Playing and Composing:

Tuning the Gestures
by Psychophysical Insight into Music
EPARM - Teaching of Music

- teaching to produce MUSIC
- teaching to play MUSIC
- teaching to compose MUSIC

QUESTIONS
- what (concept of ) MUSIC should be taught to be composed and performed?
- what do we mean as MUSIC?
Teaching of Music

• what we do mean as MUSIC?

I do not want to investigate the complexity of this phenomenon

but I directly consider the action of MUSIC in its manifestation without defining what it is
Teaching of Music

• what we do mean as MUSIC?

MUSIC and its ACTION on the human being is the key point of our interest. A wide investigation on it is necessary to teach, play and compose MUSIC with awareness of its potential.
Teaching of Music

• what we do mean as MUSIC?

We assume that good music can modify the psychophysiological asset of the listener roughly according to the purpose of the performer and the composer (if there is one!)
Teaching of Music

- what we do mean as MUSIC?

The student that knows the relationship between MUSIC and its ACTION will be able to compose/perform music according to his desired artistic intentions.
Teaching of Music

- what we do mean as MUSIC?

We try to understand the foundation of this relationship deepening the different forms of the music perception through the knowledge brought from the natural sciences in the last years.
Teaching of Music

• what we do mean as MUSIC?

I think that HME should understand the effectiveness of music even within the meaning brought to light by natural scientific research
Here I want to introduce a new aspect of understanding music. I do not bring any "new pedagogical method", but I will show new possibilities to enrich any pedagogical method.
operative MUSIC concept

we focus the concept of MUSIC on its production and on its listening process
operative MUSIC concept

we focus the concept of MUSIC on its production and on its listening process

• what is music?
• what is music listening (process)?
operative MUSIC concept

• what is music?
  • ordered system of sounds?
  • acoustic artistic expression?
  • communication process?
    » source > music > receiver

• aesthetical process? (what is an aesthetical process?)
  » source >>>>> music <<<<< receiver
operative MUSIC concept

• what is music?
  • ordered system of sounds?
  • acoustic expression of a person?
  • communication process? (natural sciences)
    » source > music > receiver
    • the receiver receives the sound information
  • aesthetical process? (humanities)
    » source >>>>> music <<<< receiver
    • the receiver listens to the music (active!)
operative MUSIC concept

- what is music?
- what is music listening process?
  
  two main opposite forms
  
  - physiological sound perception
  - cultural listening
operative MUSIC concept

• what is music listening process?

• physiological sound perception features
  » immediate reaction to external environment information
  » decoding acoustic information by Short Term Memory (STM)
  » perceiving acoustical structures through experiential time
  » reconstructing the properties of external mass and space concrete

• cultural listening features
  » mediate reflection to a defined ritual (uses/customs)
  » looking for known sound elements and units (blocks)
  » decoding by Long Term Memory (LTM)
  » reconstructing known formal structures abstract
operative MUSIC concept

• what is music listening process?
  – we concentrate our attention to
    • physiological sound perception
      » immediate reaction to external environment information
      » decoding acoustic information by Short Term Memory (STM)
      » perceiving acoustical structures through experiential time
      » reconstructing the features of external mass and space
  – leaving out of our interest of our discussion
    • cultural listening
      » mediate reflection to a defined ritual
      » looking for known sound elements and units (blocks)
      » decoding by long term memory (LTM)
      » reconstructing formal structures
operative MUSIC concept

• what is music listening process?
  – we concentrate our attention to
    • physiological sound perception
      » immediate reaction to external environment information
      » decoding acoustic information by Short Term Memory (STM)
      » perceiving acoustical structures through experiential time
      » reconstructing the features of external mass and space

and we deepen its main characteristics
operative MUSIC concept

• what is music listening process?
  – we concentrate our attention to
    • physiological sound perception
      » immediate reaction to external environment information
        • critical element: INFORMATION
        • critical function: DIFFERENTIAL FEELING
          • we are able to perceive CHANGES
          • CHANGES are the cause of receiving information
          • information stimulates the attention
          • information flow oscillations produce attention
          • peaks of information value active STM processes
operative MUSIC concept

- **what is music listening process?**
  - we concentrate our attention to
    - physiological (neurophysiological) sound perception
      - **immediate reaction** to external environment information
      - **decoding acoustic information** by Short Term Memory (STM)
        - decoding process is based on the parsing function
        - parsing function is possible through PERCEIVING AND DISTINGUISHING (acoustic) STRUCTURES (boundaries)
        - distinguishing structures > boundaries recognition
        - **critical element: INFORMATION PEAKS**
        - INFORMATION PEAKS are normally located in the BOUNDARIES of the sound structures
operative MUSIC concept

• what is music listening process?
  – today we concentrate our attention to
    • neurophysiological sound perception

• the action of music on the listener is strong influenced by the information flow shape (information dynamics) of the music
  • critical element: INFORMATION PEAKS
  • INFORMATION PEAKS are normally located in the BOUNDARIES of the sound structures
operative MUSIC concept

• what is music listening process?
  – today we concentrate our attention to
    • neurophysiological sound perception

• the knowledge of this feature in the music parameters could give to the player/composer crucial behavior hints in playing/composing
  • critical element: INFORMATION PEAKS
  • INFORMATION PEAKS are normally located in the BOUNDARIES of the sound structures
operative MUSIC concept

• what is music listening process?
  – today we concentrate our attention to
    • neurophysiological sound perception

• the awareness of the player/composer on the “information dynamics” of their music allows a targeted gesture management
  • critical element: INFORMATION PEAKS
  • INFORMATION PEAKS are normally located in the BOUNDARIES of the sound structures
operative MUSIC concept

• what is music listening process?
  – today we concentrate our attention to
    • neurophysiological sound perception

• HOW CAN WE TOUCH THIS INFORMATION FLOW?
  HOW CAN WE FEEL THIS INFORMATION FLOW?
  HOW CAN WE SEE THIS INFORMATION FLOW?

• critical element: INFORMATION PEAKS
• INFORMATION PEAKS are normally located in the BOUNDARIES of the sound structures
THE QUESTIONS OF MY RESEARCH
THE QUESTIONS OF MY RESEARCH

1. HOW CAN WE MEASURE INFORMATION FLOW?

2. HOW CAN THIS KNOWLEDGE BE HELPFUL TO PLAY AND COMPOSE?

3. HOW CAN I SHARE THIS KNOWLEDGE TO MUSIC STUDENTS
THE QUESTIONS OF MY RESEARCH

HOW CAN WE MEASURE INFORMATION FLOW?

There are different approaches to the question the most starting from

• informational analysis of music by The Mathematical Theory of Communication related to human brain behaviour

• statistical analysis of music by Hidden Markow Models (HMM) related to computer behaviour
THE QUESTIONS OF MY RESEARCH

HOW CAN WE MEASURE INFORMATION FLOW?

I am oriented to use the model related to the human perception of music and mental decoding processes:

• informational analysis of music by The Mathematical Theory of Communication related to human brain behaviour
THE QUESTIONS OF MY RESEARCH

HOW CAN WE MEASURE INFORMATION FLOW?

I am oriented to use the model related to the human perception of music and mental decoding process

• informational analysis of music by
  The Mathematical Theory of Communication related to human brain behaviour

• measurement of the information content of MUSIC through
  – physical
  – mathematical
  – heuristic

METHODS
WHY INFORMATION FLOW OF MUSIC IS DECISIVE IN MUSIC DECODING PROCESS?

Abraham Moles (1986) hypothesizes in his analysis of the music information content:

1. It is possible, at least statistically, to know how the human operator perceives and reacts to the musical signal as it reaches him through his auditory sense

“L'attitude de base (dans cette analyse) que l'on peut appeler, « informationnelle » ou « structurale » est donc basée sur une hypothèse: il est possible, au moins de façon statistique, de connaître la façon dont l'opérateur humain perçoit et réagit au signal musical tel qu'il lui parvient par son sens auditif de l'environnement.”

WHY INFORMATION FLOW OF MUSIC IS DECISIVE IN MUSIC DECODING PROCESS?

Recent experiments have shown important features of music perception process that give an answer to this question.

2. The Information content of pitch sequences (musical melodies) increase energetic demands of neural activity (2007)

“By systematically varying the entropy of pitch sequences, we sought brain areas where neural activity and energetic demands increase as a function of entropy. Such a relationship is predicted to occur in an efficient encoding mechanism that uses less computational resource when less information is present in the signal: we specifically tested the hypothesis that such a relationship is present in the planum temporale (PT). In two convergent functional MRI studies, we demonstrated this relationship in PT for encoding, ...”

THE QUESTIONS OF MY RESEARCH

WHY INFORMATION FLOW OF MUSIC IS DECISIVE IN MUSIC DECODING PROCESS?

Recent experiments have shown important features of music perception process that give an answer to this question.

3. Phrase boundaries will occur before events for which Information Dynamics (i) and Entropy (h) are high (2008)

“The information content can be interpreted as the contextual unexpectedness or surprisal associated with an event. We propose that boundaries will occur before events for which unexpectedness (h) and uncertainty (H) are high. In addition to the musicological basis, there is a precedent for these ideas in experimental psychology.”

THE QUESTIONS OF MY RESEARCH

WHY INFORMATION FLOW OF MUSIC IS DECISIVE IN MUSIC DECODING PROCESS?

Recent experiments have shown important features of music perception process that give an answer to this question.

4. A information contents based model (Information Dynamics Of Music = IDyOM) identifies segment boundaries before unexpected events (i.e. with high information content) in a melodic sequence (2010)

“we hypothesized a relationship between expectation and grouping in auditory perception. To test this hypothesis, we introduced a new cognitive model of melodic segmentation (IDyOM) derived from an existing cognitive model of pitch expectations based on unsupervised probabilistic learning and information-theoretic prediction (Pearce and Wiggins 2006). The segmentation model identifies segment boundaries before unexpected events in a melodic sequence.”

WHY INFORMATION FLOW OF MUSIC IS DECISIVE IN MUSIC DECODING PROCESS?

Recent experiments have shown important features of music perception process that give an answer to this question.

5. Phrase boundaries have been shown to be perceived before notes with very high information content (2013)

“In this study, analyses were based on a segmentation provided by two music theorists. In future research, segmentation might be also based on the IC itself, since phrase boundaries have been shown to be perceived before notes with very high IC (Pearce, Müllensiefen, & Wiggins, 2010). Furthermore, average IC across a segment might not be representative for all notes within one segment. Individual unexpected notes might also be effective in inducing emotional responses, as was confirmed by preliminary analysis of this data set (not presented here).”

in: Hauke Egermann & Marcus T. Pearce & Geraint A. Wiggins & Stephen McAdams, Probabilistic models of expectation violation predict psychophysiological emotional responses to live concert music, Psychonomic Society, Inc. 2013
now we have an idea of WHY INFORMATION FLOW OF MUSIC IS DECISIVE IN MUSIC DECODING PROCESS

and of HOW CAN WE MEASURE INFORMATION FLOW OF MUSIC

and I show what I am making in order to answer to the second question HOW CAN THIS KNOWLEDGE BE HELPFUL TO PLAY AND COMPOSE?
THE QUESTIONS OF MY RESEARCH

HOW CAN WE MEASURE INFORMATION FLOW OF MUSIC?

HOW CAN THIS KNOWLEDGE BE HELPFUL TO PLAY AND COMPOSE?

My research tries to set up analytical tools that give the possibility of measuring the potential information content of a music piece and its evolution over time. The material of the inquire may be the sound, its symbolic representation in the score, but it can also be reduced to the symbolic representations of the syntactic material identified in the semiological analyses. The goal is to give awareness of the gestures that mainly generate the flow of information.

These analytical tools are aimed at musicians and do not necessarily require advanced mathematical knowledge, but they need to be approached to understand the heuristic evaluation methods that can be undertaken.

What is new is given by the consideration not only of the physical parameters of the sound, but also of the gestures codified in the score, which allows the analysis of the different layers corresponding to different musical parameters (corresponding to different gestures).
THE QUESTIONS OF MY RESEARCH

the last question

HOW CAN I SHARE THIS KNOWLEDGE TO MUSIC STUDENTS?

The student that knows the potential information content of a piece can understand the potential of the musical material for stimulating attention and highlighting musical structures. He can couple this information to certain sound and gestural parameters, and modulate them (emphasising/dissolving) to improve his performance/composition.

The goal of perform/compose music that has the capability to modify the listener's psychophysiological asset is realized through this awareness (to give to the listener effectiveness in structure recognition).

Through the educational activity the analytical approach should accompany the musician in everyday musical life, entering deeply into the practice of playing and composing. The exploration of the potential of the musical material is thus enriched by a conceptual instrument that permeates and supports the skills of the player and of the composer.

Playing and Composing:
Tuning the Gestures by Psychophysical Insight into Music
THE CORE OF MY RESEARCH

APPLICATION IN MUSIC LITERATURE EXAMPLE
PRACTICAL ANALYTICAL EXPERIENCES REALIZED BY THE STUDENTS

In a multi-purpose approach different methodologies are used in a combined way, based mainly on parametrical, semiological and informational analysis.

The hearth of the research is focused on the evaluation/interpretation (mathematical, physical, heuristical) of the dynamic content of musical information of the different systems of signs (score, sound, syntactical units). All that gives hints about the potential reactions of the listener to the corresponding different performative/compositional gestures.

Here I will show some examples from the musical literature:

Bartok, Webern, Chopin, (external pdf file)
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

DURCH DIE PROGRAMMIERTEN INFORMATIONSFLUSSFUNKTIONEN WURDEN DREI STÜCKE AUS VERSCHIEDENEN STILEN ANALYSIERT

1. SARABANDA, AUS DER „PARTITA IN A-MOLL FÜR FLÖTE“ VON J.S. BACH BWV 1013
   MONODISCH
   ES WIRD IN VERSCHIEDENEN UNTERTEILUNG BERÜCKSICHTIGT

2. VARIATIONEN, AUS „MIKROKOSMOS“ FÜR KLAVIER VON B. BARTOK
   MEHRSTIMMIG (BIS 4 STIMMEN)
   ES WIRD IN VERSCHIEDENEN UNTERTEILUNG BERÜCKSICHTIGT

3. BAGATELLE N. 1, AUS „SECH BAGATELLEN FÜR STREICHQUARTETT“ VON A. WEBERN, OP. 9
   MEHRSTIMMIG (BIS 8 STIMMEN)
   ES WIRD NUR ALS GANZES STÜCK BERÜCKSICHTIGT
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
SARABANDA

DIE SARABANDA, AUS DER „PARTITA IN A-MOLL FÜR FLÖTE“ VON J.S. BACH BWV 1013, BESTEHT AUS 46 TAKTEN.

UM DIE INFORMATIONSFLUSSWERTE IM BEZUG AUF IHREN SAMPLEGRÖSSEABHÄNGIGKEIT ZU UNTERSUCHEN HABE ICH DAS STÜCK IN DEN FOLGENDEN FÜNF SAMPLES UNTERGETEILT:

VON TAKT 1 BIS TAKT 9
VON TAKT 1 BIS TAKT 16
VON TAKT 17 BIS TAKT 34
VON TAKT 35 BIS TAKT 46
VON TAKT 1 BIS TAKT 46
ANWENDUNG DER INFORMATIONSFLOUSSFUNKTIONEN

SARABANDA

5 UNTerteilungen

(A) VON TAKT 1 BIS TAKT 9

(B) VON TAKT 1 BIS TAKT 16

(C) VON TAKT 17 BIS TAKT 34

(D) VON TAKT 35 BIS TAKT 46

(E) VON TAKT 1 BIS TAKT 46
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
SARABANDA

INFORMATIONSFLUSS DES ERSTEN SAMPLES
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
SARABANDA
INFORMATIONSFLUSS DES ZWEITEN SAMPLES

Sarabanda aus der Ripartita BWV 1013 B
Johann Sebastian Bach
information flow in bits

Sarabanda aus der Ripartita BWV 1013 B

time in smallest note unit
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

SARABANDA

INFORMATIONSFLUSS DES DRITTEN SAMPLES
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
SARABANDA
INFORMATIONSFLUSS DES VIERTEN SAMPLES

![Graph showing information flow in bits over time for a Sarabanda piece from the Partita BWV 1013 D by Johann Sebastian Bach.](image)
ANWENDUNG DER INFORMATIONSFLOUSSFUNKTIONEN
SARABANDA
INFORMATIONSFLOUSS DES GANZEN STÜCKS
information flow in bits

Sarabanda aus der Ripartita BWV 1013
Johann Sebastian Bach

time in smallest note unit
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN VARIATIONS

DIE VARIATIONEN, NR. 87 AUS „MIKROKOSMOS“ FÜR KLAVIER VON B. BARTOK, BESTEHEN AUS 69 TAKTEN.

UM DIE INFORMATIONSFLUSSWERTE IM BEZUG AUF IHREN SAMPLEGROSSEABHÄNGIGKEIT ZU UNTERSUCHEN HABE ICH DAS STÜCK IN DEN FOLGENDEN ZEHN SAMPLES UTERGETEILT:

(A) VON TAKT 1 BIS TAKT 13
(B) VON TAKT 1 BIS TAKT 20
(C) VON TAKT 21 BIS TAKT 33
(D) VON TAKT 21 BIS TAKT 40
(E) VON TAKT 1 BIS TAKT 40
(F) VON TAKT 41 BIS TAKT 51
(G) VON TAKT 41 BIS TAKT 56
(H) VON TAKT 41 BIS TAKT 61
(I) VON TAKT 41 BIS TAKT 69
(J) VON TAKT 1 BIS TAKT 69
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

10 UNTerteilungen

Variationen A
VON TAKT 1 BIS TAKT 13

Variationen B
VON TAKT 1 BIS TAKT 20

Variationen C
VON TAKT 21 BIS TAKT 33
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
VARIATIONS

10 UNTERTEILUNGEN

Variationen D
VON TAKT 21 BIS TAKT 40

Bela Bartok

Variationen E
VON TAKT 1 BIS TAKT 40

Bela Bartok
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

10 UNTERTEILUNGEN

Variationen F
VON TAKT 41      BIS TAKT 51

Variationen G
VON TAKT 41      BIS TAKT 56

Variationen H
VON TAKT 41      BIS TAKT 61
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

10 UNTERTEILUNGEN

Variationen I

VON TAKT 41 BIS TAKT 69

VON TAKT 1 BIS TAKT 69
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

INFORMATIONSFLUSS DES ERSTEN SAMPLES
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONEN INFORMATIONSFLUSS DES ERSTEN SAMPLES
ANWENDUNG DER INFORMATIONSFUSSFUNKTIONEN
VARIATIONS
INFORMATIONSFUSS DES ZWEITEN SAMPLES

Variationen B

Information flow in bits

Bela Bartók

Allegrò moderato, $q = 112$
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONEN INFORMATIONSFLUS DES ZWEITEN SAMPLES

information flow in bits

Variationen B

Allegro moderato, \( \text{\textit{\textbf{Bela Bartok}}} \)

Musical notation with red circles on measures 10, 20, 30, 40, 50, 60, 70, and 80.
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

INFORMATIONSFLUSS DES DRITTEN SAMPLES
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
VARIATIONS
INFORMATIONSFLUSS DES VIERTEN SAMPLES
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS INFORMATIONSFLUSS DES VIERTEN SAMPLES

Variationen D

Bela Bartók

Più mosso \( \frac{4}{4} \)
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
VARIATIONS
INFORMATIONSFLUSS DES FÜNFTEN SAMPLES

Information flow in bits

Variationen E

Bela Bartók
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONEN INFORMATIONSFLUSS DES FÜNFTEN SAMPLES

Variationen E

Bela Bartok
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

INFORMATIONSFLUSS DES SÄCSHTEN SAMPLES
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONEN

INFORMATIONSFLUSS DES SÄCHSCHEN SAMPLES

information flow in bits

Variationen F

Lo stesso tempo ($=138$), tranquillo

Bela Bartok
ANWENDUNG DER INFORMATIONSFLOUSSFUNKTIONEN

VARIATIONS

INFORMATIONSFLOUSS DES SIPTEN SAMPLES

Variationen G

information flow in bits

Lo stesso tempo ($\frac{\lambda}{4} = 138$), tranquillo

Bela Bartok
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONEN INFORMATIONSFLUSS DES SIPTEN SAMPLES

information flow in bits

Variationen G

Lo stesso tempo (\(J = 138\)), tranquillo

Bela Bartok
ANWENDUNG DER INFORMATIONSFUSSFUNKTIONEN

VARIATIONS

INFORMATIONSFUSS DES ACHTEN SAMPLES
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONEN INFORMATIONSFLUSS DES ACHTEN SAMPLES

Variationen H

Bela Bartok

information flow in bits
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

INFORMATIONSFLUSS DES NEUNTEN SAMPLES

Variationen I

Bela Bartok
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONEN INFORMATIONSFLUSS DES NEUNTEN SAMPLES

Variationen I

Bela Bartok
ANWENDEUNG DER INFORMATIONSFLUSSFUNKTIONEN

VARIATIONS

INFORMATIONSFLUSS DES ZEHNTEN SAMPLES = GANZES STÜCK
ANWENDUNG DER INFORMATIONSFLUSSFUNKTIONEN
BAGATELLE
GANZES STÜCK
ANWENDUNG DER INFORMATIONSFLOSSFUNKTIONEN

BAGATELLE

INFORMATIONSFLOSS DES GANZEN STÜCKS
Information Flow Analysis of

Frédéric Chopin,
Prelude Nr. 4 in E moll
from Preludes op. 28
Time Series Plot: Information flow in bits

Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28

Part 1

Information Flow of all score parameters
Information flow in bits

Time Series Plot: Information flow in bits

Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28

Part 1
Information Flow of all score parameters
with information flow trends

Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28

Prelude 4.1
Op. 28 Frédéric Chopin
Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28

Part 2

Information Flow of all score parameters

Time (in smallest note unit)
Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28

Part 2

Information Flow of all score parameters

with information flow trends
Information Flow of all score parameters

Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28
Part 3

Time Series Plot: Information flow in bits
Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28

Part 3

Information Flow of all score parameters

with information flow trends

Time Series Plot: Information flow in bits

Time (in smallest note unit)
Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28
Information Flow of all score parameters with information flow trends

Frederic Chopin, Prelude Nr. 4 in E minor from Preludes op. 28

Part 4

Information Flow in bits

Time Series Plot: Information flow in bits

Time (in smallest note unit)
with information flow trends

Information Flow of all score parameters

Frédéric Chopin, Prelude Nr. 4 in E moll from Preludes op. 28
THE CORE OF MY RESEARCH

APPLICATION IN MUSIC LITERATURE EXAMPLE
PRACTICAL ANALYTICAL EXPERIENCES REALIZED BY THE STUDENTS

In a multi-purpose approach different methodologies are used in a combined way, based mainly on parametrical, semiological and informational analysis.

The hearth of the research is focused on the evaluation/interpretation (mathematical, physical, heuristical) of the dynamic content of musical information of the different systems of signs (score, sound, syntactical units). All that gives hints about the potential reactions of the listener to the corresponding different performative/compositional gestures.

Here I will show some examples from the musical literature:

Bartok, Webern, Chopin, (external pdf file)

Following two short extracts from the analytic work of the student:

• the first who calculated a value of the information flow of the pitches of a piece of Morton Feldmann and compared it with the articulations of the semiological analysis of the same piece;
• the second one that calculated the information flow of the syntactic units drawn from the semiological analysis of Schumann's 4th Symphony, here in the first movement.
Questi ultimi grafici mostrano come gli elementi di più elevata improbabilità di apparizione
(f, d, e) coincidano, nel grafico dell’asse sintagmatico, ai segnali finali e dunque ai punti
prevalentemente cadenzali e di conclusione fraseologica.

**Conclusioni all’analisi del primo movimento**

In conclusione, tirando le fila del lavoro fatto fino ad ora, ripercorro e sintetizzo brevemente
i passaggi effettuati in questa prima analisi: sono partita da un’intuizione percettiva da
dimostrare empiricamente, quella di un monotematismo di base unito ad un andamento
ciclico degli elementi grammaticali principali, il tutto accompagnato dall’ipotesi di una
costante accelerazione insita nel pezzo.

Dopo aver analizzato il primo movimento a livello formale (inquadrandone soprattutto i
temi, l’andamento dinamico, ritmico e agogico, il tessuto armonico e l’elemento di densità
strumentale), ho diviso e descritto i singoli parametri analizzandone la ricorsività e la
variabilità.

Dopo aver quantizzato il grado di variazione con diversi grafici, ovvero l’elemento di
novità inteso come poca ricorrenza, ho potuto individuare sull’asse sintagmatico i
raggruppamenti, gli andamenti ed infine le funzioni dei diversi elementi grammaticali.
Ricorrenze dei singoli elementi sull’asse sintagmatico:

\[ x^1 = 7 \]
\[ ab = 4 \]
\[ j^1 = 10 \]
\[ g^1 = 6 \]
\[ g^2 = 6 \]
\[ y^1 = 15 \]
\[ c^1 = 5 \]
\[ j = 16 \]
\[ c^2 = 16 \]

Infine il seguente grafico mostra il grado di variazione (ricorrenza e improbabilità di apparizione) dei vari elementi grammaticali:
Abbiamo fin qui quantizzato il grado di variazione, ovvero la novità intesa come poca ricorrenza; tuttavia è da tenere presente che il valore di tale novità è strettamente correlato con l’elemento che lo precede. Questo dato ci fornisce gli strumenti per individuare dei raggruppamenti, degli andamenti e infine per distinguere le funzioni dei diversi elementi grammaticali.

Passiamo quindi ora ad analizzare nel dettaglio le singole funzioni derivanti dalle varie tipologie di segnale (funzione iniziale, finale, interna e di prolungamento):

- Segnali Iniziali e Finali (SI) e (SF) = si trovano come incipit di una sezione o micro sezione e ricoprono sia una funzione iniziale che una funzione finale o conclusiva.

- Segnali Interni o di contenuto (SIn) = si trovano all’interno di sezioni e danno origine a varianti individuate lungo lo svolgimento della composizione.
Dall’unione infine dell’asse sintagmatico e del grafico che ci ha fornito il grado di variazione degli elementi grammatical, ne consegue un ulteriore grafico mostrante un'accelerazione progressiva analoga a quella riscontrata nel primo movimento:
La parte $e$, prolungamento della chiusura spande dalla misura 88 alla misura 101. Questa parte ha una *relexing* funzione grazie alla stasi delle prime 6 misure, in cui le stesse quattro unità si ripetono:

$m. 88 - 93: \{2-AA, 2N, 2-T, 2-S\} + \{2-AA, 2N, 2-T, 2-S\}$

Nella misura 95 si verifica lo stesso gesto di chiusura appena citata dalle misure 84 e 64. Tra queste tre trasformazioni dello stesso elemento, rimane tutte le unità uguali tranne la prima nota di acciaccatura e l’accordo finale:

prima acciaccatura + \{2-C, 2-H, 2-D\} + accordo lungo

Finalmente termina la parte $e$ con un forte elemento di chiusura, vale a dire la doppia occorrenza delle note corte nella mano sinistra.

La chiusura della macro-sezione, 0-A, è affermato anche dall’analisi del flusso di informazione. Per definire questo parametro, partiamo dalla formula per l’entropia, $H$, usata da J. E. Youngblood:

$H = -(p_1 \log_2 p_1 + p_2 \log_2 p_2 + ... + p_n \log_2 p_n)$

dove $p_n$ rappresenta la probabilità di occorrenza dell’unità $n$.

$p_n = \frac{occorrenze dell’unità n}{occorrenze di tutte le unità}$

I $\log$ hanno un base di 2 per riflettere i due stati possibili (occorrente o non occorrente) di ogni unità. Con questa espressione si intende che il livello di informazione sia proporzionale alla imprevedibilità della occorrenza di una data
unità—quindi la regolarità della distribuzione probabilistica tra tutto ciò che appare affatto.

Per normalizzare il valore, questa espressione viene divisa da \( H_r \), l’entropia relativa, ovvero il massimo livello di informazione possibile se la probabilità fosse distribuita ugualmente tra tutte le unità:

\[ H_r = \log_2 n \]

Finalmente, essendo una misura statica l’entropia, includiamo una emivita, \( \lambda \), che rappresenta più o meno la velocità con cui gli eventi passati sono dimenticati dall’ascoltatore. Un’emivita di 25 misure va bene per i nostri dati. Questa significa che le occorrenze lontane da 25 misure hanno una metà l’influenza sul calcolo della probabilità di occorrenza riferita a un dato punto.

In somma, il livello di informazione \( I_m \) in una misura \( m \) sarà definito secondo le seguenti funzioni:

\[
P_m = \sum_d (O_{m+d} 0.5^{d/\lambda}) / O_t \quad \text{dove} \quad O_{m+d} \quad \text{significa le occorrenze di un’unità a distanza} \quad d \quad \text{dalla misura} \quad m, \quad \text{e} \quad O_t \quad \text{è l’occorrenze di tutte le unità}
\]

\[
I_m = -(p_{1m} \log_2 p_{1m} + p_{2m} \log_2 p_{2m} + \ldots p_{nm} \log_2 p_{nm}) / H_r
\]

Da queste formule risulta il grafico sulla pagina successiva. Il livello di informazione arriva ad un picco locale verso la misura 101. Questo da conferma all’ipotesi che il segno 0-A chiude a quel punto. Poi il livello di informazione comincia a diminuire durante il prolungamento della chiusura, che costituisce un riassunto di molte delle unità di chiusura usate in precedenza. Questa tendenza relaxing continua durante il segno 0-B (m. 120 - 163) che secondo il nostro modello sarebbe la parte \( b \) sul livello 0. La sensazione di riposo come risposta al tensing di 0-A è dovuta sopra tutta a la regolarità metrica e la ridondanza relativa di questo segno.

Nelle seguenti due pagine si trova il grafico del flusso di informazione, e poi un riassunto del analisi finora di 0-A, m. 1 - 119.
Flusso di informazione per misura

- 0-A, m. 1 - 101
- Prolungamento di chiusura e 0-B, m. 102 - 171
- 0-A', ricorrenza di tensing, m. 172 - 286
- 0-C, chiusura, m. 287-341
- O-D, prolungamento di chiusura, m. 342-437
THE CORE OF MY RESEARCH

EFFECTIVE SHARING AND TEACHING OF THE METHODOLOGY AND ITS INSIGHT IN THE MUSICAL ACTION

finally I show some aspects and impressions of my teaching practice of this vision of music

• countless opportunities for informational and syntactic evaluations on the compositional technique of writing (in the draft phase) during decades of lessons, the result of which remains in the trace of the compositional works revised according to the perceptual principles exposed;
• countless opportunities for informational and syntactical evaluations on the performing technique during chamber music sessions and rehearsals, which leave a trace in the awareness of the performers and more clarity and expressive intention in the performances.
• all this in the consideration of music as an art that modifies the psychological state of the listener:
  - the clearer the means is (stimulus generation),
  - the more effective the result (change of the listener's attitude)
THE WHISH OF MY RESEARCH

I HOPE
I HAVE INFORMED YOU ABOUT INFORMATION
AND
I HAVE AWEAKENED YOUR ATTENTION
ON THE ATTENTION GENERATED BY INFORMATION

THANK YOU FOR YOUR ATTENTION!

Playing and Composing:
Tuning the Gestures by Psychophysical Insight into Music

giorgio tedde