian origins)
Julius Katchen	(1926-1969)	American (European origins)

See Appendix C Pictures of 10 Pianists, (p.104)

The recordings were selected based on criterias that;

a) they were easily downloadable and saved into Audacity **TM** files

b) the recordings were sonically clear and compatible with Audacity **TM**

c) the inter-tempi between pianists were significant

d) the performances contained various acoustic sensitivity to emotions and these variables could be quantified and verified reliably, consistently for the working of a hypothesis

e) the pianists were concert and recording artists

The selection of a "Reference" of this Sonata was based on data that was not much different from the majority of pianists in order to test consistencies at every segment. This "Reference" did not have to be near the mean value but was essential if treatment to mathematical methods highlighted differences and similarities within and between performances in order to conclude with analysis.

Additional timing characteristics were observed from the Exposition, Development, Retransition, Recapitulation and Coda. The Sonata No.1 in C was composed by Brahms when he was twenty. Unusual for young composers, this composition is fairly long and sophisticated, which for the analyst, requires a solid understanding of sonata form in order to render plausible analysis.

3.2 Time, as a parameter in calculation

In this project, time series measurements were taken at the sectional boundaries of the sonata form of each of the ten pianists. Then, observed differences (correlation) and similarities (alignment) at various structural points were taken. Pianists's profiles were repetitively observed in 3 within-runs quantifying an arithmetic Mean with its variabilities in Standard Deviations (SDs). 3 observations (time, seconds) were averaged to test consistencies at each point, ruling out possible analytical errors. Datum were summarized as Mean, Standard Deviation, SD (See *Appendix D, p.*105). A "Reference" with the least variation was selected as an Internal Control to enable reliable systematic reporting.

Interperformance Mean (Group Mean / XGroup) and Standard Deviations (SD Group) between pianists were tabled for comparative studies *(Appendix* page 114-119). By transforming Standard Deviation Index(SDI) to Emotional Index (EI), increments of deviated time were measured in the interest of musical expression.

Taking ideas from Seashore (1936), where

> *The medium of beautiful musical art lies in the deviations from the regular*
>
> *ie: Timing … and that graphic scientific measurements has musical meaning*. (p.22)

meant that the measurand in the form of deviation could be analysed through the science of mathematics which particularly dealt with graphs.

Formulations from (Ganter, 2014) were adopted in calculating timing deviations and graphically translating them for the interpretation of expressed or emotional content in music .

3.3 Standard Deviation, σ

Quantifies the degree of dispersion of data points around the mean, defined by the

formula, $$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$, where

$\sum(x_i - X)^2$ = sum of squares of differences between individual data and the mean

x_i = individual data

Mean $$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$ = $\frac{\text{Sum of Observations } (1,\ldots n)}{\text{Number of Observations}}$

A Standard Deviation, σ is the quantitative difference of data from its target Mean where this difference is the sum of random (imprecision) and systematic (bias) analytical errors. Often interpreted as a matter of precision made at each observation, the smaller the SDs, the higher the precision (Westgard, 2014).

3.3.1 Standard Deviation Index , SDI

The index of deviation (SDI) measures increments of standard deviation,

Standard Deviation Index, SDI = $\frac{(x_i - \text{XGroup})}{\text{SD Group}}$, where

xi = Individual Observation

XGroup = Group Mean

SD Group = Standard Deviation of Group

3.4 Emotion Index and Interpretation

Timing deviations were compared in parallel at indicated bars between the pianists at various emotion contours from excerpts of the Sonata. The interperformance Mean and Standard Deviations (SD) were marked as Group Mean (XGroup) and SD Group. Increments of deviations at each bar were calculated as they formed indexes that ranged in fluctuative patterns from (-2.0) to (>2.0), signalling the level of emotion or musical expression by the performers (Table 3.1). From Chapter 3.3.1, the Standard Deviation Index (SDI) is an analogue to Emotion Index (EI) where increments or dispersions from the mean are quantified as indexes of difference.

$$\text{Emotion Index} = \frac{(xi - X\ Group)}{SD\ Group}$$

where,

***xi*= individual timing**
***X Group* = Mean timing**
***SD Group*= Mean SD**

Table 3.1

Emotion Index

COGNITION	EMOTION INDEX	INTERPRETATION
	>2.0	Very Highly expressive
	1.5-2.0	Highly expressive
	1.0-1.5	Expressive
	0.5-1.0	Moderately expressive
RELAXATION	0.0-0.5	Slightly expressive
NEUTRAL	0.0	No expression
	0.0-(-0.5)	No expression
	(-0.5)-(-1.0)	No expressiom
	(-1.0)-(-1.5)	No expression
TENSION	(-1.5)-(-2.0)	No expression

3.5 Research Design

3.5.1 Overview

Studies on musical expression were limited due to the nature of difficulty in understanding the existence of implicit channels in music (Chapter 2.1.3). Defined in (Schellenberg, Stalinski & Marks, 2014), musical intentions were often vague from the beginning of its conception (Chapter 2.1.3.1) and its finest expressions of emotions were evident in composition and performance (Meyer, 1956; Corrigall & Schellenberg, 2013). From literature searched, the communication of musical expressions contained highly eventful structures in both performer and listener (Hevner, 1935; Kendall & Caterette, 1990; Schubert, 1999; Gabrielsson, 1999; Slodoba, 2000). These were described as Emotive and Cognitive concepts which had differing thoughts on the meaning of music (Meyer, 1956; Schmuckler, 1989; Butler, 1992; Schellenberg, 2010; Bhatara et al., 2011; Juslin, 2013).

On the experimental level, studies on performer expressions in timed series were demonstrated in (Schubert, 1999; Kopiez et al., 2003; Lucas, Schubert & Halpern, 2010; Nakahara et al., 2010; Bhatara et al., 2011; Shoda & Adachi, 2011).

Dimensional methods in identifying expressions in Affective and Sensorial Spaces with *Time* addressed multiple emotions (De Poli, 2003; Cannaza, 2004; Mion & De Poli, 2004; Mion & De Poli, 2007a & b).

In addressing internal structures of time, IOIs (Inter Onset Intervals) were elaborated in (Repp, 1993/1995a/1997b; Palmer, 1996). Mathematical models of time (Todd, 1992; Windsor & Clarke, 1997; Yang & Chen, 2011) contained ambiguous data due to the fine nature in emotions.

Musical calculations of a scientific nature required time consuming mapping between different worlds of knowledge. Therefore, these publications and references were very limited thus, embarking on this type of research was not only challenging but any discovery to the sciences in music would contribute to new frontiers in both fields.

The idea of translating mathematical deviations to indexes of expression had its roots in the psychological nature of expression itself. An expression or emotion is aroused as a result of expectation. These graded array of expectations in the listener are like waves of ambiguities in varying degrees of emotion, resoluting whether music heard was up to expectations or vice-versa. On the meaning of music (Meyer, 1956), a musician's deviation from the score were critical to the deliverance of affective aesthetic experience. Musical emotions depended on expectations and these created patterns of opposites in Tension-Relaxation, the beauty in Ambiguity-Clarity and the affective Dissonance-Consonances in the expected listener. These opposites were mapped to positive and negative deviations generated by data as musical expression emerged with *TIME*. Seashore (1936) also postulated deviations from the regular or fixed, necessary to endorse affection.

3.5.2 Design

The measurement of the acoustical variable in *Time* of 10 piano performances were treated to systematic analysis of timing deviations. All of the identified timings were collected in Windows Excel 2010. These timing deviations from the 10 pianists were treated mathematically to make inferences regarding musical expression. The following steps in (A, B & C) explained translational mathematics in its application with music expression.

A i) An excerpt from the Retransition (bar 153-160) was selected as an example

ii) Timing patterns of 2 pianists (Sokolov & Jones) were treated to Audacity ™

	Performing time		Interperformance (10 pianists)		Emotion Index	
Pianist	Sokolov	Jones	Mean	SD	Sokolov	Jones
153	2.902	2.291	2.284	0.442	1.398	0.016
154	2.137	1.664	1.874	0.354	0.745	-0.594
155	2.492	1.703	1.966	0.432	1.217	-0.609
156	2.933	2.120	2.508	0.483	0.881	-0.803
157	1.920	1.780	1.995	0.530	-0.142	-0.406
158	2.322	1.517	1.839	0.439	1.098	-0.733
159	3.034	1.633	2.024	0.450	**2.244**	**-0.868**
160	3.429	2.430	2.777	0.435	1.497	-0.797

B i) The workings of a measure in music expression were based on differences in temporal structure, where significant deviations were produced by using the variable, *Time*.

ii) By calculation (Chapters 3.3, 3.3.1 & 3.4),

Emotion Index at bar 159 (Sokolov) $= \dfrac{x_i - X\ \text{Group}}{\text{SD Group}} = \dfrac{3.034-2.024}{0.450} = \mathbf{2.244}$

Emotion Index at bar 159 (Jones) $= \dfrac{1.633-2.024}{0.450} = \mathbf{-0.868}$

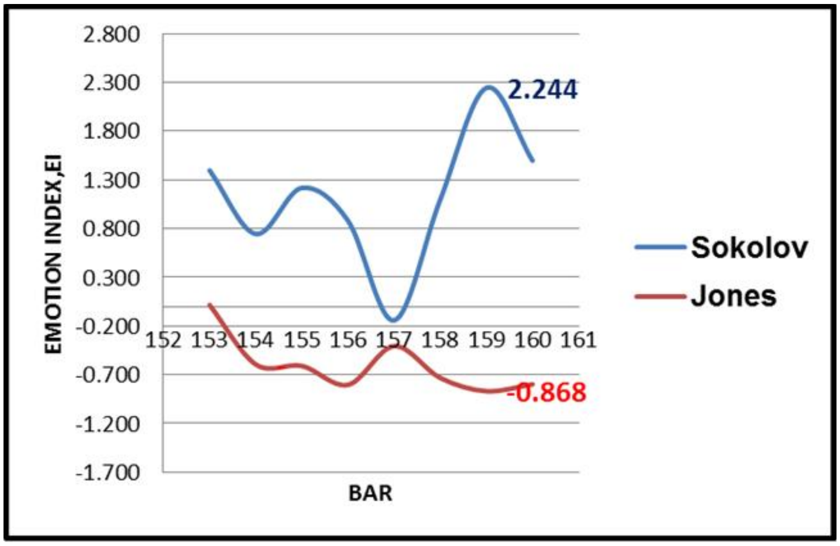


Figure 3.1 Measure in music expression

C i) Data is generated as expressions emerged in *Time*. Emotion Index, EI is plotted on a 2-Dimensional graph with *EI* (y-axis) against *Bar* (x-axis)

ii) Interpretation at bar 159 in both pianists;

a) Sokolov , **EI= 2.244** **(>2.0, very highly expressive)**

Slowing down in time, relaxing at phrase end point

b) Jones, **EI= -0.868 (no expression)**

3.6 Data Collection and Analysis of Time

3.6.1 Systematic analysis of timing deviations in 10 pianists

This study investigated the role of *Time* and its influence on expressive piano performance. Studies on traditional schools of music lineage or historical performance practice of individuals were excluded. Timing patterns of the Brahms Sonata No.1 in C (Op.1, 1st mvt) in 10 pianists were marked and segmented using the Audacity ™ (version 1.2.3) program.

Data on time series observations were plotted on a 2-Dimensional graph with *Time* at the (y-axis) against *Bar* at the (x-axis). Compartmentalized into four main divisions according to classical sonata forms, the introductory start of the Exposition begins at bars 1 till 16 containing the 1st theme, bridged by a Transition, then on to the 2nd theme from bars (36-62). An extension leads to a final Codetta from bars (75-87).

Some pianists did not perform repeats in the Exposition, thus data for non-repeats were processed to meet with criterias in consistencies. The Development bars (88-152), Retransition bars (153-172), Recapitulation bars (173-237) and Coda bars (238-270) completes this 270 bar-long first movement.

[See *Appendix A & B*, pp.90-103: Structure and Score of the Sonata No.1 (Op.1) in C (1st mvt), Johannes Brahms (1833-1897) Peters Edition (1910)].

CHAPTER 4

RESULTS

4.1 Overview

Timing of different sonata sections were identified to address

i) Temporal treatment to structure by performers

ii) The role of structure to postulate inferences on expression

iii) The discovery of new interpretation through timing

Results presented were further elaborated on

iv) Analysis of Affect (music expression) on similar structures in different sonata sections

v) Affect between sections (Exposition / Recapitulation) within pianists (horizontal comparison)

vi) Affect within sections (Retransition) between pianists(vertical comparison)

whereby, the correlation of *Time* to emotional structures in music expression were agreeable.

4.2 Timing

Pianists' timings of different parts of the Sonata were identified and lined in ascending order of Total Time in seconds(s). From (Fig.4), pianists' timing were arranged in ratios of standard deviations (SDs) from the interperformance group meanof (495.705 ± 55.794)s. Identified in green boxes (Table 4) (Biret, Jones, Rosel, Katchen, Zimerman, Turan, Schepkin and Boyde), timing measurements ranging from 439.111s till 551.499s in the 1SD cluster were favourable by (8) performers.

Table 4.0
Timing, Mean and Standard Deviations

Measuring Range,pianist,p(seconds)				439.911<p<551.499		384.117<p<611.293		
SD range			(-)1.4SD	(-)1SD	(+)1SD	(-)2SD	(+)2SD	(+)2.2SD
Units,seconds	Time	Group Mean±SD	418.23	439.11-495.705	495.705-551.499	384.117	611.293	
Pianists								
List	418.230	495.705±55.794						
Biret	448.845	495.705±55.794						
JONES	463.121	495.705±55.794						
Rosel	465.342	495.705±55.794						
Katchen	470.463	495.705±55.794						
Zimerman	500.307	495.705±55.794						
Turan	516.232	495.705±55.794						
Schepkin	523.530	495.705±55.794						
Boyde	535.177	495.705±55.794						
Sokolov	615.799	495.705±55.794						

At (Fig.4), identification of pianists at both ends of the Levey-Jennings Chart were seen in both List and Sokolov. Grouping performances within the clusters of 1SD, 2SDs and beyond were useful as general guides to performing time of pianists as further discussions on their similarities or differences could be done.

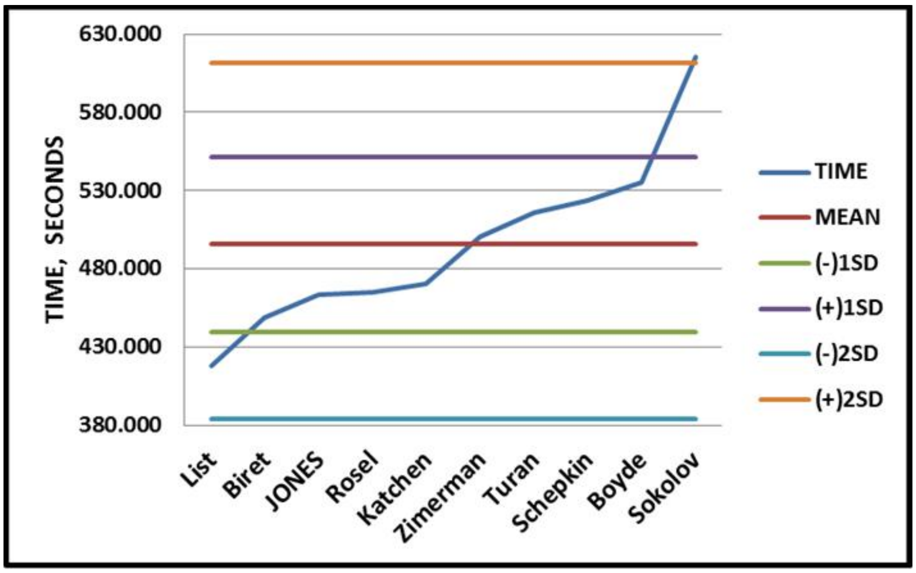


Figure 4.0 Timing, Mean and Standard Deviations (Levey-Jennings Chart)

4.3 Profiling Time according to Sections

Table 4.1
Data (Total Time) in ascending order : 4 sections of the Sonata
Performance of 10 pianists :Piano Sonata no1 in C(1st mvt) by Johannes Brahms

PIANIST	EXPO	DEV	RECAP	CODA	total
List	132.354	131.773	107.140	46.963	418.230
Biret	141.926	142.111	109.625	55.184	448.845
JONES	147.757	144.215	112.887	58.261	463.121
Rosel	152.217	146.642	114.394	52.089	465.342
Katchen	155.557	141.504	120.266	53.136	470.463
Zimerman	152.824	**173.235**	115.959	58.289	500.307
Turan	166.186	157.449	133.150	59.447	516.232
Schepkin	169.645	159.290	134.248	60.348	523.530
Boyde	176.444	166.566	134.389	57.778	535.177
Sokolov	195.597	195.808	152.644	71.750	615.799
			Interperformance		
			1)Mean Time		495.705
			2)Mean SD		55.794

	JONES	Sokolov	Boyde	Schepkin	Turan	Katchen	Zimerman	Rosel	Biret	List
EXPO	**147.757**	**195.597**	**176.444**	**169.645**	**166.186**	**155.557**	**152.824**	**152.217**	**141.926**	**132.354**
DEV	**144.215**	**195.808**	**166.566**	**159.290**	**157.449**	**141.504**	**173.235**	**146.642**	**142.111**	**131.773**
RECAP	**112.887**	**152.644**	**134.389**	**134.248**	**133.150**	**120.266**	**115.959**	**114.394**	**109.625**	**107.140**
CODA	**58.261**	**71.750**	**57.778**	**60.348**	**59.447**	**53.136**	**58.289**	**52.089**	**55.184**	**46.963**

In (Figs.4.1a & 4.1b), timings of 10 pianists were arranged in the order of systematic hierarchy where List and Sokolov were noted to be at both polarized ends of time in this movement. Sokolov displayed the most relaxed and contemplated playing whereas List was eccentric with the fastest speed time. Timing variation between the (8) pianists in Biret, Jones ,Rosel, Katchen, Zimerman, Turan, Schepkin and Boyde were arranged as ascending order in time. Their differences were subtle and their temporal treatment of structure produced significant mathematical derivations which will form the basis for further investigation.

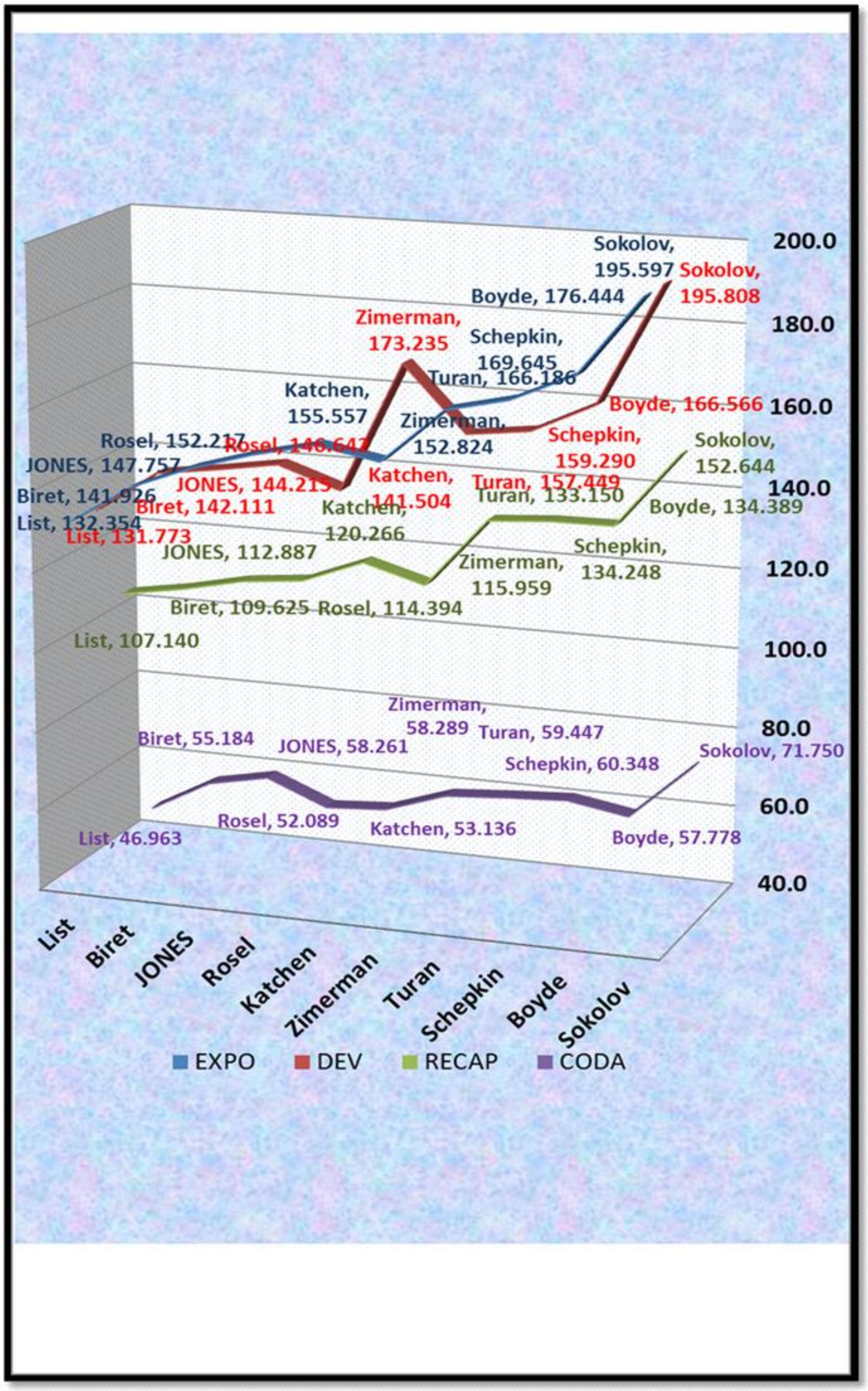


Figure 4.1a Performance of 10 pianists, Piano Sonata No.1 in C(1st mvt) by Johannes Brahms with Time as an indicator

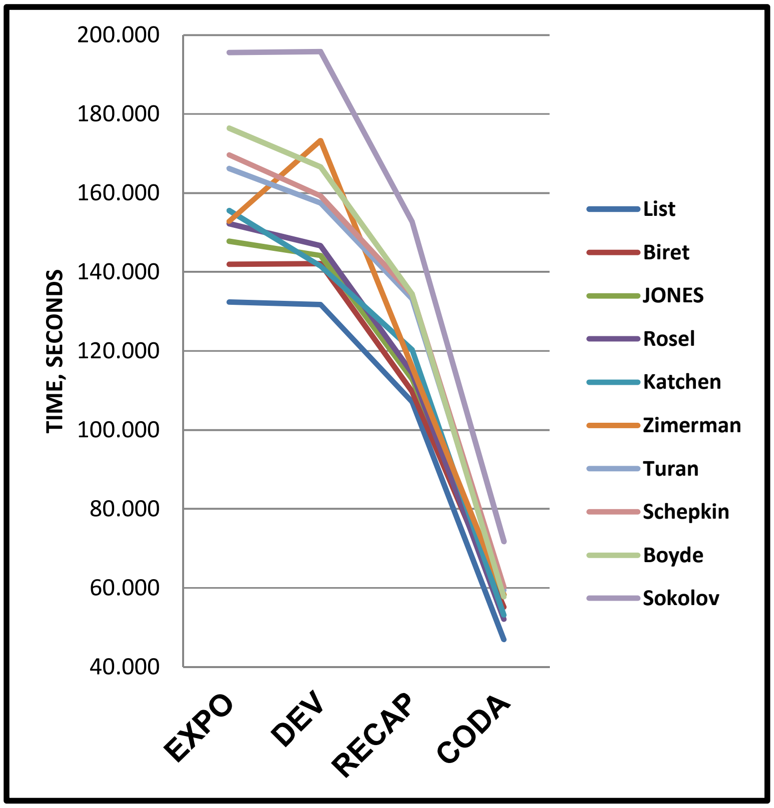


Figure 4.1b Performance of 10 pianists,Piano Sonata No.1 in C (1st mvt) by Johannes Brahms with Time as an indicator

4.4 The meaningful Internal Reference in Comparison Studies

In Figures (4.1a & 4.1b), time patterns of the pianists were shown in classical sonata form through sections displaying Exposition , Development , Recapitulation and Coda. Sequencing them in increasing order of time from List to Sokolov, the angular peak change at 29.020 seconds from Figure (4.2a) together with a distinct peak at Figure (4.2b) in *Zimerman* (Development section) was outstanding when comparisons were made to the internal reference. Martin Jones, the pianist chosen as the internal reference was a good control in this study where data was not inobstrusively apparent from the rest of the (9) pianists.

Seashore (1936) layed down essential principles of good control in scientific studies, where the reference must be kept constant while the measuring of others vary. He also delineated on observations that should be recordable and repeatable for verification.

Figures (4.2a) and (4.2b) are line and bar graphs mapping 9 pianists' comparison against the reference in 4 sections of the sonata.

Lines and bars appearing above the y–axis [(x=0 ,y= 0.027 till 51.592)] represented timings in positive trend (slower), below the y-axis [(x=0, y={(-0.484) till (-5.403)] otherwise depicted a negative trend (faster) when compared against the reference.

From bar chart (4.2b), recordings of List (418.230 s) and Biret (448.845 s) were faster and certain sections in Katchen (Dev,Coda), Rosel(Coda) and Boyde(Coda) showed minor negative trends (faster) to the reference.

Table 4.2a

Comparison study of 9 pianists against the reference (Martin Jones)in 4 sections of the Sonata Sonata No 1 in C, Johannes Brahms

	Sokolov	Boyde	Schepkin	Turan	Katchen	Zimerman	Rosel	Biret	List	JONES
EXPO	47.840	28.687	21.888	18.430	7.801	5.068	4.460	-5.831	-15.403	0
DEV	51.592	22.351	15.074	13.233	-2.711	29.020	2.427	-2.105	-12.442	0
RECAP	39.757	21.502	21.361	20.263	7.379	3.072	1.507	-3.263	-5.747	0
CODA	13.489	-0.484	2.087	1.185	-5.126	0.027	-6.173	-3.078	-11.298	0

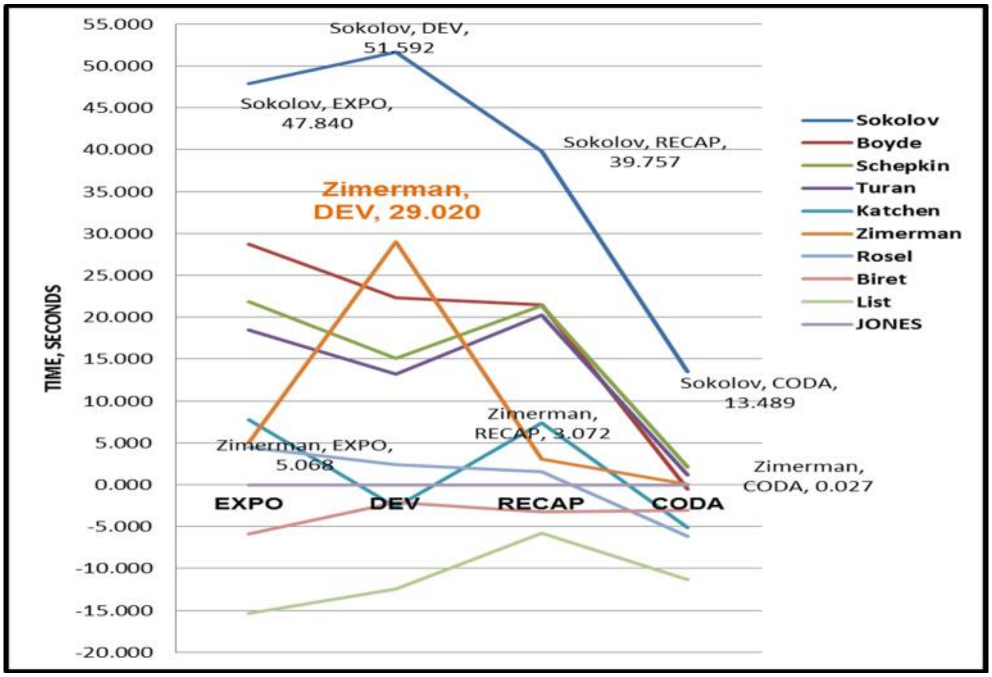
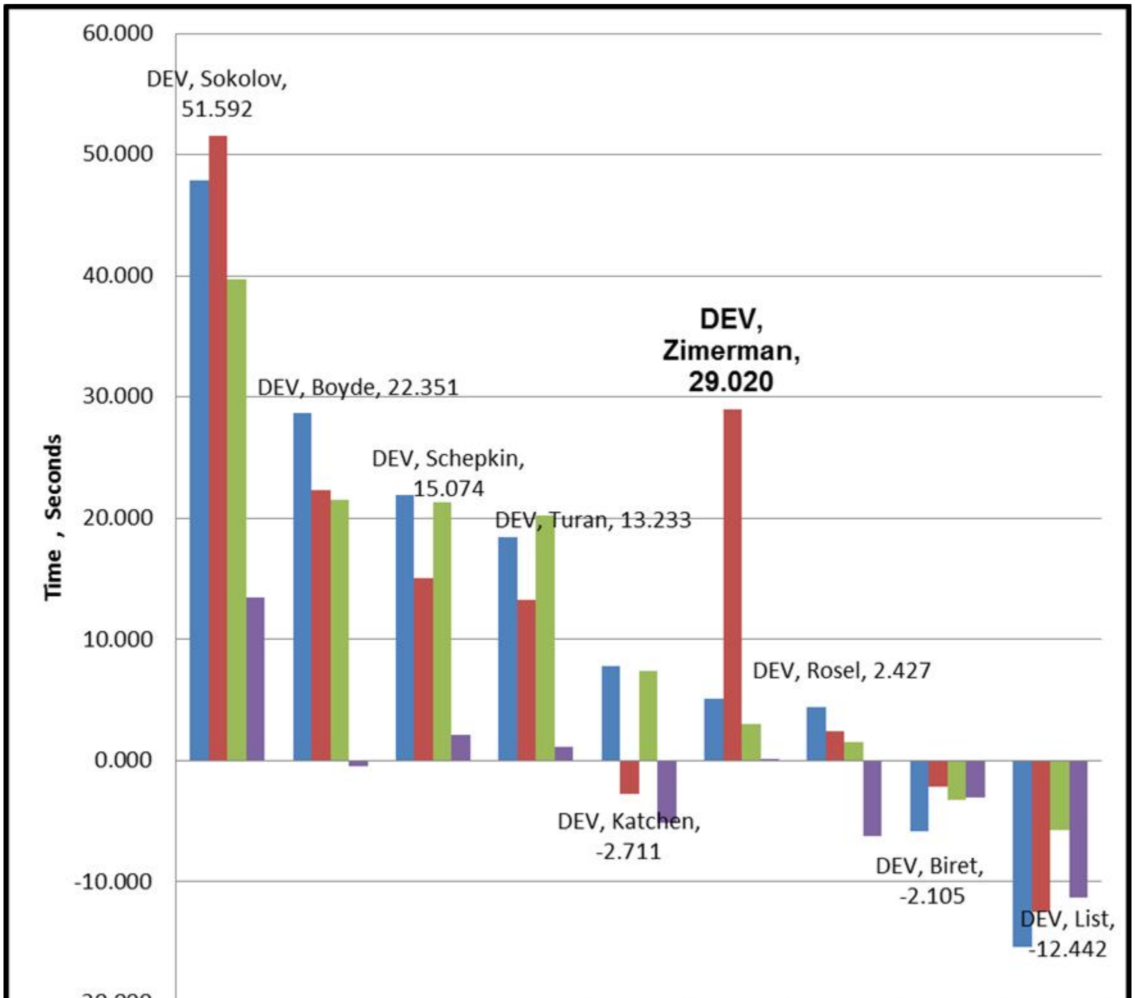


Figure 4.2a Comparison study of 9 pianists against the reference (Martin Jones) in 4 sections of the Sonata No.1 in C, Johannes Brahms



	Sokolov	Boyde	Schepkin	Turan	Katchen	Zimerman	Rosel	Biret	List
EXPO	47.840	28.687	21.888	18.430	7.801	5.068	4.460	-5.831	-15.403
DEV	51.592	22.351	15.074	13.233	-2.711	29.020	2.427	-2.105	-12.442
RECAP	39.757	21.502	21.361	20.263	7.379	3.072	1.507	-3.263	-5.747
CODA	13.489	-0.484	2.087	1.185	-5.126	0.027	-6.173	-3.078	-11.298

Figure 4.2b Comparison Study of 9 pianists against the reference (M.Jones) in 4 sections of the Sonata No.1 in C, Johannes Brahms

4.5 Relationship of Time to Structure

A shorter 24 bar 2nd theme, α was identified with similarities of its fragments

(A B A' form) between two different parts of the sonata.

Table 4.3
Comparison Studies in phrases of similar structure: Summary of structure between Exposition and Recapitulation (2nd theme, α)

Theme	Section	Length	No of Bars	Key
2ND THEME,α	**EXPOSITION**	Bars (39-62)	24	A minor
		A b (39-50)	12	
		B b (51-58)	8	
		A' b (59-62)	4	
2ND THEME,α	**RECAPITULATION**	Bars(198-221)	24	C minor
		A b(198-209)	12	
		B b(210-217)	8	
		A' b(218-221)	4	

From Table (4.3), timing was quantified using similar structures in the 2nd theme, α at sections in the Exposition (bars 39-62) and Recapitulation (bars 198-221) within the 10 performers.

Figures (4.4a & 4.4b) were excerpts taken from the two similars when compared their shape in A:B:A' form and texture. Time ratios within pianists between different sections from (Table 4.4 and Figure 4.3) indicated neutral results. In conclusion, the findings indicate that the consistency of time to similar structures occured within pianists in spaces of minor tonalities [A minor (Exposition) to C minor (Recapitulation)].

Table 4.4
Timing (within pianist) in structurally similar phrases of the 2nd theme, α at Exposition and Recapitulation sections

2nd theme	b 39-62	b198-221	
	A minor	C minor	
PIANIST	Exposition	Recapitulation	Ratio
JONES	43.140	43.410	0.994
Sokolov	57.453	57.627	0.997
Boyde	58.278	56.479	1.032
Schepkin	50.440	51.205	0.985
Turan	47.141	48.790	0.966
Katchen	43.667	43.729	0.999
Zimerman	43.197	42.818	1.009
Rosel	46.481	44.692	1.040
Biret	41.961	43.527	0.964
List	39.466	40.651	0.971

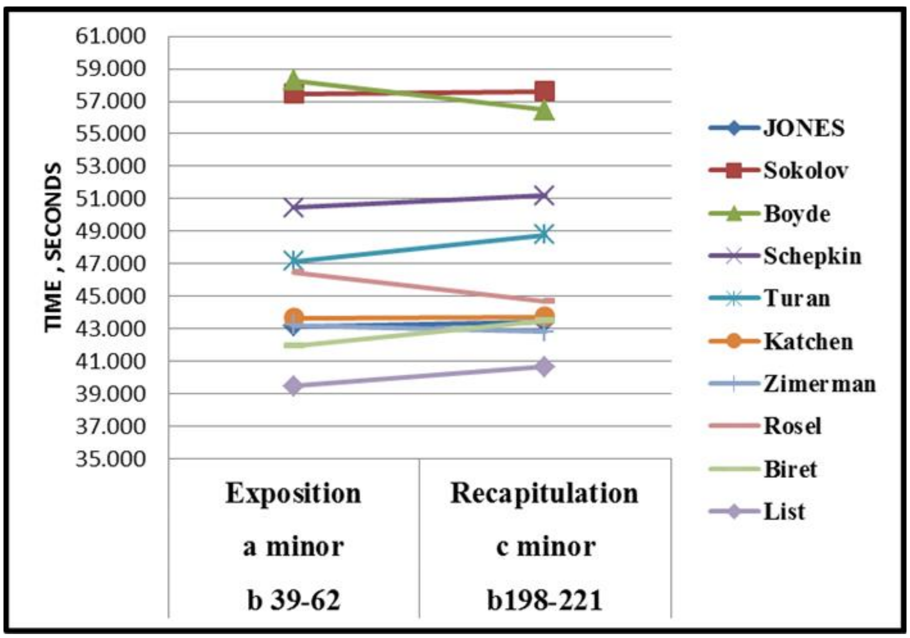


Figure 4.3 Study of time (within pianist) in the (2nd theme, α) at different sonata sections
(Exposition, bar 39-62 & Recapitulation, bar 198-221)

Figure (4.4a) Excerpts of the 2nd theme(24 bars):Exposition(bar39-62)

A(bars39-50): B(bars51-58): A’(bars59-62)

Figure (4.4b) Excerpts of the 2nd theme(24 bars):Recapitulation (bar198-221)

A(bars 198-209): B(bars 210-217): A’(bars 218-221)

CHAPTER 5

DISCUSSION

5.1 Time as an indicator of interpretation

As techniques in exploring rates of change and movement over time in musical performances depended on variables such as Structure, Tempo and Timbre, differential calculus were used in the analysis of dynamics in music (Vines, Nuzzo & Levitin, 2005). Newton's mechanics described affective energy as sinusoidal waves of musical tension; where, in the first derivative of position, *affective velocity* is connected to kinetic energy and in the second derivative of position, *affective acceleration, as* potential energy.

Kinematics of movement in timing were well known in (Vines et al., 2011; Nusseck & Wanderly, 2009; Mion & De Poli, 2004/2007a&b). Resistive movements in opposite adjectives like *Friction* (hard/heavy/angry), *Elasticity* (light/happy) and *Inertia* (sad/calm/soft) in Affective, Sensorial and Combined Spaces have their positions in perceptual metaphoric tension (De Poli, 2003; Cannaza et al., 2004; Mion & De Poli, 2004/2007a&b). Canazza et al.,(2004) described TEMPO in three categorical rates like *Slow* (heavy), *Moderate* (soft) & *Rapid* (bright,light). The *Elasticity* of nature quantified as (light,happy) and *Moderate* in tempo (soft) explained metaphoric Relaxation. In faster moving tones, adjectives in *Rapid* and *Elastic* best described bright, light and happy perceptions in music.

In the identification of expression in pianoforte playing, *Tension-Relaxation (T-R)* opposites were correlated to kinematics of body movements in timing (Nakahara et al., 2010; Shoda & Adachi, 2011). Meyer (1956) and Todd (1992) related tension to faster or slower moving tones. Repp (1995b) mentioned that faster moving tones was less expressive. Reference to the psychological analogy of *Tension-Relaxation (T-R)* and '*Gestalt'*, *Relaxation* contours were associated with a decrease in timing, resoluting at end points. Points of change in tension were described as lowering of tempo in (Rosen, 1980; Todd, 1992).

The following is an analysis of the Development-Retransition of the Sonata No.1 in C by Johannes Brahms. Figure (5.0) are timed series of the 10 pianists from bars (88-172) and further investigation into 4 identified pianists (Jones, Boyde, Sokolov and Zimerman) at (Fig.5.1) marked important differences.

(See *Appendix* B, pp.93-103 for full score)

From (Figs.5.0 & 5.1), the lowest point in Tension occurred at (bar 138, 87.159 seconds) (See *Appendix D*, p.112) after which, Zimmerman's timing pattern of change marked the end of a segment in classical sonata form.

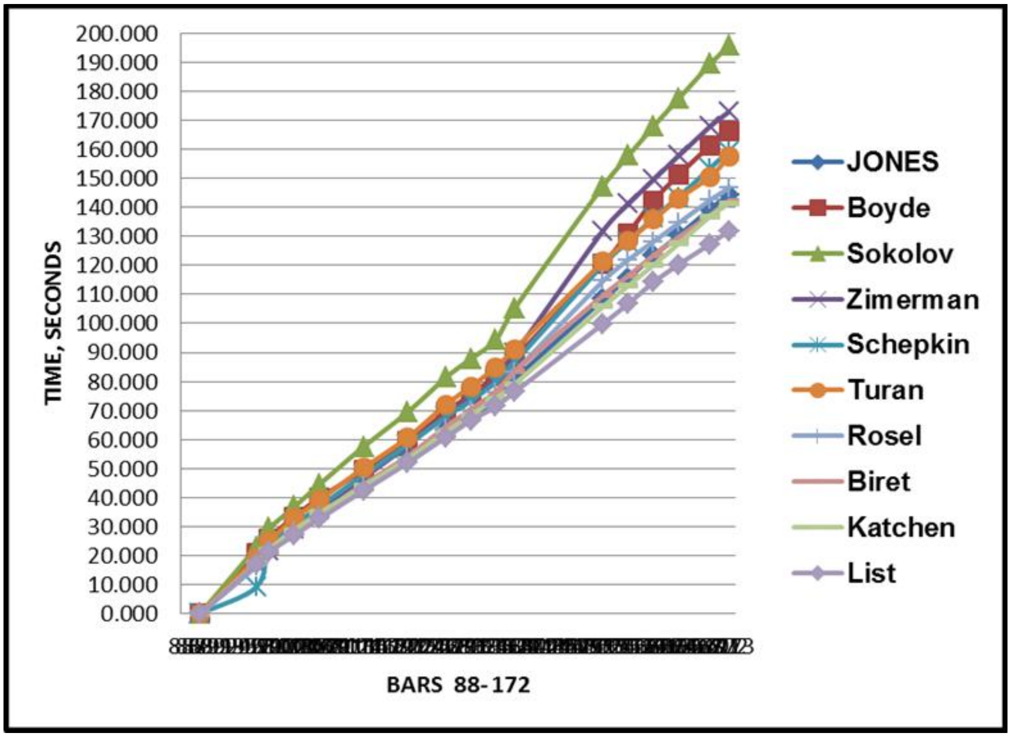


Figure 5.0 Study of time against identified bars in the Development and Retransition sections in 10 pianists

A duration of (173.235seconds) in Zimerman (Development section) was the longest among 9 pianists from Figure(4.1a) and Table (4.1). Subsequently, timing flow of 10 pianists were recorded from bars (88) till (172), a non-linear frame from subparts of the Development spanning from (bar 88) through a Retransition (bars 153-172) and before the Recapitulation at (bar 173).

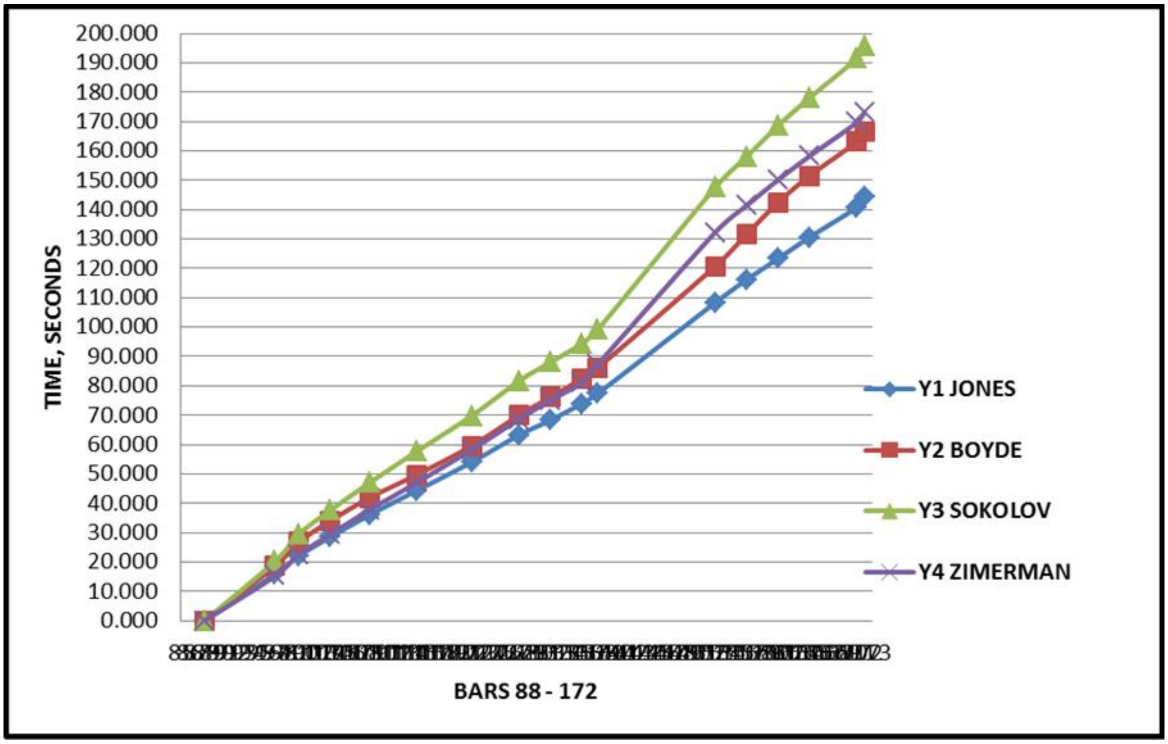


Figure 5.1 Timing flow of 4 pianists from bars (88-172) at Development to Retransition sections

From Figure (5.0), 4 pianists with significant positive slopes were isolated for further analysis. Timing profiles of Jones, Boyde, Sokolov and Zimerman were figured at (5.1). The pathways taken by Sokolov is one of long, meandering articulation in the name of time. After point (bar 138, 87.159 seconds), (y4)/ Zimerman's shifting in positive increase was moving away from the rest of the pianists.

The new Retransition section was most obvious after (bar 138) in Zimerman with the slowing down in timing (positive arching).

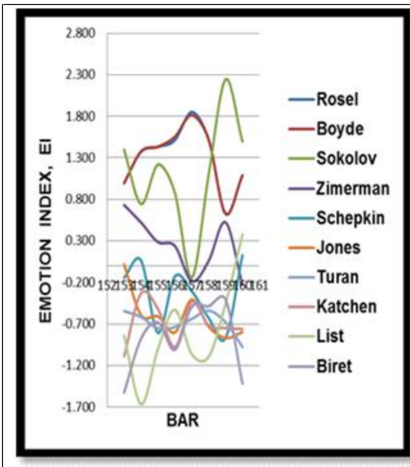
From studies of Internal Classic Clock Models (Angrilli et al.,1997; Droit-Volet & Gil, 2009; Wittmann & Van Wassenhove, 2009), *Relaxation* patterns in lowered Arousal (AR) increased estimates of duration. This theory postulated on the acceleration of internal clock speed in lowered Arousal(AR) domains thus caused an increase in duration.

By systematic calculation, one notable difference demonstrated by the pianist who decided to move the Retransition earlier by 14 bars to the start of (bar 139) from the majority at (bar 153) explained this increase in the quantitation of time in Zimerman (Zimerman's deviation, 173.235 seconds from Chapter 4.3).

Time trajectories can create elated transformations of sound into thoughts. A change of timing direction after bar 139 may be described as a musical tension releasing factor into relaxation with the introduction of shimmering cascades of 1st Themes from bar (139-152). Rich in colourful mutations from the Exposition, this section is filled with imitations in large piano registers between the RH / LH in 3 sequences, the passage ends with a 4-octave rippling descending of 1st theme fragments in time.

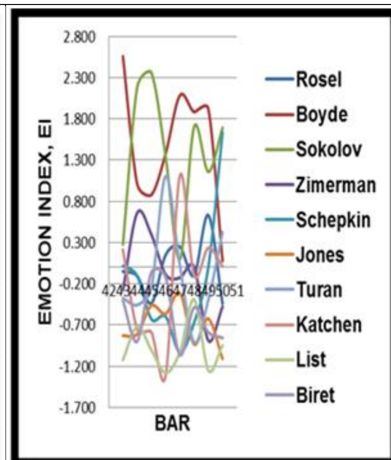
5.2 Data collection and analysis of Affect (emotional expression) in piano performances

A model of Emotion Index, EI (Chapter 3.4) was created by translating mathematical logics in Standard Deviation Index, SDI (Chapter 3.3.1) to the essence of deviation in performance. Smaller fragments of the 2nd theme (8 bars) were studied at bars (43-50)-(Exposition, Table 5.5 & Fig.5.2, Fig.5.2a), bars (202-209)-(Recapitulation,Table 5.5 & Fig.5.3, Fig.5.3a) and bars (153-160)-(Retransition, Table 5.5 & Fig.5.4, Fig.5.4a). Emotion Contours within and between 10 pianists, within and between sonata sections in major tonalities were compared (Fig.5.5).



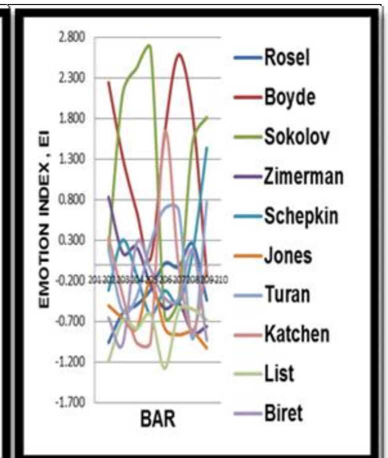
Key: G major

Figure 5.4 Emotion Index Retransition (bar 153-160)



C major

Figure 5.2 Emotion Index Exposition (b43-50)



Bb major

Figure 5.3 Emotion Index Recapitulation (bar 202-209)

Figures (5.2-5.4) Emotion Index

Emotion contours at Figures (5.2), (5.3) & (5.4) provided an impression on structure where the Retransition contours were different from both Exposition and Recapitulation. From (Palmer, 1996), expression from performances contained perceptual structure specified in composition and temporal deviations. Schubert (2004) described the 2D Model of VA_AR as contours of emotion with different transformations in time. In studying the nature of timing, Fryden,L. hypothesized that musical performance should be shaped accordingly with the presence of metre and rhythm (Bresin, Friberg & Sundberg, 2006).

From literature reviewed (Chapter 2), simple categorial decriptors of time as ‘faster or slower’ moving tones equated happiness or sadness to music. *Tension Relaxation (T-R)* models better described music as dynamic events in the process of time. Cognitivists viewed musical emotions as antecedents of undulating flows of *Tension* following *Relaxation* in their consequents, thus created expressions. Presented as metaphorical *Tensions and Relaxations (T-R)* in Sensorial and Affective Spaces, these affective kinetic energies were also described as sinusoidal waves of *(T-R)* in mechanics.

The graphical representation of Emotion Index, EI through derivations in Standard Deviation as Indexes of *time* were found to be also undulating in waves of *Tension and Relaxation (T-R)* from Figures (5.2), (5.3) & (5.4). Figure (5.5) summarizes the Emotion Contours of 10 pianists in the Retransition, Exposition and Recapitulation sections. Further analysis of *Time* relating to perceptual structure in *affect* better described performances between and within these pianists.

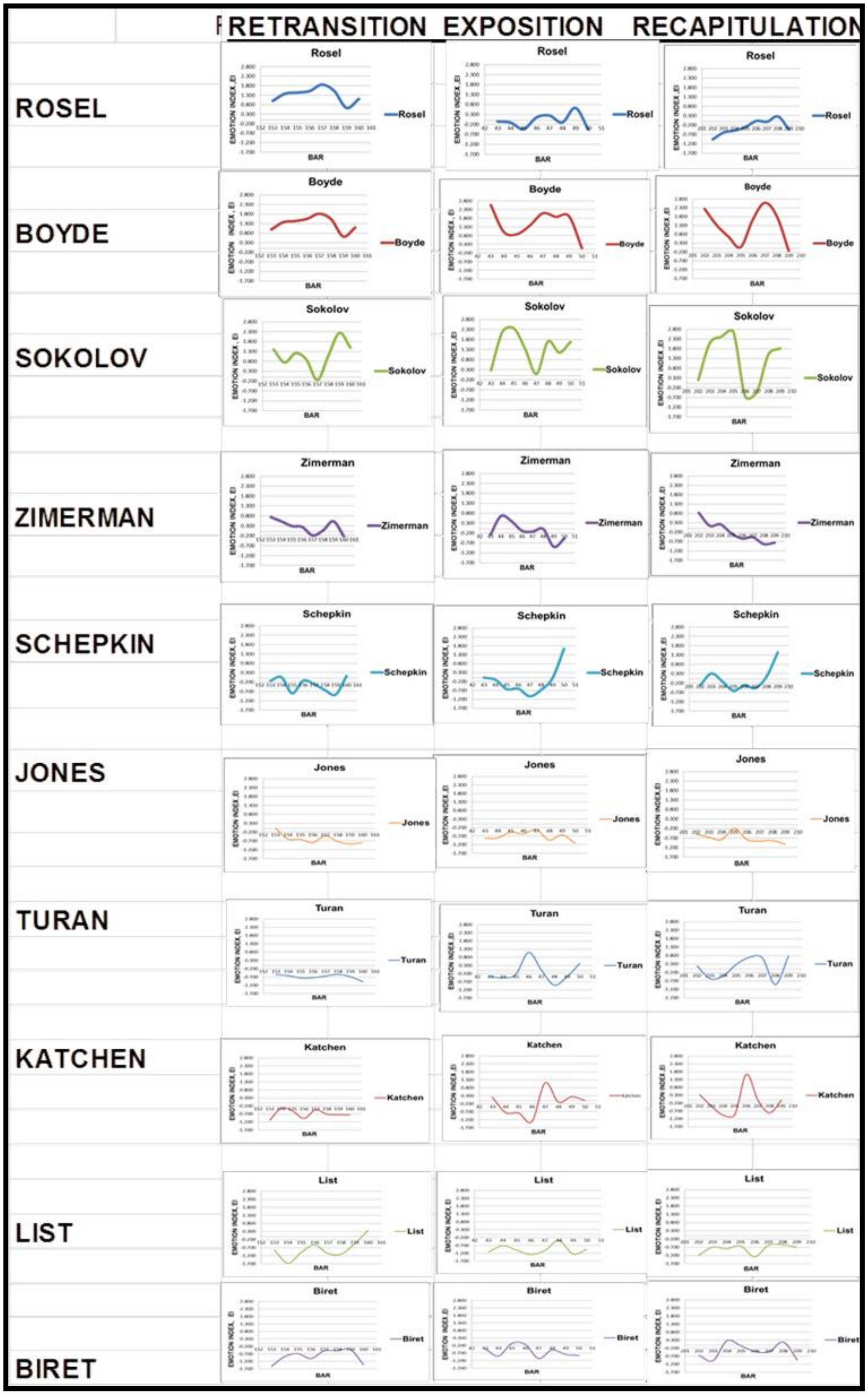


Figure 5.5 Emotion Contour Comparison Studies in 10 pianists

Table (5.5) is an organization of descriptive undulating Peaks and Valleys from the illustration in Figure (5.5).

Table 5.5

Emotion Contours summarizing Figure 5.5 (Bars, EI, Peaks and Valley)

Section	EXPOSITION				RECAPITULATION		
Boyde EI	Bar45 0.878 Valley	Bar47 2.083 Peak	Bar49 1.920 Peak	Bar50 0.077 Valley	Bar 205 0.078 Valley	Bar207 2.588 Peak	
Sokolov EI	Bar45 2.361 Peak	Bar47 0.097 Valley	Bar48 1.701 Peak	Bar49 1.160 Valley	Bar205 2.656 Peak	Bar206 -0.631 Valley	
Turan EI	Bar46 1.102 Peak	Bar48 -0.908 Valley			Bar203 -0.567 Valley	Bar206 0.694 Peak	Bar208 -0.914 Valley
Katchen EI	Bar46 -1.315 Valley	Bar47 1.110 Peak			Bar204 -0.961 Valley	Bar206 1.639 Peak	Bar208 -0.811 Valley

Section	RETRANSITION			
Rosel EI	Bar157 1.852 Peak	Bar159 0.628 Valley		
Boyde EI	Bar 157 1.814 Peak	Bar159 0.628 Valley		
Sokolov EI	Bar154 0.745 Valley	Bar155 1.217 Peak	Bar157 -0.142 Valley	Bar159 2.244 Peak
Zimerman EI	Bar157 -0.186 Valley	Bar159 0.524 Peak		

5.3 Time and Structural Similarities in the Exposition and Recapitulation

5.3.1 Affect between Sections(Exposition/Recapitulation) within pianists (Horizontal Comparison)

The EI contours of *Boyde, Sokolov, Turan and Katchen* (4 pianists) from Figures (5.2 & 5.3) were somewhat similar within the 8 bars (2nd theme) in both Exposition and Recapitulation .

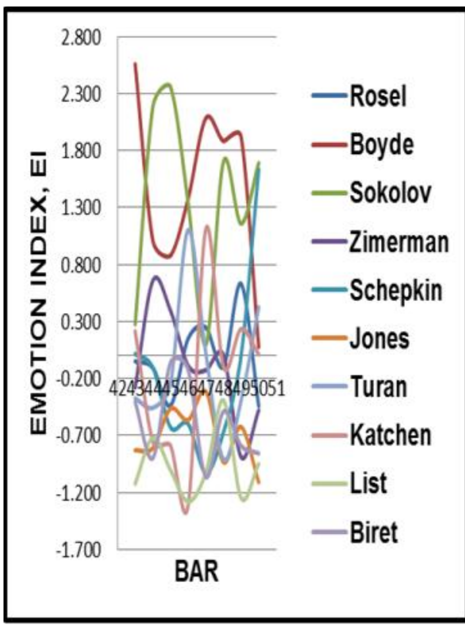


Figure 5.2 Emotion Index at Exposition Section (bar43-50) in 10 pianists

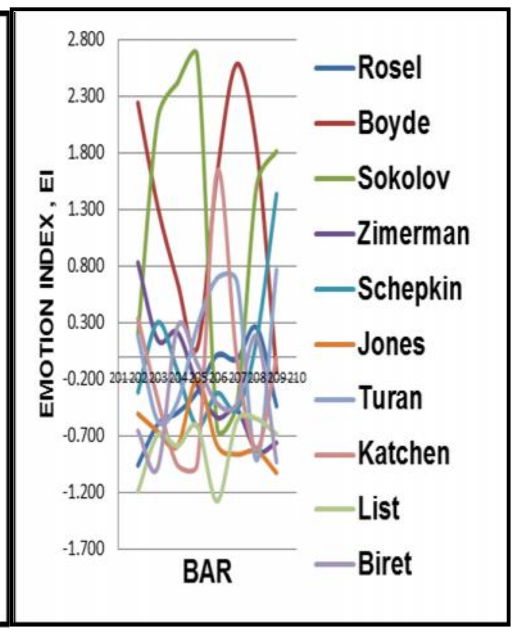


Figure 5.3 Emotion Index at Recapitulation Section (bar 202-209) in 10 pianists

This group achieved undulating peaks of positive emotional reflection from (0.694 <EI <2.656), greater than the cut-off point of expressiveness at (EI>0.5) and valleys within (0.077<EI<0.878) signifying relaxing impressions in music. Meyer (1956) described relaxing patterns in melodic terms as decline in tension when pitches and tempo lowered and progressions descended to a close.

From Seashore (1936) where,

> *Deviation from the exact on the whole was for the conveying of the beautiful in Emotion*.(p.22)

deviants within the phrase like *Rubato* and *Ritardandi* were practical functions to performer's expressive intentions. *Sokolov* and *Boyde*'s contours were high in the graph with peaks of {EI(2.361(Expo) and 2.656(Recap)} in the former and {EI(2.083(Expo) and 2.588(Recap)} in the latter, suggested very highly expressive performance in same relaxation events.The others, comprising *Rosel*, *Zimerman*, *Schepkin*, *Jones*, *List and Biret* were in tensing modes (EI<0.5), the index of emotion ranged in valleys fluctuating from{(-)1.280<EI<(-)0.438} and peaks from {(-)0.061<EI<0.658}. Restlessness at negative trends below the y-axis of EI (See *Appendix D*: Table 5.2 & 5.3, pp.114 & 116) did not reflect much difference within these pianists .

According to (Margulis, 2005), three types of tensing phenomenas were generated when anticipating future events in music differentiated as tension-denied or surprised and tension in expectation. In Affective and Sensorial Spaces, musical tensions in perceptual positions in Friction (hard-heavy-angry) contained adjectives in combined high / low kinematics and high (VA_AR) (De Poli, 2003; Cannaza et al., 2004; Mion & De Poli, 2004/2007a & b).

With reference to findings in Chapter 4.5, (Table 4.4 & Fig.4.3), timings within pianists in structurally similar phrases of the 2nd theme, α at Exposition and Recapitulation sections were similar. The same containment of expression (EI) were also found in analysis of similar structural elements (Fig.5.2 & 5.3) within pianists.The correlation of time to emotional structures were agreeable in my findings.

5.3.2 Emotion Contours of the 2nd theme (Exposition, bar 43-50) within pianists

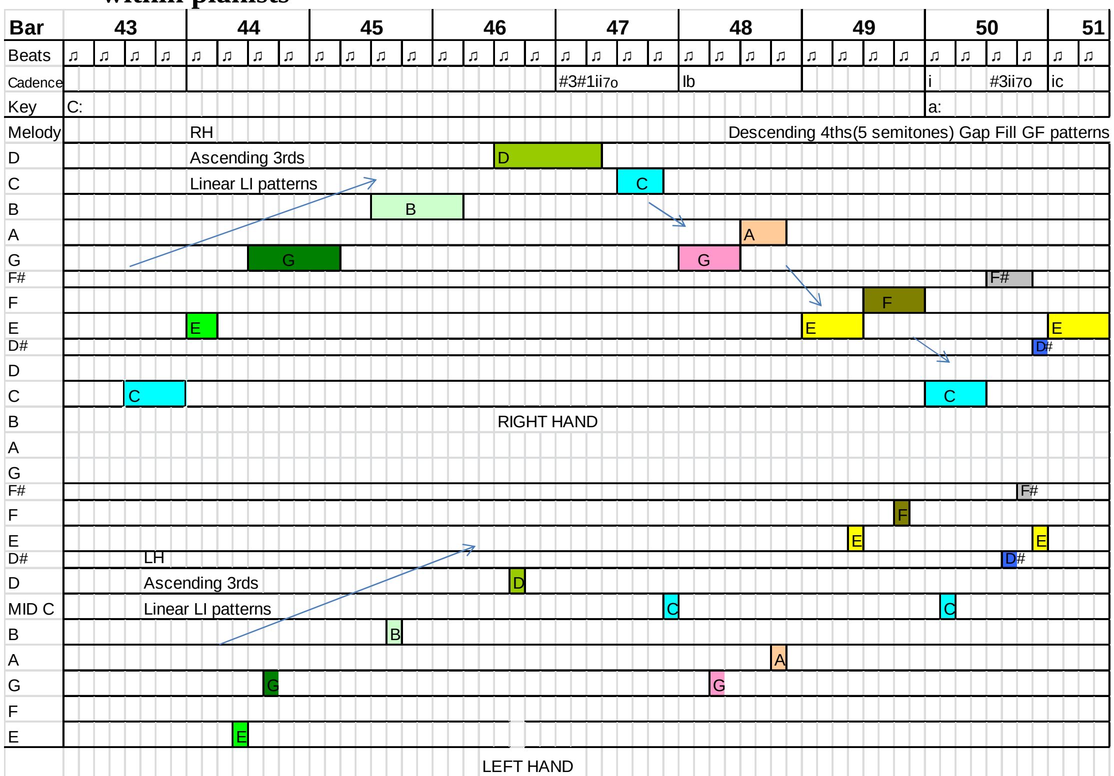


Figure 5.6 Abstraction of 2nd theme bar (43-50) Exposition, Sonata No.1 in C

The following work examined theories on psychological presentation of structure as implicit perceptual images related to time (Chapter 2.1.3). Figure (5.6) is an excerpt of 8 bars taken from the Exposition (bars 43-50, Fig.5.2a) as it would also recur in the Recapitulation (bars 202-209, Fig.5.3a).Emotion Contours of the same pianists *(Boyde, Sokolov, Turan and Katchen)* showed relative patterns of *Tension Relaxation (T-R)* at Figures (5.2 & 5.3).

5.4 Time and Structural Differences in the Retransition

5.4.1 Affect within sections (Retransition) between pianists (Vertical Comparison)

In the following, a slight change of material in different sections tested ideas on the influence of structure to affect in performances. Emotion contours (EI) from Figures (5.2 & 5.3) were graphically different in Fig. (5.4). The emotional streaming of *Tension-Relaxation* patterns in the Retransition at (Fig.5.4) were significant when compared to the Exposition and Recapitulation sections (Figs. 5.2 & 5.3). Positive expressive EI in *Rosel, Boyde, Sokolov and Zimerman* (4 pianists) were ranged from peaks (0.524<EI<2.244) to valleys {(-)0.186<EI<0.628}. Performances in Schepkin, Jones, Turan, Katchen, List and Biret ranged from { (-)0.540< EI <0.064} at peaks and {(-)1.665<EI< (-)0.868} at valleys (See *Appendix D*: Table 5.4, p.118).

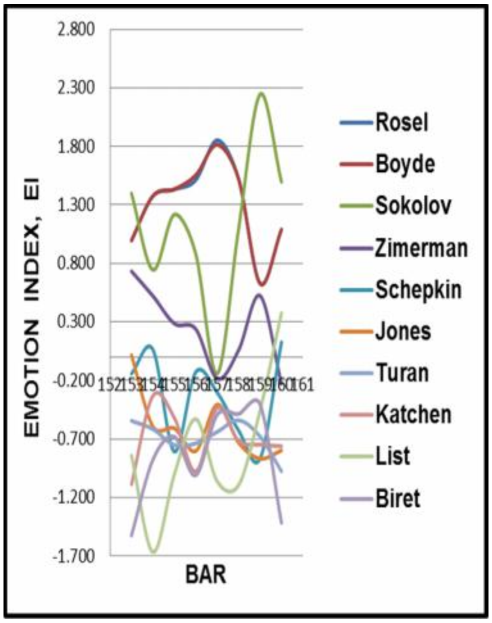


Figure 5.4 Emotion Index at Retransition Section (bar 153-160) in 10 pianists

5.4.2 Emotion Contours of the 2nd theme (Retransition, bar 153-160) between pianists

Different structural elements in the Retransition (bar 153-160) and its corresponding abstraction are shown below.

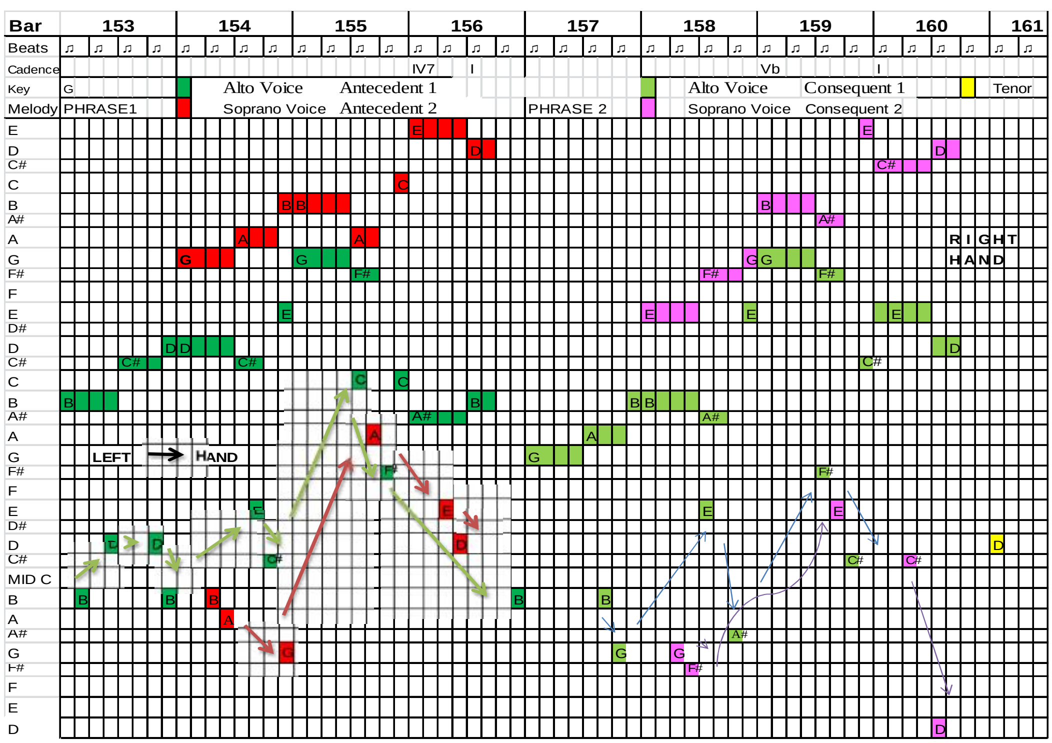


Figure 5.7 Abstraction of 2nd theme bar(153-160) Retransition, Sonata No.1 in C

The analysis of this abstraction from the Retransition was interesting when different structural elements altered the timings in emotional profiles(EI). Reflected as doubled-inversion to one another in successive time spans (Fig. 5.7), phrase 1 and 2 were rewritten in notation form for further analysis. The application of elision in contrapuntal voice parts in different rhythms and timing added to surmounted effects. Beneath the surface of piano scores in (phrase 1), the alto voice lead in antecedent1 followed by the soprano in antecedent 2 in elision, the same canonic imitation mechanism also applied to phrase 2 (alto voice leading at bar 157 in consequent1 followed by soprano in bar 158 at consequent 2).

Combined together in shifted derivations of the soprano voice an octave lower, both parts voiced in thirds at the begin of bar 153 ends with (A#-E), a Diminished 5^{th} chromatically altered cadence point at the end of (bar 156). Two following sequences of syncopations in soprano and alto at (bar 154.875-156) in phrase 1 and (bar 158.875-160) in phrase 2 emphasized resolute closure at phrase endpoints.

From Figure (5.7), the left hand (LH) margined by arrows were in diminution when combined with augmentation in the right hand(RH), in different registers over time. Systematic reductions and extensions in Diminution / Augmentation were implied tension in music as acceleration and deceleration is infered. The dissonant Diminished 5^{th} at the end of phrase 1 of (bar156) signified emotional tension with valleys ranging from {EI (-)0.42/(-)0.186} in both *Sokolov* and *Zimerman* but this was resolved into relaxation very high in point in Sokolov (EI 2.244) and Zimerman (EI 0.524) towards ending in (bar 160).

Timings in 10 different pianists were altered in this segment. Patterns of emotion contours within 4 pianists (*Boyde, Sokolov, Turan, Katchen*) in the Exposition and Recapitulation differed in this Retransition because of the shift in structure.

Decorated in composition colours, the 2nd theme within this musical structure resulted in different affective varieties in performers. The examination of combined shared voice structures allowed the analysis of separated effects of deviations after music had made its way in performance. Separated in time, the contribution from musical structure could result in an explosion of affect as psychological 'Gestalt' explained, music heard is larger than all its parts combined. Emotion Contours of the Retransition (Fig.5.7) contained mirror images of each antecedent and consequent, its voice parts separated in octaves at different elision interventions in this perceptual image may have highlighted effects on affect.

Emotional structures hidden under the 'Gestalt' of *Time* were two important features in the execution of affect and expression in good piano performances. In attracting listeners to perceive extra ordinary performances, skills were required for implementing affective piano deviations. From analyzing differences in structures from these examples (Fig. 5.4) & (Figs. 5.2 & 5.3), modeled applications could be useful when teaching or implying musical affect.

CHAPTER 6

CONCLUSION

6.1 Overview

In conclusion, this analysis has applied interpretation of time in timings and its influence to structure of affect through contours of emotion in the (2nd theme) of the Sonata No.1 in C by pianists. It has defined the meaning of emotions in music with the parameter in ***Time*** and marked differences between expressive performances through a derivative method. Time in musical expeditions have strong prints with their interpretative meaning. Shifts in structure could alter time and thus indirectly infer expressive differences that resulted in new interpretation. In the analysis of musical affection, comparisons between and within pianists in different sections demonstrated emotional markers in music that rendered extra-musical features in different performances. The study of temporal deviations and their translations to emotional measurements have made a valuable contribution to affective piano performance.

6.2 Implication of Research

Effective teaching resulting in markers of distinction in performing candidates can be both tiring and gruesome for some but delightful in others. The expressive art in performing with great interpretation gathered from foundations in empirical knowledge and theories of musical emotions is an ongoing search.

New research on paradigms in piano performance pedagogy concentrating on emotional intelligence (EIt) in piano should be interesting. These programmes should contain music computerization with performing and teaching strategies for efficient affective playing.

6.3 Limitation of Research

A method is considered robust when it can measure something as subjective as musical emotions, quantify it meaningfully, specific and sensitive enough to detect variations as music unfolds in time. Deviations in translational methods were tedious in quantitation even with the aid of modern computers. Better software solutions are needed.

6.4 Suggestion for Future Research

A computerized algorithm to capture all emotional deviations (EI) in piano expression could be solutions to the current research and future development. The complexity in music parameters like dynamics, texture and timbre could be further addressed in the context of musical emotions.

6.5 Conclusion

Inferences through mathematical derived indexes of change in time had significantly demonstrated emotional contours of music expression. I have complied in my study of emotional structures in music through systematic quantification of musical emotions using *one* of its so many parameters, in *TIME*.

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APPENDICES

Appendix A

Structure of the Sonata no.1 in C (1ST Movement) by Johannes Brahms (1833-1897)

Theme	**Symbols**
1st theme	**X**
Fragmented 1st theme (7 species)	**X1**
	X2
	X3
	X4
	X5
	X6
	X7
	X'7
2nd theme	**α**

Section/subsection	**Bars**	**Phrase**	**Description**
EXPOSITION **1ST THEME**	1-16		1st theme
TRANSITION	17-36 Fragmentation Imitation Sequence Modulation Syncopation		1st Theme Transformations X1:
EXPOSITION **2ND THEME**	36-62		A minor Melody motive abcbfedc 2nd theme: **α**
	59-62		Same syncopated melody in arpeggiac contrary motions Sospirando=sighing.
<u>EXTENSION</u>	(63-74)		Section filled with imitations and syncopations.

<u>CODETTA</u>	(75-87)	Faster RH melodic rhythm:Diminution: (86-87) This section ends the exposition.
<u>DEVELOPMENT</u>	(88-152)	C minor: Genius's mettle here long,diverse colourful devices mutated from the Exposition. The appearance of 1st and 2nd themes and their fragments were so beautifully crafted.
<u>RETRANSITION</u>	(153-172)	(153-154) to (157-157). Decorative soprano: Alto (153) to Soprano (154) is altered in 3rds to Alto (157) and Soprano at (158). (161-166) Fragments of 2nd theme, α appears in the LH with RH rippling effect triplets and registrally change at following (163-164). Repetition of (161-162) at (165-166) and 3 imitations at (167-169). (170-171) Change in rhythmic diminution and the triplets are taken over at the descending staccato octaves (172) LH against RH in a cross like rhythm Hemiola.

RECAPITULATION	(173-237)	The return of 1st, X and 2nd theme, α dependent material from the Exposition.
CODA	(238-270)	Varied 2nd theme in contrapuntal texture.
	(250-270)	Varied 1st theme,X.
	Cadenza @ (261-270) towards end	RH rippling triplets on upward motion (257-260). The rippling triplets are taken over at LH in ascending and descending motion with arppeggiated figures ending in chords into the return of the opening 1st theme,X ending in Augmentation of X3.

Appendix B

Score of the Sonata No.1 in C (op.1) by Johannes Brahms (1833-1897)

Peters Edition(1st mvt)

Composer **Brahms, Johannes**

Opus/Catalogue Number **Op.1**

Key **C major**

Movements/Sections 4 movements

I. Allegro

II. Andante

III. Scherzo: Allegro molto e con fuoco

IV. Finale: Allegro con fuoco

Year/Date of Composition **1852–53**

First Performance 17.12.1853

Leipzig: Gewandhaus. Johannes Brahms, piano

First Publication 1853 (December) – Leipzig: Breitkopf & Härtel, Plate 8833, 40 pages.

Peters Edition,1910

Dedication **Joseph Joachim (1831–1907)**

Average Duration 30 minutes

Piece Style **Romantic**

Instrumentation **Piano** (solo)

Sonate

Allegro.

Johannes Brahms, Op. 1. *(1853)*

Edition Peters.

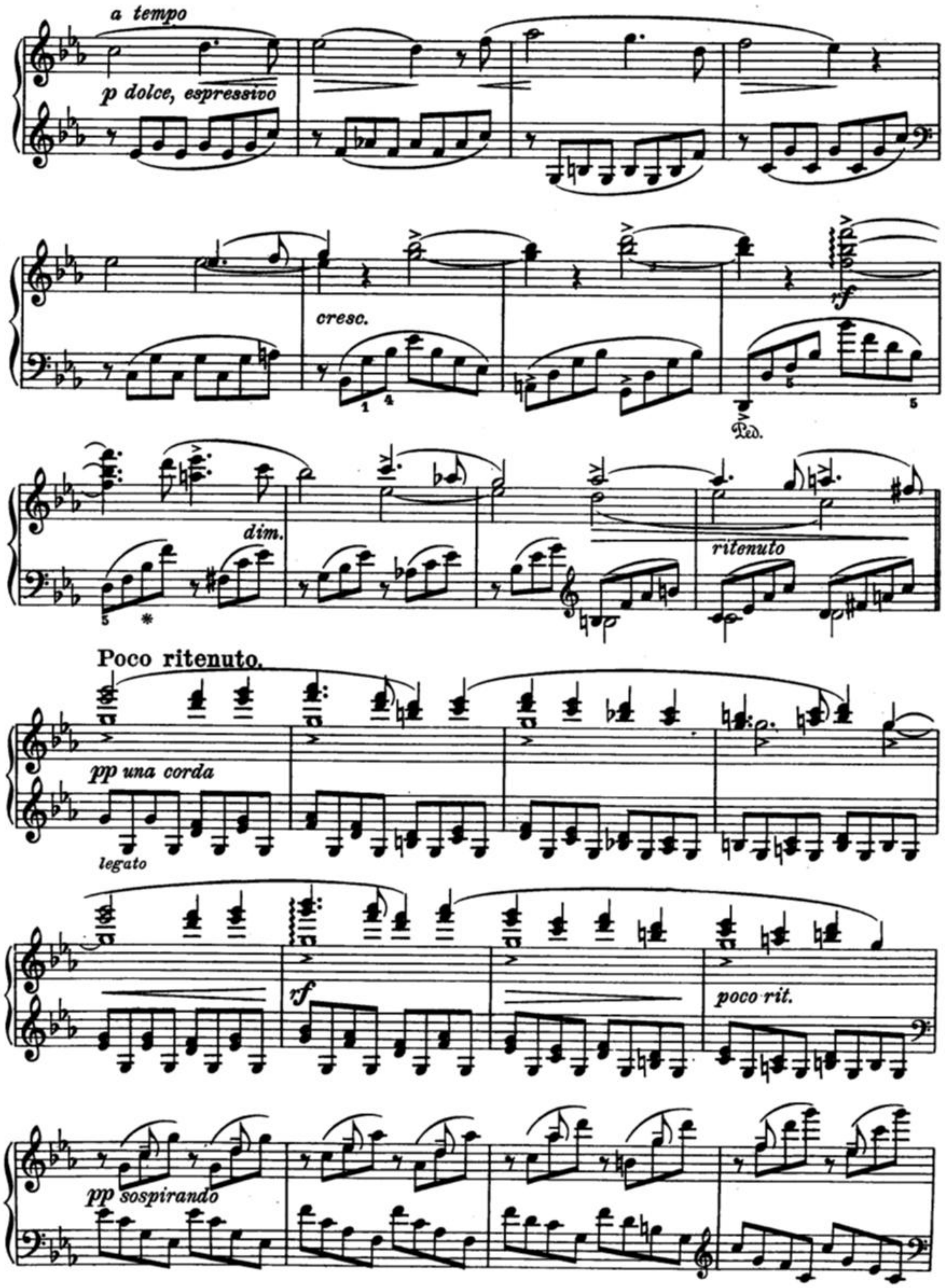

dolce
p
rf
poco sf
p leggiero
sostenuto legato
rit.
pp una corda
legato
pp sostenuto
p
cresc. ed accel.
f brillante
f
dim.

con espressione
p
pp
dim. e rit.
f a tempo
ben marcato
cresc.
ff
sf
ff
marc.
marc.


7
Ped.
ff
ben marcato
marc.
cresc.
sf
dim.
p
Edition Peters.
9487 a


8
pp dolcissimo
portamento ma in tempo
Ped.
sempre dim. e calando
poco rit.
con espressione
p
m. s.
mf
dim.
pp leggiero
legg.
Edition Peters.
9487a


cresc.
Ped.
più f
pesante
ff
ten.
a tempo
tr
ff
sf
sf
ben marcato e sempre ff
f
p
rit.


a tempo
p dolce, espressivo
cresc.
rf
Ped.
dim.
ritenuto
Poco ritenuto.
pp una corda
legato
rf
poco rit.
pp sospirando

Edition Peters. 9487 a


Più facile
ff
largamente

Appendix C
Pictures of 10 Pianists

Appendix D
Tables and Graphs

Table 4.1
Data (Total Time) in ascending order : 4 sections of the Sonata
Performance of 10 pianists :Piano Sonata no1 in C(1st mvt) by Johannes Brahms

PIANIST	EXPO	DEV	RECAP	CODA	total
List	132.354	131.773	107.140	46.963	418.230
Biret	141.926	142.111	109.625	55.184	448.845
JONES	147.757	144.215	112.887	58.261	463.121
Rosel	152.217	146.642	114.394	52.089	465.342
Katchen	155.557	141.504	120.266	53.136	470.463
Zimerman	152.824	**173.235**	115.959	58.289	500.307
Turan	166.186	157.449	133.150	59.447	516.232
Schepkin	169.645	159.290	134.248	60.348	523.530
Boyde	176.444	166.566	134.389	57.778	535.177
Sokolov	195.597	195.808	152.644	71.750	615.799
			Interperformance		
			1)Mean Time		**495.705**
			2)Mean SD		55.794

	JONES	Sokolov	Boyde	Schepkin	Turan	Katchen	Zimerman	Rosel	Biret	List
EXPO	**147.757**	**195.597**	**176.444**	**169.645**	**166.186**	**155.557**	**152.824**	**152.217**	**141.926**	**132.354**
DEV	**144.215**	**195.808**	**166.566**	**159.290**	**157.449**	**141.504**	**173.235**	**146.642**	**142.111**	**131.773**
RECAP	**112.887**	**152.644**	**134.389**	**134.248**	**133.150**	**120.266**	**115.959**	**114.394**	**109.625**	**107.140**
CODA	**58.261**	**71.750**	**57.778**	**60.348**	**59.447**	**53.136**	**58.289**	**52.089**	**55.184**	**46.963**

Worksheet for Table 4.1
Average of 3 observations

	1	2	3	Mean	SD
PIANIST	EXPO	Bars 1-87			
List	132.307	132.348	132.406	**132.354**	**0.050**
Biret	141.967	141.960	141.850	**141.926**	**0.066**
JONES	147.726	147.772	147.772	**147.757**	**0.027**
Rosel	152.179	152.269	152.203	**152.217**	**0.047**
Katchen	155.658	155.573	155.441	**155.557**	**0.109**
Zimerma	152.787	152.783	152.903	**152.824**	**0.068**
Turan	166.162	166.227	166.170	**166.186**	**0.035**
Schepki	169.604	169.656	169.674	**169.645**	**0.036**
Boyde	176.542	176.355	176.434	**176.444**	**0.094**
Sokolov	195.885	195.535	195.370	**195.597**	**0.263**

	1	2	3	Mean	SD
PIANIST	DEV	bars 88-172			
List	131.750	131.820	131.750	**131.773**	**0.040**
Biret	142.060	142.106	142.166	**142.111**	**0.053**
JONES	144.126	144.266	144.254	**144.215**	**0.078**
Rosel	146.611	146.654	146.661	**146.642**	**0.027**
Katchen	141.456	141.497	141.559	**141.504**	**0.052**
Zimerma	173.276	173.171	173.257	**173.235**	**0.056**
Turan	157.448	157.349	157.549	**157.449**	**0.100**
Schepkir	159.398	159.292	159.179	**159.290**	**0.110**
Boyde	166.609	166.534	166.556	**166.566**	**0.039**
Sokolov	195.767	195.791	195.865	**195.808**	**0.051**

	1	2	3	Mean	SD
PIANIST	RECAP	Bars 173-237			
List	107.121	107.100	107.199	**107.140**	**0.052**
Biret	109.621	109.639	109.614	**109.625**	**0.013**
JONES	112.942	112.940	112.780	**112.887**	**0.093**
Rosel	114.358	114.389	114.436	**114.394**	**0.039**
Katchen	120.271	120.219	120.309	**120.266**	**0.045**
Zimerma	115.985	116.002	115.891	**115.959**	**0.060**
Turan	133.095	133.191	133.165	**133.150**	**0.050**
Schepkir	134.249	134.154	134.341	**134.248**	**0.094**
Boyde	134.490	134.328	134.350	**134.389**	**0.088**
Sokolov	152.556	152.694	152.683	**152.644**	**0.077**

	1	2	3	Mean	SD
PIANIST	CODA	Bars 238-270			
List	46.981	46.967	46.942	**46.963**	**0.020**
Biret	55.246	55.135	55.170	**55.184**	**0.057**
JONES	58.256	58.113	58.415	**58.261**	**0.151**
Rosel	52.128	51.954	52.184	**52.089**	**0.120**
Katchen	53.053	53.204	53.150	**53.136**	**0.077**
Zimermar	58.325	58.305	58.236	**58.289**	**0.047**
Turan	59.489	59.340	59.511	**59.447**	**0.093**
Schepkin	60.330	60.328	60.386	**60.348**	**0.033**
Boyde	57.631	57.838	57.864	**57.778**	**0.128**
Sokolov	71.751	71.726	71.773	**71.750**	**0.024**

Comparison studies against the reference in phrases of similar structure

Table 4.3
Comparison Studies in phrases of similar structure: Summary of structure between Exposition and Recapitulation (2nd theme, α)

Theme	Section	Length	No of bars	Key
2nd theme,α	Exposition	Bars 39-62	24bars	a minor
2nd theme,α	Recapitulation	Bars 198-221	24bars	c minor

Worksheet for Table 4.4
Average of 3 observations:
Timing within pianist in structurally similar phrases of the 2nd theme, α at the Exposition (bar39-62) and Recapitulation (bar198-221)

	Bar 39					Bar 62					
PIANIST	**EXPO**			**Mean**	**SD**	**EXPO**			**Mean**	**SD**	**difference**
JONES	67.059	67.087	67.087	**67.078**	**0.016**	110.222	110.221	110.210	**110.218**	**0.007**	**43.140**
Sokolov	85.966	85.919	85.965	**85.950**	**0.027**	143.435	143.390	143.383	**143.403**	**0.028**	**57.453**
Boyde	66.363	66.367	66.482	**66.404**	**0.055**	124.423	124.820	124.804	**124.682**	**0.225**	**58.278**
Schepkir	64.459	64.462	64.420	**64.447**	**0.023**	114.812	114.927	114.921	**114.887**	**0.065**	**50.440**
Turan	66.339	66.548	66.559	**66.482**	**0.124**	113.626	113.670	113.573	**113.623**	**0.049**	**47.141**
Katchen	67.825	67.724	67.796	**67.782**	**0.052**	111.519	111.335	111.492	**111.449**	**0.099**	**43.667**
Zimerma	67.175	67.199	67.174	**67.183**	**0.014**	110.395	110.403	110.342	**110.380**	**0.033**	**43.197**
Rosel	60.743	60.775	60.801	**60.773**	**0.029**	107.240	107.251	107.272	**107.254**	**0.016**	**46.481**
Biret	58.584	58.484	58.501	**58.523**	**0.054**	100.553	100.442	100.456	**100.484**	**0.060**	**41.961**
List	51.293	51.432	51.409	**51.378**	**0.075**	90.790	90.832	90.909	**90.844**	**0.060**	**39.466**

	Bar 198					Bar 221					
PIANIST	**RECAP**			**Mean**	**SD**	**RECAP**			**Mean**	**SD**	**difference**
JONES	485.445	485.360	485.499	**485.435**	**0.070**	528.851	528.830	528.852	**528.844**	**0.012**	**43.410**
Sokolov	645.401	645.423	645.394	**645.406**	**0.015**	703.023	703.039	703.037	**703.033**	**0.009**	**57.627**
Boyde	565.313	565.333	565.287	**565.311**	**0.023**	621.830	621.781	621.759	**621.790**	**0.036**	**56.479**
Schepkir	371.992	372.036	372.116	**372.048**	**0.063**	423.254	423.256	423.248	**423.253**	**0.004**	**51.205**
Turan	536.988	536.940	536.960	**536.963**	**0.024**	585.745	585.759	585.753	**585.752**	**0.007**	**48.790**
Katchen	343.466	343.352	343.415	**343.411**	**0.057**	387.091	387.248	387.080	**387.140**	**0.094**	**43.729**
Zimerma	525.042	525.053	525.024	**525.040**	**0.015**	567.858	567.837	567.877	**567.857**	**0.020**	**42.818**
Rosel	338.384	338.678	338.580	**338.547**	**0.150**	383.218	383.232	383.268	**383.239**	**0.026**	**44.692**
Biret	468.239	468.195	468.193	**468.209**	**0.026**	511.804	511.682	511.722	**511.736**	**0.062**	**43.527**
List	433.047	433.024	433.073	**433.048**	**0.025**	473.731	473.596	473.770	**473.699**	**0.091**	**40.651**

Table 4.4
Timing within pianist in structurally similar phrases of the 2nd theme, α at Exposition and Recapitulation sections

2nd theme	b 39-62	b198-221	
	a minor	c minor	
PIANIST	Exposition	Recapitulation	Ratio
JONES	43.140	43.410	0.994
Sokolov	57.453	57.627	0.997
Boyde	58.278	56.479	1.032
Schepkin	50.440	51.205	0.985
Turan	47.141	48.790	0.966
Katchen	43.667	43.729	0.999
Zimerman	43.197	42.818	1.009
Rosel	46.481	44.692	1.040
Biret	41.961	43.527	0.964
List	39.466	40.651	0.971

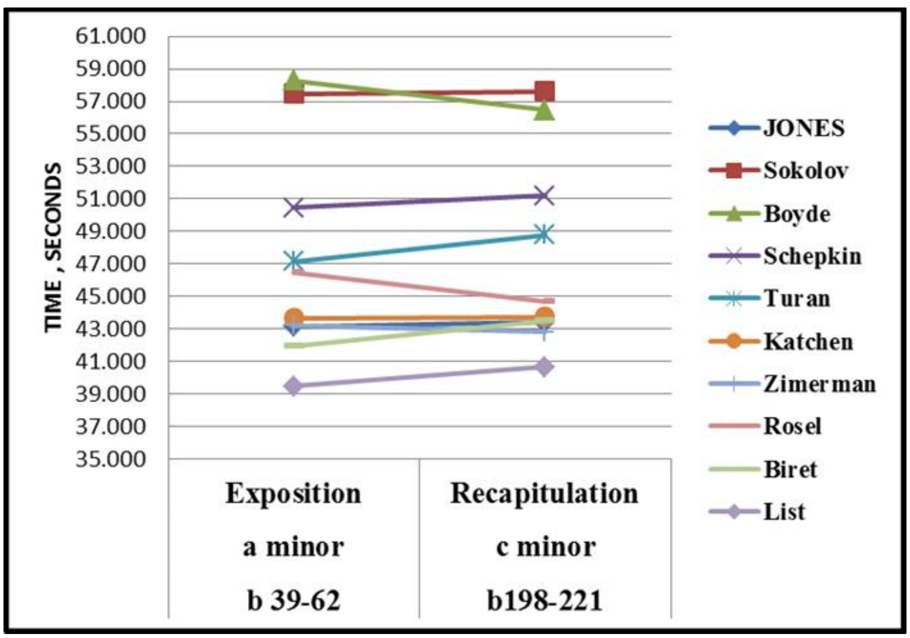


Figure 4.3 Study of time (within pianist) in the (2nd theme,α) at different sonata sections (Exposition, bar 36-62 & Recapitulation, bar 198-221)

Table 5.0
Study of time against identified bars in 10 pianists performing the Development /Retransition sections

BAR	JONES	Boyde	Sokolov	Zimerman	Schepkin	Turan	Rosel	Biret	Katchen	List
88	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
97	17.6	20.8	23.1	17.3	9.315	19.296	16.463	17.485	17.485	17.043
99	21.9	26.0	29.4	21.8	23.611	24.985	21.595	21.177	22.245	21.269
103	28.4	33.5	36.9	29.0	30.624	32.880	28.236	28.189	28.886	27.098
107	33.9	39.9	44.6	35.9	37.009	39.172	33.855	34.041	34.784	32.787
114	44.2	49.5	57.6	46.8	47.806	50.295	43.909	44.675	44.026	42.469
121	53.8	59.4	69.5	58.1	58.325	60.767	53.476	54.312	53.360	52.013
127	63.1	69.4	81.3	68.3	67.752	71.959	63.832	64.412	62.555	60.720
131	67.9	75.6	87.8	74.3	73.348	78.205	69.707	70.357	68.406	66.542
135	73.8	82.0	94.3	80.8	79.850	84.985	76.046	76.719	74.188	71.401
138	80.9	88.1	105.3	89.6	86.746	91.255	83.359	83.569	79.181	76.463
152	108.3	120.5	147.3	131.9	120.229	121.301	114.590	109.668	105.791	99.869
156	115.6	131.1	157.7	141.1	128.147	128.476	121.927	116.379	112.966	106.789
160	123.3	142.3	167.8	149.5	136.344	135.698	128.150	123.484	120.094	114.126
164	130.3	151.1	177.4	157.7	143.565	143.058	134.559	129.707	127.455	120.303
169	139.4	161.3	189.3	167.8	153.457	150.466	142.482	137.277	136.836	127.361
172	144.3	166.4	195.7	172.9	159.143	157.501	146.61	142.292	141.364	131.936

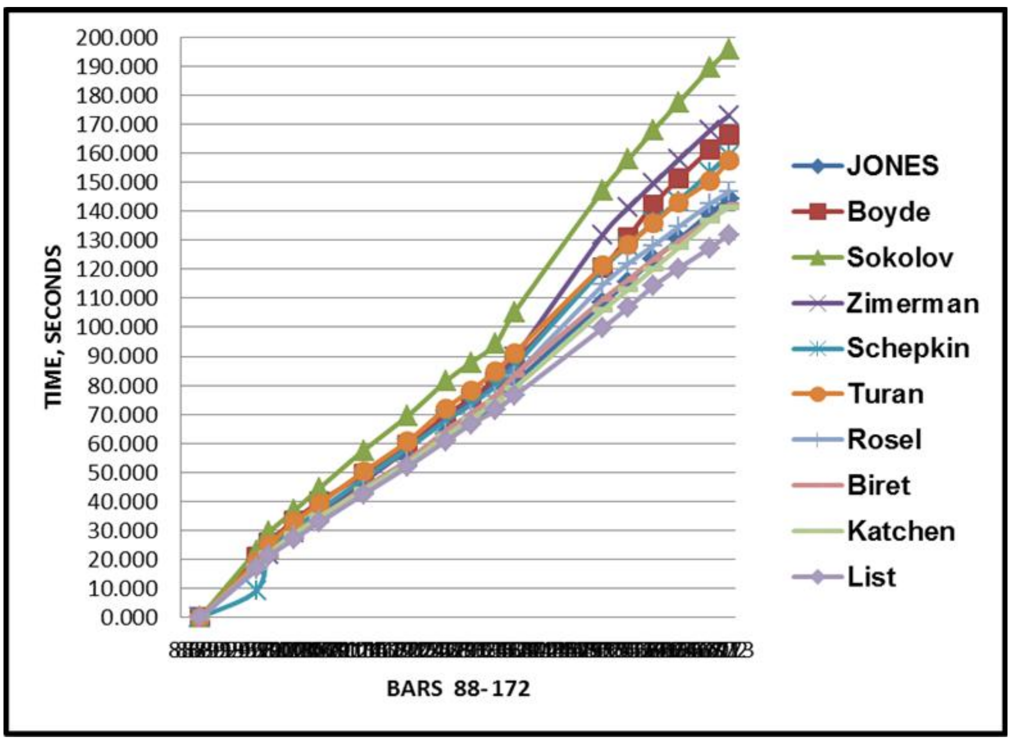


Figure 5.0 Study of time against identified bars in the Development and Retransition sections in 10 pianists

Worksheet for Table 5.0

Average of 3 observations :Timing flow of 4 pianists (bars 88-172) from Development to Retransition sections

x	y1	y1	y1	mean	sd
BAR	JONES				
88	301.404	301.414	301.411	**301.410**	**0.005**
97	317.250	317.408	317.316	**317.325**	**0.079**
100	323.427	323.538	323.539	**323.501**	**0.064**
104	329.789	329.947	329.902	**329.879**	**0.081**
109	337.359	337.470	337.448	**337.426**	**0.059**
115	345.718	345.759	345.784	**345.754**	**0.033**
122	355.354	355.489	355.374	**355.406**	**0.073**
128	364.619	364.614	364.662	**364.632**	**0.026**
132	369.681	369.606	369.770	**369.686**	**0.082**
136	375.463	375.249	375.320	**375.344**	**0.109**
138	378.690	378.732	378.710	**378.711**	**0.021**
153	409.748	409.707	409.778	**409.744**	**0.036**
157	417.700	417.556	417.510	**417.589**	**0.099**
161	424.712	424.893	424.685	**424.763**	**0.113**
165	432.096	431.975	432.046	**432.039**	**0.061**
171	442.336	442.192	442.147	**442.225**	**0.099**
172	446.000	446.001	446.001	**446.001**	**0.001**

x	y2	y2	y2	mean	sd
BAR	Boyde				
88	355.423	355.420	355.435	**355.426**	**0.008**
97	374.046	374.204	374.143	**374.131**	**0.080**
100	382.150	382.215	382.200	**382.188**	**0.034**
104	389.487	389.227	389.515	**389.410**	**0.159**
109	396.964	397.076	397.945	**397.328**	**0.537**
115	405.161	405.133	405.165	**405.153**	**0.017**
122	414.983	414.959	414.964	**414.969**	**0.013**
128	425.362	425.385	425.482	**425.410**	**0.064**
132	431.492	431.492	431.450	**431.478**	**0.024**
136	437.947	437.831	437.905	**437.894**	**0.059**
138	441.523	441.430	441.504	**441.486**	**0.049**
153	476.167	476.144	476.125	**476.145**	**0.021**
157	487.243	487.197	486.922	**487.121**	**0.174**
161	497.971	497.785	497.998	**497.918**	**0.116**
165	506.934	506.934	507.031	**506.966**	**0.056**
171	518.544	518.520	518.548	**518.537**	**0.015**
172	522.120	522.166	522.077	**522.121**	**0.045**

x	y3	y3	y3	mean	sd
BAR	Sokolov				
88	397.179	397.181	397.189	**397.183**	**0.005**
97	417.483	417.497	417.543	**417.508**	**0.031**
100	426.723	426.692	426.645	**426.687**	**0.039**
104	434.734	434.861	434.772	**434.789**	**0.065**
109	444.184	444.195	444.107	**444.162**	**0.048**
115	454.819	454.876	454.881	**454.859**	**0.034**
122	466.986	466.974	466.978	**466.979**	**0.006**
128	478.898	478.770	478.797	**478.822**	**0.067**
132	485.098	485.201	485.136	**485.145**	**0.052**
136	491.623	491.587	491.568	**491.593**	**0.028**
138	496.267	496.185	496.259	**496.237**	**0.045**
153	544.750	544.737	544.765	**544.751**	**0.014**
157	555.245	555.210	555.330	**555.262**	**0.062**
161	565.857	565.891	565.779	**565.842**	**0.057**
165	575.261	575.365	575.230	**575.285**	**0.071**
171	588.775	588.696	588.674	**588.715**	**0.053**
172	592.955	592.991	592.830	**592.925**	**0.085**

x	y4	y4	y4	mean	sd
BAR	Zimerman				
88	307.271	307.251	307.311	**307.278**	**0.031**
97	322.597	322.577	322.474	**322.549**	**0.066**
100	329.702	329.775	329.811	**329.763**	**0.056**
104	336.573	336.685	336.741	**336.666**	**0.086**
109	345.073	345.030	345.044	**345.049**	**0.022**
115	354.338	354.342	354.309	**354.330**	**0.018**
122	365.529	365.577	365.510	**365.539**	**0.035**
128	375.792	375.936	375.950	**375.893**	**0.087**
132	382.341	382.298	382.381	**382.340**	**0.042**
136	388.307	388.312	388.372	**388.330**	**0.036**
138	394.230	394.760	394.321	**394.437**	**0.283**
153	439.648	439.512	439.507	**439.556**	**0.080**
157	448.658	448.754	448.726	**448.713**	**0.049**
161	457.342	457.438	457.477	**457.419**	**0.069**
165	465.539	465.472	465.534	**465.515**	**0.037**
171	477.009	477.051	476.915	**476.992**	**0.070**
172	480.539	480.441	480.374	**480.451**	**0.083**

Table 5.1
Study of time from bars 88-172 in 4 identified pianists

X	Y1	Y2	Y3	Y4
BAR	JONES	BOYDE	SOKOLOV	ZIMERMAN
88	0.000	0.000	0.000	0.000
97	15.915	18.705	20.325	15.272
100	22.092	26.762	29.504	22.485
104	28.470	33.984	37.606	29.389
109	36.016	41.902	46.979	37.771
115	44.344	49.727	57.676	47.052
122	53.996	59.543	69.796	58.261
128	63.222	69.984	81.639	68.615
132	68.276	76.052	87.962	75.062
136	73.934	82.468	94.410	81.053
138	77.301	86.060	99.054	87.159
153	108.335	120.719	147.568	132.278
157	116.179	131.695	158.079	141.435
161	123.354	142.492	168.659	150.141
165	130.629	151.540	178.102	158.237
171	140.815	163.111	191.532	169.714
172	144.591	166.695	195.742	173.174

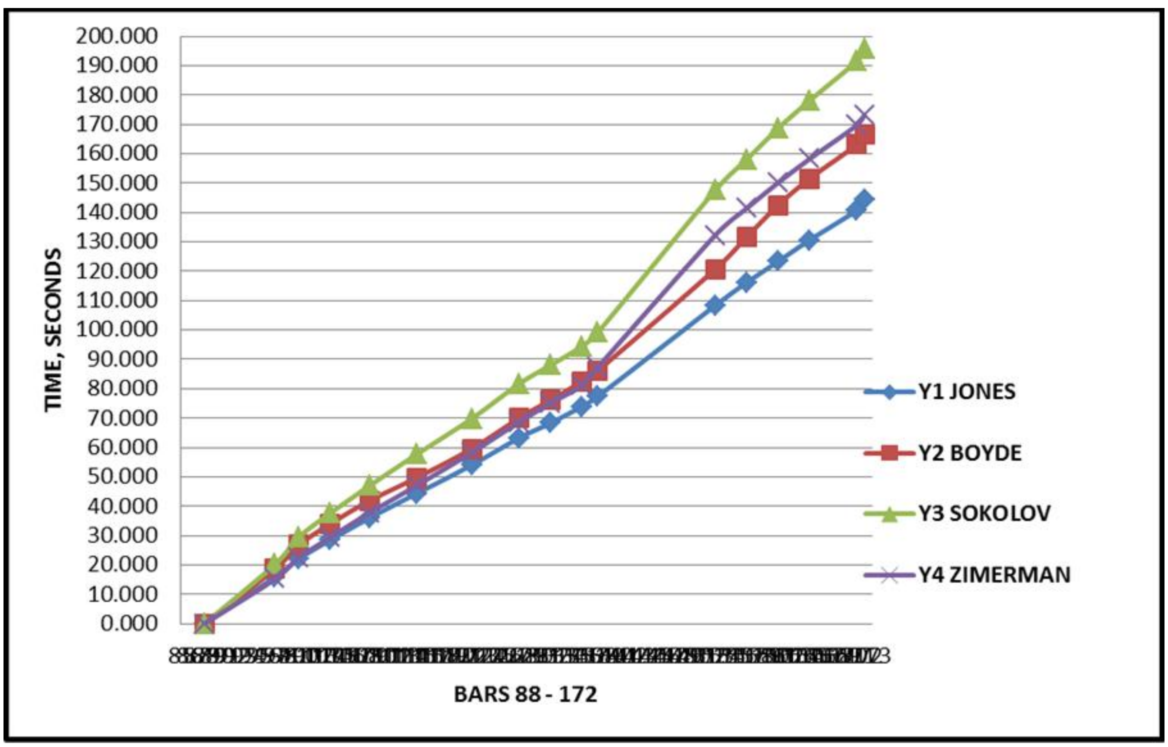


Figure 5.1 Timing flow of 4 pianists from bars (88-172) at Development to Retransition sections

Worksheet for Table 5.2

Average of 3 observations :

Data from bars (43-50) Exposition Section for EI calculation

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR			SOKOLOV					BOYDE			SCHEPKIN	
43	1.741	1.835	1.718	1.765	2.183	2.485	2.252	2.307	1.764	1.742	1.602	1.703
44	2.229	2.159	2.299	2.229	2.136	1.695	1.927	1.919	1.719	1.509	1.649	1.626
45	2.485	2.345	2.276	2.369	2.020	1.880	1.927	1.942	1.462	1.556	1.509	1.509
46	2.159	2.276	2.322	2.252	2.136	2.346	2.299	2.260	1.835	1.718	1.881	1.811
47	1.672	1.649	1.718	1.680	2.113	1.950	2.206	2.090	1.439	1.533	1.37	1.447
48	2.276	2.368	2.252	2.299	2.485	2.345	2.229	2.353	1.51	1.509	1.764	1.594
49	2.275	2.136	2.276	2.229	2.391	2.508	2.322	2.407	2.066	2.020	1.788	1.958
50	4.876	4.714	4.669	4.753	3.367	3.367	3.553	3.429	4.389	4.946	4.784	4.706

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR				TURAN				ROSEL			KATCHEN	
43	1.602	1.533	1.695	1.610	1.718	1.579	1.765	1.687	1.649	1.881	1.719	1.750
44	1.556	1.532	1.510	1.533	1.625	1.742	1.509	1.625	1.462	1.347	1.556	1.455
45	1.602	1.672	1.579	1.618	1.626	1.532	1.533	1.564	1.626	1.370	1.393	1.463
46	2.206	2.206	2.182	2.198	1.973	2.044	1.927	1.981	1.579	1.764	1.602	1.648
47	1.672	1.672	1.649	1.664	1.626	1.718	1.788	1.711	1.764	1.928	1.974	1.889
48	1.555	1.486	1.532	1.524	1.718	1.811	1.765	1.765	1.858	1.625	1.811	1.765
49	1.812	1.950	1.835	1.866	2.183	2.043	2.089	2.105	1.974	2.020	2.043	2.012
50	3.645	3.785	3.715	3.715	3.018	2.949	3.042	3.003	3.529	3.251	3.344	3.375

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR			ZIMERMAN					BIRET				JONES
43	1.718	1.625	1.555	1.633	1.556	1.788	1.463	1.602	1.393	1.533	1.579	1.502
44	1.788	1.788	1.904	1.827	1.370	1.439	1.440	1.416	1.556	1.393	1.370	1.440
45	1.904	1.765	1.742	1.804	1.881	1.579	1.556	1.672	1.672	1.509	1.486	1.556
46	1.904	1.904	1.974	1.927	1.741	2.113	1.904	1.919	1.742	1.834	1.881	1.819
47	1.533	1.626	1.741	1.633	1.394	1.301	1.625	1.440	1.602	1.626	1.556	1.595
48	1.974	1.718	1.695	1.796	1.764	1.579	1.602	1.648	1.509	1.509	1.532	1.517
49	1.602	1.881	1.765	1.749	1.742	1.834	1.742	1.773	1.765	1.788	1.881	1.811
50	2.972	3.088	2.856	2.972	2.693	2.577	2.716	2.662	2.345	2.508	2.508	2.454

					Interperformance	
	1	2	3	Mean	Mean	SD
BAR				LIST	X Group	SD Group
43	1.556	1.486	1.254	1.432	1.699	0.238
44	1.556	1.417	1.417	1.463	1.653	0.264
45	1.347	1.323	1.532	1.401	1.690	0.288
46	1.555	1.765	1.649	1.656	1.947	0.227
47	1.440	1.347	1.556	1.448	1.660	0.206
48	1.718	1.764	1.551	1.678	1.794	0.297
49	1.602	1.579	1.815	1.665	1.958	0.234
50	2.624	2.694	2.439	2.586	3.365	0.821

Table 5.2
Calculation table on Emotion Index (EI) from bars 43-50, for 10 pianists, a selected 8 bar excerpt from the Exposition Section

Pianist	Rosel	Boyde	Sokolov	Zimerma	Schepki	Jones	Turan	Katcher	List	Biret
43	-0.049	2.557	0.276	-0.279	0.016	-0.830	-0.374	0.213	-1.123	-0.407
44	-0.106	1.009	2.184	0.658	-0.105	-0.810	-0.458	-0.752	-0.721	-0.899
45	-0.438	0.878	2.361	0.396	-0.628	-0.466	-0.250	-0.788	-1.005	-0.061
46	0.149	1.377	1.341	-0.088	-0.598	-0.565	1.102	-1.315	-1.280	-0.123
47	0.247	2.083	0.097	-0.127	-1.028	-0.315	0.023	1.110	-1.027	-1.064
48	-0.098	1.884	1.701	0.006	-0.672	-0.934	-0.908	-0.098	-0.391	-0.490
49	0.630	1.920	1.160	-0.890	0.002	-0.625	-0.393	0.234	-1.248	-0.790
50	-0.441	0.077	1.690	-0.479	1.633	-1.110	0.426	0.011	-0.949	-0.857

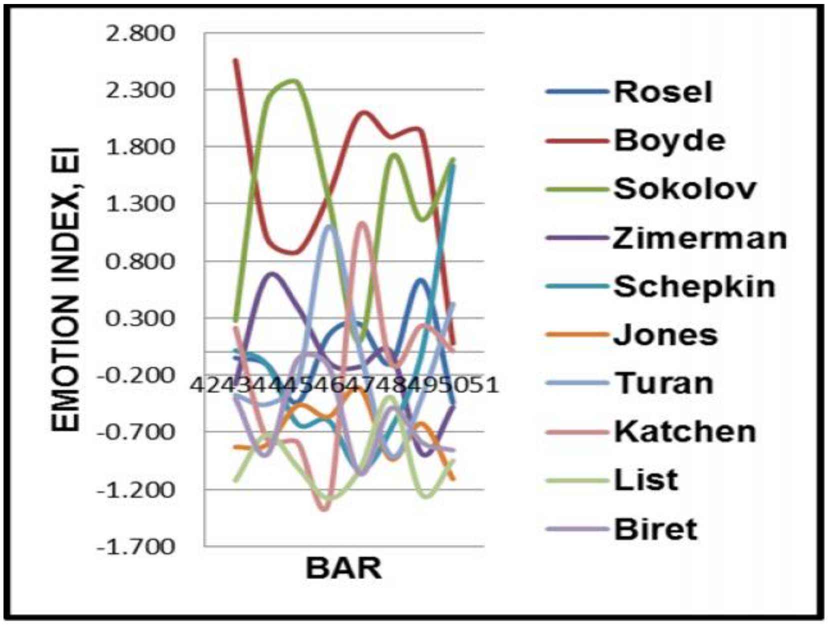


Figure 5.2 Emotion Index at Exposition Section (bar 43-50) in 10 pianists

Worksheet for Table 5.3

Average of 3 observations :

Data from bars (202-209) Recapitulation Section for EI calculation

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR			SOKOLOV					BOYDE			SCHEPKIN	
202	1.718	1.788	1.742	1.749	1.857	2.276	2.462	2.198	1.602	1.695	1.741	1.679
203	2.090	2.136	2.043	2.090	2.044	1.880	1.764	1.896	1.672	1.672	1.579	1.641
204	2.624	2.252	2.555	2.477	2.043	1.835	1.881	1.920	1.671	1.602	1.742	1.672
205	2.809	2.787	2.670	2.755	1.950	2.113	2.044	2.036	1.835	1.811	1.880	1.842
206	1.440	1.811	1.695	1.649	2.137	2.206	2.298	2.214	1.718	1.788	1.672	1.726
207	1.811	1.532	1.625	1.656	2.159	2.066	2.160	2.128	1.672	1.695	1.579	1.649
208	2.415	2.369	2.379	2.388	2.554	2.508	2.392	2.485	2.020	1.951	1.974	1.982
209	4.737	5.038	4.760	4.845	3.181	3.437	3.250	3.289	4.621	4.505	4.574	4.567

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR				TURAN				KATCHEN				ROSEL
202	1.811	1.742	1.788	1.780	1.811	1.695	1.928	1.811	1.579	1.440	1.626	1.548
203	1.417	1.416	1.440	1.424	1.556	1.486	1.370	1.471	1.417	1.463	1.370	1.417
204	1.555	1.602	1.602	1.586	1.393	1.439	1.393	1.408	1.532	1.602	1.532	1.555
205	2.253	2.067	1.950	2.090	1.834	1.695	1.718	1.749	1.927	1.904	1.951	1.927
206	1.857	2.020	2.067	1.981	2.206	2.221	2.229	2.219	1.788	1.811	1.834	1.811
207	2.113	1.649	1.718	1.827	1.672	1.765	1.719	1.719	1.695	1.742	1.718	1.718
208	1.393	1.764	1.835	1.664	1.625	1.811	1.648	1.695	1.974	1.950	2.113	2.012
209	4.013	4.087	3.970	4.023	3.414	3.344	3.413	3.390	3.112	3.112	2.903	3.042

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR			ZIMERMAN					BIRET				LIST
202	1.857	1.997	1.881	1.912	1.649	1.556	1.625	1.610	1.533	1.417	1.555	1.502
203	1.672	1.510	1.625	1.602	1.207	1.393	1.364	1.321	1.253	1.509	1.417	1.393
204	1.765	1.741	1.834	1.780	1.881	1.765	1.742	1.796	1.533	1.463	1.393	1.463
205	2.113	1.997	1.719	1.943	1.927	1.996	2.066	1.996	1.788	1.857	1.881	1.842
206	1.463	1.649	1.904	1.672	1.765	1.765	1.579	1.703	1.579	1.417	1.463	1.486
207	1.741	1.625	1.579	1.648	1.649	1.626	1.695	1.657	1.532	1.672	1.695	1.633
208	1.719	1.718	1.625	1.687	2.043	1.973	1.951	1.989	1.858	1.695	1.764	1.772
209	2.786	2.787	2.763	2.779	2.577	2.717	2.624	2.639	2.763	2.809	2.949	2.840

					Interperformance	
	1	2	3	Mean	Mean	SD
BAR				JONES	X Group	SD Group
202	1.486	1.672	1.764	1.641	1.743	0.203
203	1.486	1.393	1.324	1.401	1.566	0.249
204	1.463	1.486	1.439	1.463	1.712	0.316
205	1.974	1.973	1.928	1.958	2.014	0.279
206	1.556	1.626	1.648	1.610	1.807	0.251
207	1.602	1.532	1.626	1.587	1.722	0.157
208	1.765	1.672	1.625	1.687	1.936	0.298
209	2.484	2.624	2.578	2.562	3.398	0.814

Table 5.3
Calculation table on Emotion Index (EI) from bars 202-209, for 10 pianists, a selected 8 bar excerpt from the Recapitulation Section

Pianist	Rosel	Boyde	Sokolov	Zimerma	Schepki	Jones	Turan	Katcher	List	Biret
202	-0.960	2.244	0.203	0.831	-0.314	-0.505	0.184	0.336	-1.190	-0.656
203	-0.598	1.326	2.104	0.147	0.303	-0.661	-0.567	-0.381	-0.693	-0.981
204	-0.496	0.657	2.421	0.215	-0.128	-0.789	-0.398	-0.961	-0.788	0.266
205	-0.310	0.078	2.656	-0.254	-0.616	-0.199	0.273	-0.949	-0.616	-0.063
206	0.016	1.619	-0.631	-0.538	-0.323	-0.785	0.694	1.639	-1.277	-0.414
207	-0.024	2.588	-0.421	-0.470	-0.468	-0.863	0.666	-0.022	-0.568	-0.417
208	0.256	1.842	1.516	-0.835	0.153	-0.835	-0.914	-0.811	-0.550	0.178
209	-0.437	-0.133	1.815	-0.761	1.437	-1.027	0.769	-0.009	-0.685	-0.932

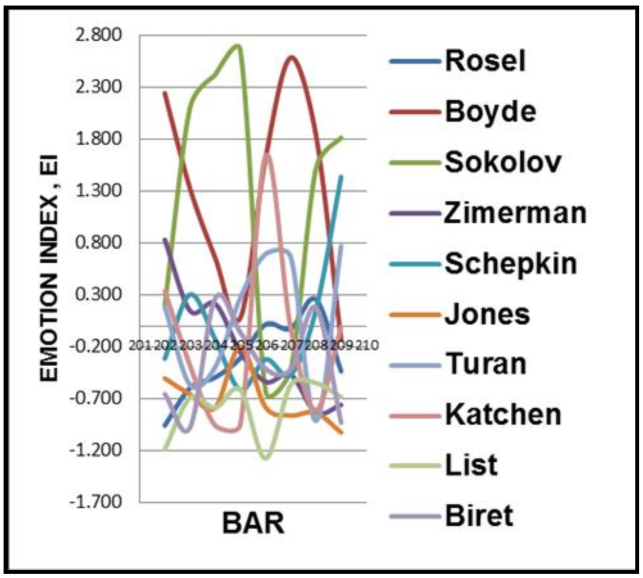


Figure 5.3 Emotion Index at Recapitulation Section (bar 202-209) in 10 pianists

Worksheet for Table 5.4

Average of 3 observations :

Data from bars (153-160)Retransition Section for EI calculation

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR				ROSEL				BOYDE			SOKOLOV	
153	2.647	2.740	2.787	2.725	2.647	2.740	2.787	2.725	2.995	2.879	2.833	2.902
154	2.438	2.368	2.275	2.360	2.438	2.368	2.275	2.360	2.090	2.183	2.139	2.137
155	2.462	2.671	2.624	2.586	2.462	2.671	2.624	2.586	2.438	2.531	2.508	2.492
156	3.283	3.181	3.251	3.238	3.343	3.181	3.251	3.258	2.903	2.995	2.902	2.933
157	3.079	3.042	2.809	2.977	3.019	3.042	2.809	2.957	1.997	1.858	1.904	1.920
158	2.693	2.298	2.531	2.507	2.693	2.298	2.531	2.507	2.252	2.345	2.369	2.322
159	2.206	2.299	2.415	2.307	2.206	2.299	2.415	2.307	3.042	2.995	3.065	3.034
160	3.091	3.204	3.460	3.252	3.088	3.204	3.460	3.251	3.506	3.483	3.297	3.429

	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR				TURAN				KATCHEN				LIST
153	2.066	1.997	2.067	2.043	1.812	1.672	1.927	1.804	1.950	1.835	1.951	1.912
154	1.672	1.742	1.555	1.656	1.741	1.718	1.811	1.757	1.185	1.323	1.347	1.285
155	1.556	1.648	1.719	1.641	1.811	1.765	1.649	1.742	1.486	1.509	1.602	1.532
156	2.206	2.137	2.113	2.152	2.067	2.020	2.020	2.036	2.461	2.206	2.09	2.252
157	1.672	1.672	1.625	1.656	1.695	1.811	1.788	1.765	1.324	1.533	1.439	1.432
158	1.602	1.555	1.649	1.602	1.509	1.533	1.532	1.525	1.382	1.393	1.301	1.359
159	1.672	1.742	1.741	1.718	1.649	1.718	1.695	1.687	1.741	1.811	1.904	1.819
160	2.414	2.415	2.229	2.353	2.461	2.531	2.346	2.446	2.856	2.949	3.018	2.941
	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
BAR				ZIMERMAN				SCHEPKIN				JONES
153	2.647	2.531	2.647	2.608	2.206	2.322	2.136	2.221	2.415	2.253	2.206	2.291
154	2.020	2.043	2.113	2.059	1.858	1.974	1.858	1.897	1.672	1.625	1.695	1.664
155	2.044	2.113	2.113	2.090	1.648	1.602	1.602	1.617	1.649	1.742	1.718	1.703
156	2.740	2.577	2.554	2.624	2.415	2.415	2.508	2.446	2.205	2.136	2.020	2.120
157	1.811	1.951	1.928	1.897	1.858	1.811	1.834	1.834	1.672	1.741	1.927	1.780
158	1.881	1.881	1.834	1.865	1.602	1.532	1.556	1.563	1.579	1.579	1.394	1.517
159	2.206	2.275	2.299	2.260	1.649	1.695	1.556	1.633	1.510	1.719	1.671	1.633
160	2.577	2.833	2.624	2.678	2.647	2.740	3.111	2.833	2.647	2.322	2.322	2.430

					Interperformance	
	1	2	3	Mean	Mean	SD
BAR				BIRET	X Group	SD Group
153	1.695	1.603	1.533	1.610	2.284	0.442
154	1.487	1.602	1.602	1.564	1.874	0.354
155	1.718	1.672	1.625	1.672	1.966	0.432
156	1.997	2.043	2.021	2.020	2.508	0.483
157	1.718	1.672	1.811	1.734	1.995	0.530
158	1.625	1.672	1.579	1.625	1.839	0.439
159	1.858	1.834	1.834	1.842	2.024	0.450
160	2.206	2.252	2.025	2.161	2.777	0.435

Table 5.4
Calculation table on Emotion Index (EI) from bars 153-160, for 10 pianists, a selected 8 bar excerpt from the Retransition Section

Pianist	Rosel	Boyde	Sokolov	Zimerma	Schepkin	Jones	Turan	Katchen	List	Biret
153	0.996	0.996	1.398	0.733	-0.142	0.016	-0.545	-1.086	-0.841	-1.524
154	1.376	1.376	0.745	0.522	0.064	-0.594	-0.615	-0.332	-1.665	-0.877
155	1.433	1.433	1.217	0.287	-0.807	-0.609	-0.752	-0.519	-1.003	-0.681
156	1.513	1.554	0.881	0.240	-0.128	-0.803	-0.737	-0.978	-0.530	-1.010
157	1.852	1.814	-0.142	-0.186	-0.303	-0.406	-0.639	-0.435	-1.062	-0.493
158	1.520	1.520	1.098	0.059	-0.628	-0.733	-0.540	-0.716	-1.094	-0.487
159	0.628	0.628	2.244	0.524	-0.868	-0.868	-0.679	-0.748	-0.456	-0.404
160	1.090	1.088	1.497	-0.228	0.127	-0.797	-0.976	-0.761	0.376	-1.417

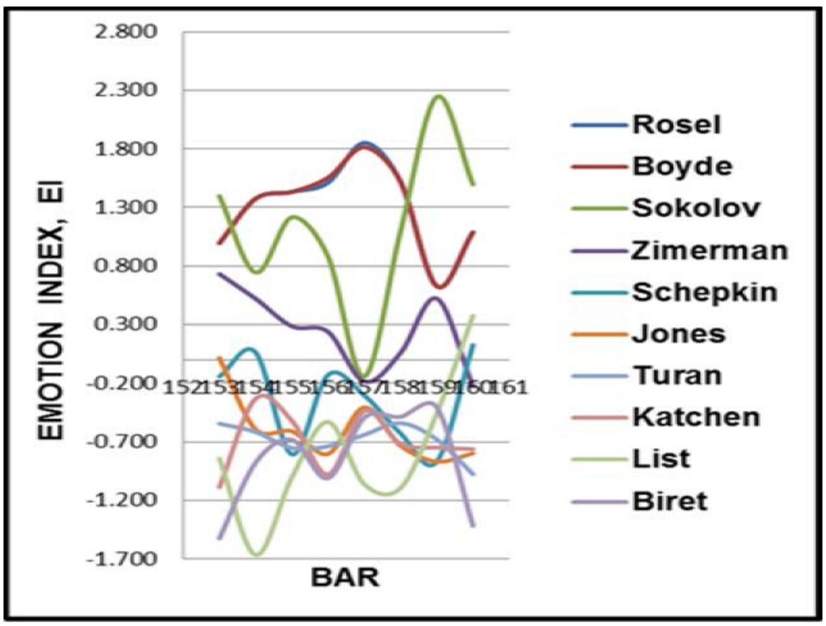


Figure 5.4 Emotion Index at Retransition Section (bar 153-160) in 10 pianists

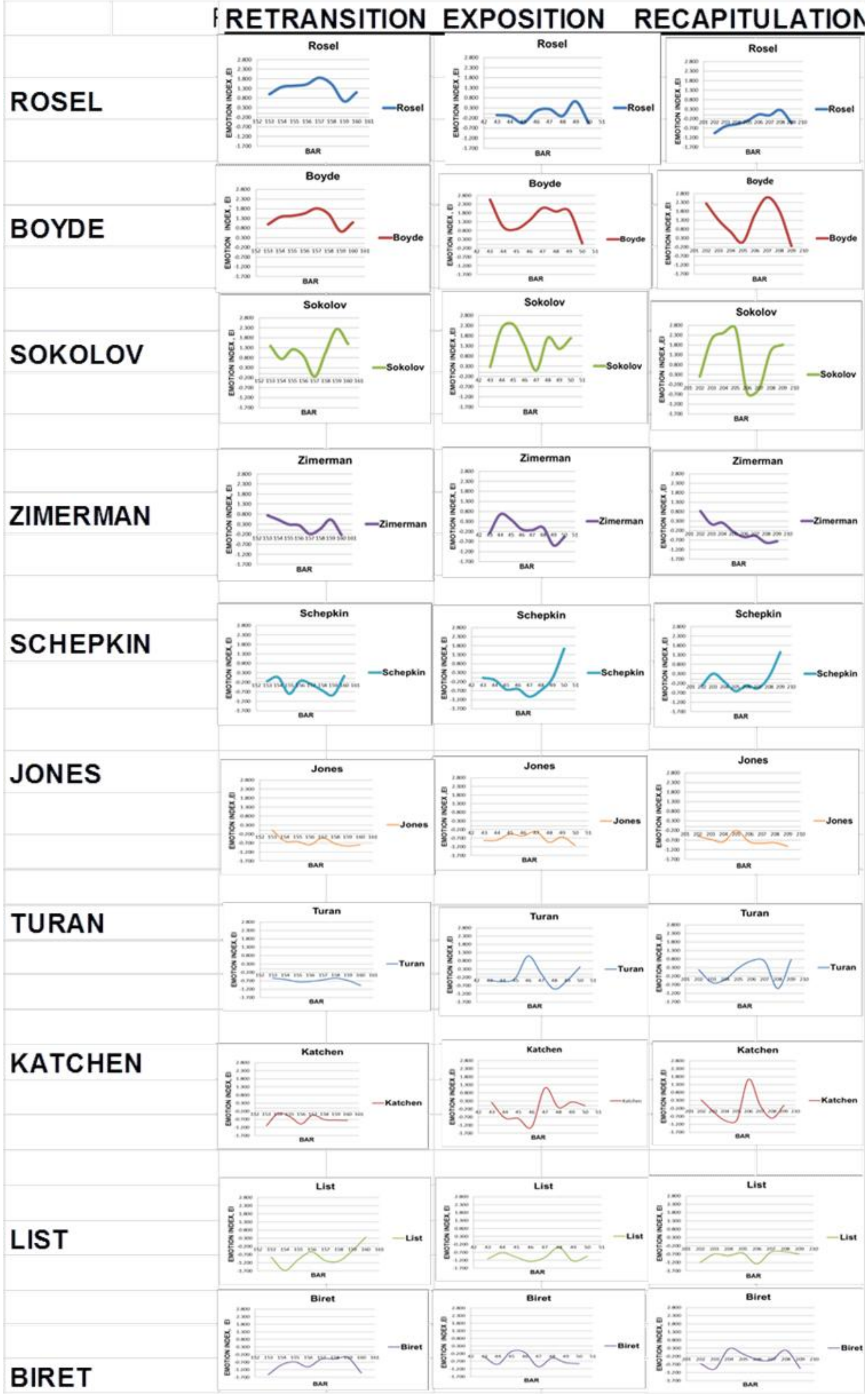


Figure 5.5 Emotion Contour Comparison Studies in 10 pianists