

Ligeti's Combinatorial Tonality



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Étude 1: Désordre

Musical score for Etude 1: Désordre, page 116. The score consists of two staves. The top staff is in treble clef and the bottom staff is in bass clef. Both staves have a key signature of four sharps. The time signature is 8/8, indicated by a circled '8'. The tempo is marked as '116'. The dynamics are 'f' (fortissimo) and 'p' (pianissimo). The score features six measures of music. Measure 1: Treble staff has a note with a '1' above it, followed by a grace note with a '3' above it. Bass staff has a note with a '1' above it, followed by a grace note with a '2' above it. Measure 2: Treble staff has a note with a '1' above it, followed by a grace note with a '3' above it. Bass staff has a note with a '1' above it, followed by a grace note with a '2' above it. Measure 3: Treble staff has a note with a '1' above it, followed by a grace note with a '3' above it. Bass staff has a note with a '1' above it, followed by a grace note with a '2' above it. Measure 4: Treble staff has a note with a '1' above it, followed by a grace note with a '3' above it. Bass staff has a note with a '1' above it, followed by a grace note with a '2' above it. Measure 5: Treble staff has a note with a '1' above it, followed by a grace note with a '3' above it. Bass staff has a note with a '1' above it, followed by a grace note with a '2' above it. Measure 6: Treble staff has a note with a '1' above it, followed by a grace note with a '3' above it. Bass staff has a note with a '1' above it, followed by a grace note with a '2' above it.

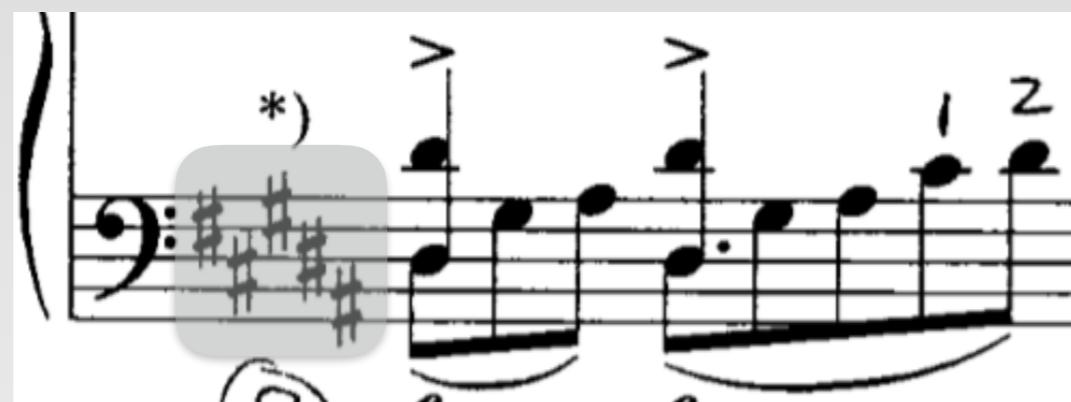
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Étude 1: Désordre

right hand on white keys



Étude 1: Désordre



left hand on black keys

Étude 1: Désordre diatonic

white key / black key system

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"I am trying to develop a harmony and melody which are no genuine return to tonality, which are neither tonal nor atonal but rather something else, above all in connection with a very high degree of rhythmic and metric complexity."

—Ligeti, quoted from Bossin 1984

Introduction

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“I am trying to develop a harmony and melody which are no genuine return to tonality, which are neither tonal nor atonal but rather something else, above all in connection with a very high degree of rhythmic and metric complexity.”

—Ligeti, quoted from Bossin 1984

The allocation to each hand of different but complementary scales gives to these pieces what one might call their own '**combinatorial tonality**' (i.e. the illusion of a third or resultant tonality created from the combination of the other two).

—Steinitz (2003)



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Étude 10: Der Zauberlehrling

Musical score for Étude 10, featuring two staves of piano music. The top staff begins at measure 67, marked *cresc. poco a poco*, leading into measure 15 where it is marked *pp*. The bottom staff begins at measure 15, marked *poco a poco tre corde*. The score consists of two staves, one for each hand, with various dynamics and performance instructions.

white key / black key system

Musical score for Ligeti's Combinatorial Tonality, featuring a single staff of piano music. The score is highly rhythmic and melodic, with many grace notes and dynamic markings like *f p*. Measures are numbered 1 through 13. The score is presented in a minimalist style with a white background.

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Piano Concerto I

Musical score for Piano Concerto I, showing two staves in 12/8 time. The top staff is in C major (G clef) and the bottom staff is in G major (C clef). The music consists of eighth-note patterns with dynamic markings like *mf*, *pp*, and *mf*. Measure 10 is highlighted with a gray oval. The score includes performance instructions such as "sim." and ">)" above notes.

Dorian hexachord [023579] system

Close-up of a musical score showing a Dorian hexachord [023579] system. The top staff is in A major (F# clef) and the bottom staff is in E major (B clef). The score shows six-note chords with dynamic markings like *f* and *p*. Measures 10 and 11 are highlighted with gray ovals.

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Étude 11: En Suspens

Musical score for piano, page 18, showing two staves of music. The top staff starts with a dynamic ***pp***. Above the staff, there are two slurs with arrows pointing right, indicating a melodic line. The bottom staff also starts with a dynamic ***pp***. Above the staff, there is a dynamic ***p*** followed by ***pp***. The music consists of eighth-note patterns with various slurs and grace notes. The instruction ***non arp.*** appears above the top staff, and ***non arp.*** appears above the bottom staff. The instruction ***< p*** is placed below the bottom staff, and the instruction ***pp*** is placed below the bottom staff, aligned with the end of the measure.

Guidonian system

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Étude 12: Entrelacs

A musical score for piano featuring two staves. The top staff is in common time (indicated by 'C') and the bottom staff is in 12/16 time (indicated by '12/16'). The key signature is one flat. The music consists of eighth-note patterns. Dynamic markings include *mf*, *pp*, *sim.*, and *con ped.*. Articulation marks like dots and dashes are also present. The score is framed by a large, thin-lined bracket at the top and bottom.

Guidonian system

A musical score for piano in 11/16 time, indicated by '11/16' above the staff. The key signature is one flat. The music features eighth-note patterns with dynamic markings like *f* and *p*. Articulation marks are present. The score is framed by a large, thin-lined bracket at the top and bottom.

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Étude 7: Galamb Borong

Musical score for Étude 7: Galamb Borong. The score consists of two staves. The top staff is in treble clef and the bottom staff is in bass clef. Both staves are in B-flat major (two flats). Measure 7 begins with a dynamic of *pochissimo cresc.* followed by a decrescendo (dashed line) leading to a forte dynamic (**p**). The instruction "tre corde" is written below the bass staff. The score features eighth-note patterns and grace notes.

whole-tone system

Musical score for Ligeti's Combinatorial Tonality, titled "Introduction". The score consists of two staves. The top staff is in treble clef and the bottom staff is in bass clef. Both staves are in B-flat major (two flats). The score features complex rhythmic patterns with sixteenth-note figures and grace notes. The instruction "f p" (fortissimo, piano) is repeated several times. Measure numbers 1, 2, 3, and 4 are indicated above the staves.

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Violin Concerto V

A

Oboe (Ob.)
Bassoon (Bass.)
Violin solo (Vln. solo)
Viola (Va.)
Cello (Vcl.)

with fear, as if screaming
mit Angst, gleichsam schreiend, ferocie

al talone

poco cresc.

poco cresc.

mp espr. dim.

mp espr. dim.

ff (semperf)

ff (semperf)

ff (semperf)

ff (semperf)

separate bowing, legato
Strich für Strich, legato
con sord., punta d'arco
sim.

pp leggiero

whole-tone system

Introduction

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Properties of intra- and inter-harmonies

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Lewin's interval function

$$\text{IC}_{A,B}(k) = \text{IFUNC}(A, B)(k) = \#\{(a, b) \in A \times B, b - a = k\}$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Lewin's interval function

$$\text{IC}_{A,B}(k) = \text{IFUNC}(A, B)(k) = \#\{(a, b) \in A \times B, b - a = k\}$$

$$\text{IC}_{\{0,2\}, \{1,3\}} = (0, 2, 0, 1, 0, 0, 0, 0, 0, 0, 1)$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Lewin's interval function

$$\text{IC}_{A,B}(k) = \text{IFUNC}(A, B)(k) = \#\{(a, b) \in A \times B, b - a = k\}$$

$$\text{IC}_{\{0,2\},\{1,3\}} = (0, 2, 0, 1, 0, 0, 0, 0, 0, 0, 1)$$

$$\text{IC}_{A,A} = \text{IC}_A$$

$$\text{IC}_{\{0,2,4,5,7,9,11\}} = (7, 2, 5, 4, 3, 6, 2, 6, 3, 4, 5, 2)$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

intra-harmonies

$$A_{\text{intra}} = \text{IC}_A + \text{IC}_{\bar{A}}$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

intra-harmonies

$$A_{\text{intra}} = \text{IC}_A + \text{IC}_{\bar{A}}$$

$$W = \{0, 2, 4, 5, 7, 9, 11\}$$

$$W_{\text{intra}} = \text{IC}_W + \text{IC}_{\bar{W}}$$

$$W_{\text{intra}} = (7, 2, 5, 4, 3, 6, 2, 6, 3, 4, 5, 2) + (5, 0, 3, 2, 1, 4, 0, 4, 1, 2, 3, 0)$$

$$W_{\text{intra}} = (12, 2, 8, 6, 4, 10, 2, 10, 4, 6, 8, 2)$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

inter-harmonies

$$A_{\text{inter}} = \text{IC}_{A,\bar{A}} + \text{IC}_{\bar{A},A}$$

$$A_{\text{inter}} = 2 \cdot \text{IC}_{A,\bar{A}}$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

inter-harmonies

$$A_{\text{inter}} = \text{IC}_{A,\bar{A}} + \text{IC}_{\bar{A},A}$$

$$A_{\text{inter}} = 2 \cdot \text{IC}_{A,\bar{A}}$$

$$W = \{0, 2, 4, 5, 7, 9, 11\}$$

$$W_{\text{inter}} = 2 \cdot \text{IC}_{W,\bar{W}}$$

$$W_{\text{inter}} = 2 \cdot (0, 5, 2, 3, 4, 1, 5, 1, 4, 3, 2, 5)$$

$$W_{\text{inter}} = (0, 10, 4, 6, 8, 2, 10, 2, 8, 6, 4, 10)$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

The combination of intra-harmonies and inter-harmonies
yields the interval content of the aggregate.

$$A_{\text{intra}} + A_{\text{inter}} = \text{IC}_{\mathbb{Z}_n} = (n, \dots, n)$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

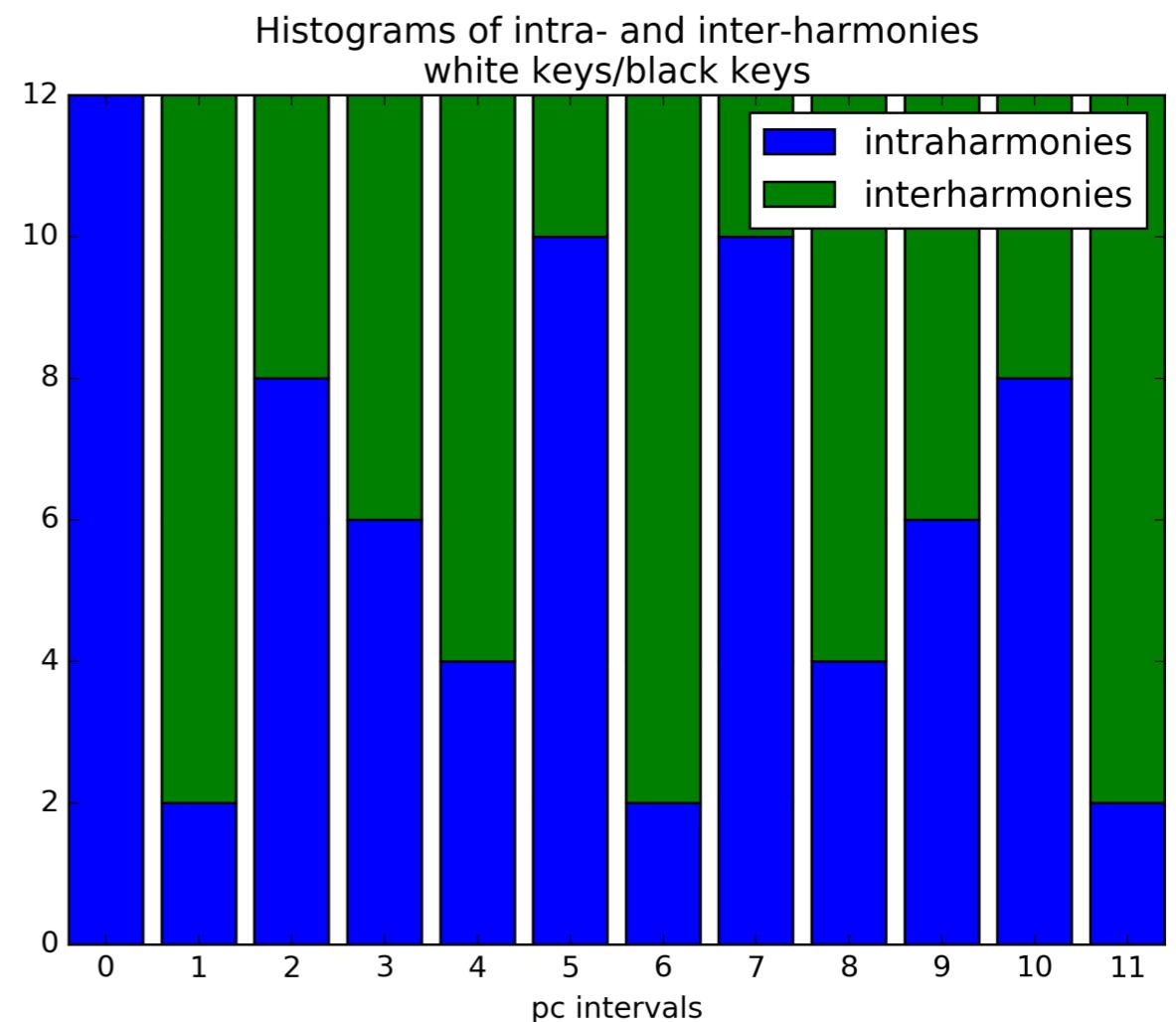
Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

$$A_{\text{intra}} + A_{\text{inter}} = \text{IC}_{\mathbb{Z}_n} = (n, \dots, n)$$

white key/black key system



$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

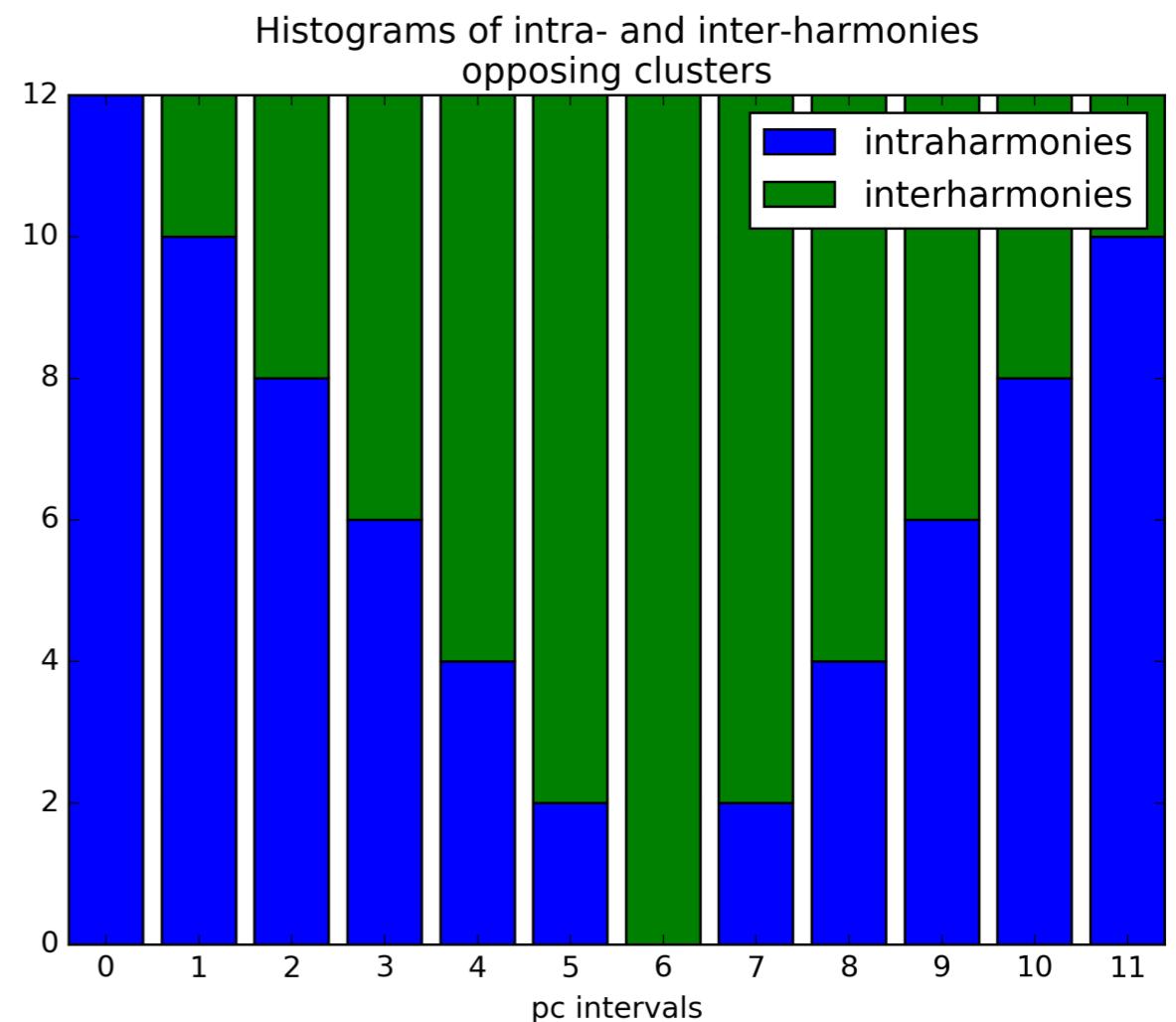
Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

$$A_{\text{intra}} + A_{\text{inter}} = \text{IC}_{\mathbb{Z}_n} = (n, \dots, n)$$

opposing six-note clusters



$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

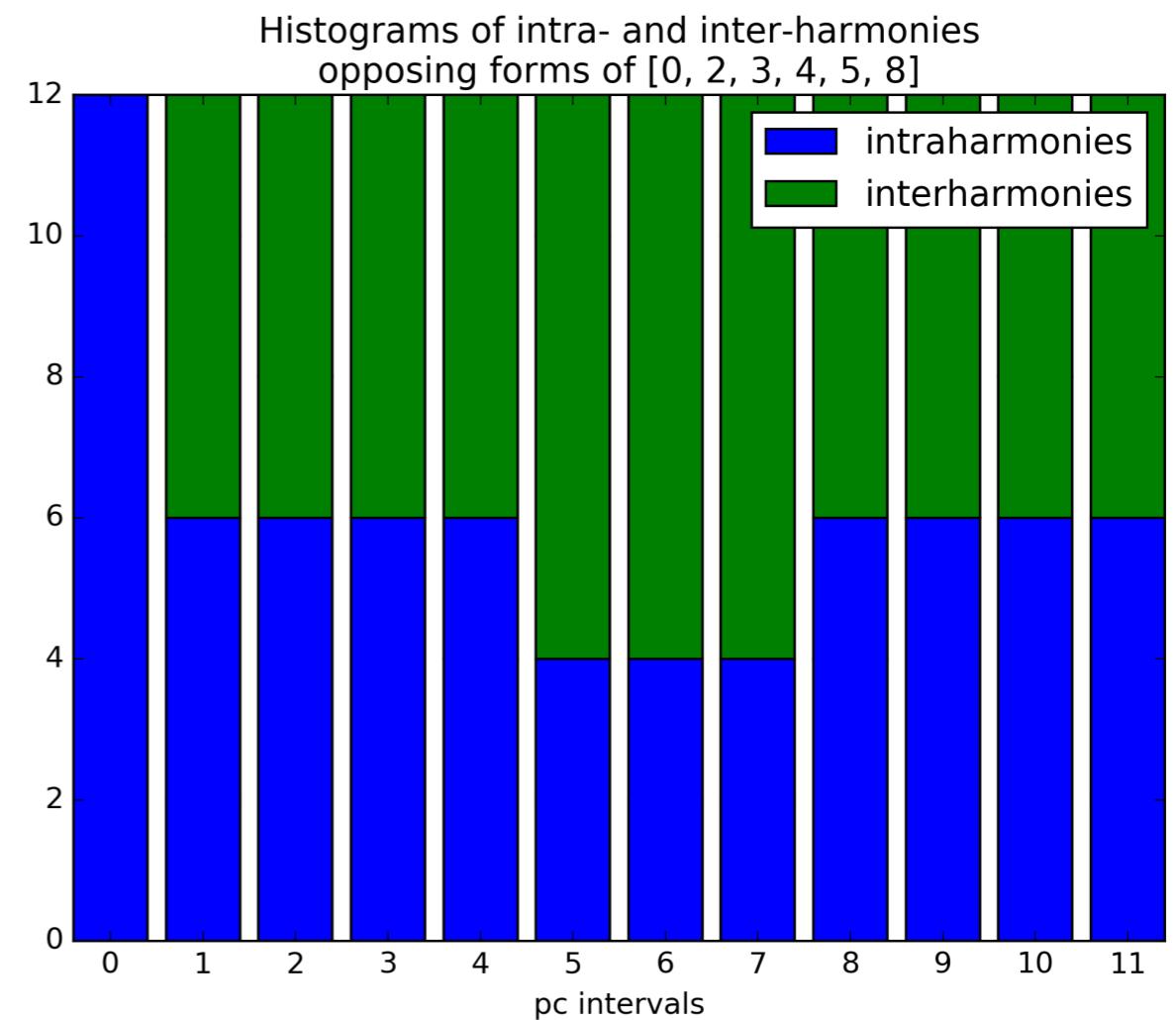
Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

$$A_{\text{intra}} + A_{\text{inter}} = \text{IC}_{\mathbb{Z}_n} = (n, \dots, n)$$

opposing $[0, 2, 3, 4, 5, 8]$



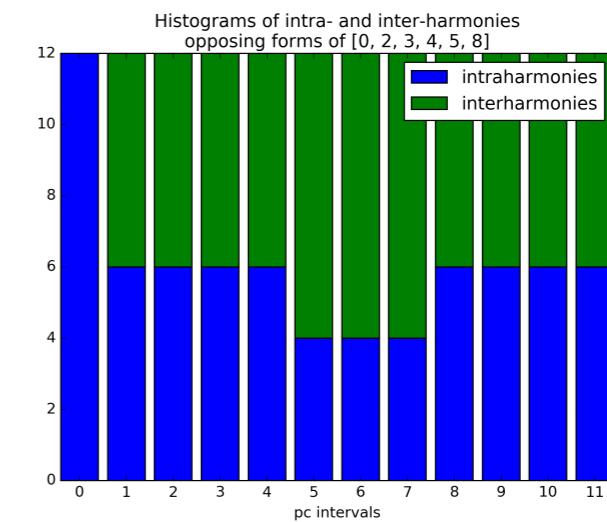
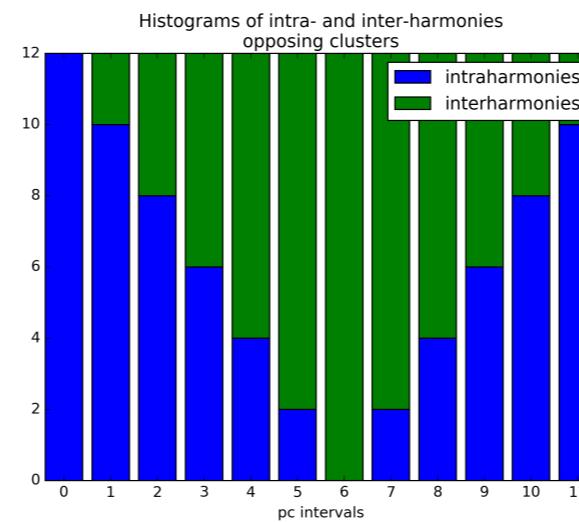
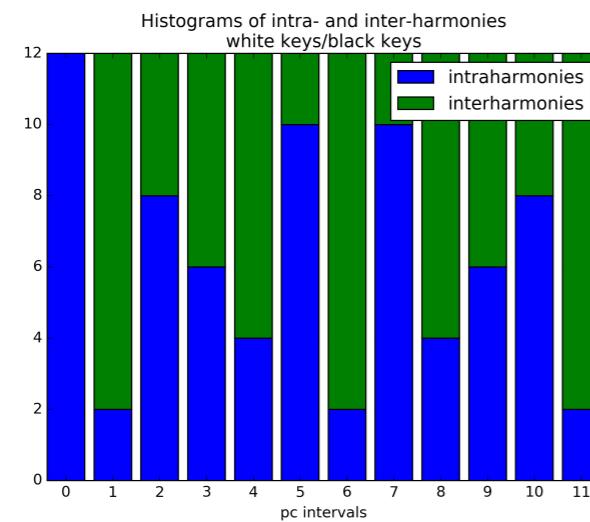
$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring “distinctiveness” or “salience” of the interval content



$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring “distinctiveness” or “salience” of the interval content

Guidonian
 $\sigma(\text{IC}_{\{0,2,4,5,7,9\}}) = 1.78$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring “distinctiveness” or “salience” of the interval content

Guidonian
 $\sigma(\text{IC}_{\{0,2,4,5,7,9\}}) = 1.78$

“flat” hexachord
 $\sigma(\text{IC}_{\{0,2,3,4,5,8\}}) = 1.0$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring “distinctiveness” or “salience” of the interval content

Guidonian
 $\sigma(\text{IC}_{\{0,2,4,5,7,9\}}) = 1.78$

“flat” hexachord
 $\sigma(\text{IC}_{\{0,2,3,4,5,8\}}) = 1.0$

whole-tone
 $\sigma(\text{IC}_{\{0,2,4,6,8,10\}}) = 3.0$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring “distinctiveness” or “salience” of the interval content

$$\sigma(\text{IC}_A) = \sigma(\text{IC}_{\bar{A}})$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring “distinctiveness” or “salience” of the interval content

$$\sigma(\text{IC}_A) = \sigma(\text{IC}_{\bar{A}})$$

$$\sigma(A_{\text{intra}}) = \sigma(A_{\text{inter}})$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring Euclidean distance between intra- and inter-harmonies

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring Euclidean distance between intra- and inter-harmonies

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2$$

$$W = \{0, 2, 4, 5, 7, 9, 11\}$$

$$\|W_{\text{inter}} - W_{\text{intra}}\|_2 = 22.98$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring Euclidean distance between intra- and inter-harmonies

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2$$

$$W = \{0, 2, 4, 5, 7, 9, 11\}$$

$$\|W_{\text{inter}} - W_{\text{intra}}\|_2 = 22.98$$

$$X = \{0, 2, 3, 4, 5, 8\}$$

$$\|X_{\text{inter}} - X_{\text{intra}}\|_2 = 13.86$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring Euclidean distance between intra- and inter-harmonies

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2$$

$$\text{if } \#A = \#\bar{A}$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Properties of intra- and inter-harmonies

Measuring Euclidean distance between intra- and inter-harmonies

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2$$

$$\text{if } \#A = \#\bar{A}$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

$$\text{if } \#A \neq \#\bar{A}$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \underset{\sim}{\propto} \sigma(\text{IC}_A)$$

$$\|A_{\text{inter}} - A_{\text{intra}}\|_2 \propto \sigma(\text{IC}_A)$$

Properties of intra- and inter-harmonies

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Désordre

dédicace à Pierre Boulez
Étude 1: Désordre

György Ligeti

Molto vivace, vigoroso, molto ritmico, $\text{c} = 63$

*Use the pedal sparingly throughout.
Play the melody legato in both hands.

Unterdrückt wird das Pedal vorsichtig benutzt.
Die Melodie ist in beiden Händen legato.

*Stern opernweise Gehalten des Pedals
Die Melodie in beiden Händen legato

10

(cresc.)
mf
(cresc.)
mf
(cresc.)
mf
(cresc.)
mf
(cresc.)
mf
ff (cresc.)
ff

ff

90a

7

*Use the pedal sparingly throughout.
Play the melody legato in both hands.

Unterdrückt wird das Pedal vorsichtig benutzt.
Die Melodie ist in beiden Händen legato.

*Stern opernweise Gehalten des Pedals
Die Melodie in beiden Händen legato

11

*Use the pedal sparingly throughout.
Play the melody legato in both hands.

Unterdrückt wird das Pedal vorsichtig benutzt.
Die Melodie ist in beiden Händen legato.

*Stern opernweise Gehalten des Pedals
Die Melodie in beiden Händen legato

12

*Use the pedal sparingly throughout.
Play the melody legato in both hands.

Unterdrückt wird das Pedal vorsichtig benutzt.
Die Melodie ist in beiden Händen legato.

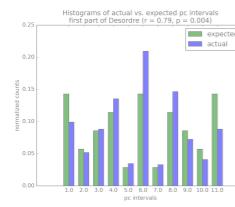
*Stern opernweise Gehalten des Pedals
Die Melodie in beiden Händen legato

13

*Use the pedal sparingly throughout.
Play the melody legato in both hands.

Unterdrückt wird das Pedal vorsichtig benutzt.
Die Melodie ist in beiden Händen legato.

*Stern opernweise Gehalten des Pedals
Die Melodie in beiden Händen legato



Désordre

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Désordre

first part

dédicace à Pierre Boulez
Étude 1: Désordre
György Ligeti

Molto vivace, vigoroso, molto ritmico, $\alpha = 63$

*Use the pedal sparingly throughout.
Play the melody legato in both hands.

*Stern opernweise Gehauenes des Pedals
Die Melodie in beiden Händen legato

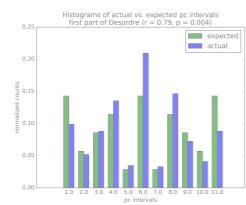
10

ff cresc. molto

13

Duritt ca. 2' 20"

second part

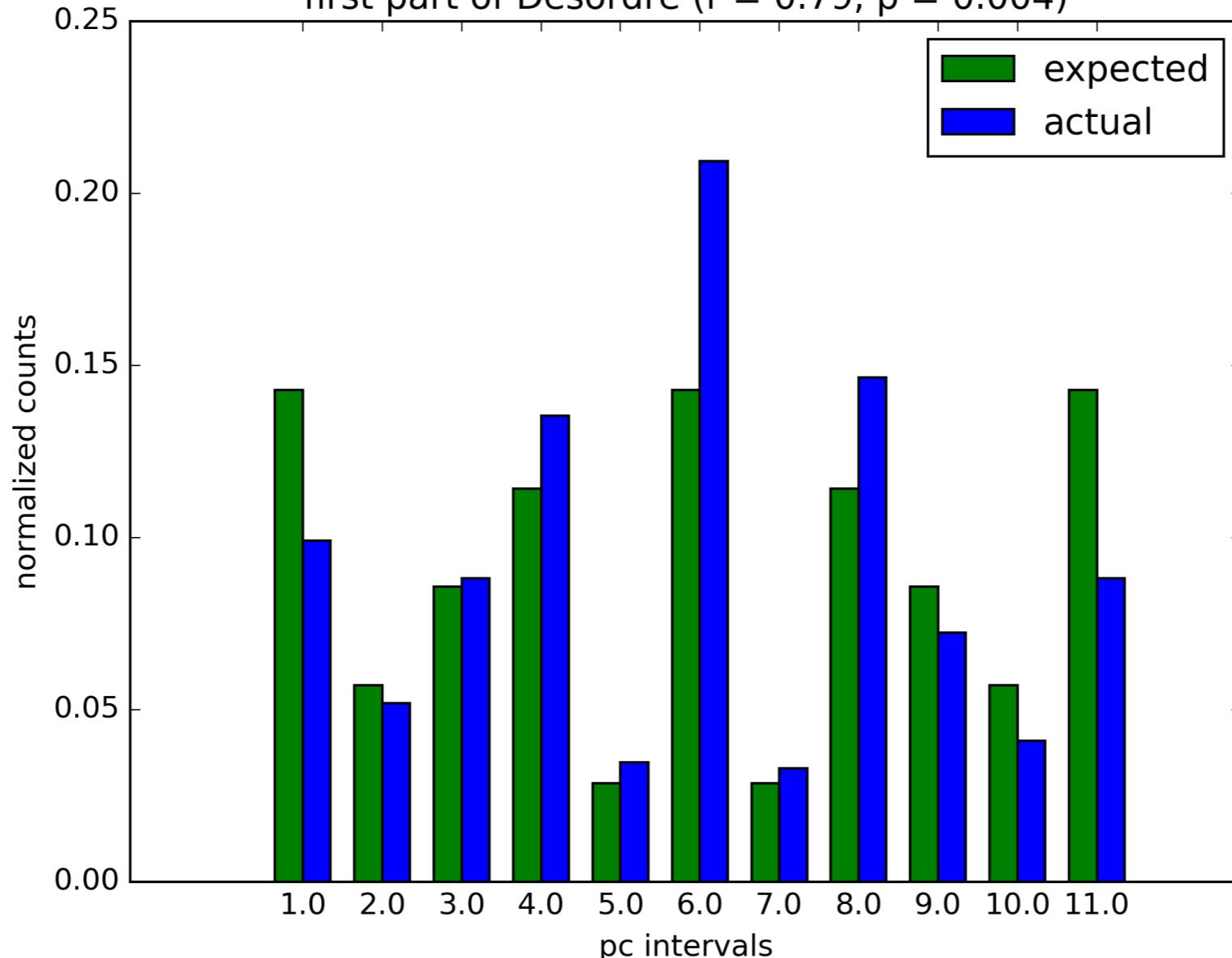


Désordre

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Désordre

Histograms of actual vs. expected pc intervals
first part of Desordre ($r = 0.79$, $p = 0.004$)



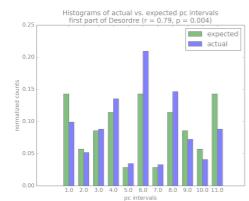
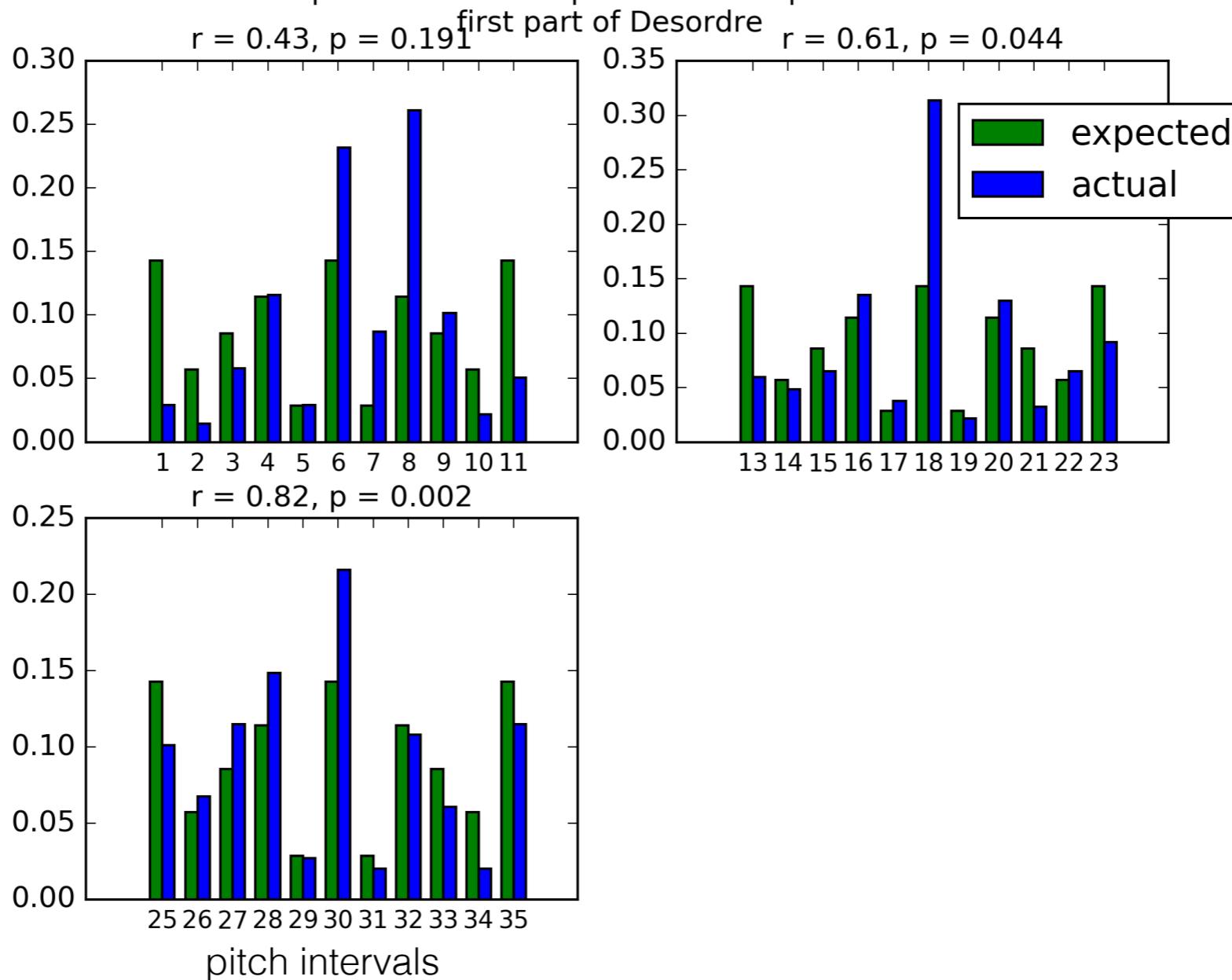
Désordre

(See Quintet, 2014)

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Désordre

Expected vs. actual pitch intervals per octave



Désordre

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Désordre

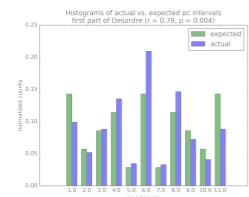
Expected vs. actual pitch intervals by time
first part of Désordre

correlations

first third: $r = 0.51, p < 0.11$

second third: $r = 0.78, p < 0.005$

final third: $r = 0.95, p < 0.001$



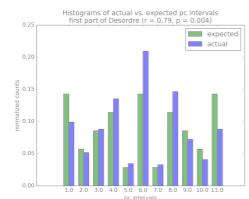
Désordre

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Désordre

Two explanations:

- 1) pitch proximity
- 2) iso-rhythmic structure



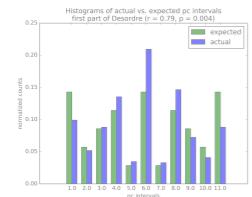
Désordre

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Désordre

pitch proximity

As distance in pitch space increases, perception of interval quality decreases.



Désordre

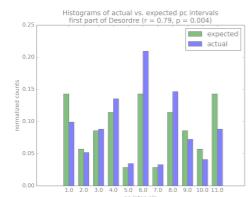
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Désordre

pitch proximity

As distance in pitch space increases, perception of interval quality decreases.

Distance between left and right hands gradually increases through the first part.



Désordre

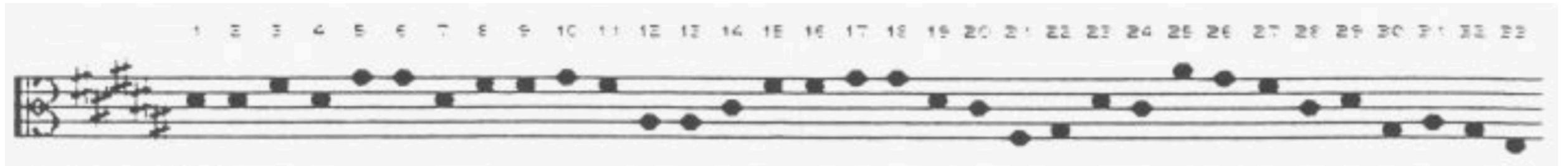
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Désordre

iso-rhythmic structure

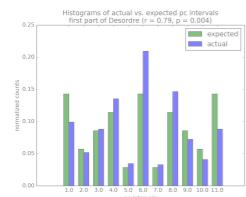


right-hand color



left-hand color

(Taken from Kinzler, 1991)



Désordre

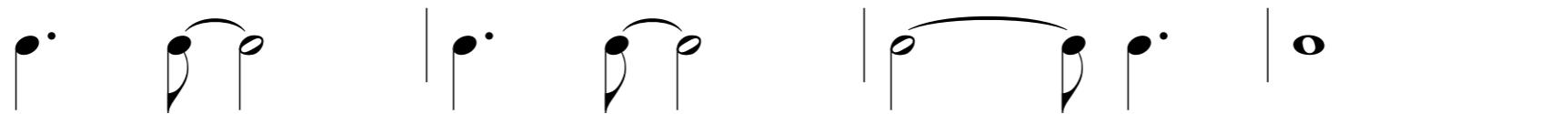
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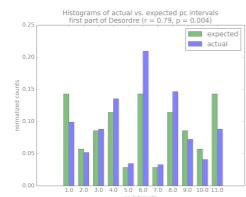
iso-rhythmic structure



beginning of right-hand talea



beginning of left-hand talea



Désordre

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Désordre

iso-rhythmic structure

progressive diminution of talea

$3 + 5 | 3 + 5 | 5 + 3 | 8 | \dots$

$3 + 4 | 3 + 4 | 4 + 3 | 7 | \dots$

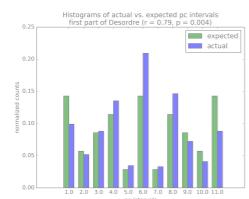
$2 + 4 | 2 + 4 | 4 + 2 | 6 | \dots$

$2 + 3 | 2 + 3 | 3 + 2 | 5 | \dots$

$1 + 3 | 1 + 3 | 3 + 1 | 4 | \dots$

$1 + 2 | 1 + 2 | 2 + 1 | 3 | \dots$

$1 + 1 | 1 + 1 | 1 + 1 | 2 | \dots$



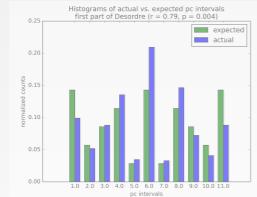
Désordre

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Désordre

iso-rhythmic structure

$$3 + 5 \mid 3 + 5 \mid 5 + 3 \mid 8 \mid \dots$$



Désordre

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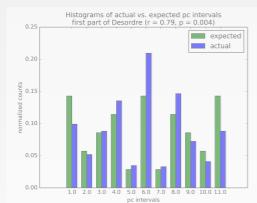
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Désordre

iso-rhythmic structure

$$\begin{array}{c|c|c|c|c} 3+4 & 3+4 & 4+3 & 7 & \dots \\ 2+4 & 2+4 & 4+2 & 6 & \dots \\ 2+3 & 2+3 & 3+2 & 5 & \dots \\ 1+3 & 1+3 & 3+1 & 4 & \dots \end{array}$$



Désordre

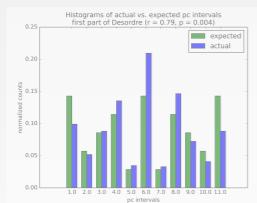
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iso-rhythmic structure

1 + 2 | 1 + 2 | 2 + 1 | 3 | ...

A musical score for two staves. The top staff is in treble clef and the bottom staff is in bass clef. Both staves have a key signature of three sharps. The music consists of various note heads and rests, some with horizontal strokes above them, indicating specific rhythmic values or performance techniques.



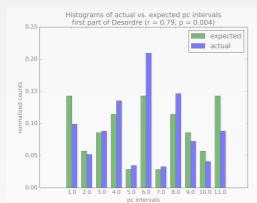
Désordre

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Désordre

iso-rhythmic structure

$$\begin{aligned} & 1 + 1 | 1 + 1 | 1 + 1 | 2 | \dots \\ & 1 + 1 \dots \end{aligned}$$

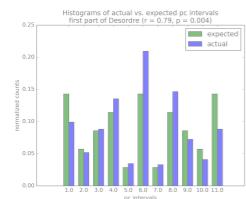
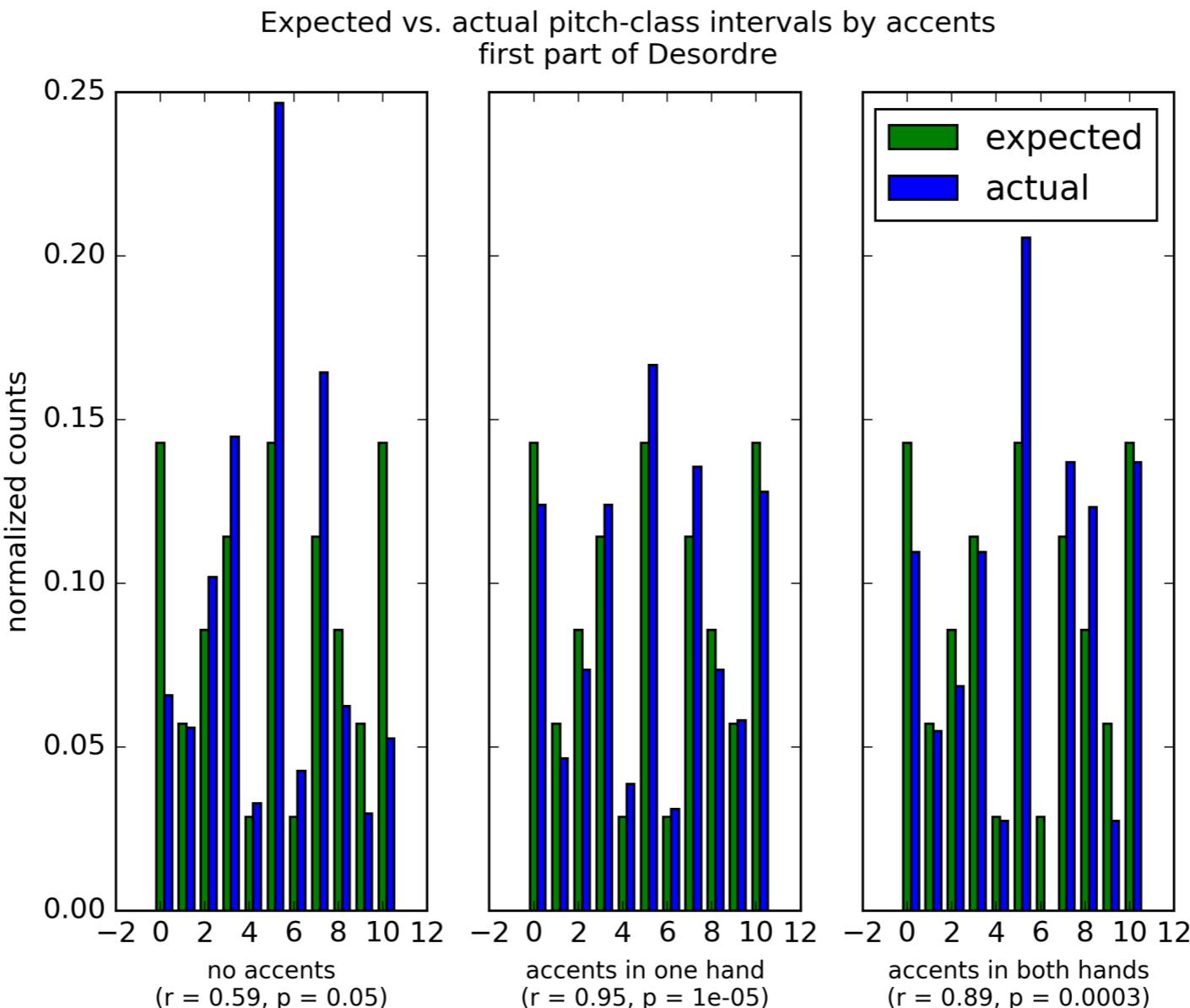


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Désordre

Expected vs. actual by number of accents



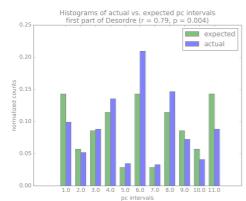
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Désordre

Expected vs. actual by number of accents and by time

	no accents	one accent
first third:	$r = 0.39$	$r = 0.75$
	$p = 0.24$	$p = 0.008$
second third:	$r = 0.65$	$r = 0.81$
	$p = 0.028$	$p = 0.003$
final third:	$r = 0.61$	$r = 0.93$
	$p = 0.048$	$p < 0.001$



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What else?

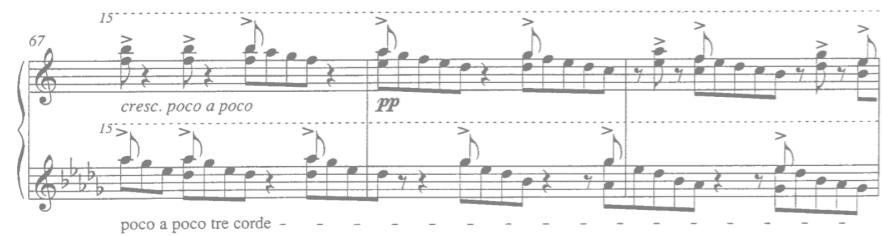


What else?

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We could have talked about:

intra- and inter-trichords, tetrachords, and so on



What else?

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non-tonal triad motion in *Der Zauberlerling*



What else?

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in white key / black key and other systems of complementary collections



What else?

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degrees of consonance (*Piano Concerto I*) and dissonance (*En Suspens*)
in white key / black key and other systems of complementary collections

other melodic/harmonic combinations

major sixths by whole-tone (*Violin Concerto V*)

diatonic sonorities by whole-tone scales

whole-tone sonorities by pentatonic scales



What else?

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Thank you!

For more information:
cliftoncallender.com

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