Musical Creativity and Conceptual Blending: The *CHAMELEON* melodic harmonisation assistant

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Forms of Creativity

Boden has proposed three forms of creativity:

- Exploratory
- Transformational
- Combinational

Combinational creativity, has proved to be the hardest to describe formally (Boden 1990).

Combinational creativity: "novel ideas (concepts, theories, solutions, works of art) are produced through unfamiliar combinations of familiar ideas." (iccc2014)

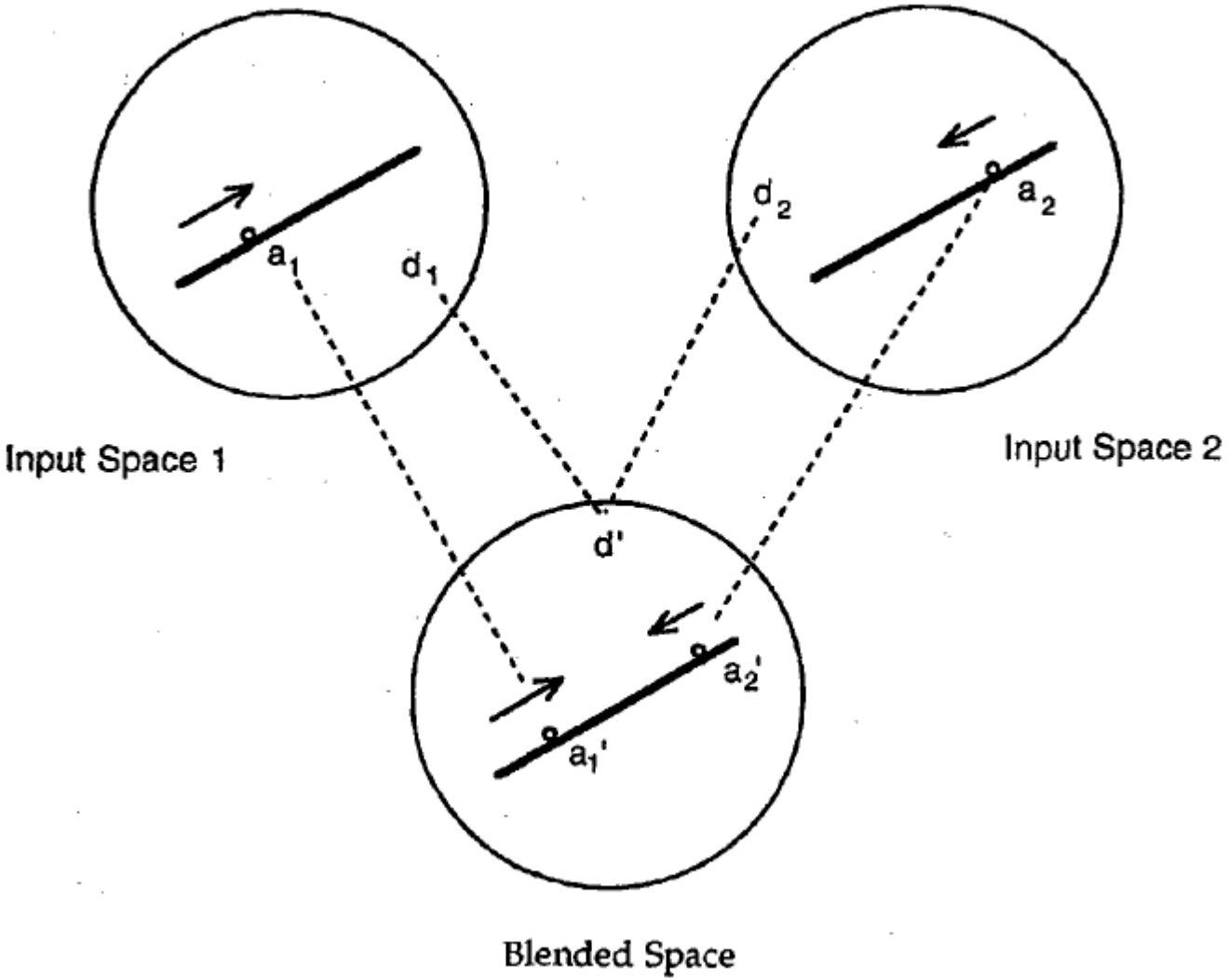
Conceptual Blending

- Conceptual blending is a cognitive theory developed by Fauconnier and Turner (2001)
- Elements from diverse, but structurally-related, mental spaces are ‘blended’ giving rise to new conceptual spaces.
- Such spaces often posses new powerful interpretative properties allowing better understanding of known concepts or the emergence of novel concepts.

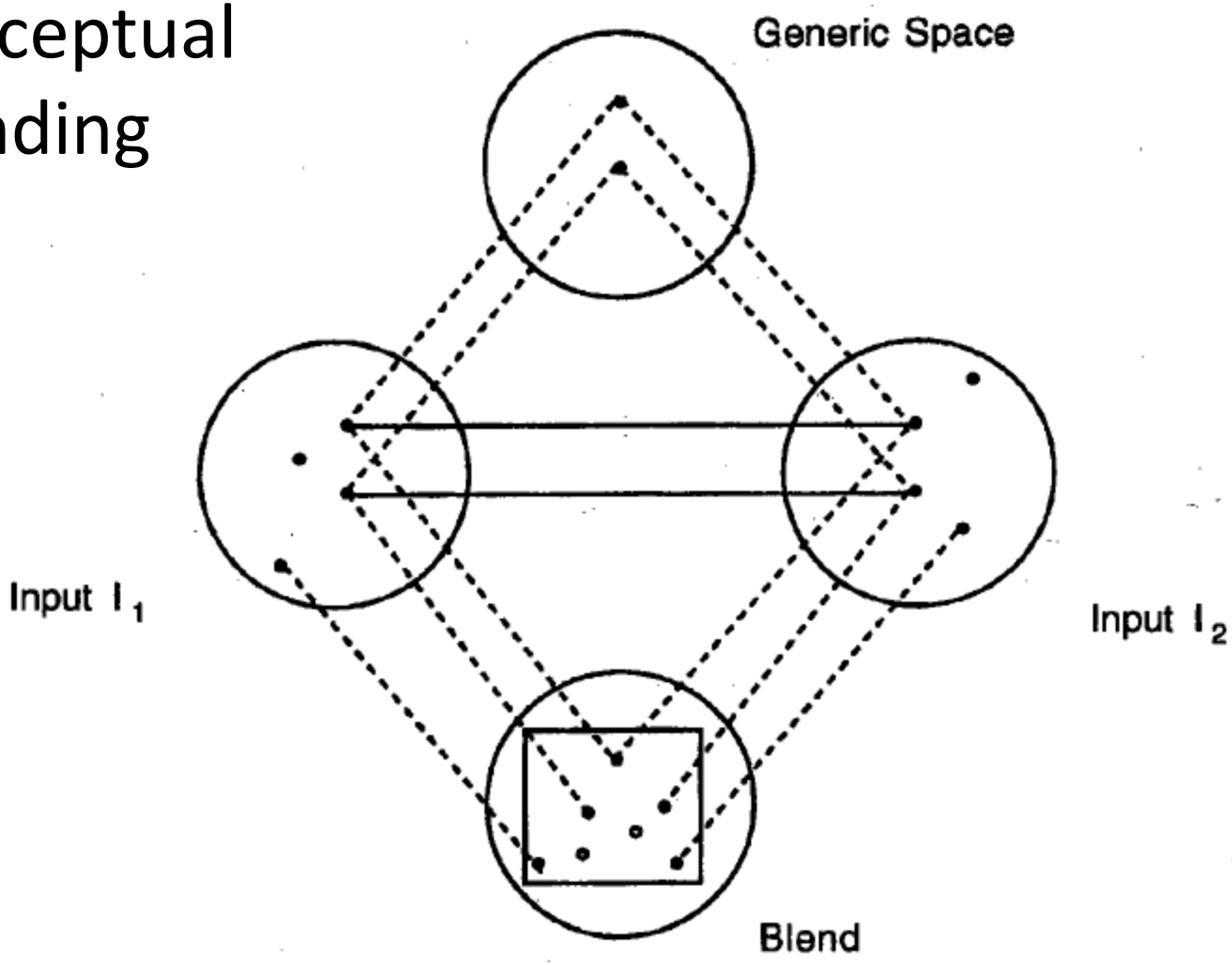
Buddhist monk puzzle

- Consider a classic puzzle of inferential problem-solving (Koestler, 1964):
- A Buddhist monk begins at dawn one day walking up a mountain, reaches the top at sunset, meditates at the top for several days until one dawn when he begins to walk back to the foot of the mountain, which he reaches at sunset. Make no assumptions about his starting or stopping or about his pace during the trips. Riddle: is there a place on the path which he occupies at the same hour of the day on the **two** separate journeys?

Solution: blending the monk's ascent with his descent



Conceptual blending



Coinvent (EU project FP7, 2013-2016)

The overall aim of COINVENT is to develop a computationally feasible, cognitively-inspired formal model of concept creation

• The model draws on Fauconnier and Turner's theory of conceptual blending, and grounds it on a sound mathematical theory of concepts.

• To validate the model, a proof of concept of an autonomous computational creative system are implemented and evaluated by humans in two testbed scenarios:

– mathematical reasoning

– melodic harmonization.

Musical Meaning

- structural meaning: arising from structural features/relations of musical contexts/spaces (melodic, harmonic, rhythmic, textural)
- 'musicogenic' meaning: arising from physical, gestural, embodied, emotional alignment
- 'extra'-musical or referential meaning (e.g. text and music, moving image and music, programme music, etc.)

Tripartite Models:

- Intramusical, Extramusical, Musicogenic (Koelsch 2013)
- Formal, Emotional, Referential (Brandt 2009)
- Emotion, Cognition, Kinaesthetics (Kuhl 2007)

Blending in harmony

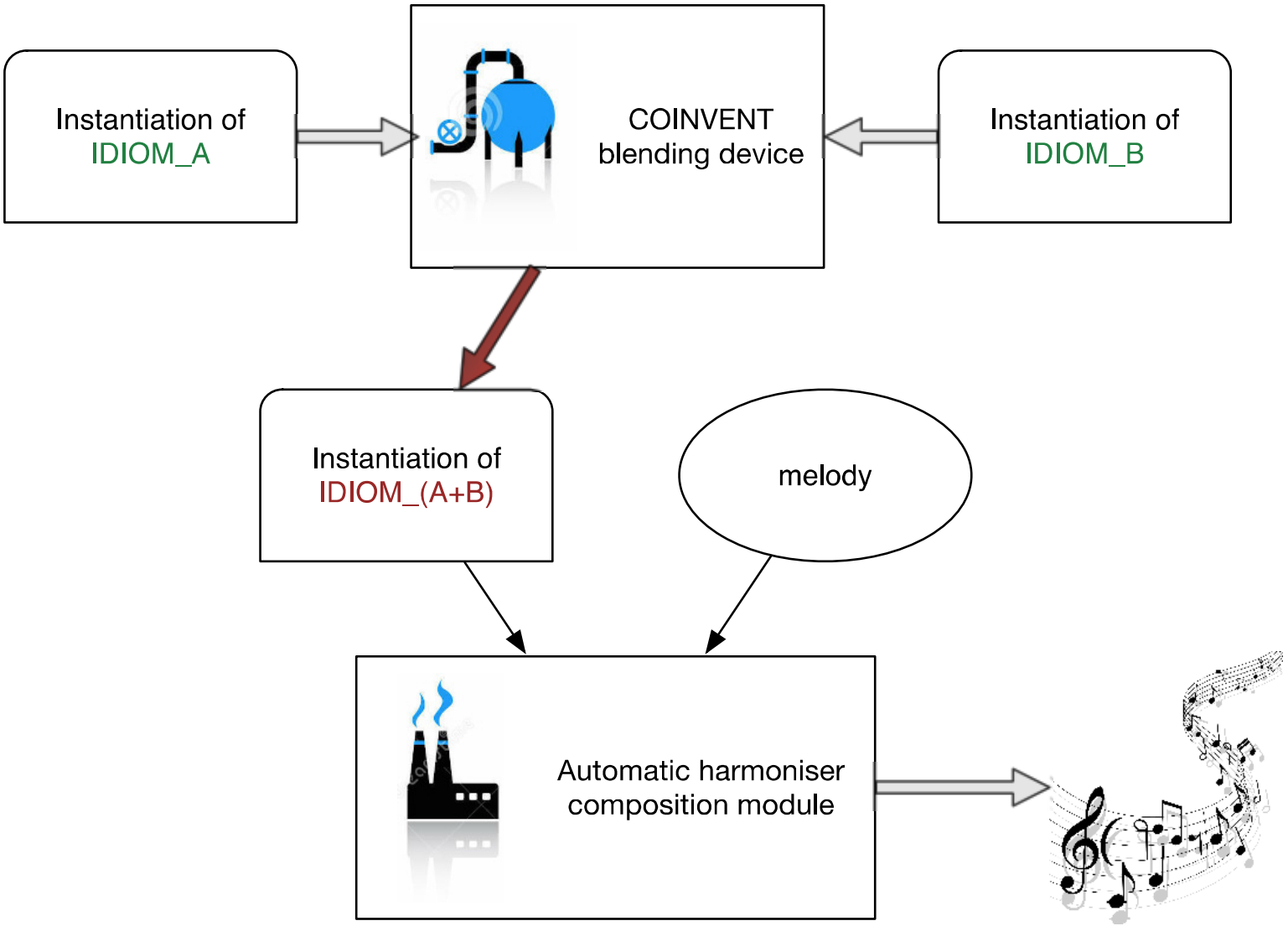
Focus on creating novel blends (rather than interpreting existing blends)
Emphasis on the creation of new music as a product of *structural* blending.

Creative Harmonisation of MELodies via LEarning & bLEnding of ONtologies

- A system that harmonises melodies
- The user inputs a melody
- The output is a harmonised melody
- The produced harmony features **blended** characteristics from different **learned** harmonic idioms.

www.ccm.web.auth.gr/chameleonmain.html

Melodic harmonizer



Dataset and Encoding

Harmonic training dataset

- Over 400 pieces from 7 main domains and several more specific idioms
- Harmonic reduction by experts
- Important harmonic structural info annotated by experts (phrase boundaries – scale info)
- Data extraction tools
- Automatic labelling of chords using the ***General Chord Type (GCT)*** representation

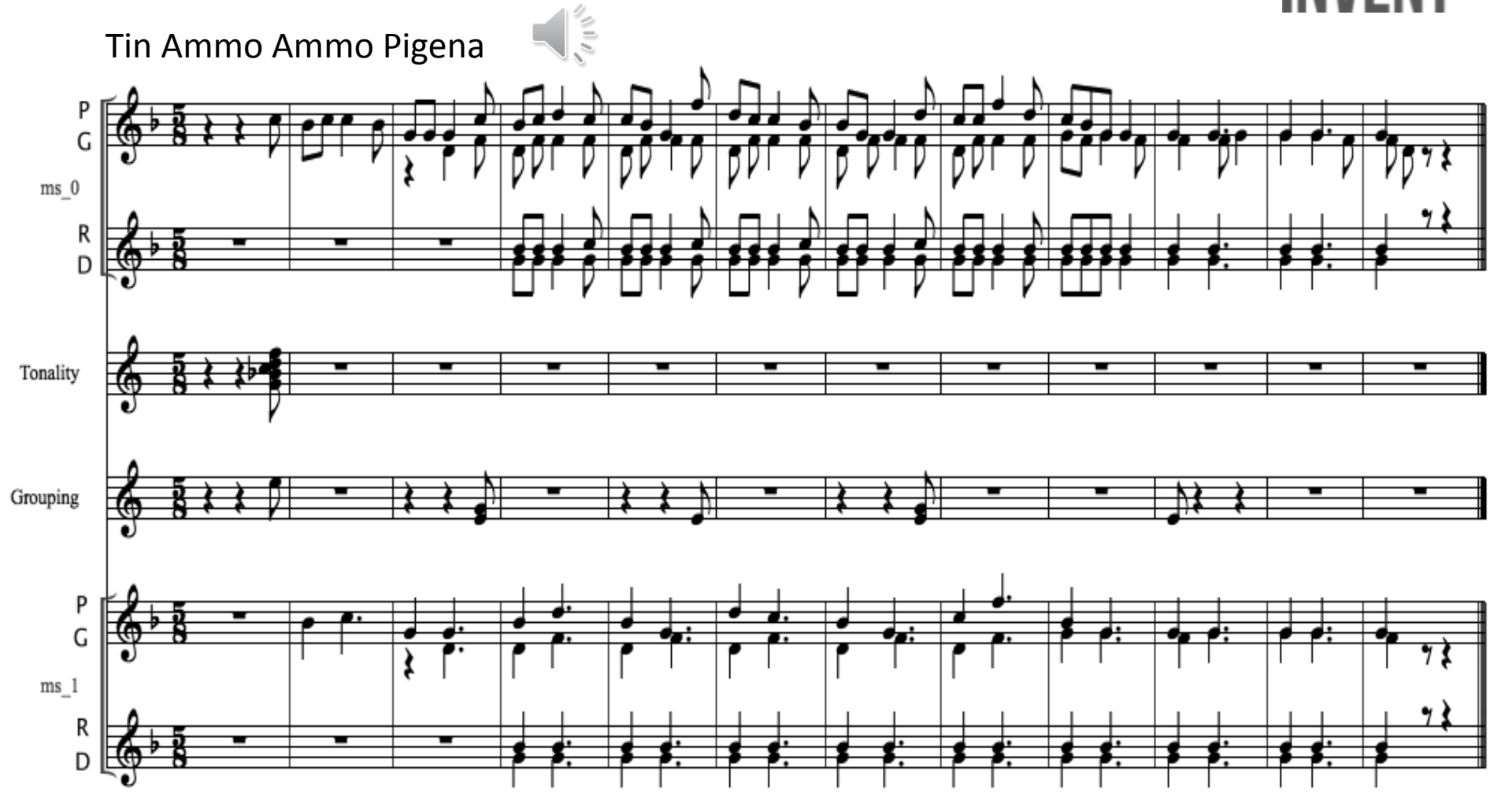
Harmonic Dataset

The dataset comprises seven broad categories of musical idioms, further divided into sub-categories, and presented in the following list:

- Modal harmonisation in the Middle Ages (11th – 14th centuries): includes subcategories of the Medieval harmonic styles of Organum and Fauxbourdon
- Modal harmonisation in the Renaissance (15th – 17th centuries): includes modal music from the 16th – 17th centuries along with modal chorales
- Tonal harmonisation (17th – 19th centuries): includes a set of the Bach Chorales, the Kostka-Payne corpus
- Harmonisation in National Schools (19th – 20th centuries): includes 19th – 20th century harmonisation of folk songs from Norway, Hungary and Greece
- Harmonisation in the 20th century: includes mainly vocal music by Cl. Debussy, P. Hindemith, E. Whitacre, I. Stravinsky, among others. Also, includes 20th-century harmonic concepts extracted from short musical excerpts
- Harmonisation in folk traditions: includes Tango (classical and nuevo styles), Epirus polyphonic songs and Rebetiko songs
- Harmonisation in 20th-century popular music and jazz: includes mainstream jazz, piano pieces by Bill Evans and a collections of songs from The Beatles

Annotated score

Tin Ammo Ammo Pigena



GCT representation

It is a representation that is a generalisation of the standard tonal typology, applicable to any type of music.

***General Chord Type* Algorithm (*GCT* algorithm)**

INPUT:

- Consonant/dissonant interval vector, e.g. [1,0,0,1,1,1,0,1,1,1,0,0]
- Tonality/key

ALGORITHM CORE:

- Reordering of pitch classes (most compact form) such that consonant intervals constitute the 'base' of the chord (left-hand side) & pitches that introduce dissonant intervals in relation to the 'base' are the extension (to the right)

OUTPUT:

- Chord-type and extension
- Root of chord (root-finding)
- Relative root position in current key

Examples of GCT representation

	EXAMPLE
Tonality - key	G: [7, [0, 2, 4, 5, 7, 9, 11]]
Consonance Vector	[1, 0, 0, 1, 1, 1, 0, 1, 1, 1, 0, 0]
Input Pitches	[60, 62, 66, 69, 74]
pc-set	[0, 2, 6, 9]
Maximal subsets	[2, 6, 9]
Narrowest range	[2, 6, 9]
Add extensions	[2, 6, 9, 12]
Lowest is root	2 (note D)
Chord in root position	[2, [0, 4, 7, 10]]
Relative to key	[7, [0, 4, 7, 10]]

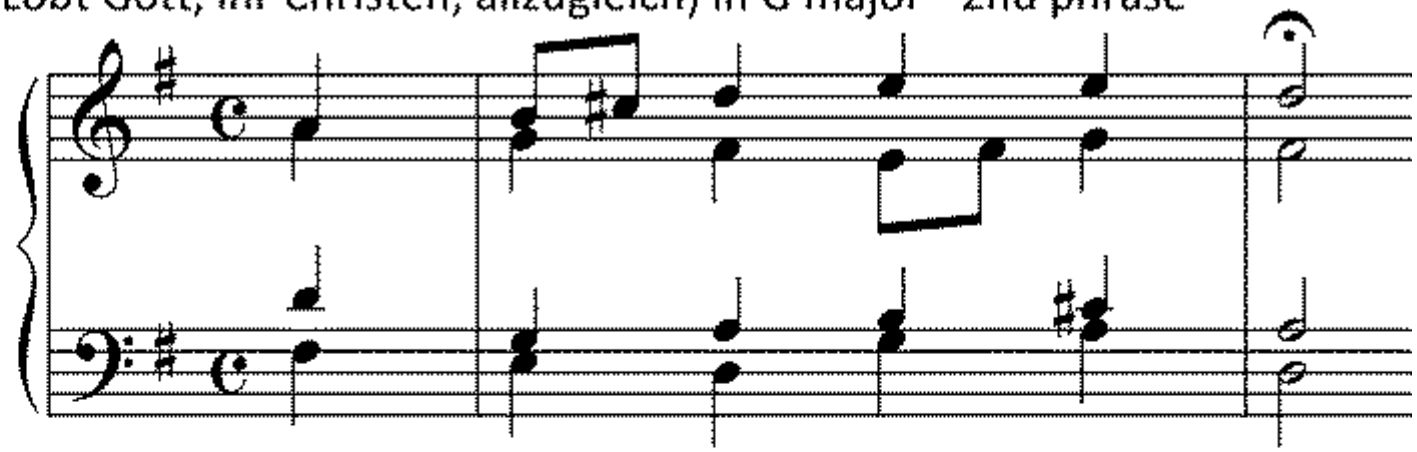
[60, 62, 66, 69, 74] $\rightarrow$ [7,[0,4,7,10]] i.e. dominant seventh in G major

		EXAMPLE 2
	Tonality - key	C: [0, [0, 2, 4, 5, 7, 9, 11]]
	Cons. Vector	[1, 0, 0, 1, 1, 1, 0, 1, 1, 1, 0, 0]
	Input	[50, 60, 62, 65, 69]
	pc-set	[0, 2, 5, 9]
	Maximal subsets	[2, 5, 9] and [5, 9, 0]
	Narrowest range	[2, 5, 9] and [5, 9, 0]
	Add extensions	[2, 5, 9, 12] and [5, 9, 0, 14]
	Lowest is root	2 and 5 (notes D & F)
	Chord in root position	[2, [0, 3, 7, 10]] & [5, [0, 4, 7, 9]]
	Relative to key	[2, [0, 3, 7, 10]] & [5, [0, 4, 7, 9]]
Extra	Maximal subset overlap	[2, [0, 3, 7, 10]]

Supertonic II7 or subdominant IV6

Symmetric chords such as diminished sevenths or augmented chord are ambiguous. Context is required for resolution.

J.S.Bach - Chorale 54 (Lobt Gott, ihr Christen, allzugleich) in G major - 2nd phrase



Roman Numeral Analysis:

D major	I^6	vii_o^6	I	ii^6	V^7	I

GCT Analysis (tonal major profile)

2,[0,2,4,5,7,9,11]	0,[0,4,7]	11,[0,3,6]	0,[0,4,7]	2,[0,3,7]	7,[0,4,7,10]	0,[0,4,7]

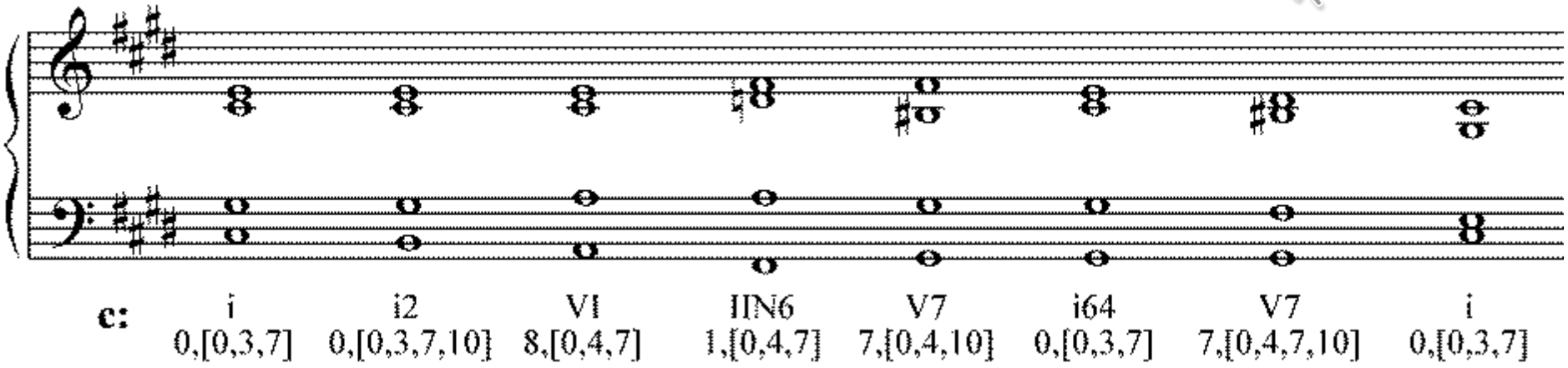
Pc-Set Analysis (chromatic scale):

normal orders	[0,4,7]	[0,3,6]	[0,4,7]	[0,3,7]	[0,2,6,9]	[0,4,7]
prime forms	[0,3,7]	[0,3,6]	[0,3,7]	[0,3,7]	[0,3,6,8]	[0,3,7]

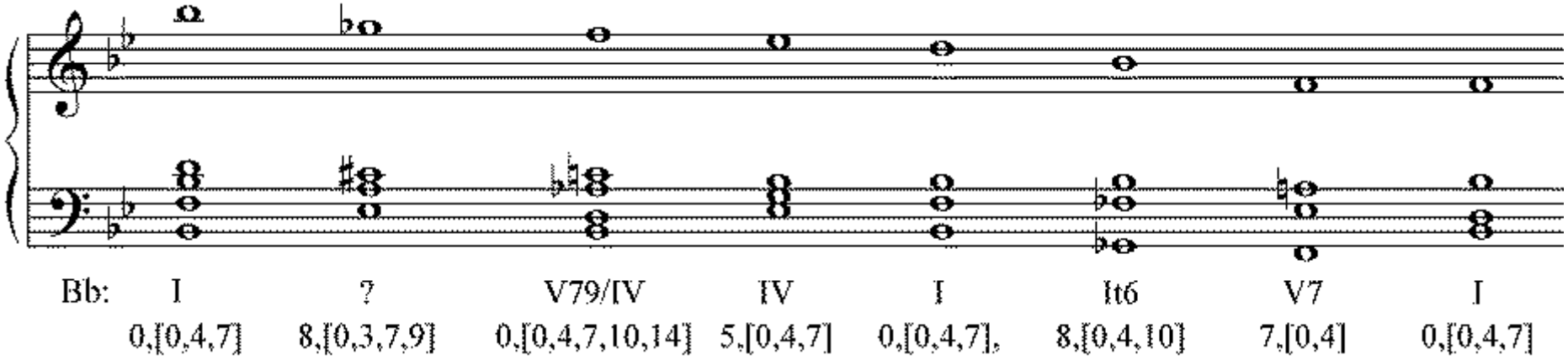
GCT Analysis (atonal profile)

[0,1,2,3,4,5,6,7,8,9,10,11]	2,[0,4,7]	1,[0,3,6]	0,[0,4,7]	4,[0,3,7]	7,[0,2,6,9]	2,[0,4,7]

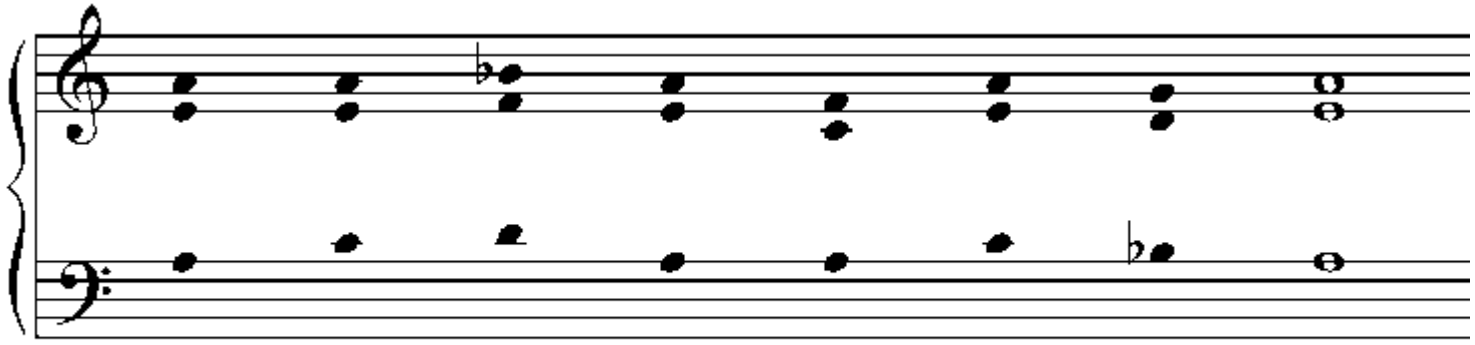
Beethoven, Sonata 14, op.27-2 (reduction of first measures)



G. Gershwin, Rhapsody in Blue (reduction of first five measures)

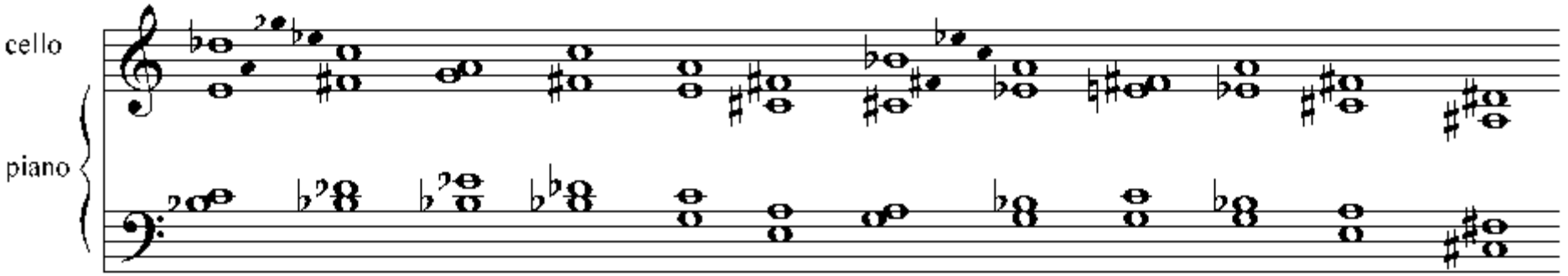


G. Dufay's Kyrie (reduction) - first phrase in A phrygian mode)



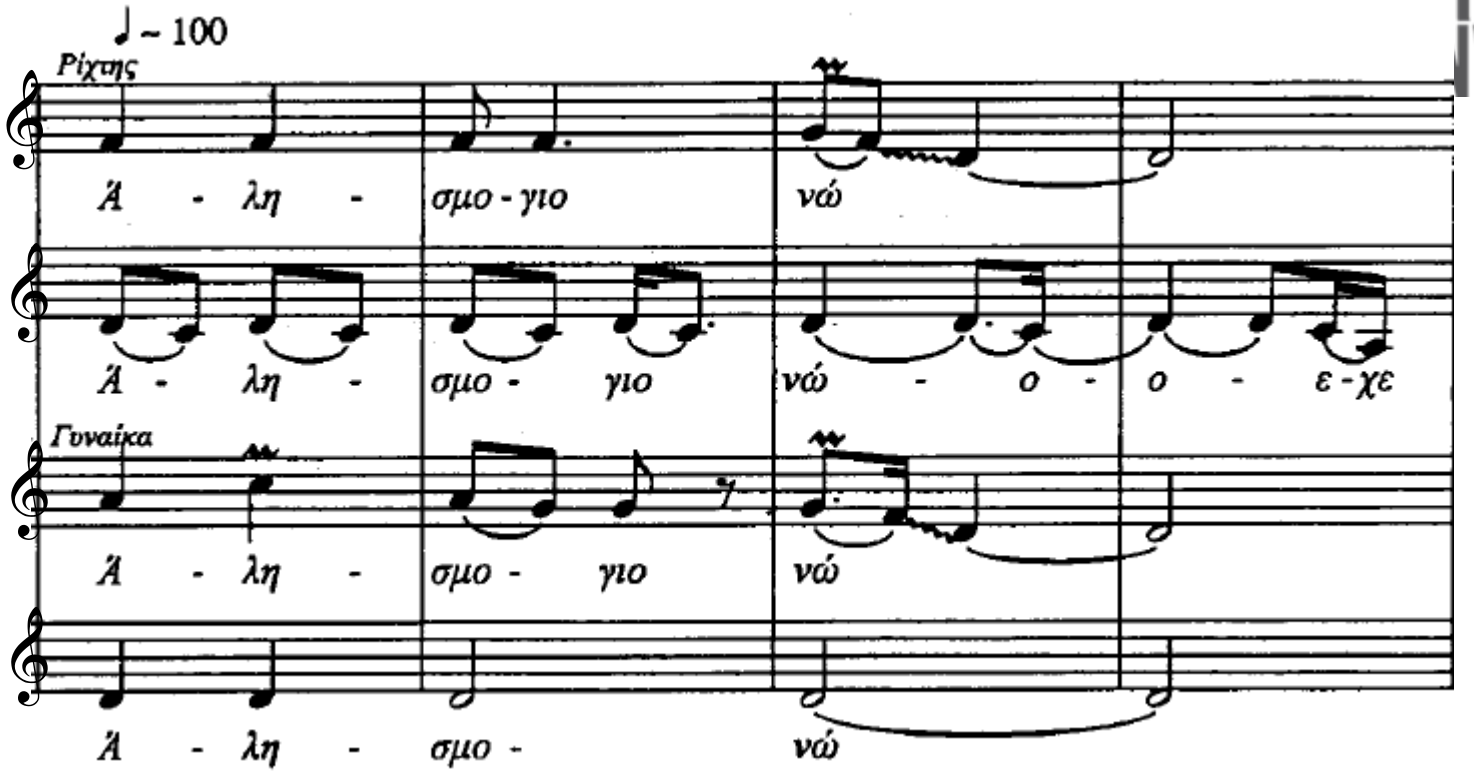
0.[0,7] 0.[0,3,7] 1.[0,4,7] 0.[07] 8.[0,4,7] 0.[0,3,7] 10.[0,3,7] 0.[0,7]

O. Messiaen, Quartet for the End of Time, Quartet VII (reduction of first 6 measures)



GCT- common practice consonance vector	0.[0,4,10,13]	3.[0,4,7,18]	9.[0,3,7,10]	9.[0,4,10,13]	0.[0,4,7,18]	6.[0,3,7,10]
	6.[0,4,7,18]	6.[0,4,7,18]	6.[0,3,7,10]	3.[0,4,7,18]	3.[0,4,7,18]	3.[0,3,7,10]
GCT- atonal cons. vector (normal order)	10.[0,2,3,6]	3.[0,4,6,7]	4.[0,3,5,8]	7.[0,2,3,6]	0.[0,4,6,7]	1.[0,3,5,8]
	6.[0,4,6,7]	6.[0,4,6,7]	1.[0,3,5,8]	3.[0,4,6,7]	3.[0,4,6,7]	10.[0,3,5,8]

76. Αλησμονώ και Χαίρομαι



Same 'root' →	0-037	0-03710	0-0310	0-0310	0-037	0-051015	0-035	0-051015	5-07	0-03	0-0	0-010	0-0
Similarity →	0-037	7-0358	10-025	10-025	0-037	10-0257	0-035	10-0257	0-05	0-03	0-0	0-02	0-0

Consonant intervals 345789

Consonant intervals 234578910

Statistical learning of harmonies

The harmoniser is based on a statistical learning approach that combines different learning modules:

- chord types
- chord transitions
- cadences
- bass line voice leading

The training material comprises many diverse musical idioms, annotated by human experts.

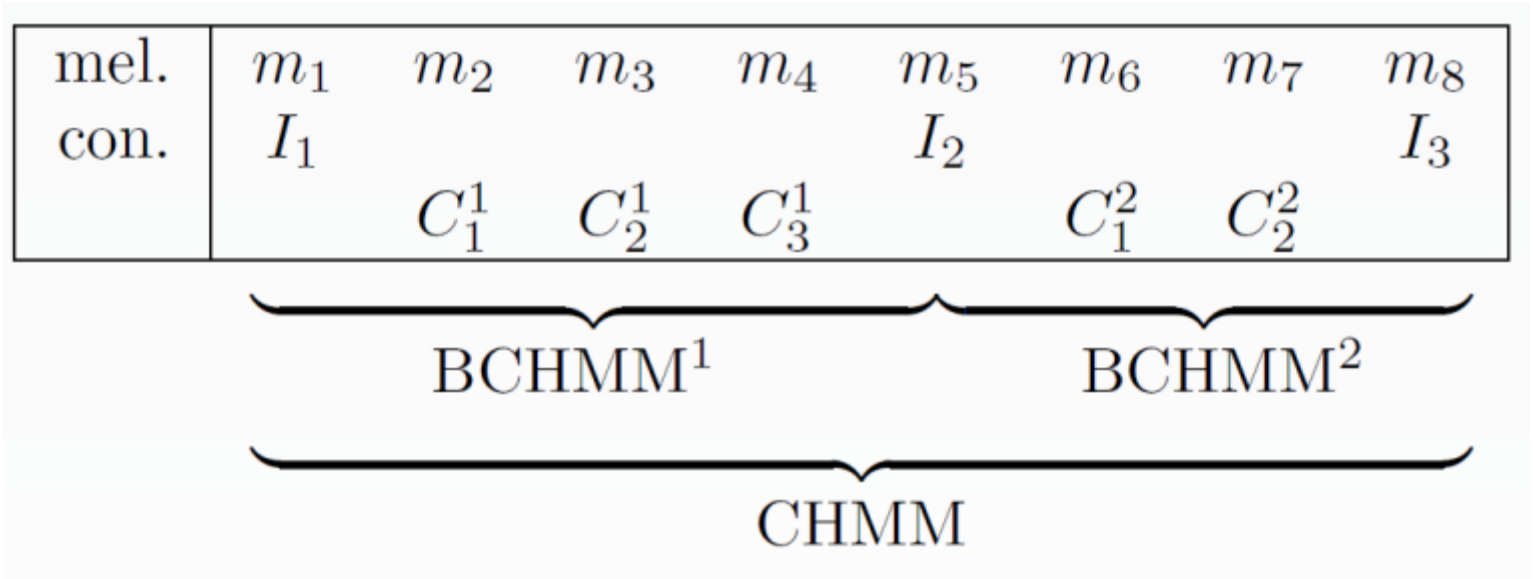
Chord learning & generation

Idiom dependent probabilistic harmonization under chord constraints (**constrained HMM**)

- Chord transitions learned from an idiom
- Novel sequences generated that statistically:
  - preserve the learned characteristics, AND
  - are constrained by fixed ‘checkpoint’ chords

Bach Chorales: Analysis, Generation

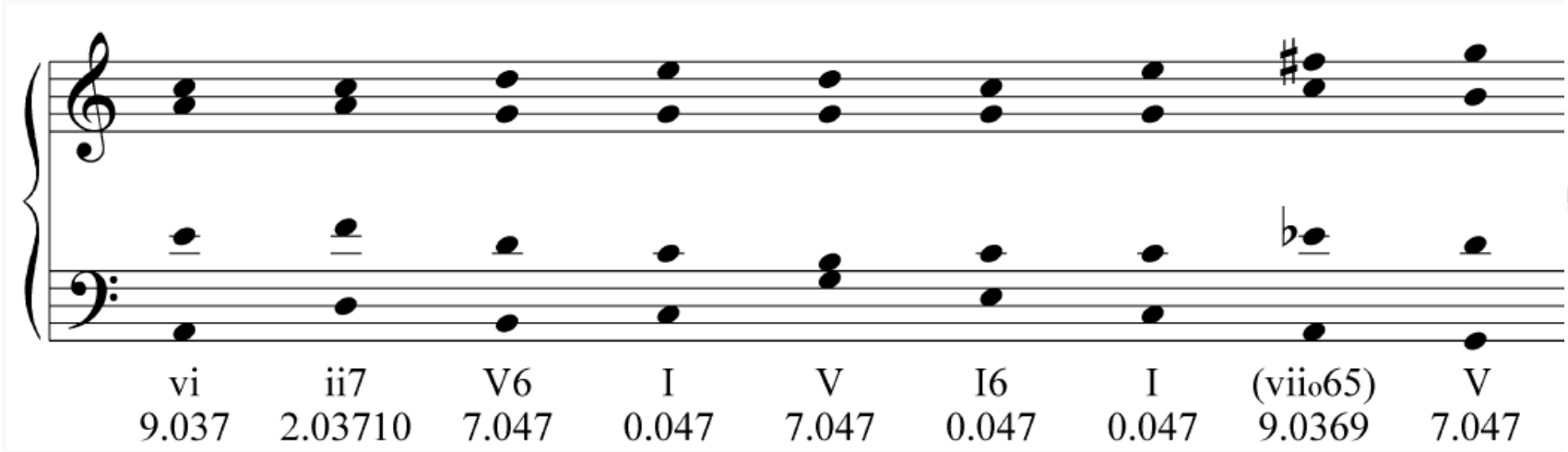
- Statistical learning from GCT Bach Chorale dataset via HMM
- Use of Boundary Constrained HMM

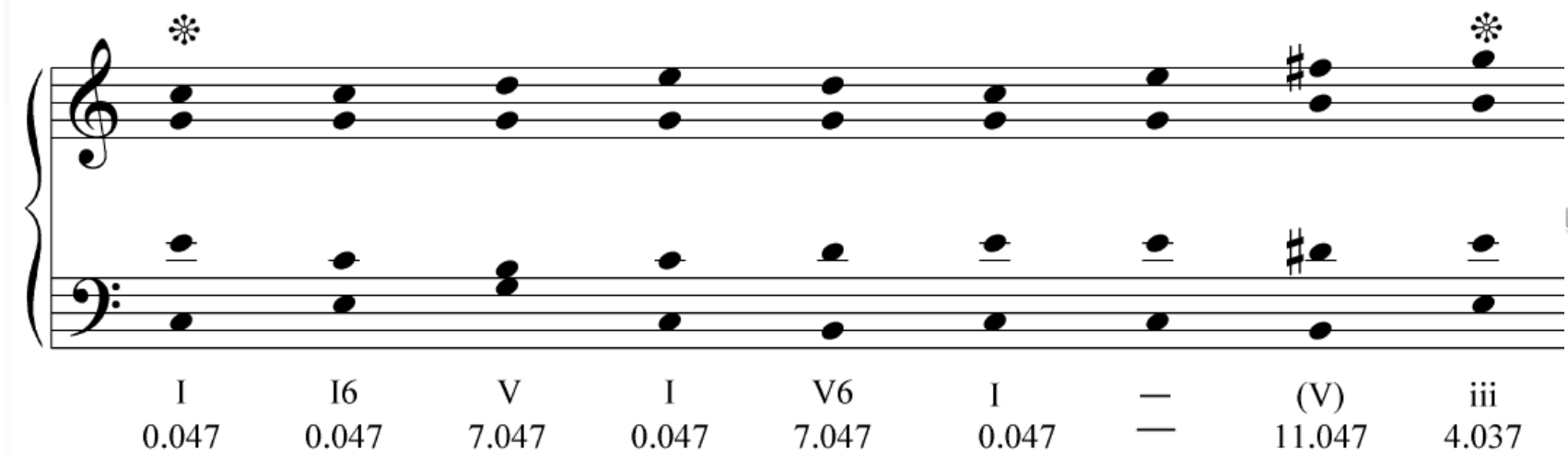


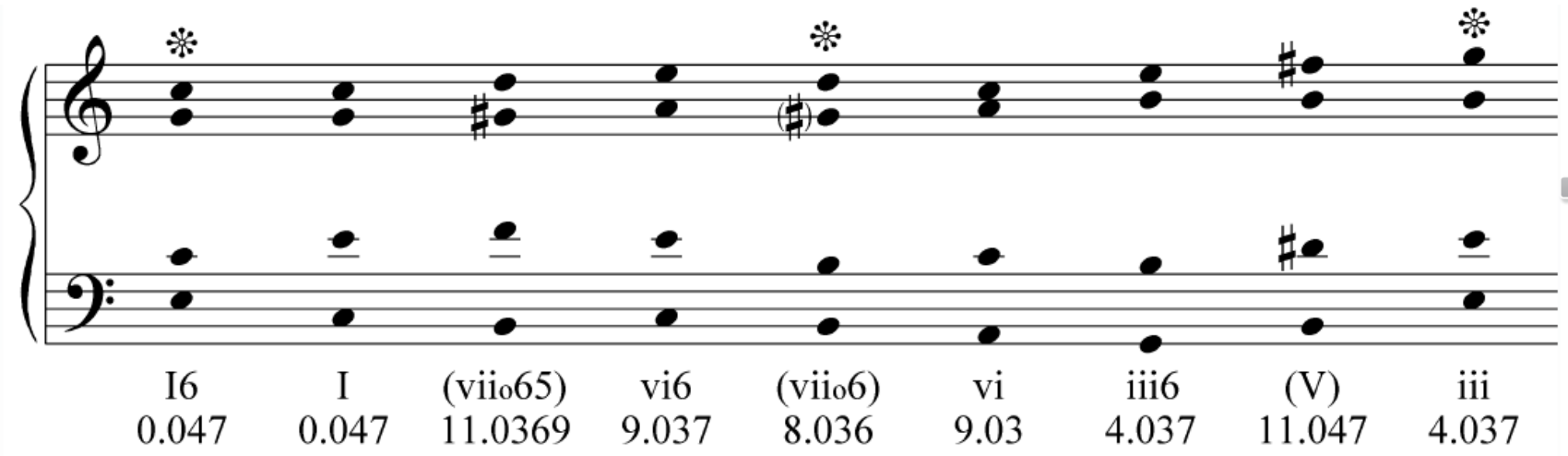
Boundary Constrained HMM (BCHMM)

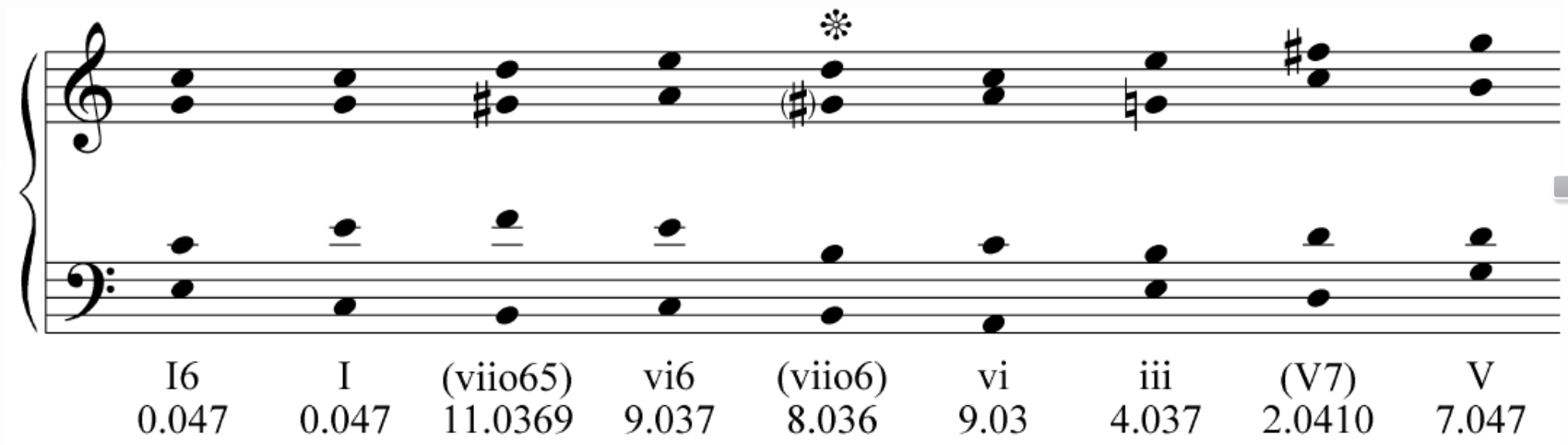
Constrained HMM

Harmonisations with different constraints

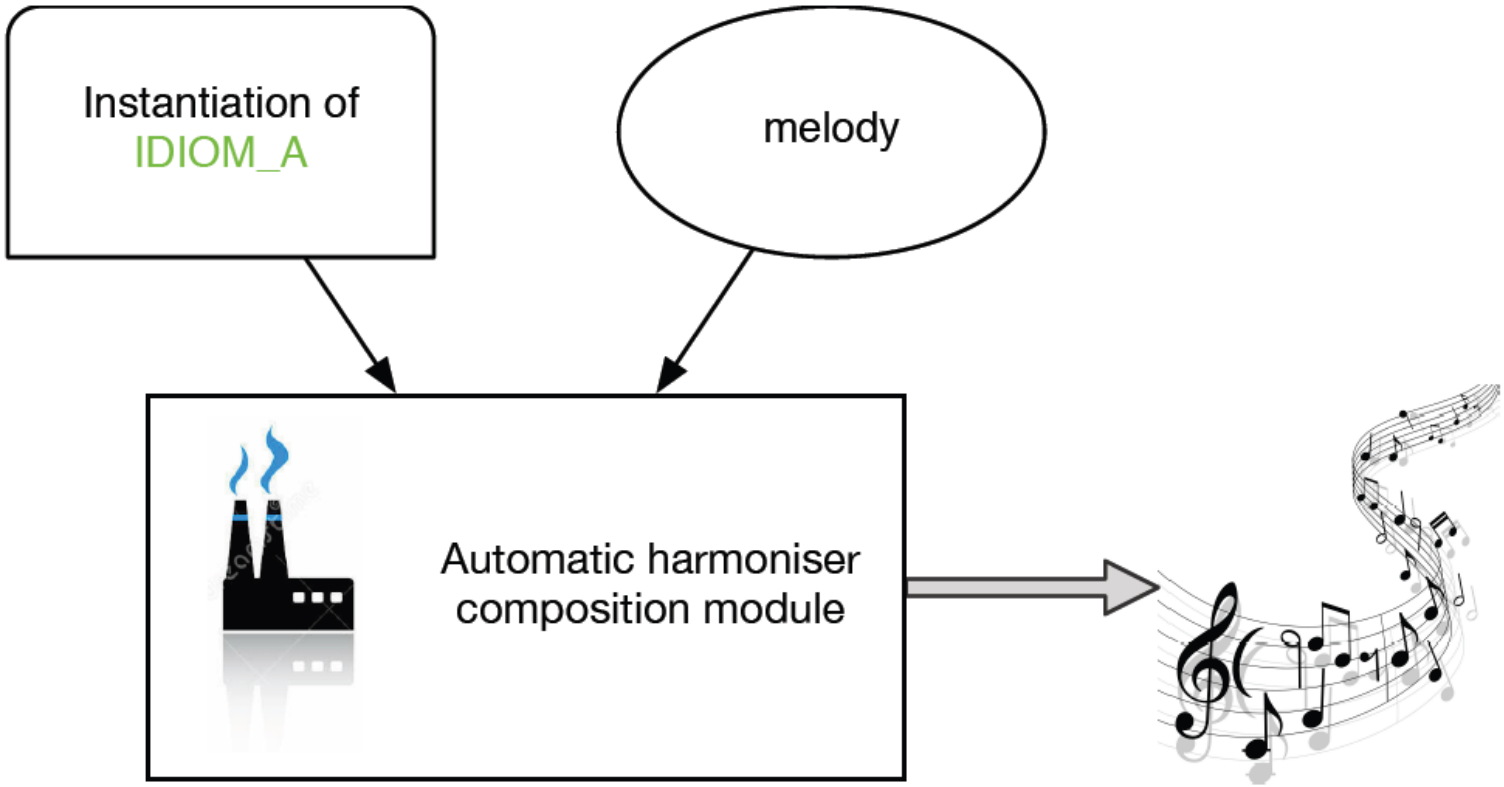





I6 0.047
I 0.047
(viio65) 11.0369
vi6 9.037
(viio6) 8.036
vi 9.03
iii6 4.037
(V) 11.047
iii 4.037


I6 0.047
I 0.047
(viio65) 11.0369
vi6 9.037
(viio6) 8.036
vi 9.03
iii 4.037
(V7) 2.0410
V 7.047

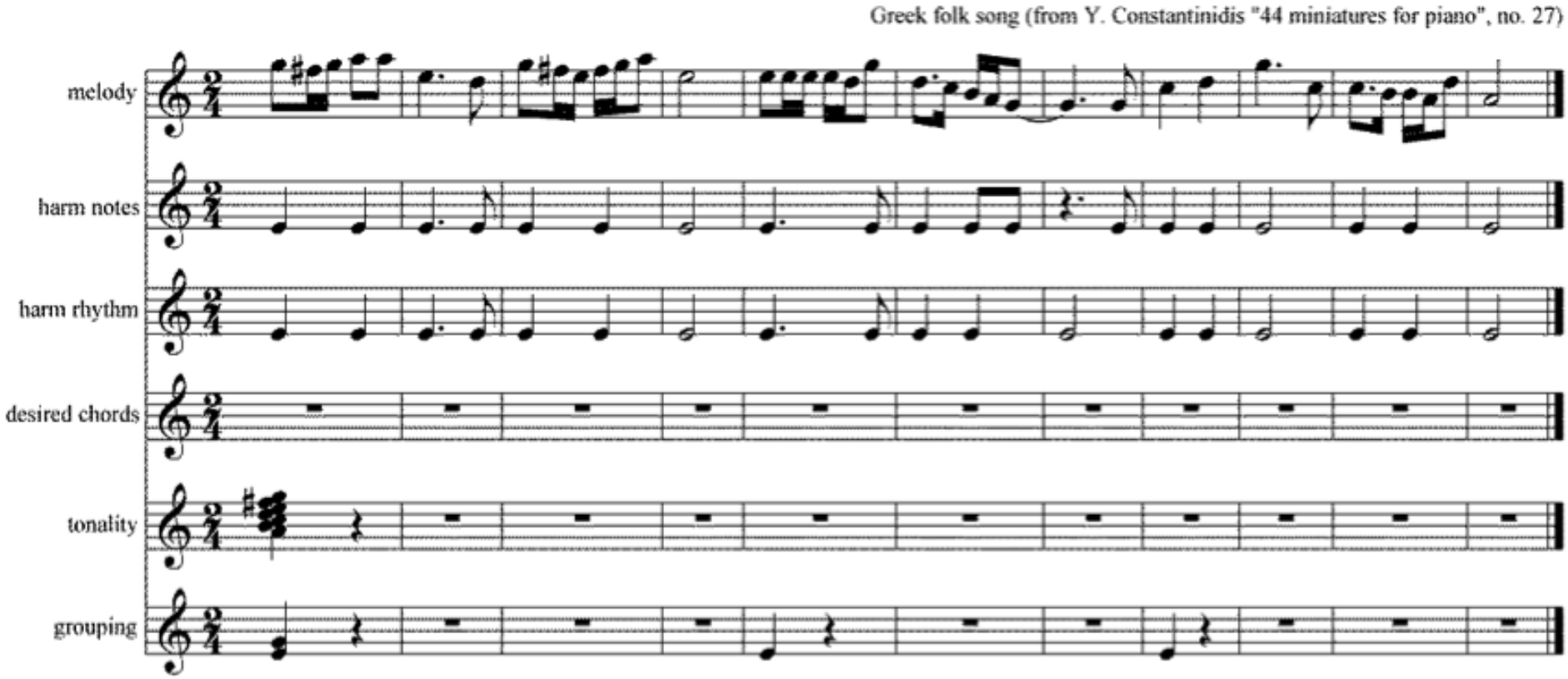
Melodic Harmonisation



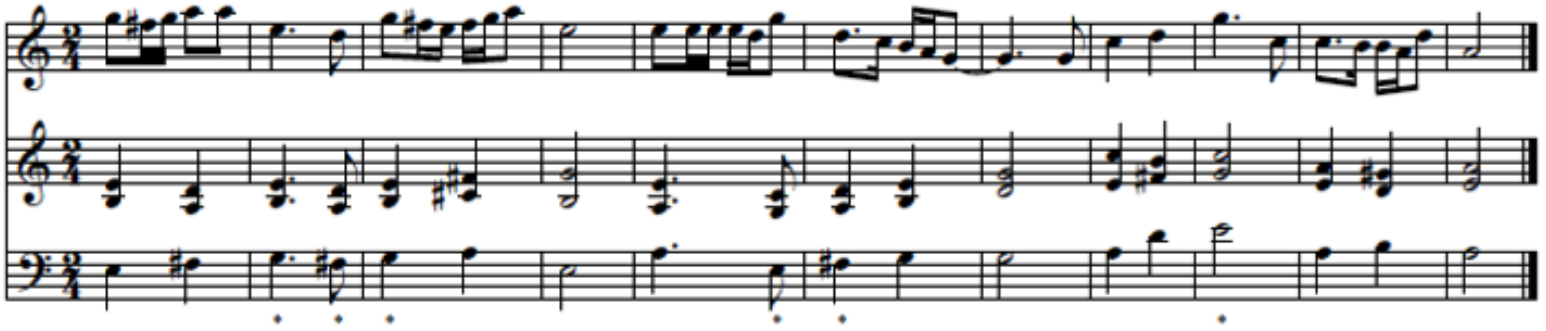
Blending is relevant in the sense that the implied harmonic space of melody and an appropriate harmonic space are combined.

Melodic Input

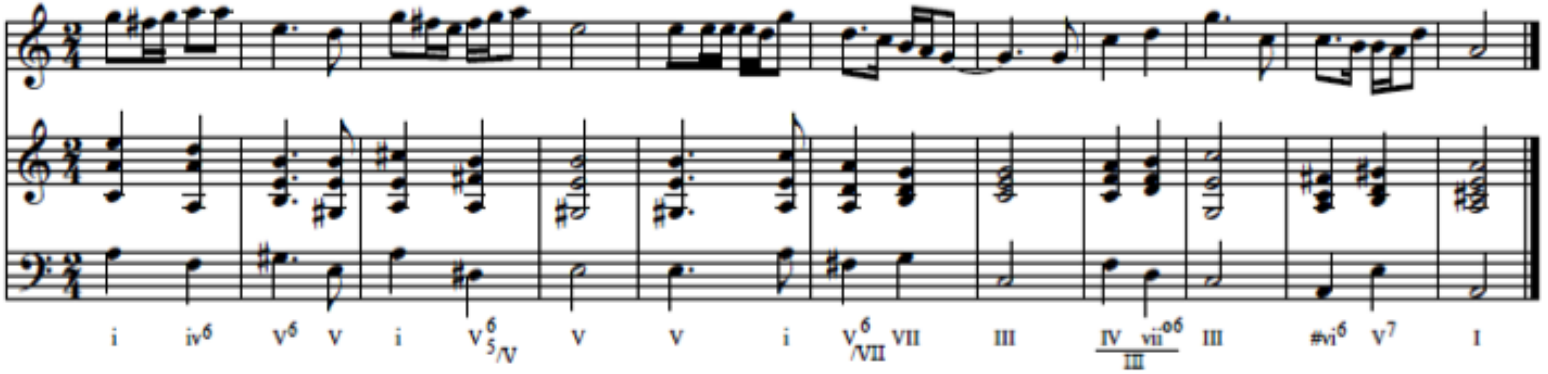
At this stage, the input melody is manually annotated by the user as to harmonic rhythm, harmonically important notes, key and phrase structure. The user provides the information and an xml file is produced.



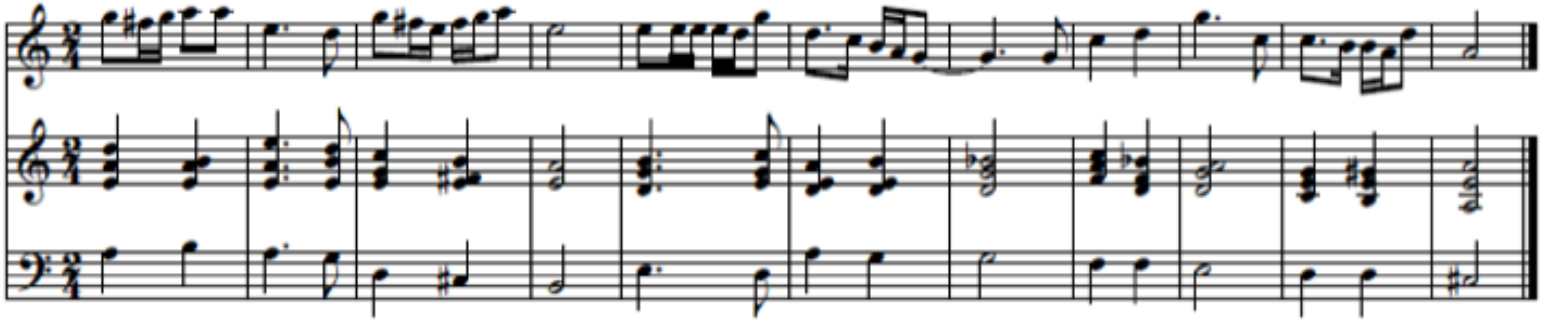
Diverse Musical Idioms



(a) Traditional melody harmonised in the style of fauxbourdon.



(b) Traditional melody harmonised in the Bach Chorale style.



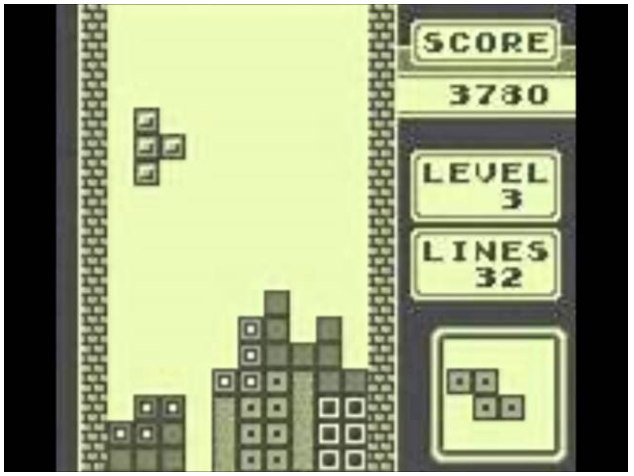
(c) Traditional melody harmonised in the style of Hindemith.

Tetris tune harmonisation

- Tetris theme
- Korobeneiki (russian folk song)

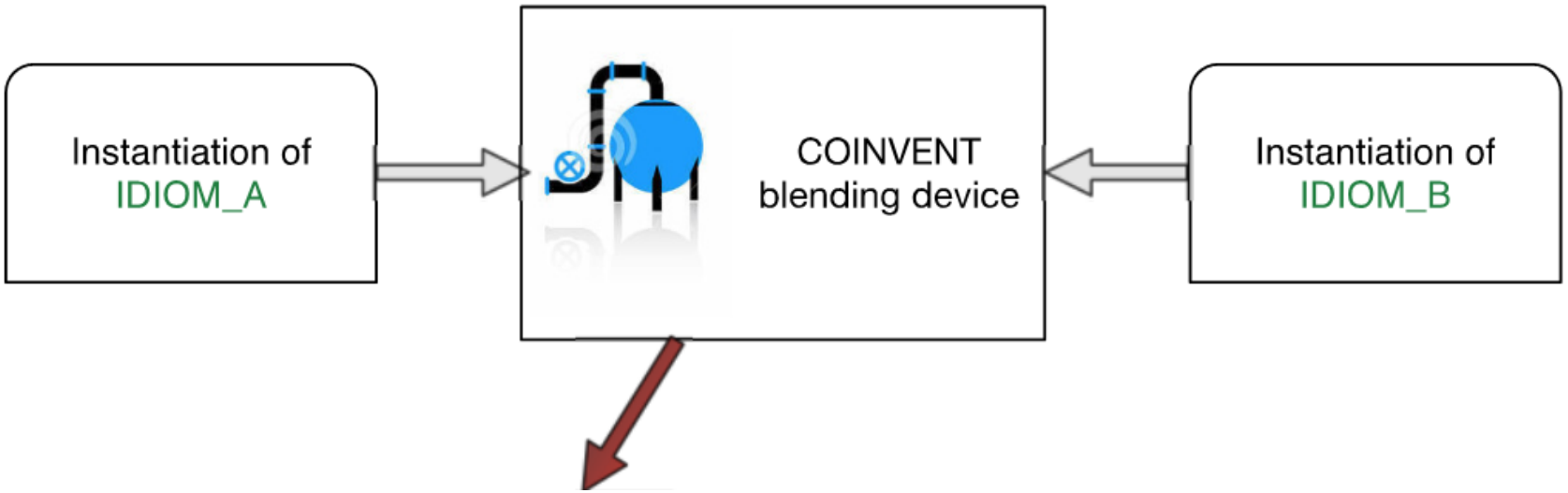
Harmonisations

- Bach chorales
- Modal chorales
- Kostka-Payne
- Konstantinidis
- Jazz
- Hindemith
- Epirus folk songs
- Organum
- Faux Bourdon

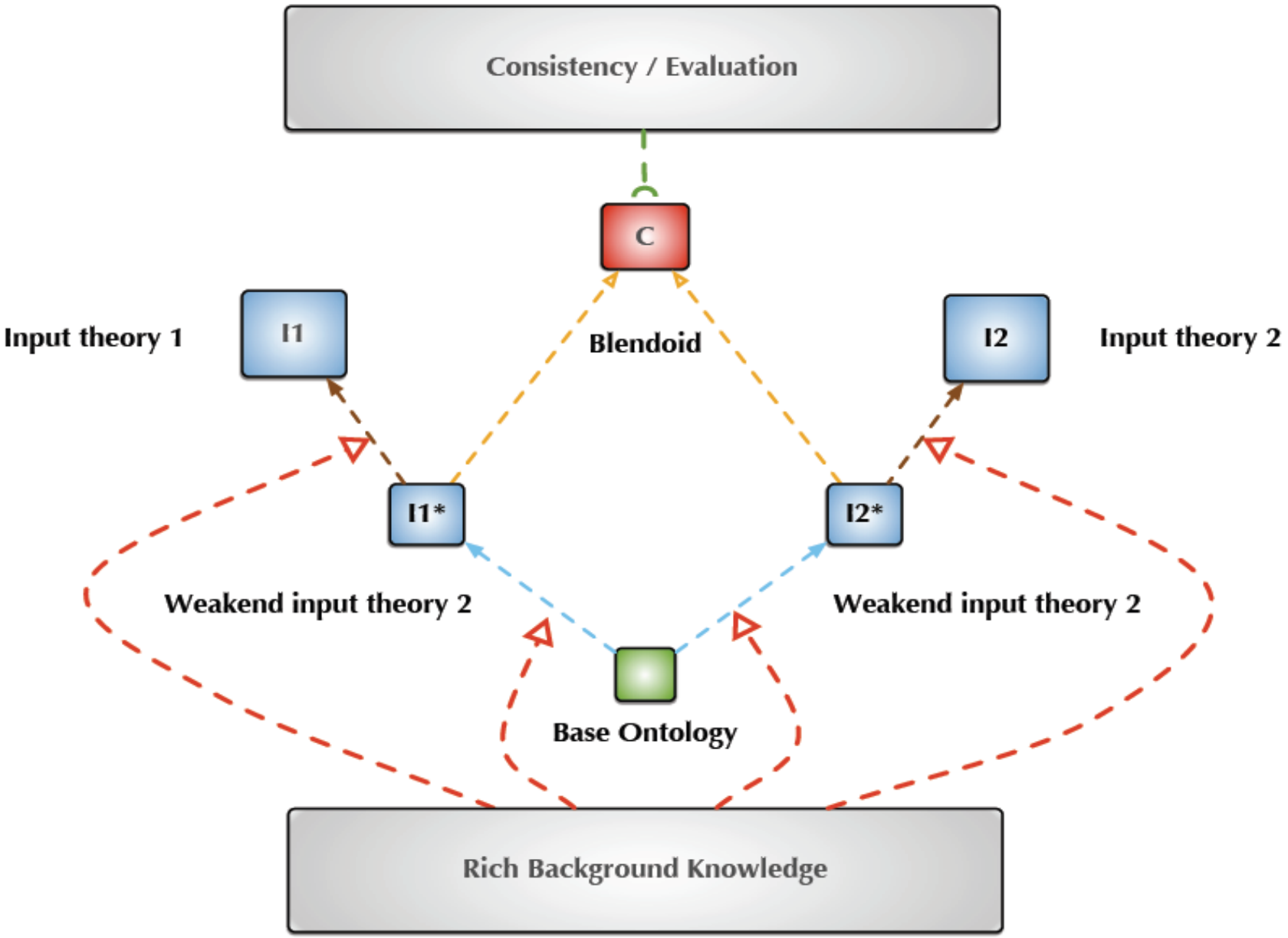


Blending & Harmony

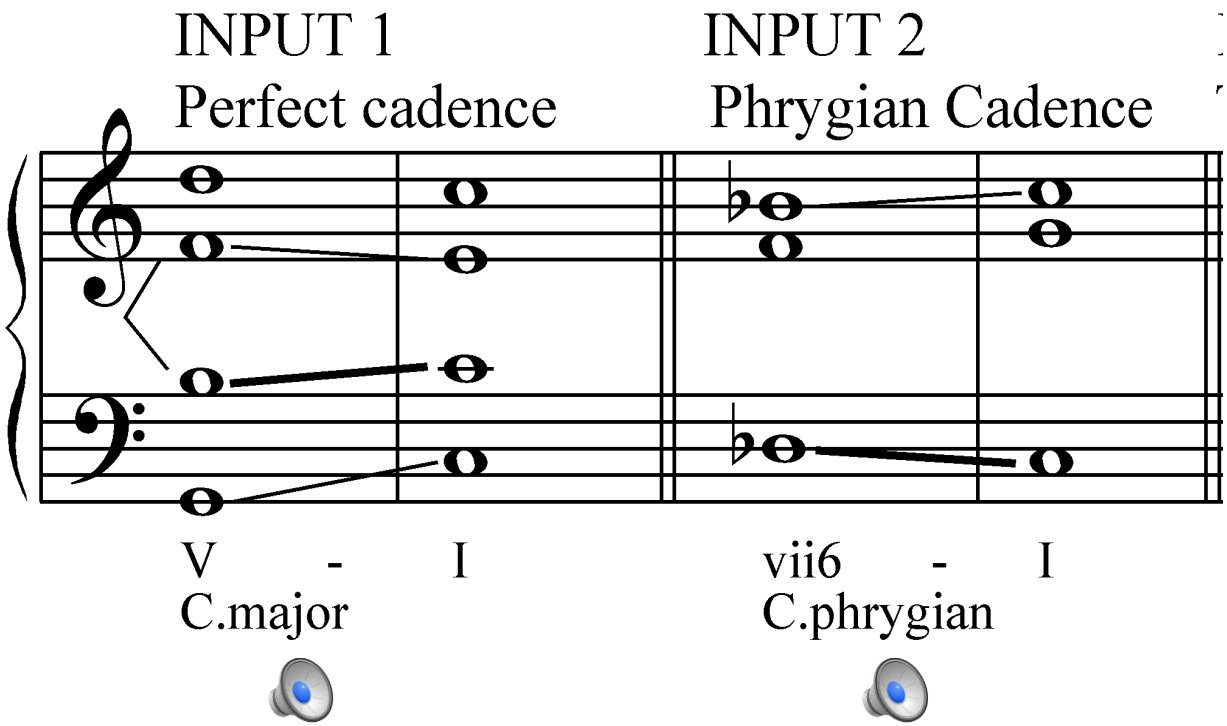
- Chord-level blending
- Chord-sequence level blending
- Harmonic-structure level blending
- Cross-domain level blending



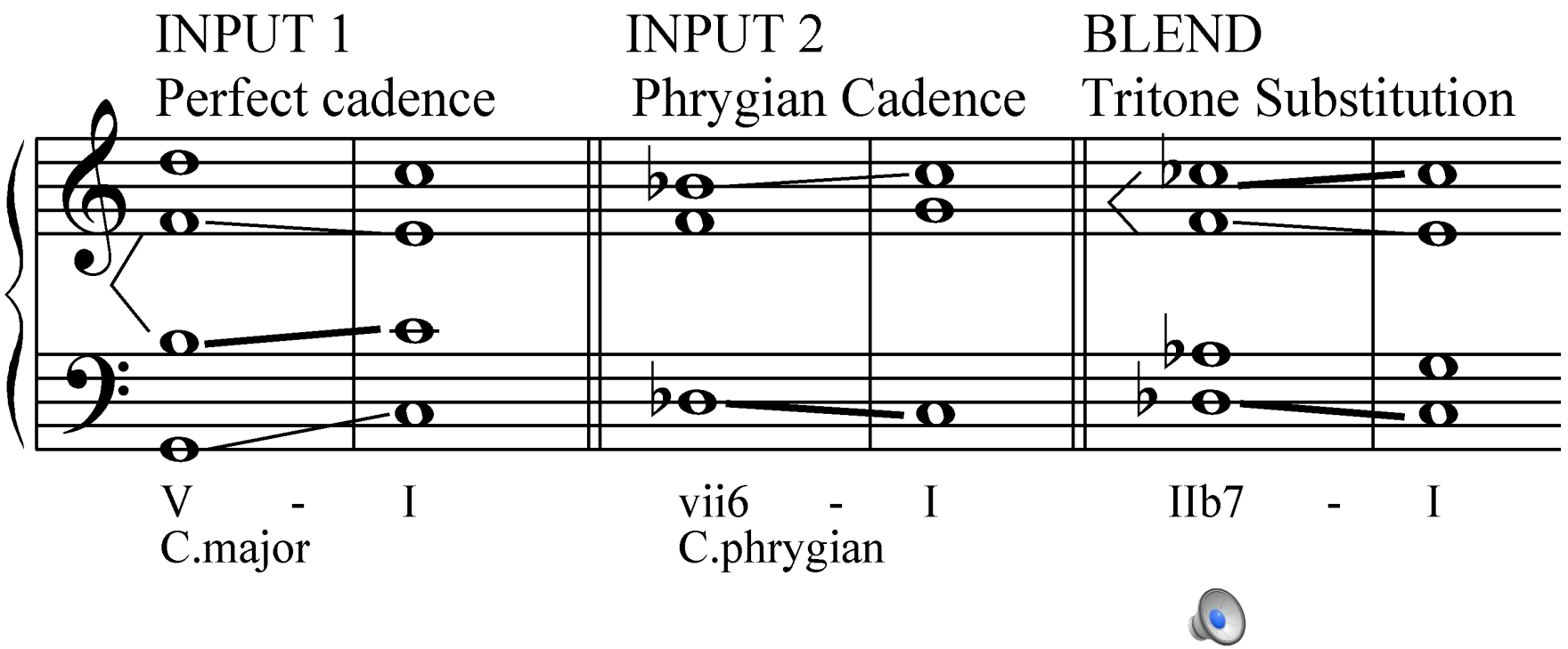
COINVENT blending model



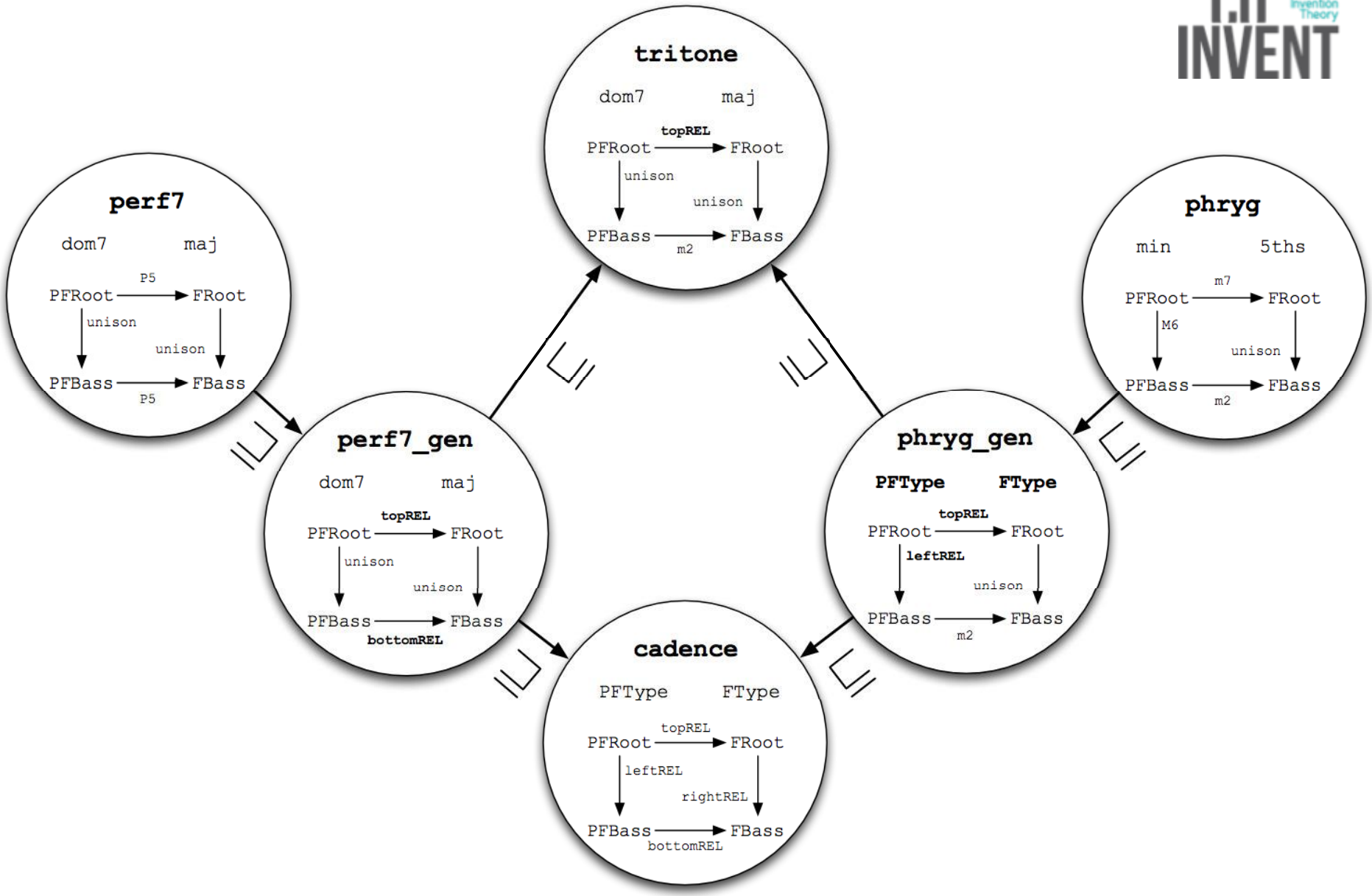
Chord level blending (cadences)



Chord level blending (cadences)

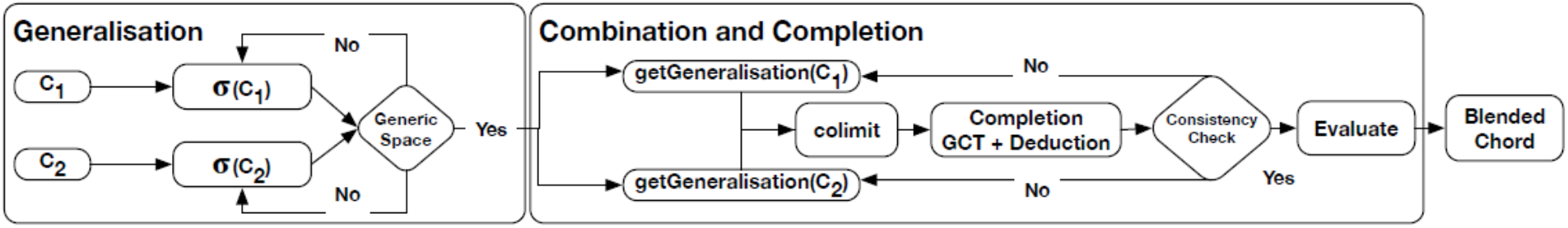


Formalised in the core-model…



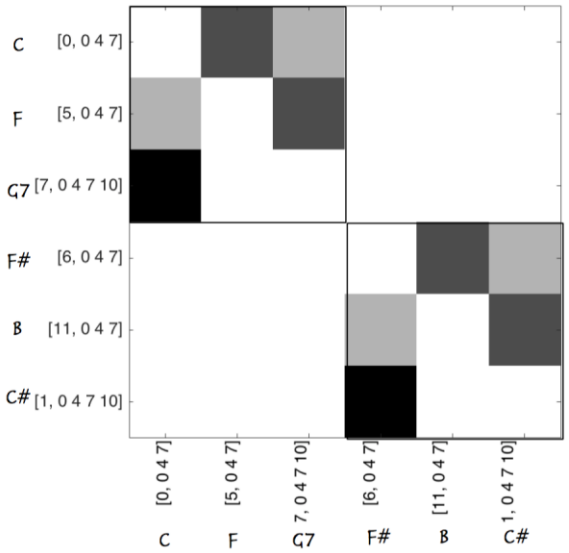
Combination & Completion

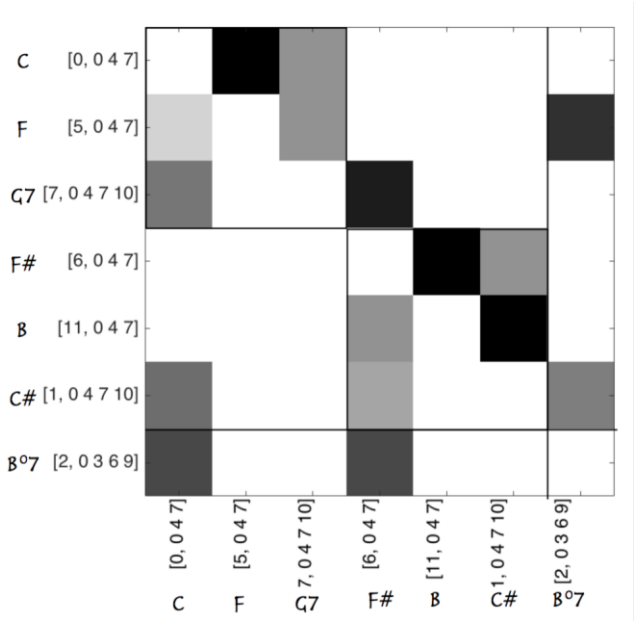
- **Generalisation** towards the *generic* space
  - least general generalisation for each input space
  - priorities.
- **Combination:** avoid inconsistencies
  - Balanced generalisation: double-scope blends
- **Completion & elaboration**: enrich composition with background knowledge

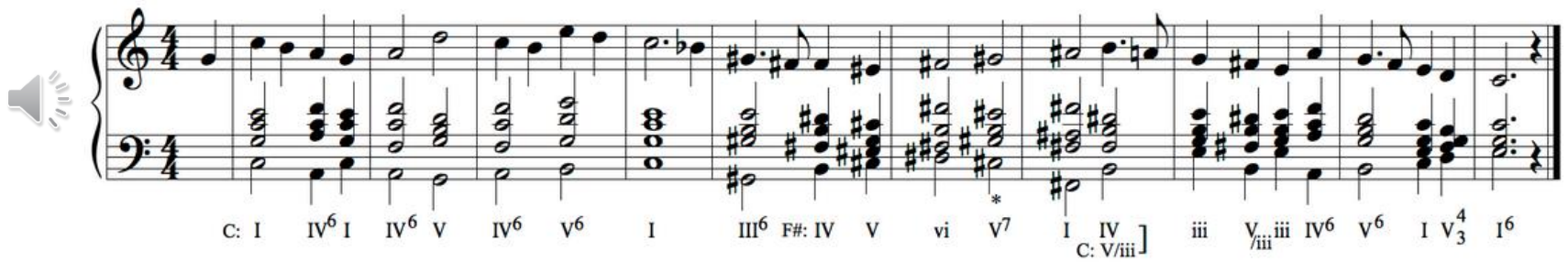


Blending chord transition matrices

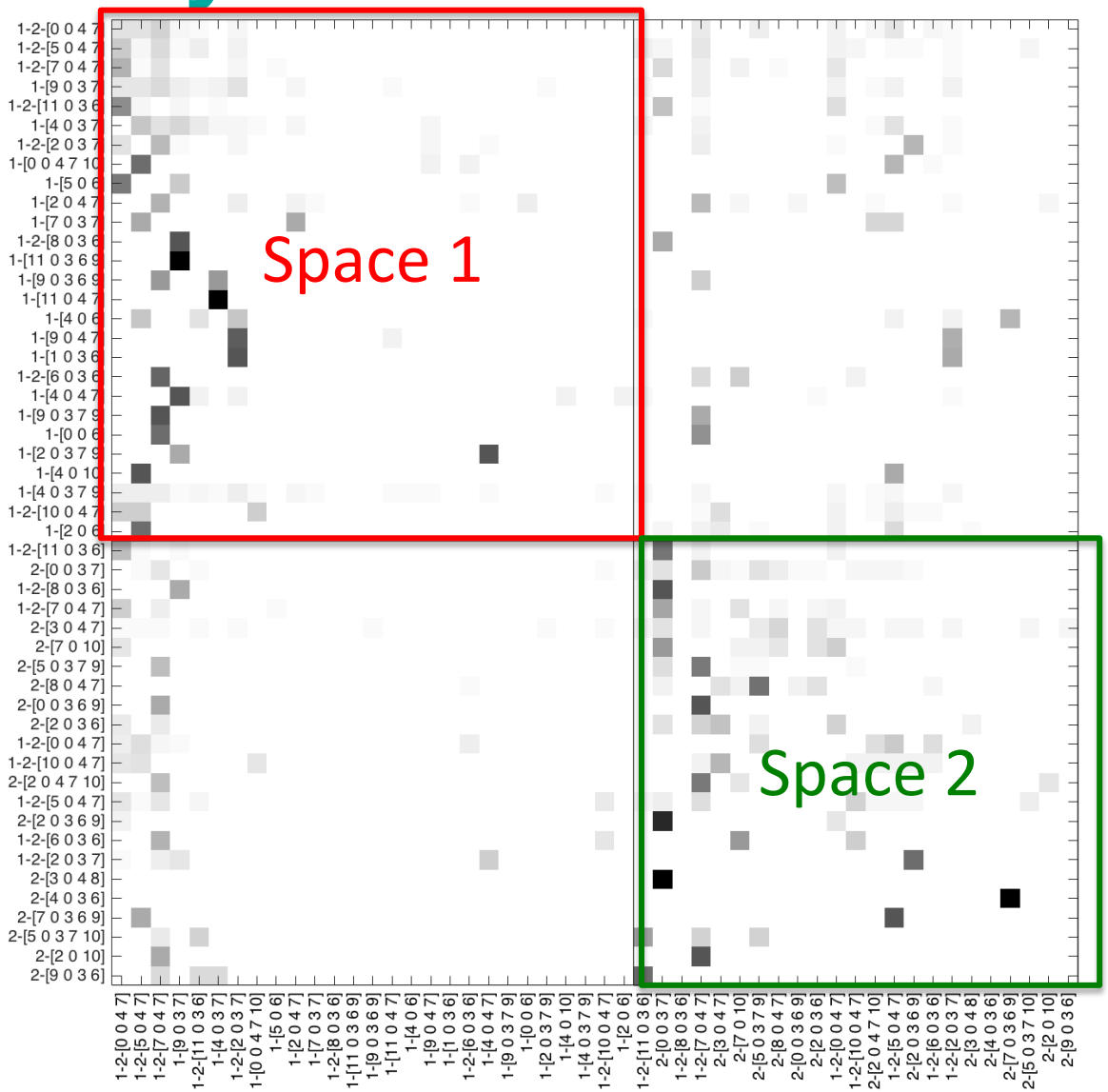
- User selects two idioms from a list.
- System automatically blends the most common transitions
- The ‘best’ resulting blends are integrated in a compound matrix.



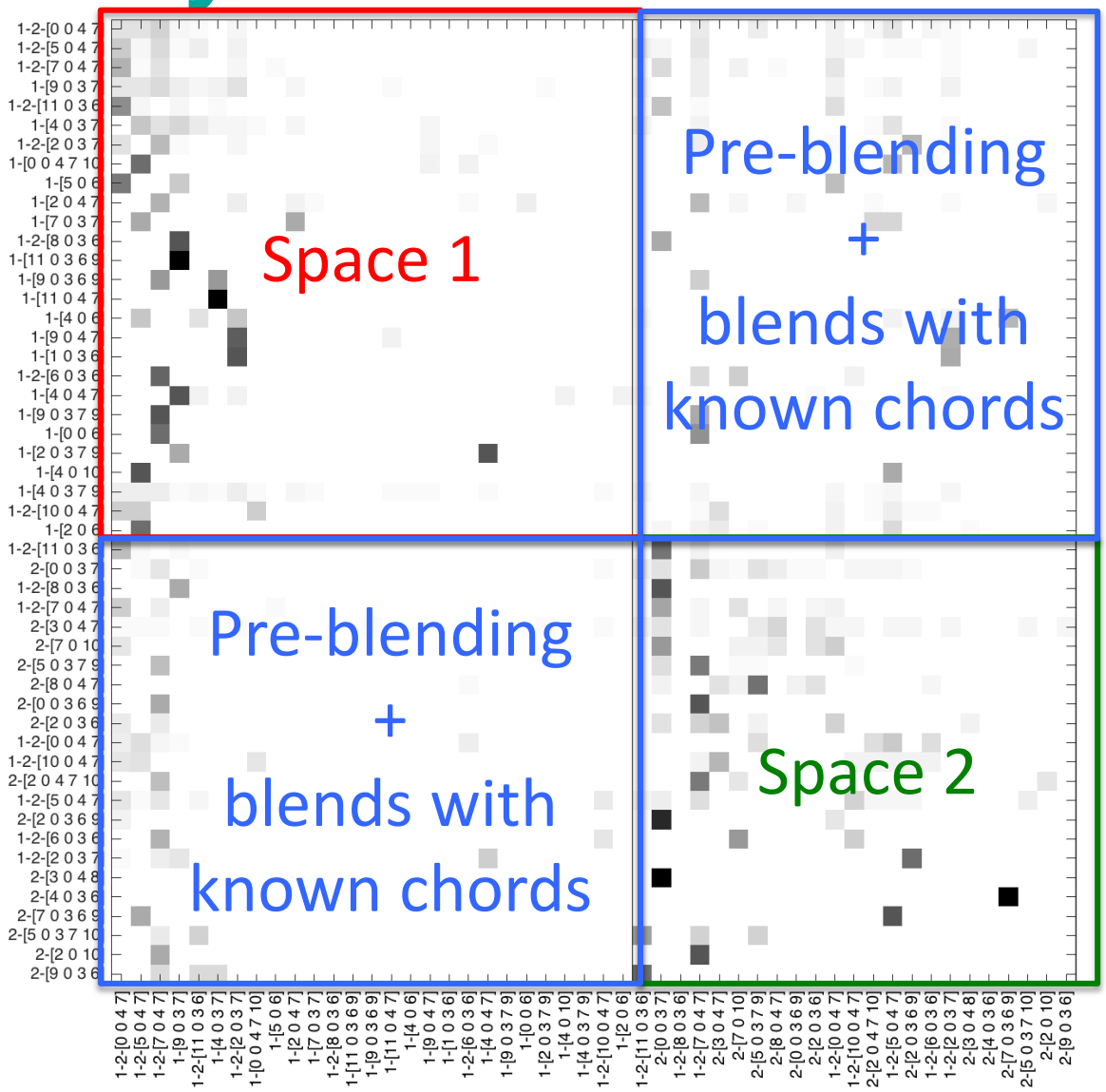




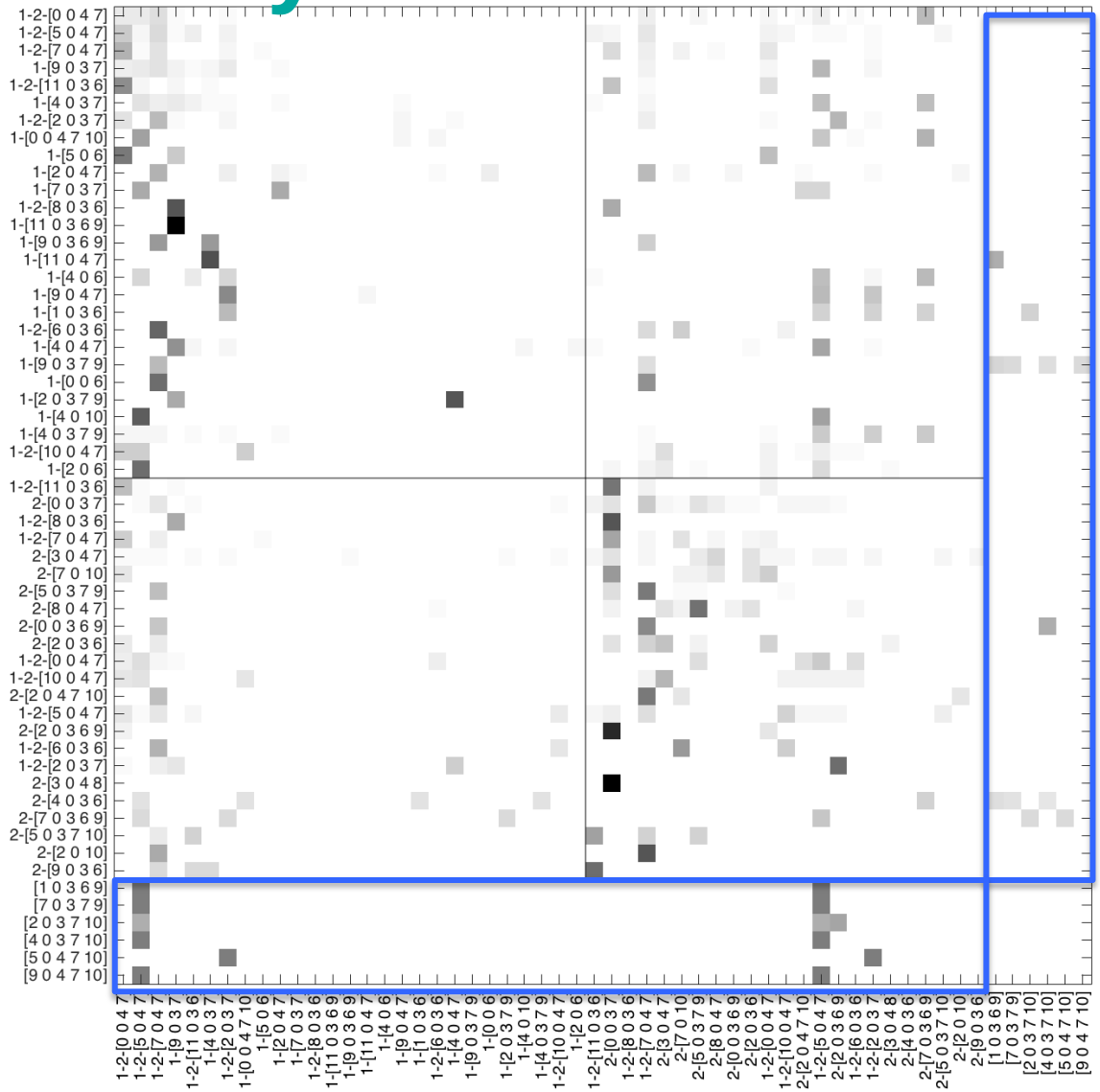
From to transition blends to probability matrices



From to transition blends to probability matrices



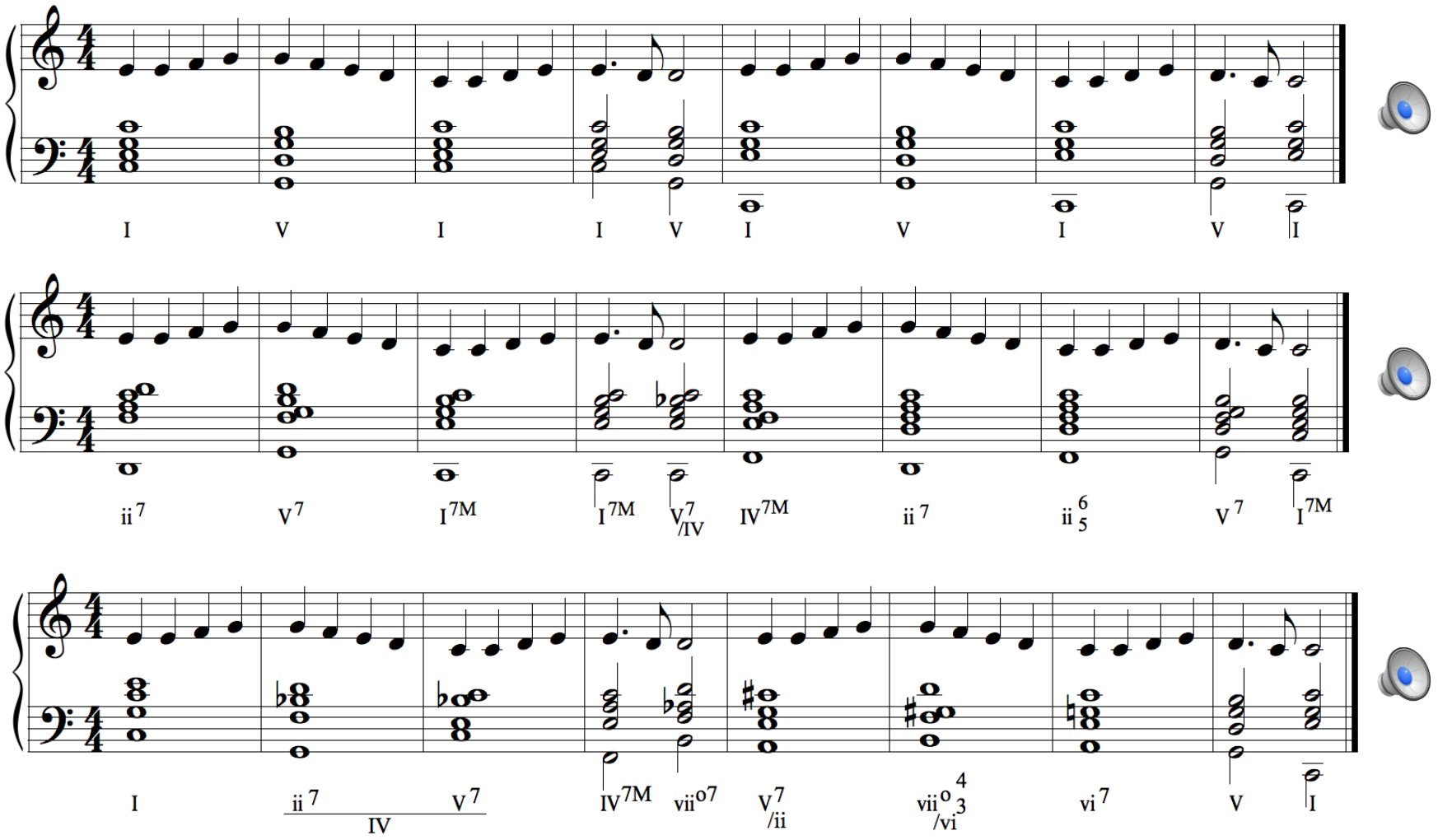
From to transition blends to probability matrices



New chords created through blending

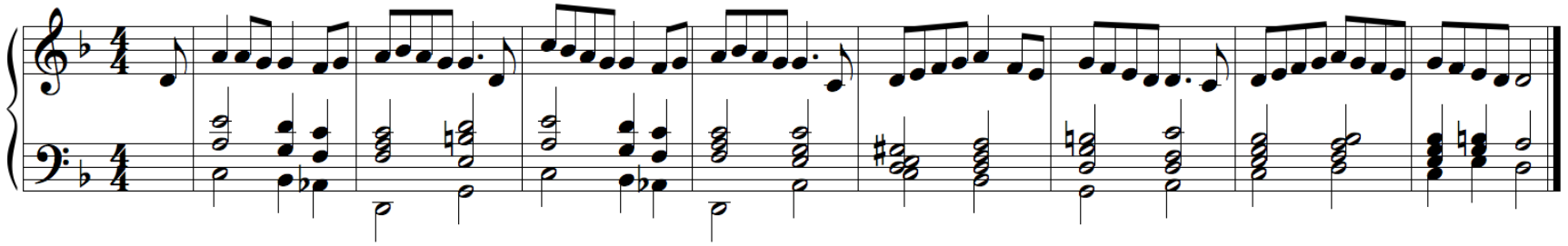
Blending Harmonic Spaces

L.v. Beethoven's "**Ode to joy**" with three harmonisations:
BC major (Bach chorale), JA major (Jazz), Blend of BC major/JA major

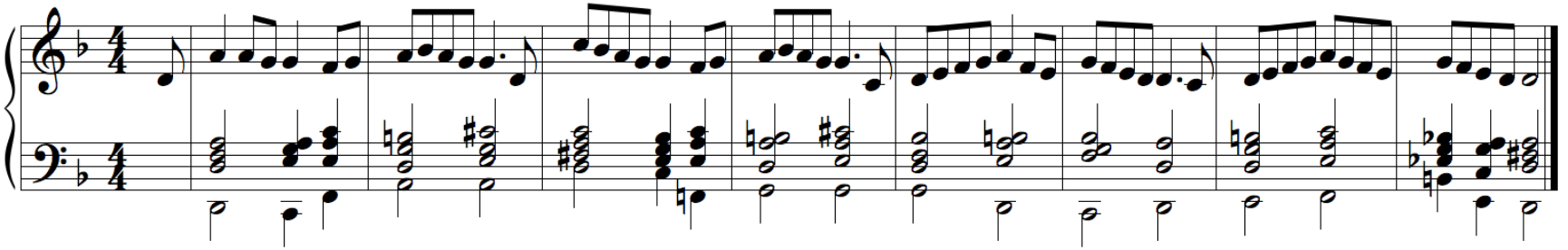


Blending Harmonic Spaces

The Greek folk song ***Apopse ta mesanychta*** (Tonight at midnight) with two harmonisations: Blend of CN/WT and Blend of HM/JA minor



Apopse ta mesanychta – Constantinidis/whole-Tone blend



Apopse ta mesanychta – Hindemith/Jazz blend

Evaluating CHAMELEON:

Computational creativity evaluation is not trivial

- Artistic creativity – aesthetic value
- Product or process?
- Dimensions: novelty, value, surprise, problem solving ability, originality, divergence (Jourdanous 2012-2016)
- Empirical testing
- User interaction with creative system

Evaluating CHAMELEON: Experiments with students of the School of Music Studies

Passive Evaluation through listening

1. Experiments in harmony class:

Idiom classification, mode classification

2. Experiment in analysis/theory class:

Type of chromaticism classification

Active evaluation through creative/compositional use

3. Creative harmonisation in stylistic composition class

Idiom classification

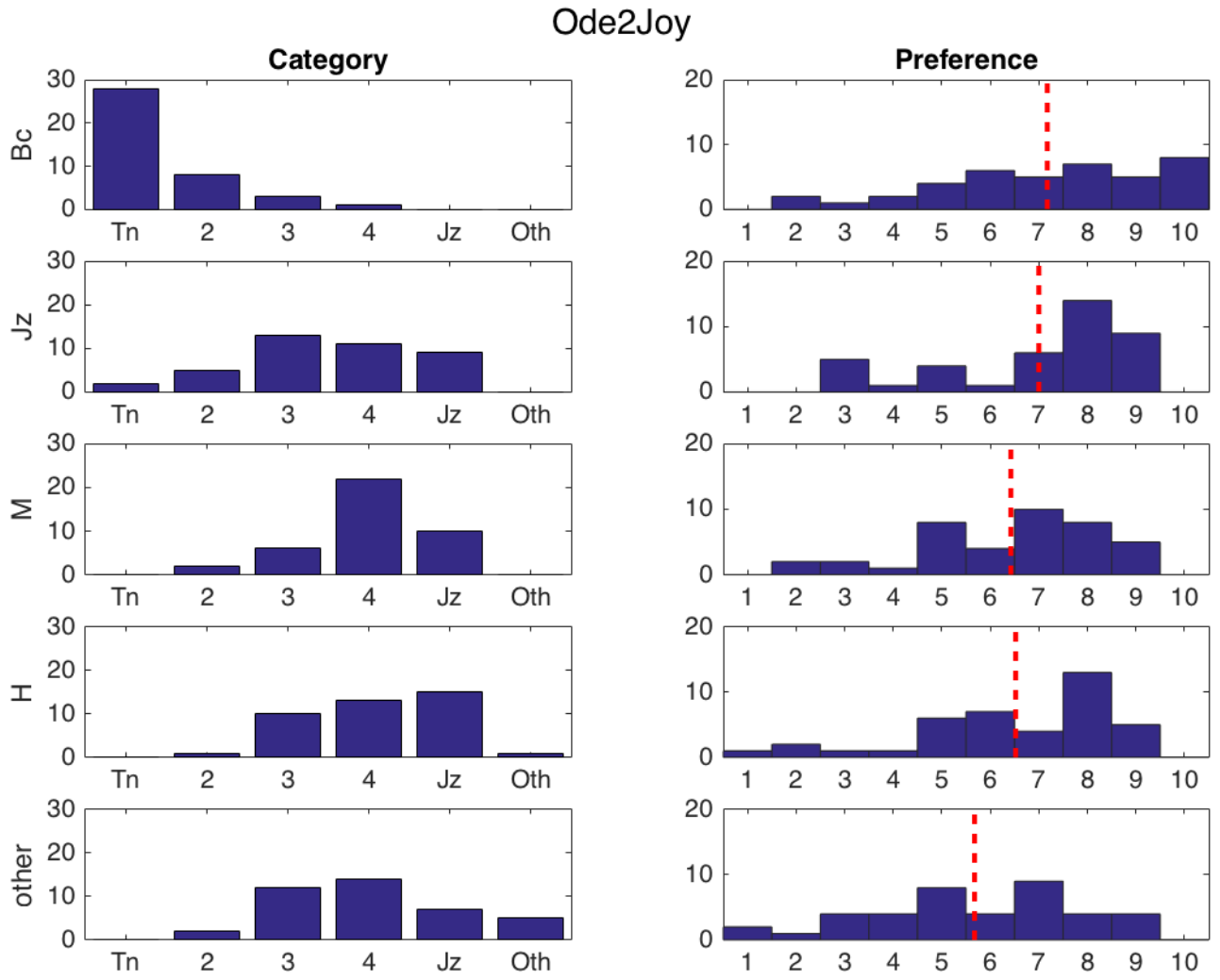
Melodies used:

- "Ode to joy", from L.v. Beethoven's 9th Symphony
- "Ah vous dirai-je, maman", French children's song, used as theme in W.A. Mozart's Piano Variations K265
- "Some day my prince will come", by Frank Churchill, soundtrack from Disney's *Snow White and the Seven Dwarfs* (1937)
- "Summertime", by George Gershwin
- "Του Κίτσου η μάνα", Greek folk song

Aim of experiment:

- Assess the extent to which harmonic blending can affect idiom perception.
- Assess preference (i.e., attributed aesthetic value)

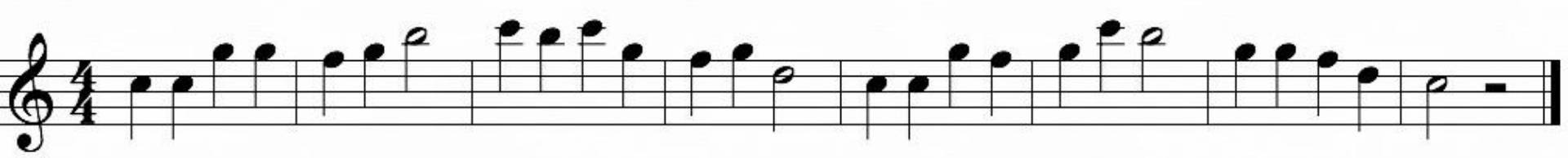
Results for "Ode to Joy"



Mode classification

Melody used:

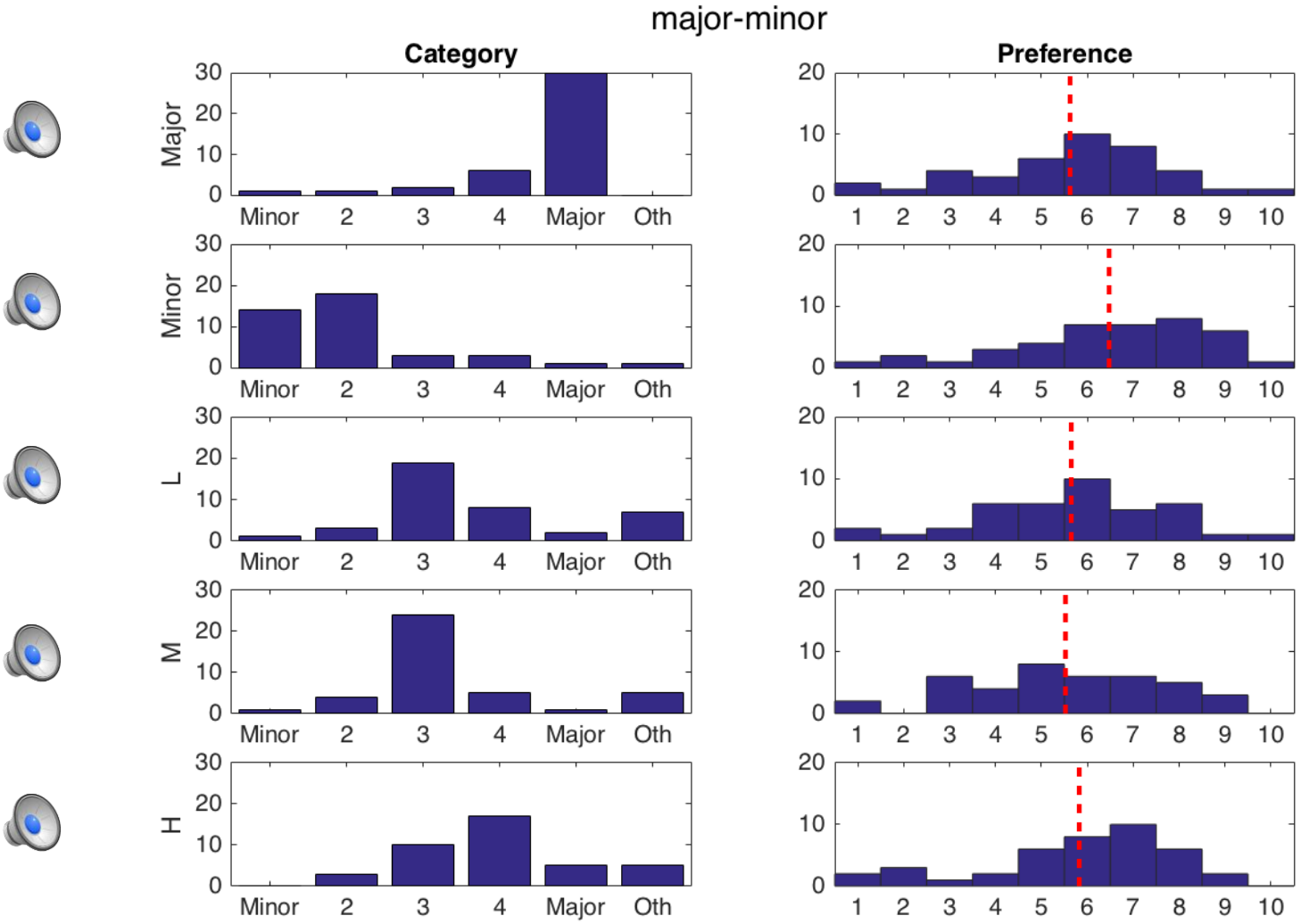
- Custom-created melody intentionally lacking the 3rd and 6th melodic degrees, so as to avoid major-minor classification



Aim of experiment:

- Assess the extent to which harmonic blending can affect perception of mode.
- Assess preference (i.e., attributed aesthetic value)

Results for "Major-Minor" melody



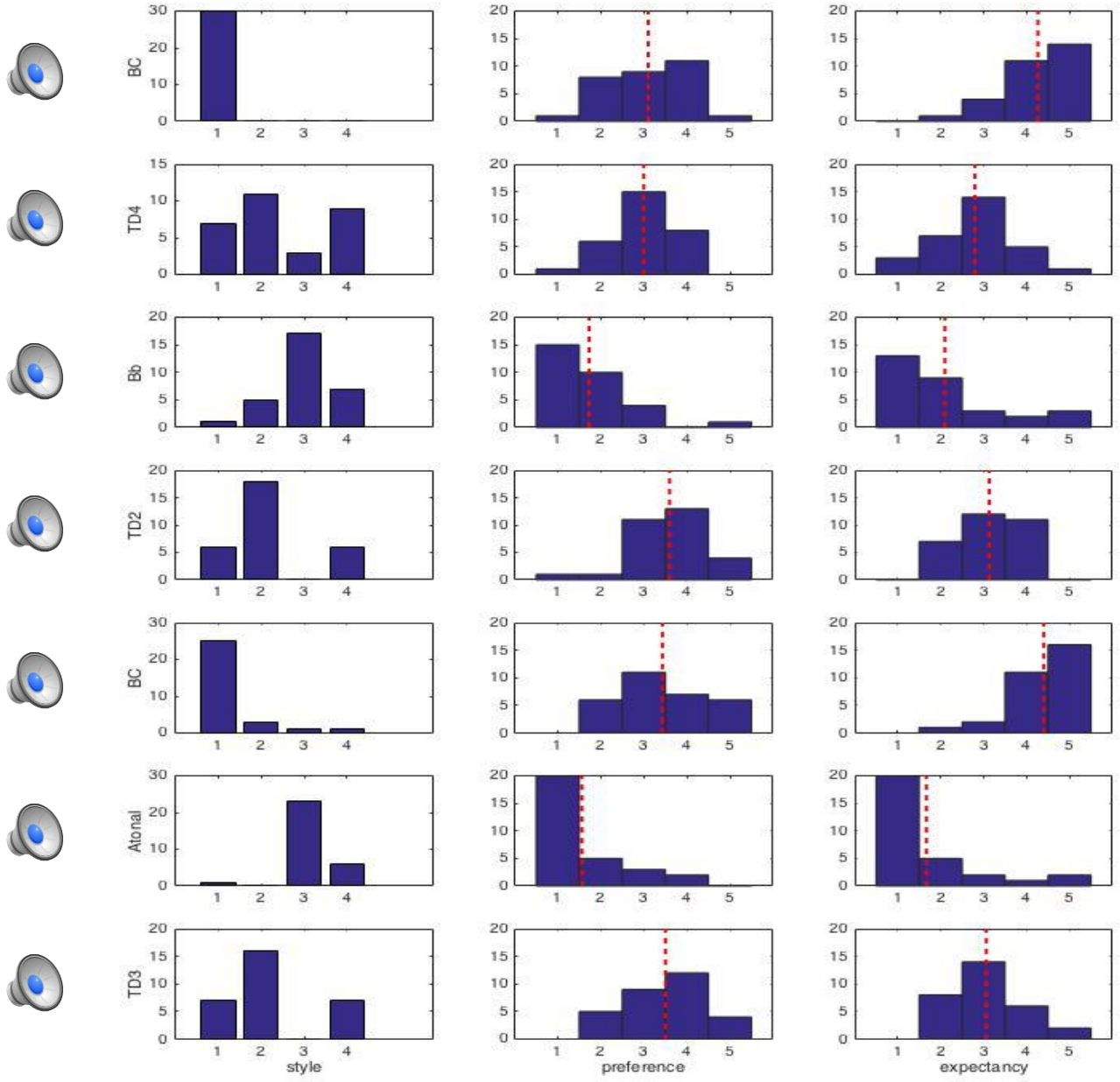
Type of chromaticism classification

Melody used for harmonisation:

- "Ye banks and braes", Scottish folk song

Aim of experiment:

- Assess the extent to which harmonic blending can affect perception of chromaticism.
- Assess preference (i.e., attributed aesthetic value)
- Assess expectancy (i.e., perceived novelty)



Results for "Ye banks and braes"

Creative harmonisation assisted by CHAMELEON

Melodies used for harmonisation and variation:

Three Greek folk songs:

- Είχα μιαν αγάπη (*Eicha mian agapē*, I had a love)
- Απόψε τα μεσάνυχτα (*Apopse ta mesanychta*, Tonight at midnight)
- Μωρή κοντούλα λεμονιά (*Mōrē kontoula lemonia*, Oh short lemon tree)

Aim of experiment:

Creative use of produced CHAMELEON harmonisations (40 for each melody) as a structural harmonic framework for the building of rich musical textures and original variations.

Public Concert

Musical Blender: Artificial Intelligence & Creativity

Presentation and Concert

20:00, 19 Oct 2016

Macedonian Museum of Contemporary Art, Thessaloniki

***Seven Piano Miniatures* (14') –** Fani Karagianni (Piano)

Michalis Goutis: Apopse ta mesanychta
Zesses Seglias: Tonight Midnight
Giorgos Papaoikonomou: Apopse ta mesanychta
Dimitris Maronidis: 7 COnsecutive INVENTions
Lazaros Tsavdaridis: Mōrē kontoula lemonia
Yiannis Sakellaris: Mōrē kontoula lemonia
Stella Dalampira: Mōrē kontoula lemonia

http://ccm.web.auth.gr/creativeusecomposers.html




Selected Publications

- Kaliakatsos-Papakostas, M., Queiroz, M., Tsougras, C., & Cambouropoulos, E. (2017). Conceptual blending of harmonic spaces for creating melodic harmonisation, *Journal of New Music Research*.
- Zacharakis, A., Kaliakatsos-Papakostas, M., Tsougras, C., & Cambouropoulos, E. (2017). Empirical methods for evaluating musical structural blends: A case study on melodic harmonisation, *Musicae Scientiae,* (Forthcoming).
- Zacharakis, A., Kaliakatsos-Papakostas, M., Tsougras, C., & Cambouropoulos, E., (2017). Creating musical cadences via conceptual blending: Empirical evaluation and enhancement of a formal model. *Music Perception,* (Forthcoming).
- Kaliakatsos-Papakostas M., Makris D., Tsougras C., Cambouropoulos E. (2016) Learning and creating novel harmonies in diverse musical idioms: An adaptive modular melodic harmonisation system. *Journal of Creative Music Systems 1(1)*.

Thank you!

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www.coinvent-project.eu

www.ccm.web.auth.gr
www.ccm.web.auth.gr/chameleonmain.html