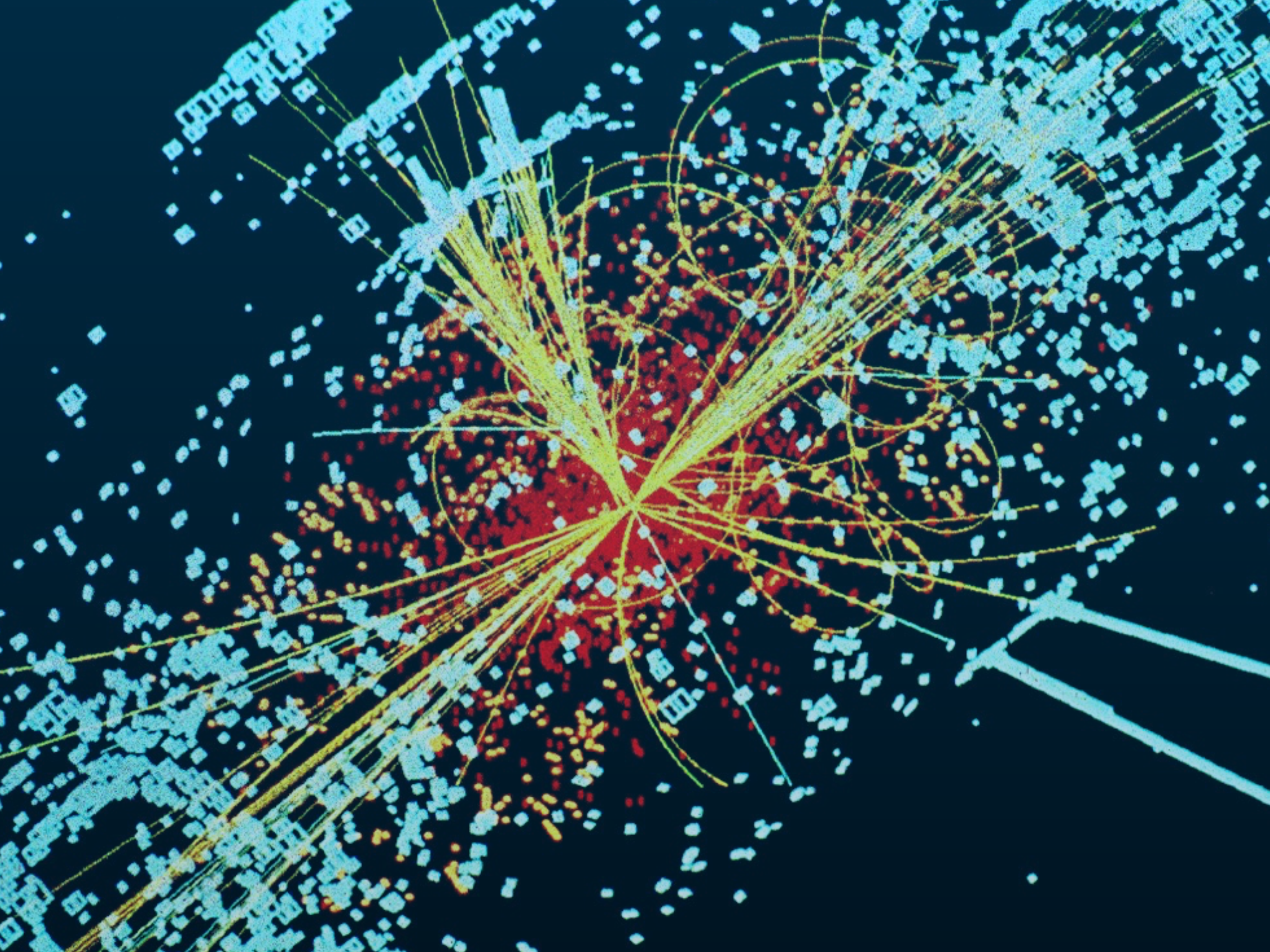


Sound Asleep

Harmonic Cadences in the Human Sleep Cycle

Prof Morten Kringelbach University of Oxford

Dr Milton Mermikides University of Surrey



Blue Jay Way

Minor Modes

Major Modes

Dorian

6th

3rd

Sharpe
(Brighte

Aeolian

Mixolydian

Abstract Musical Mechanics

The Modal Compass

2nd

7th

Phrygian

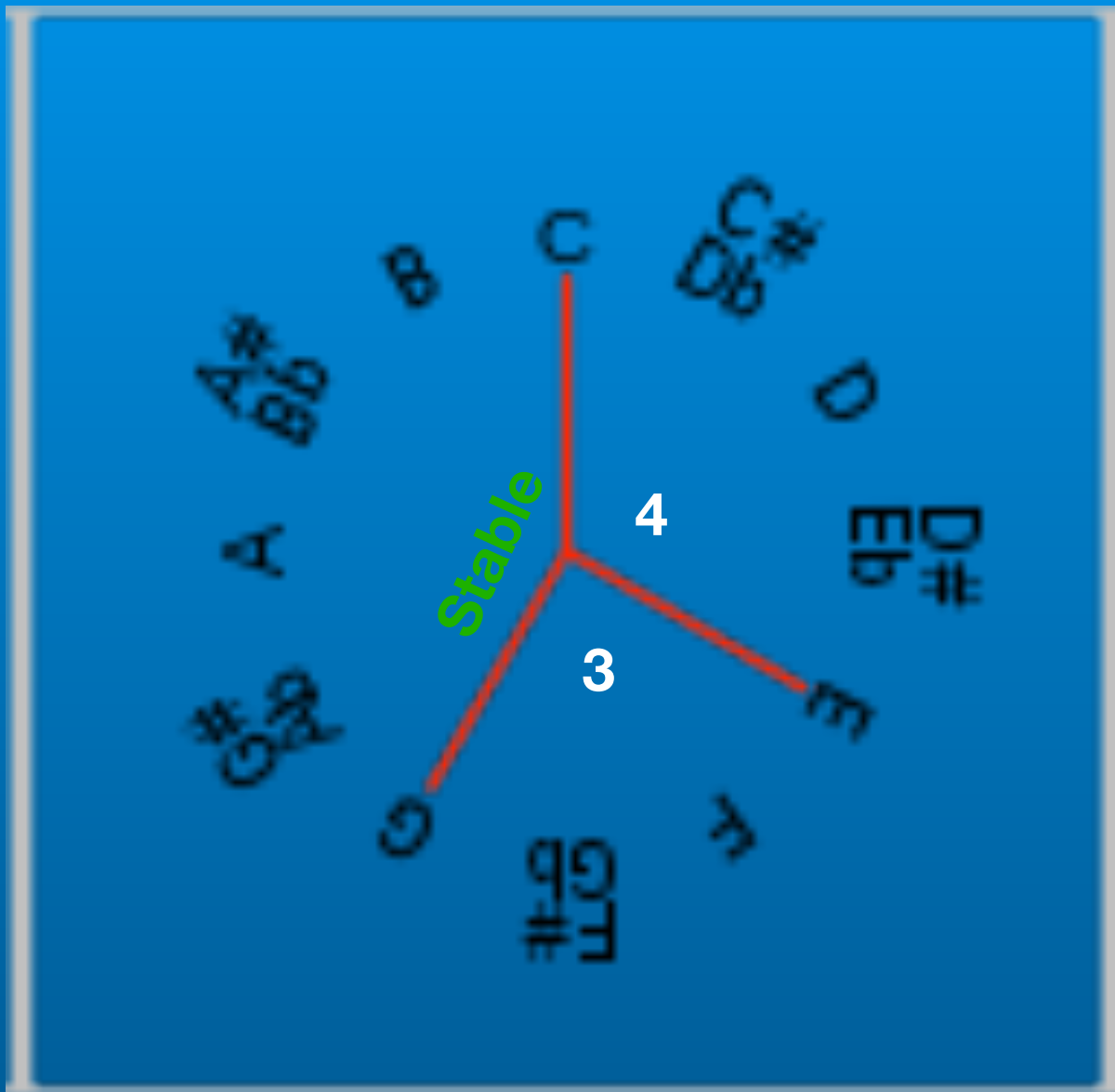
Ionian

5th

4th

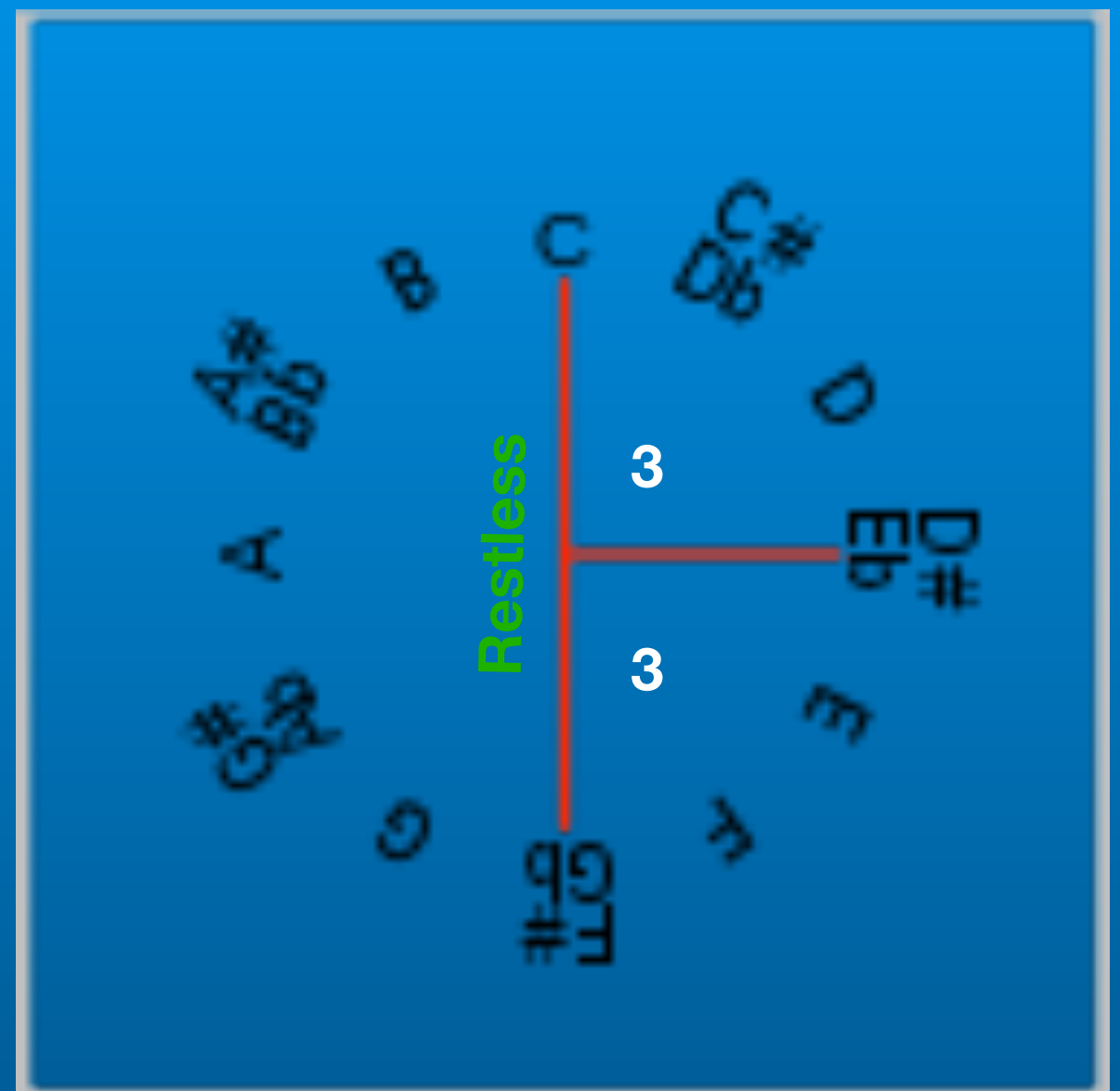
Invert

Major



Simple Harmonic Ratios
Consonant

Diminished



More complex Harmonic Ratios
Dissonant

Blue Jay Way analysis

Slowly

mp

1. There's a fog up on L.

C

A.,
(2.) show,
(3.) know,

Cdim

And my friends have lost their
And I told them where to
And I'd real-ly like to

C

way.
go.
go.

Cdim

We'll be o - ver soon they
Ask a p'liceman on the
Soon will be the break of

said,
street,
day,

Cdim7

Now they've lost them-selves in -
There's so man - y there to
Sitting here in blue jay

C

stead.
meet.
way.

Blue Jay Way's strange cadence

Slowly

The musical score is divided into two systems. The first system contains the first two lines of music. The second system contains the last two lines. The score is annotated with red and green background blocks. Red blocks indicate dissonance, and green blocks indicate consonance. The lyrics are: '1. There's a fog up on L. A., (2.) show, (3.) know, And my friends have lost their way. go. go. And I told them where to go. go. We'll be o-ver soon they said, street, day, Now they've lost them-selves in - stead. meet. way. Ask a p'liceman on the street, day, There's so man - y there to meet. way. Sitting here in blue jay way.' The chords are labeled as C, Cdim, and Cdim7.

mp
1. There's a fog up on L.

A.,
(2.) show,
(3.) know,

And my friends have lost their way.
And I told them where to go.
And I'd real-ly like to go.

We'll be o-ver soon they said,
Ask a p'liceman on the street,
Soon will be the break of day,

Now they've lost them-selves in -
There's so man - y there to
Sitting here in blue jay

stead.
meet.
way.

Cdim

C

Cdim

C

Cdim

Cdim7

C

Dissonance

Consonance

Blue Jay Way Harmonic Reduction - Dissonance resolved in place

The diagram shows a musical staff with a treble clef. The first chord is a C major triad (C^o) with notes C4, E4, and G4, highlighted in a red box. Two black arrows point from the E4 and G4 notes to the second chord, which is a C major triad (C) with notes C4, E4, and G4, highlighted in a green box. The third chord is a C major triad with a flat fifth (C(b5)) with notes C4, E4, and Bb4, highlighted in a red box. The fourth chord is a C major triad (C) with notes C4, E4, and G4, highlighted in a green box. The bass line consists of a single C2 note throughout.

There's a fog up on.... LA
And my friends have lost their... way

Blue Jay Way Sanitised Version - Dissonance resolved 'away'

The diagram shows a musical staff with a treble clef. The first chord is a C major triad (C^o) with notes C4, E4, and G4, highlighted in a red box. Two black arrows point from the E4 and G4 notes to the second chord, which is a D-flat major triad (D^b) with notes D^b4, F^b4, and A^b4, highlighted in a green box. The third chord is a D-flat major triad with an added fourth (D^b(add4)) with notes D^b4, F^b4, A^b4, and C^b5, highlighted in a yellow-green box. The fourth chord is a D-flat major triad (D^b) with notes D^b4, F^b4, and A^b4, highlighted in a green box. The bass line consists of a single D^b2 note throughout.

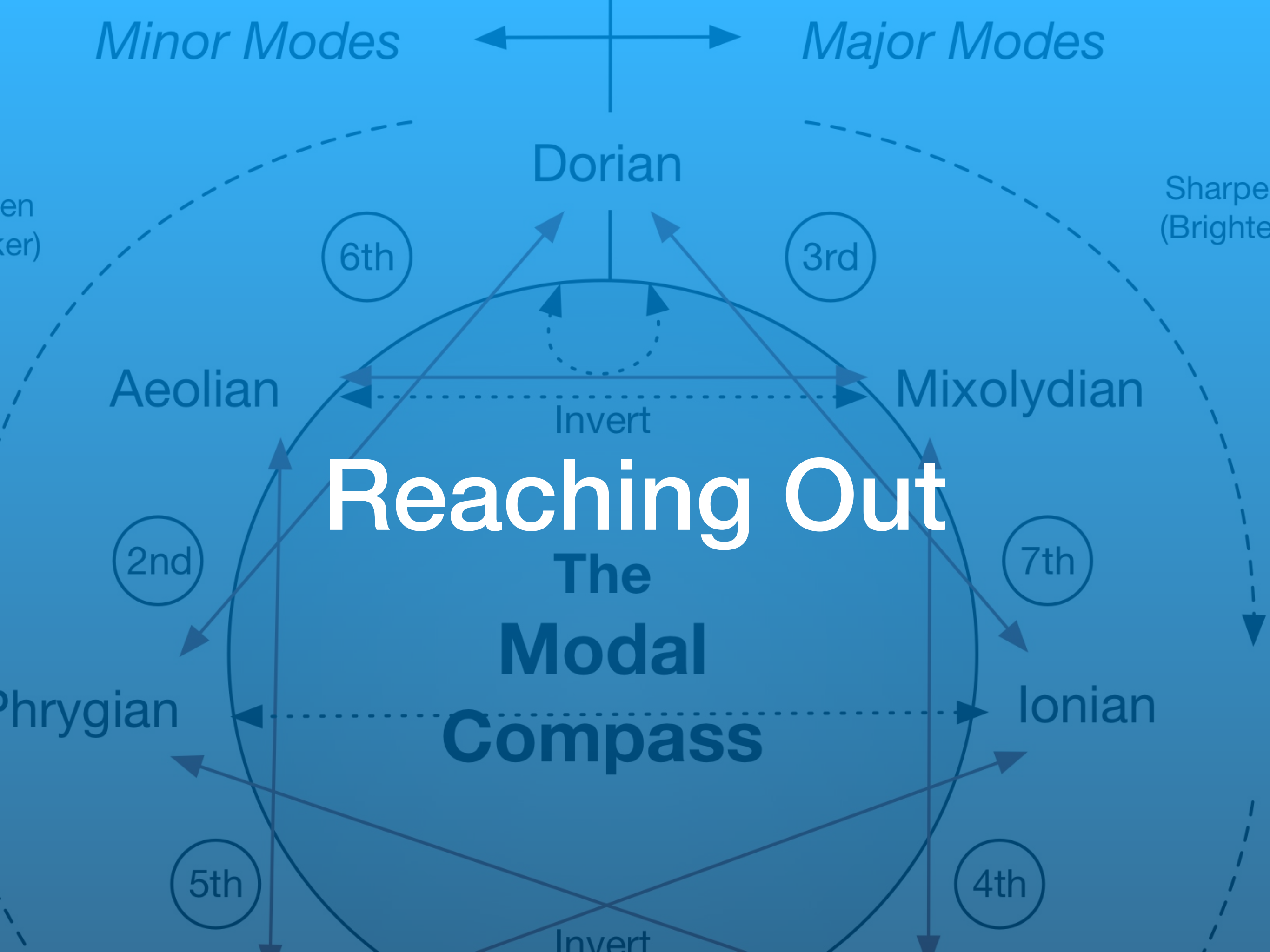
Blue Jay Way Harmonic Reduction - Dissonance resolved 'in place'

The diagram shows a musical staff with a treble clef. The first chord is C^o (C major triad), highlighted in a red box. Two arrows point from the notes of this chord to the notes of the second chord, C (C major triad), which is highlighted in a green box. The third chord is C(b5) (C major triad with a flat fifth), highlighted in a red box. The fourth chord is C (C major triad), highlighted in a green box. The notes of the C(b5) chord are shown in red, while the notes of the other chords are in green. The bass line consists of a single note, C, in the bass clef.

There's a fog up on.... LA
And my friends have lost their... way

Blue Jay Way Sanitised Version - Dissonance resolved 'away'

The diagram shows a musical staff with a treble clef. The first chord is C^o (C major triad), highlighted in a red box. Two arrows point from the notes of this chord to the notes of the second chord, D^b (D-flat major triad), which is highlighted in a green box. The third chord is D^b(add4) (D-flat major triad with an added fourth), highlighted in a yellow box. The fourth chord is D^b (D-flat major triad), highlighted in a green box. The notes of the D^b and D^b(add4) chords are shown in green, while the notes of the other chords are in red. The bass line consists of a single note, D^b, in the bass clef.



Minor Modes

Major Modes

Dorian

6th

3rd

Sharpe
(Brighte

Aeolian

Mixolydian

Invert

Reaching Out

The

Modal

Compass

2nd

7th

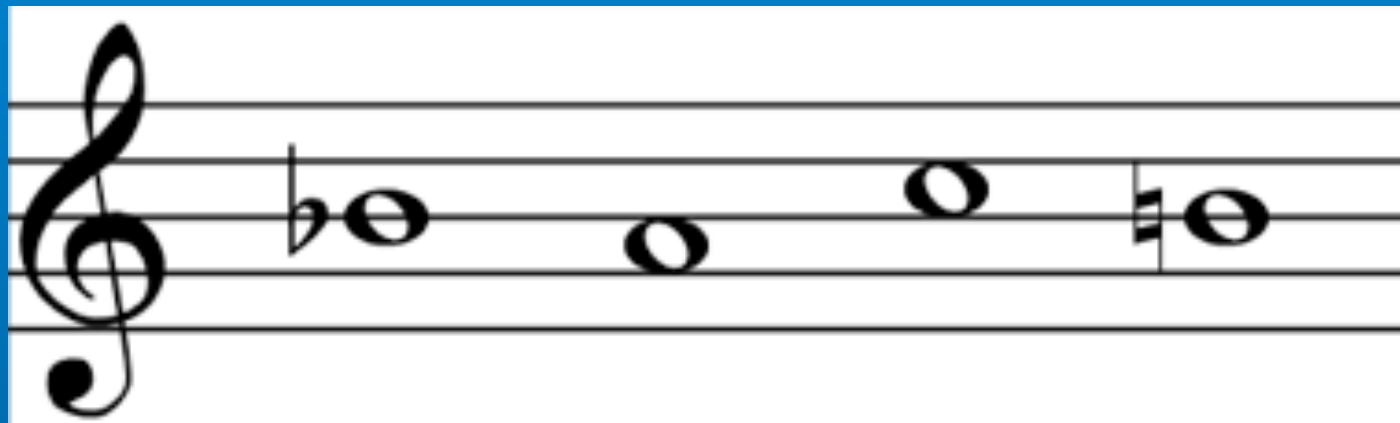
Phrygian

Ionian

5th

4th

Invert



B

A

C

H



The unfinished *Contrapunctus XIV* C.P.E. Bach's note reads "At the point where the composer introduces the name *BACH* in the countersubject to this fugue, the composer died."

Another of 100s of examples through the ages...

Dimitri Schostakovich



D Eb(S) C H

Extending the concept



Villa-Lobos
(1887-1959)



VILLA-LOBOS: NEW YORK SKY LINE MELODY - GRÁFICO DERIVADO DA
VERSÃO DE 1957. (C. KATER, 1982)



New York Skyline Melody (1939)

WILMA LORDES
WILMA LORDES

The coronal suture of the skull [has] a certain similarity to the closely wound line [...] of a phonograph [...]

Suppose, one played a trick on this needle and caused it to retrace a path not made by the graphic translation of a sound, but self-sufficing and existing in nature [...] what would happen?

...

Ur-Geräusch (Rilke 1919)

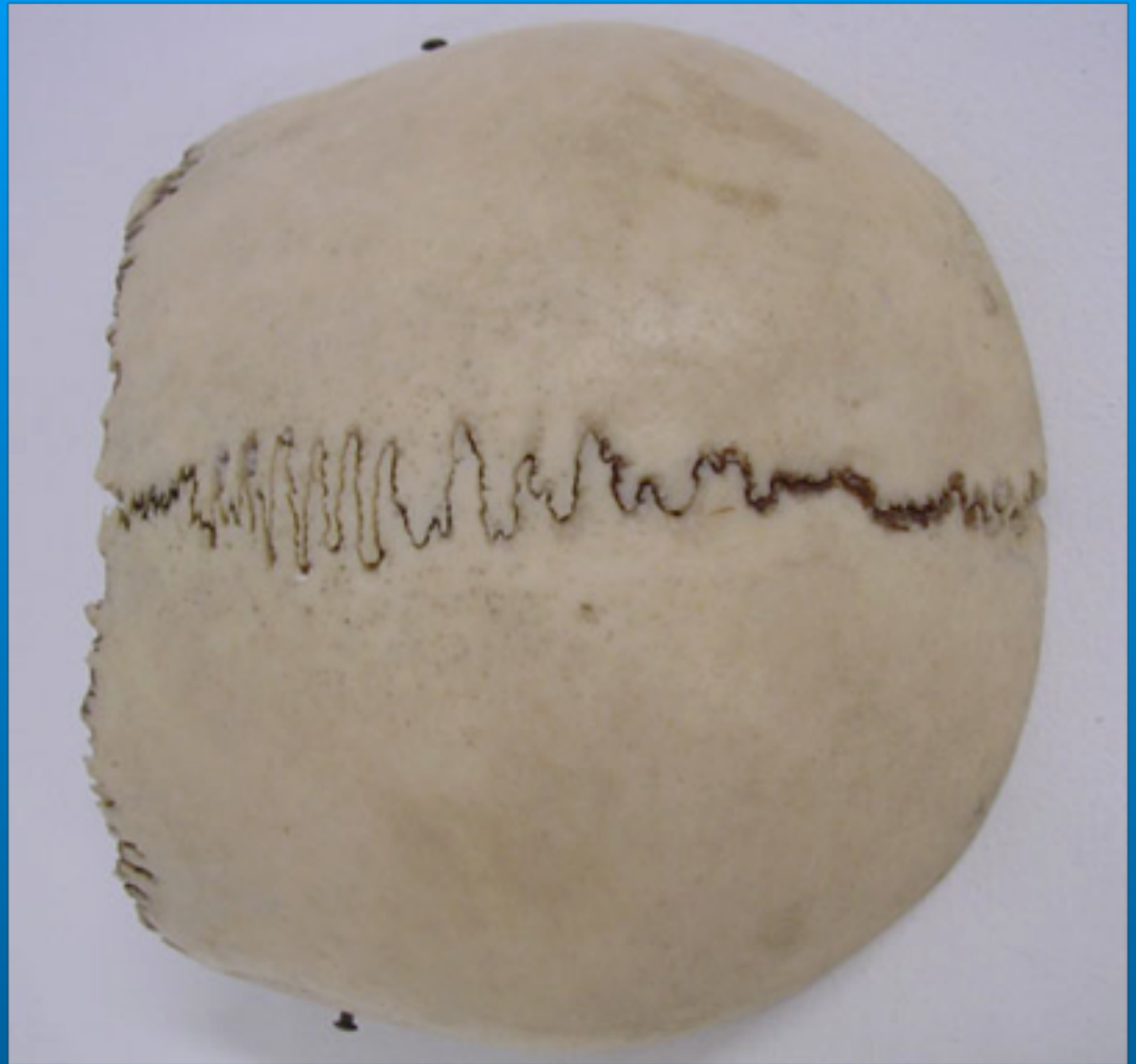


Image ©2004 Palmer

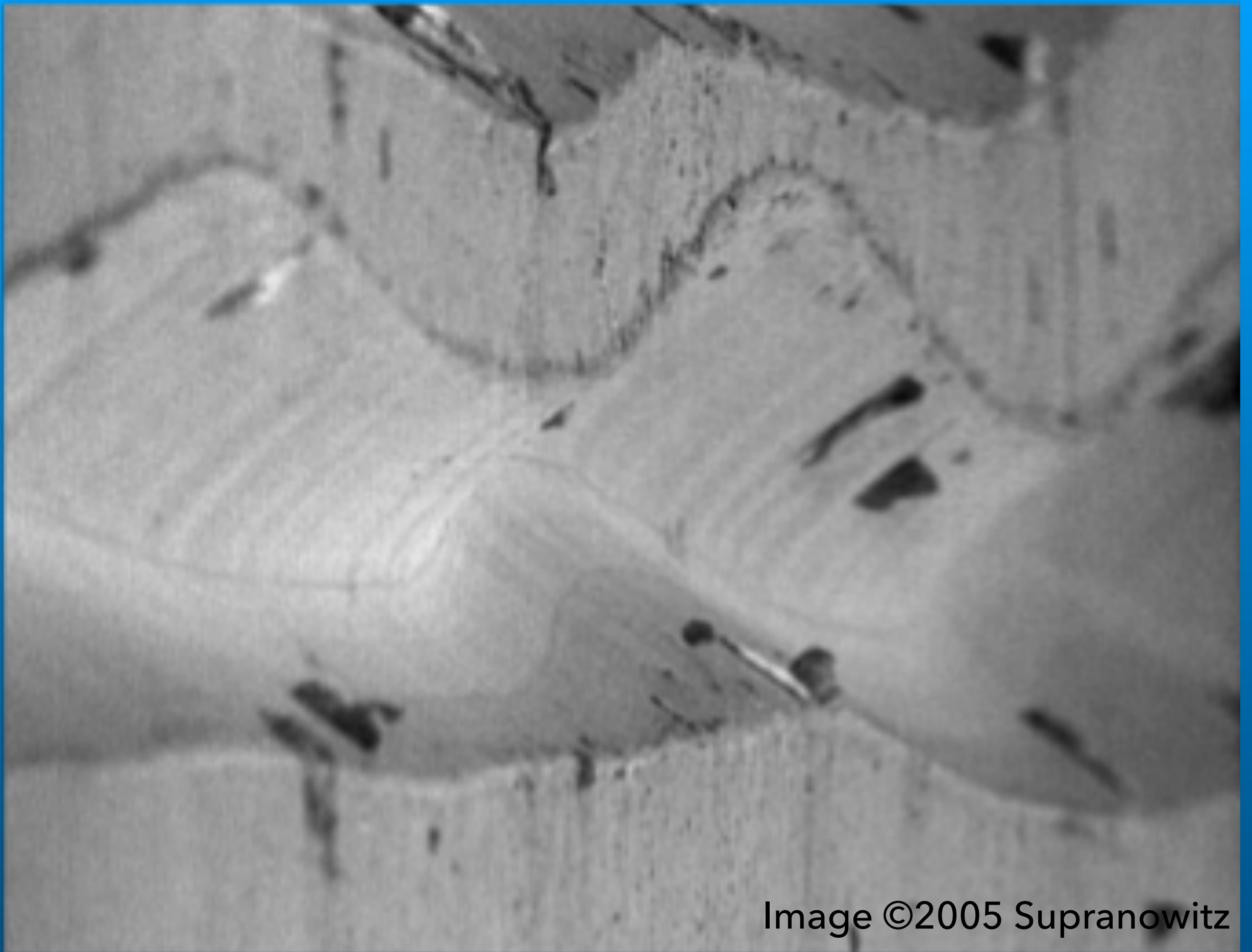
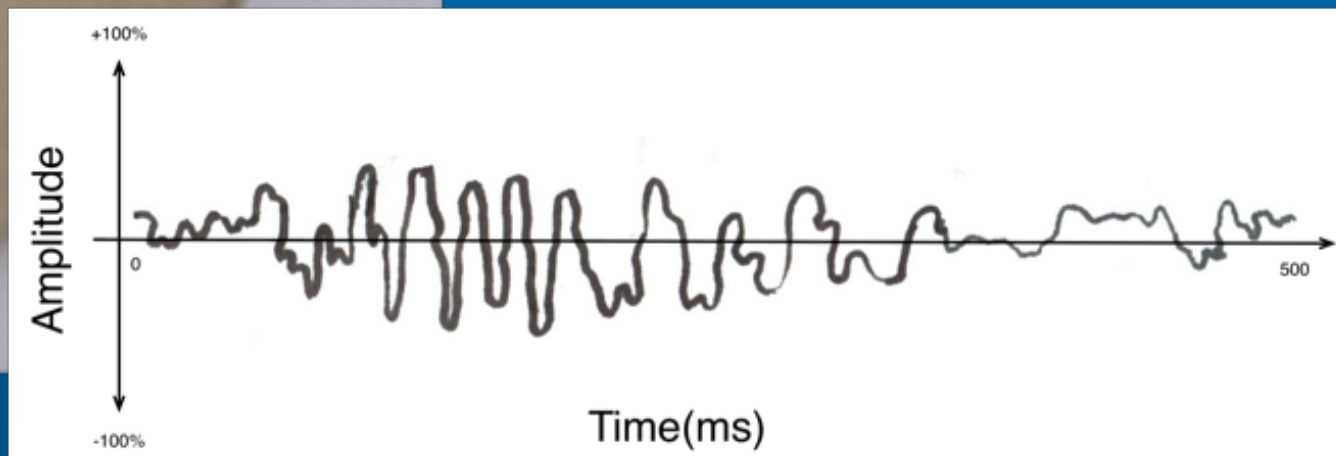
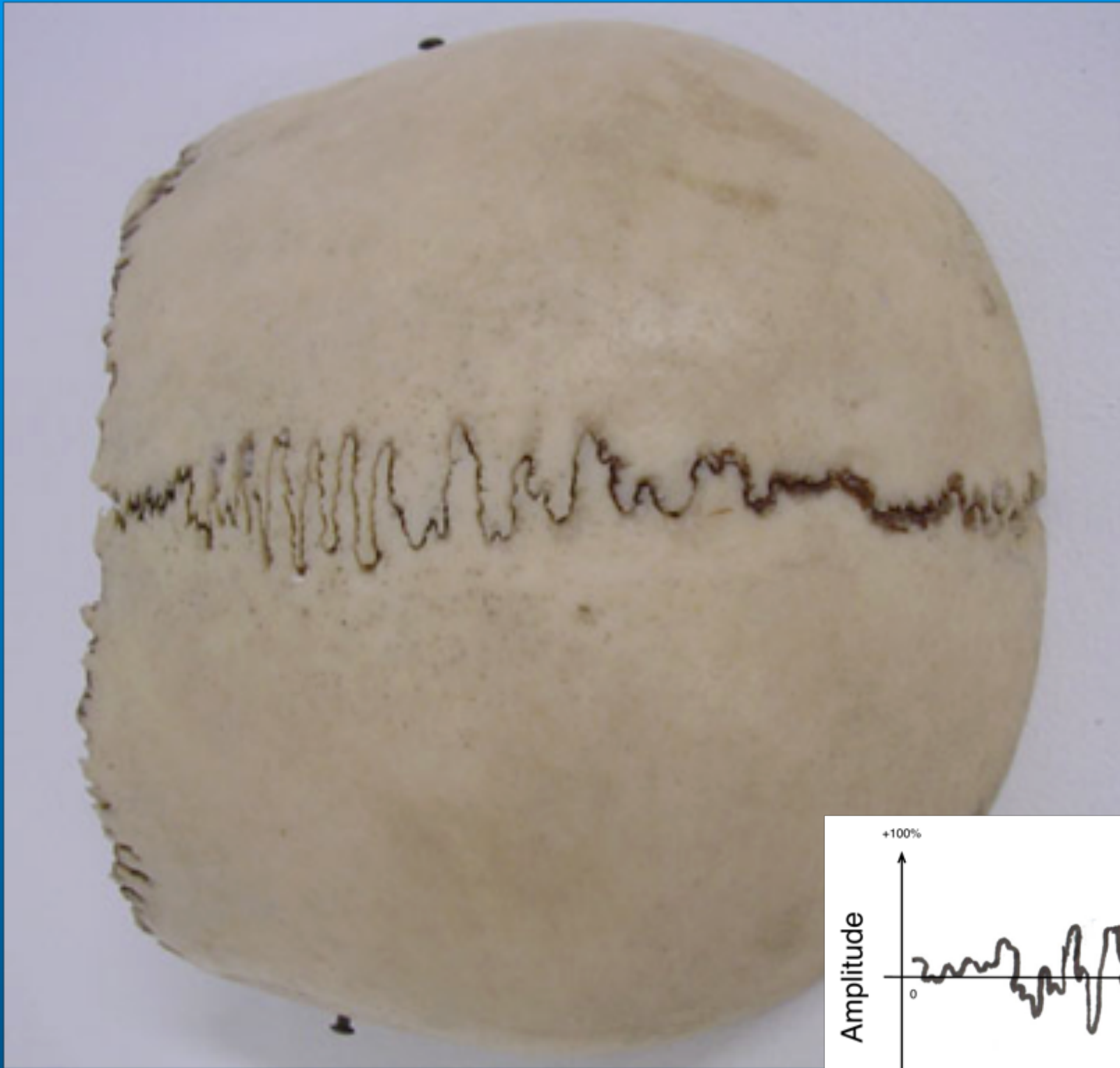


Image ©2005 Supranowitz

Primal Sound (2004)



MUSIC IN THE BLOOD

BloodLines (2004, 2013)

DATE	WBC	RBC	HB	HCT	MCV	MCH	MCHC	RDW	Platelets	Neutrophil	Lymphocy	Monocy	Eosinop	Basoph
22/11/04	340.0	5.74	10.0	0.343	59.7	17.4	29.1	17.0	31					
23/11/04	332.0	3.23	10.5	0.317	59.3	19.6	33.1	16.8	39					
24/11/04		4.74	8.3	0.280	59.2	17.5	29.5	16.5	35	14.4	311.0	19.5	0.4	0.2
24/11/04	345.0	4.66	8.5	0.200	59.3	18.3	30.8	16.8	73					
24/11/04	370.0	4.90	7.3	0.300	61.1	18.1	29.3	16.2	72					
25/11/04	242.0	4.42	8.2	0.266	60.1	18.6	31.0	16.0	72	12.4	212.0	17.5	0.3	0.2
25/11/04	81.4	4.63	9.1	0.276	59.5	19.7	33.1	15.8	50	8.6	68.6	4.0	0.2	0.0
26/11/04	17.9	4.18	8.5	0.252	60.2	20.3	33.8	15.0	32	4.4	12.7	0.7	0.0	0.0
26/11/04	16.3	4.18	8.3	0.249	59.5	18.9	33.5	15.4	32	4.4	11.3	0.5	0.0	0.0
27/11/04	6.6	3.72	7.7	0.225	60.5	20.7	34.3	15.3	18	2.5	3.9	0.2	0.0	0.0
28/11/04	5.6	3.75	7.7	0.226	59.6	20.3	34.0	15.1	17	1.8	3.7	0.1	0.0	0.0
28/11/04	5.7	3.84	7.8	0.228	59.4	20.4	34.3	15.1	16	1.7	3.8	0.1	0.0	0.0
29/11/04	4.0	3.23	6.6	0.197	61.1	20.6	33.7	15.4	13	1.1	2.9	0.1	0.0	0.0
30/11/04	5.3	4.14	8.3	0.263	63.5	22.5	35.4	20.2	36	1.9	3.3	0.1	0.0	0.0
01/12/04	5.4	3.90	8.7	0.250	64.2	22.3	34.7	20.1	30	1.6	3.6	0.1	0.0	0.0
02/12/04	5.2	4.40	9.0	0.260	63.6	22.4	35.2	20.7	43	2.1	2.8	0.3	0.0	0.0
02/12/04	5.5	4.21	9.3	0.270	64.1	22.2	34.6	20.7	37	2.9	2.3	0.3	0.0	0.0
03/12/04	2.5	3.73	8.3	0.239	64.2	22.3	34.8	20.8	51	2.0	0.5	0.0	0.0	0.0
04/12/04	3.2	3.25	7.1	0.211	65.0	21.9	33.6	20.8	66	1.5	1.6	0.1	0.0	0.0
05/12/04	2.8	3.59	8.7	0.246	68.5	24.1	35.2	22.6	113	1.4	1.4	0.0	0.0	0.0
06/12/04	4.0	3.84	9.4	0.271	70.5	24.6	34.8	22.8	220	2.7	2.1	0.0	0.0	0.0
07/12/04	3.0	3.44	8.3	0.247	71.7	24.8	33.5	23.0	240	1.1	1.9	0.0	0.0	0.0
08/12/04	2.1	3.31	8.2	0.235	71.1	24.9	35.0	23.0	281	0.6	1.4	0.1	0.0	0.0
09/12/04	2.0	3.48	8.8	0.249	71.4	25.1	35.2	23.3	270	0.0	0.9	0.2	0.0	0.0
10/12/04	3.2	4.38	10.7	0.324	74.1	24.6	33.2	23.1	289	2.1	0.9	0.2	0.0	0.0
11/12/04	2.9	4.09	10.0	0.305	74.7	24.5	32.8	23.1	292	1.7	0.9	0.1	0.0	0.0
12/12/04	1.6	4.16	10.2	0.315	75.6	24.4	32.9	23.0	290	0.6	1.0	0.0	0.0	0.0
13/12/04	2.1	4.46	10.8	0.333	74.6	24.2	32.5	23.0	313	0.3	1.7	0.0	0.0	0.0
15/12/04	11.7	4.29	10.6	0.317	73.9	24.7	33.4	23.2	316	11.3	0.4	0.0	0.0	0.0
16/12/04	17.7	4.17	10.2	0.318	76.1	24.4	32.1	23.3	288	15.7	1.8	0.2	0.0	0.0
17/12/04	5.0	4.24	10.5	0.318	75.1	24.9	33.1	23.0	296	3.2	1.5	0.2	0.0	0.0
18/12/04	4.3	4.40	10.9	0.329	74.9	24.8	33.5	22.9	323	1.8	2.2	0.3	0.0	0.0
19/12/04	2.1	3.86	9.8	0.288	74.7	25.5	34.2	22.7	221	0.6	1.4	0.1	0.0	0.0
20/12/04	2.0	3.65	9.0	0.275	75.3	24.7	32.7	22.7	210	0.7	1.3	0.0	0.0	0.0
21/12/04	2.9	3.91	8.6	0.294	75.3	24.7	32.8	22.9	241	0.9	1.9	0.0	0.0	0.0
22/12/04	3.4	3.94	8.8	0.294	74.6	24.8	33.3	22.9	281	1.4	1.9	0.1	0.0	0.0
23/12/04	2.9	3.55	9.1	0.266	75.1	25.5	34.0	22.9	225					
24/12/04	3.7	4.20	10.3	0.308	73.4	24.5	33.4	23.4	249	1.5	2.0	0.2	0.0	0.0
25/12/04	3.2	4.02	9.9	0.302	75.2	24.8	32.9	23.5	232	2.0	1.1	0.1	0.0	0.0
26/12/04	2.5	3.76	9.5	0.286	75.6	25.3	33.3	22.6	170	1.9	0.6	0.0	0.0	0.0
27/12/04	1.8	3.83	9.6	0.292	76.1	25.0	32.9	22.3	145	1.4	0.4	0.0	0.0	0.0
28/12/04	0.8	3.47	8.7	0.263	75.9	25.0	32.8	21.9	119	0.5	0.3	0.0	0.0	0.0
30/12/04	0.7	3.17	8.1	0.255	80.5	26.3	33.1	18.9	51	0.3	0.4	0.0	0.0	0.0
31/12/04	0.3	3.39	9.0	0.264	78.0	26.5	33.9	18.9	31	0.0	0.3	0.0	0.0	0.0
01/01/05	0.3	3.45	9.0	0.279	81.1	26.2	32.3	19.2	32	0.0	0.3	0.0	0.0	0.0
01/01/05	0.3	3.62	9.5	0.284	78.6	26.3	33.5	19.0	25	0.0	0.3	0.0	0.0	0.0

Hemoglobin

Platelets

Red Blood Cells

Wellcome Trust

Radio 4

Aldeburgh Music

Smithsonian Institute

UCL Neuroscience

Surrey: Microbiology, Mathematics, Medicine, Programming, Sleep Research

Rutherford Centre

Times Higher Education

British Library

Frank Moer Institute

TedX Groningen

Nordezoon Festival

CHEMISTRY

MATHE

RINI

NSM

SNRI



Milton Mermikides (University of Surrey)

Debra J. Skene (University of Surrey)

Renata Rhia (University of Edinburgh)

Vlad Vyazovskiy & Nanyi Cui (Oxford University)

Yurubi Rosales Suarez/ Professor Paul Krause (University of Surrey)

Anna Tanczos

University of Surrey

Research & Innovation Support

The Royal Society

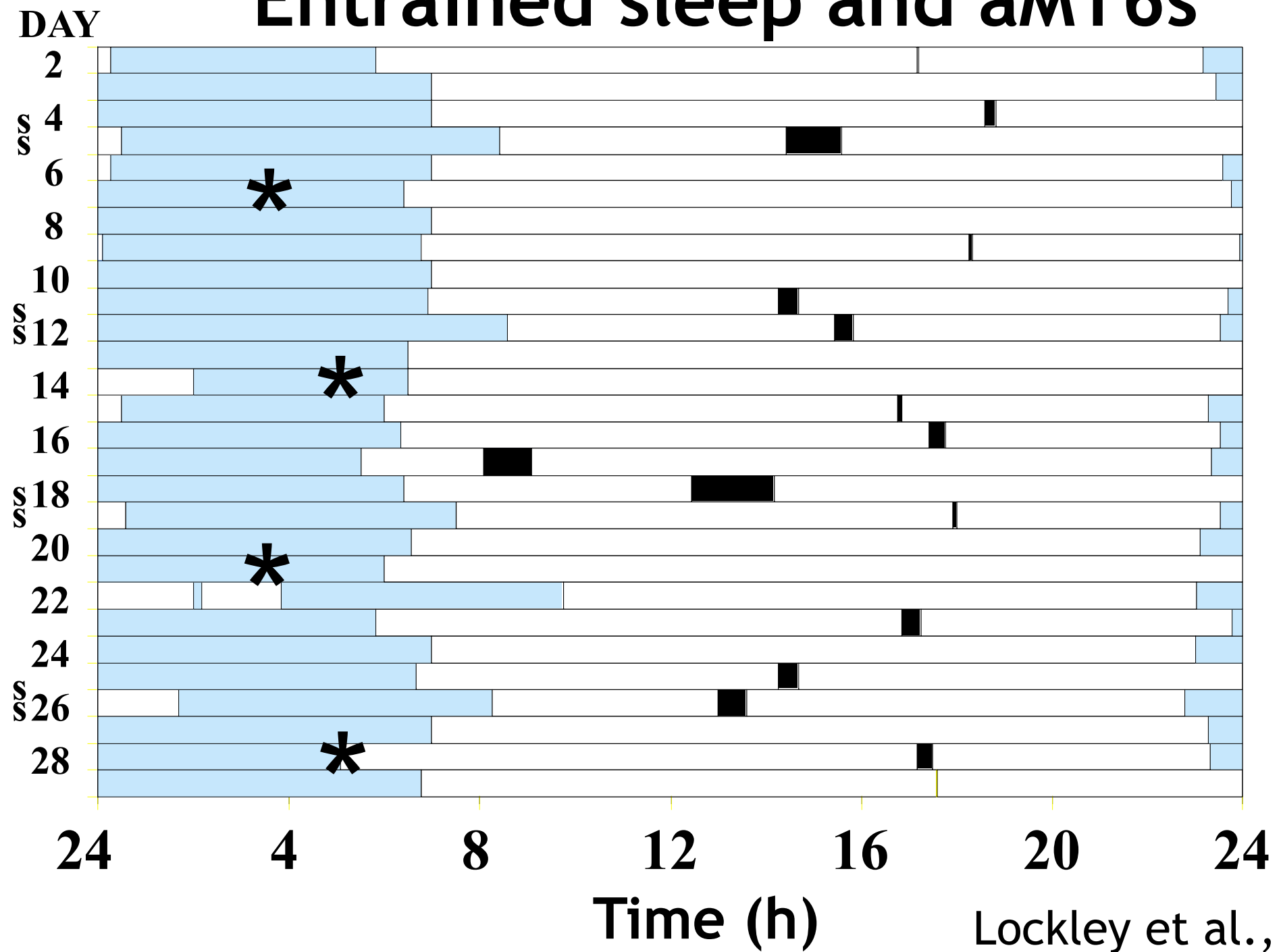
SOUND ASLEEP

MAKING SLEEP VISIBLE TO THE BLIND

Debra J. Skene (University of Surrey)

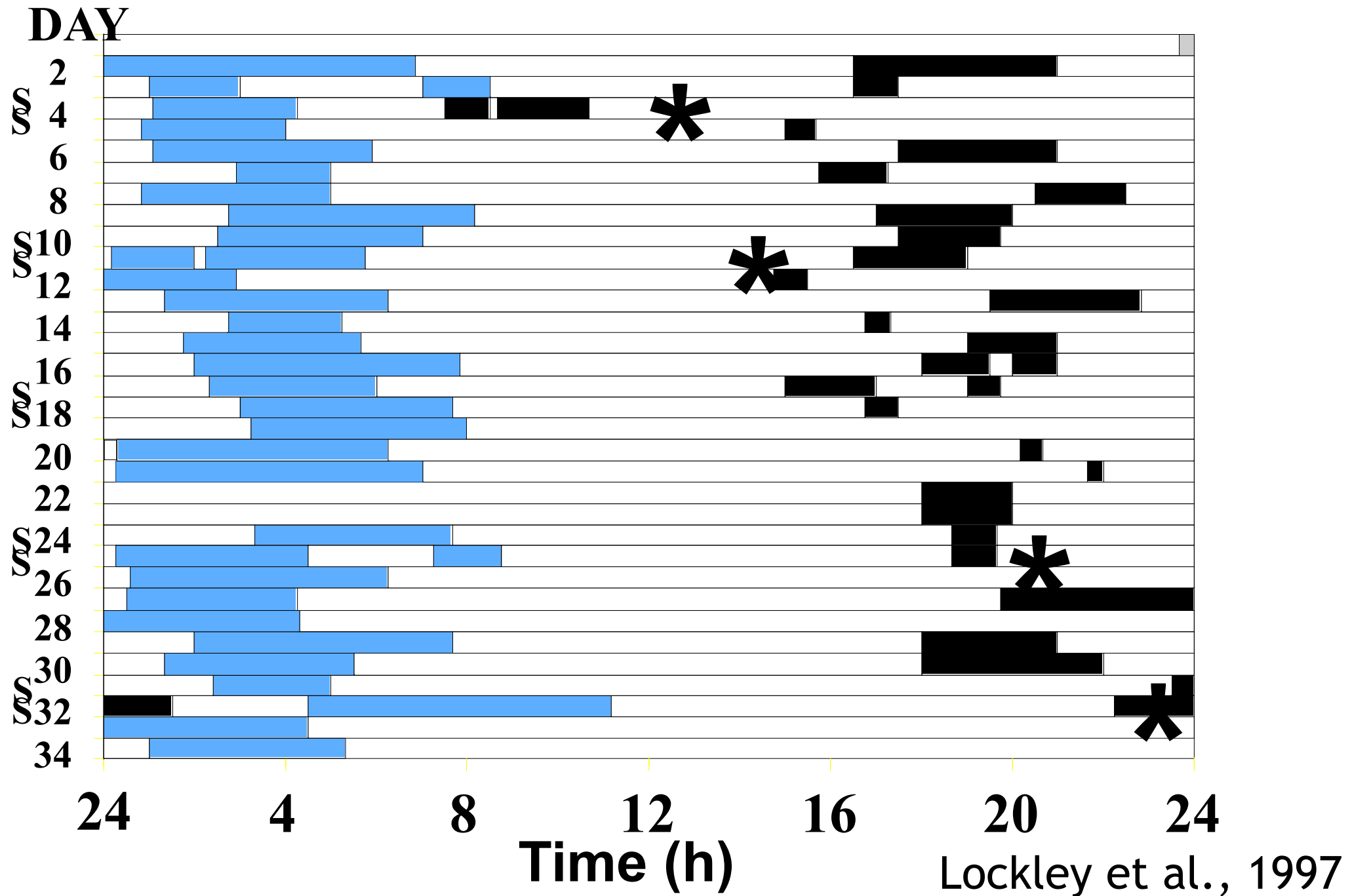
Milton Mermikides (University of Surrey)

Entrained sleep and aMT6s



Lockley et al., 1997

Abnormal circadian phase - poor sleep- daytime nap

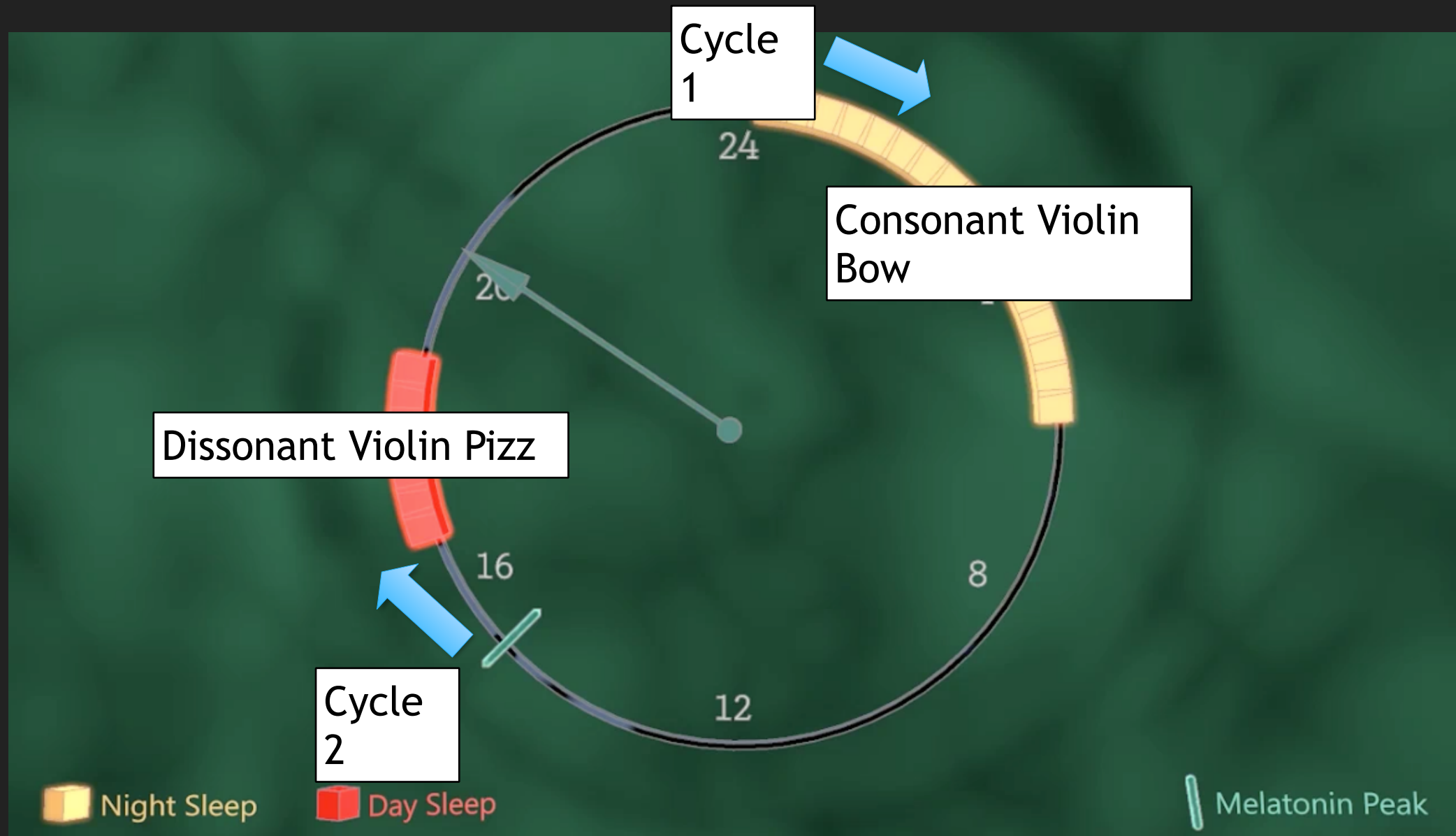


MUSICAL ANALOGIES

24-Beat Cycle (Shona Mbira)

Displacement/Phase (West Africa,
Steve Reich)

Diatonic/non-diatonic to represent
comfort




S12

ENTRAINED SLEEP



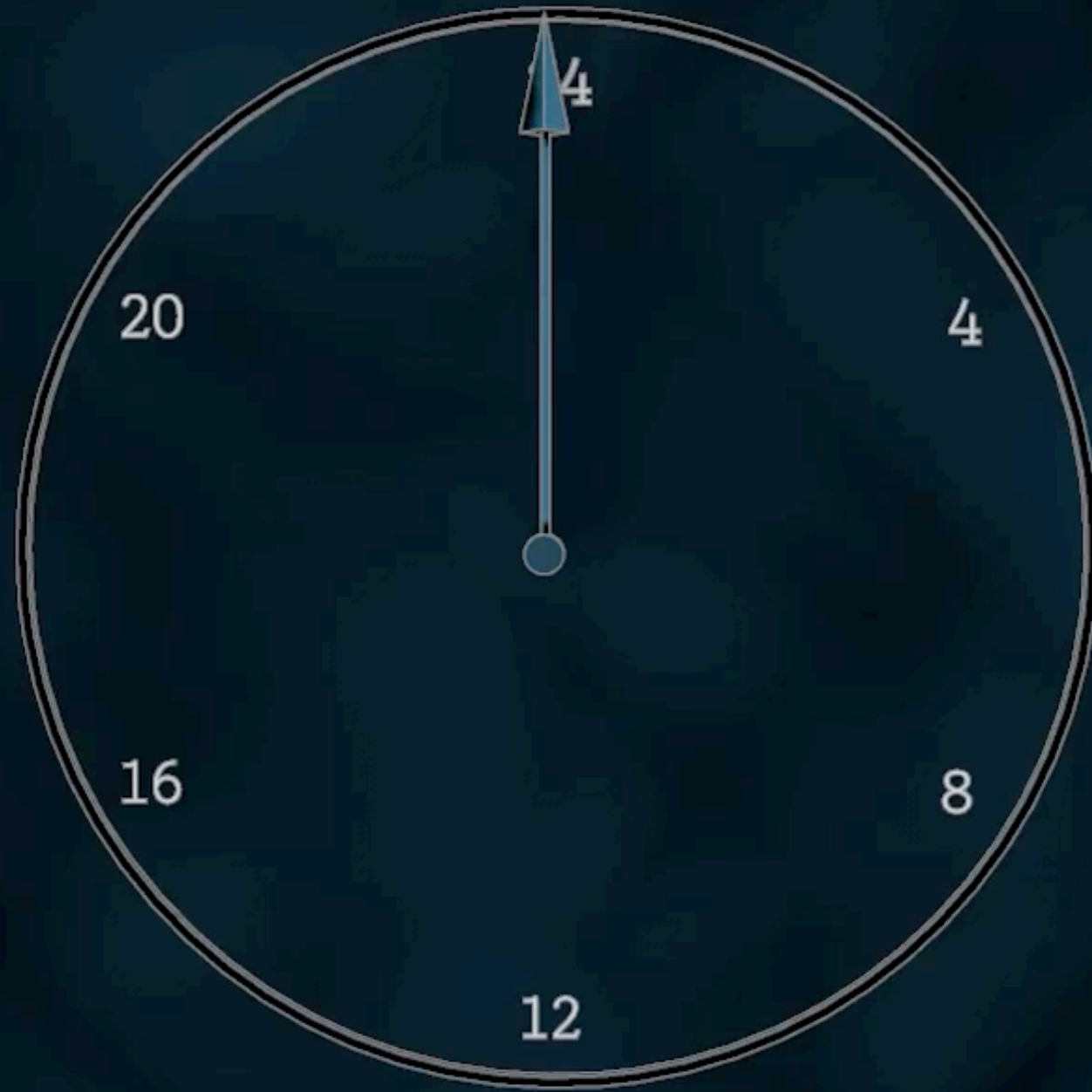
 Night Sleep


 Day Sleep


 Melatonin Peak

S23

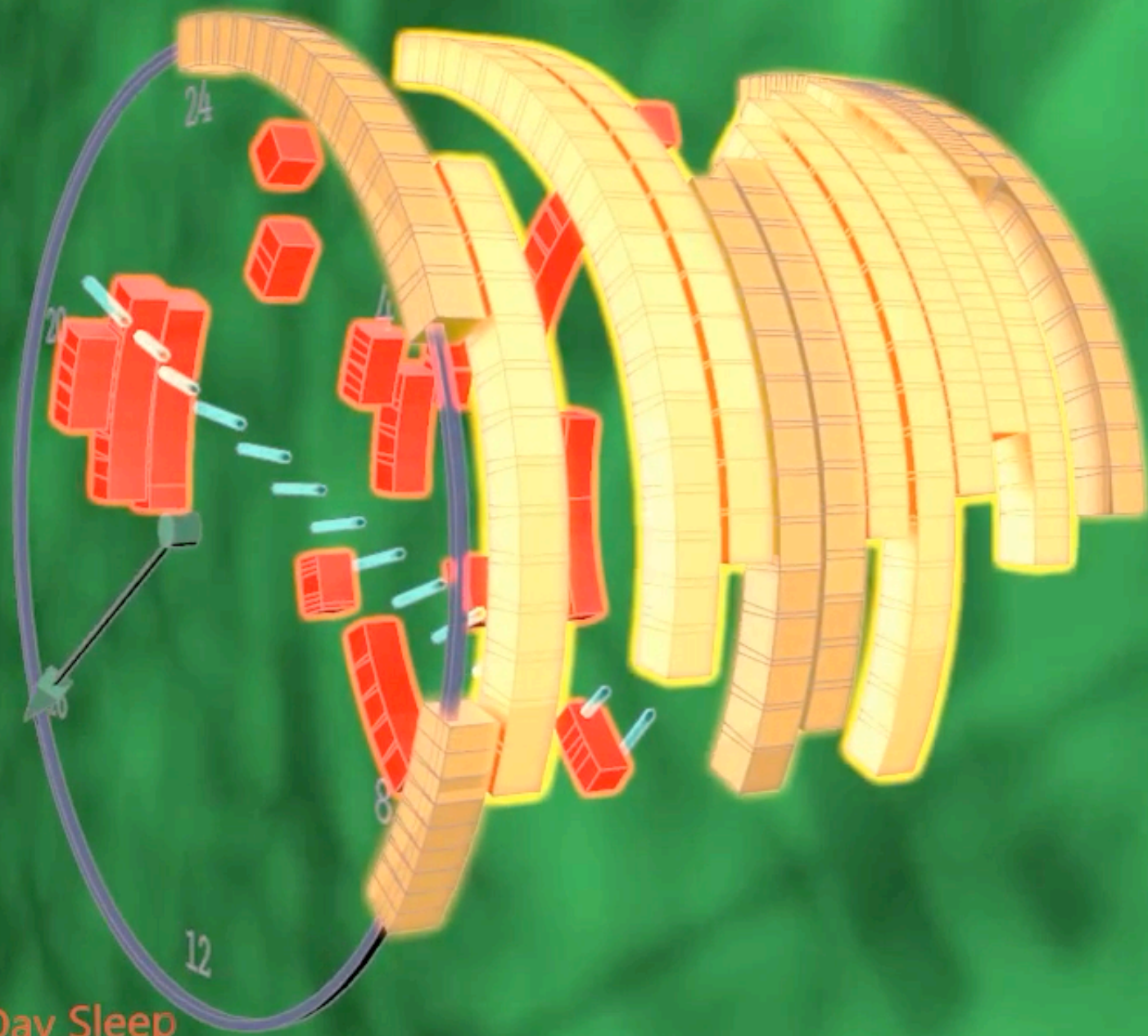
NON 24 H SLEEP/WAKE DISORDER





 Night Sleep


 Day Sleep

 Melatonin Peak



 Night Sleep

 Day Sleep

 Melatonin Peak

PSG NOCTURNE:

**CONVERTING PSG DATA INTO
MULTI-LAYERED COMPOSITIONS.**

Renata L Riha (University of Edinburgh)

PSG AS SCORE

1. { Grande Opulente Chinoise
 { Grande Caisse claire grave

2. { Gong
 { Tam-tam clair
 { Tam-tam grave

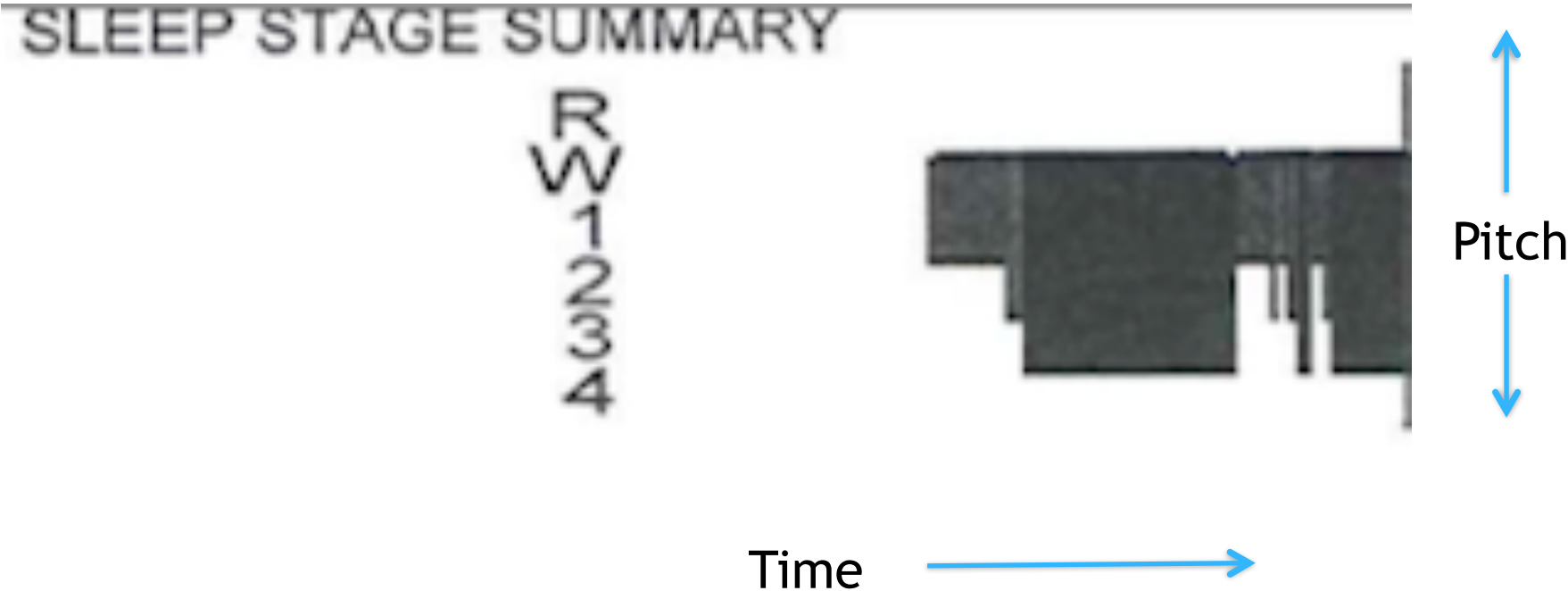
3. { 2 Bongos..... { clair
 { grave
 { Caisse roulante
 { 2 Grands Caisse { moyen
 { grave

4. { Tambour militaire
 { Caisse roulante

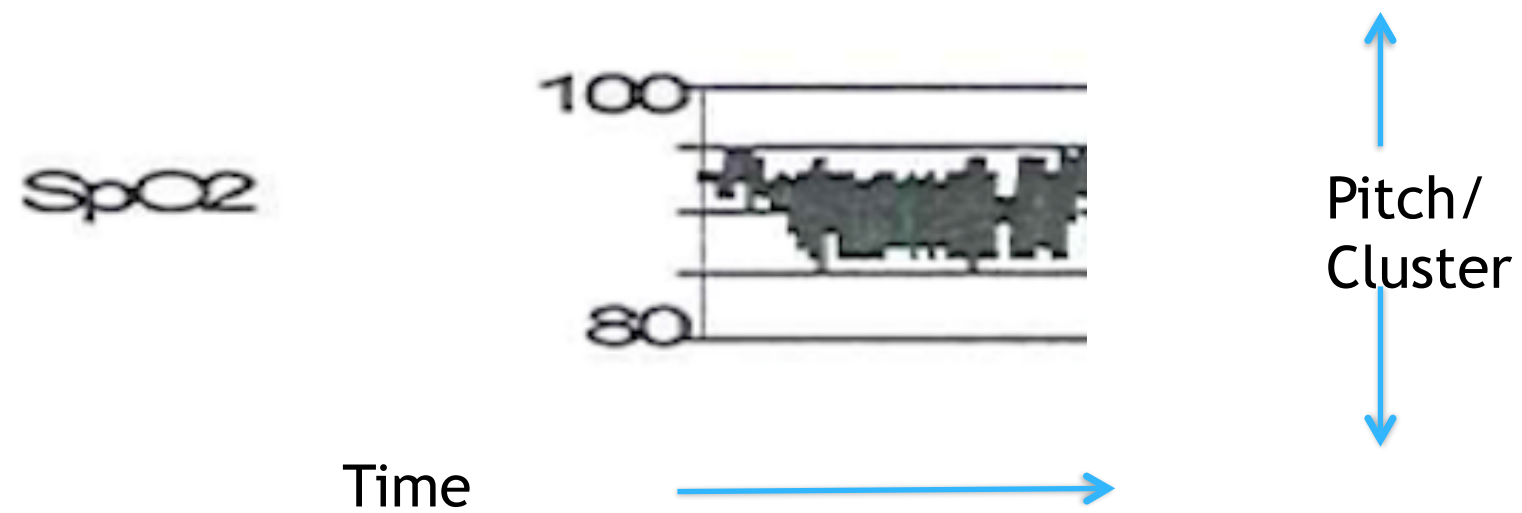
5. { Sirope clair
 { Tambour à corde

6. { Sirope grave
 { Fouet
 { Gâche

SLEEP FLUTE MELODY



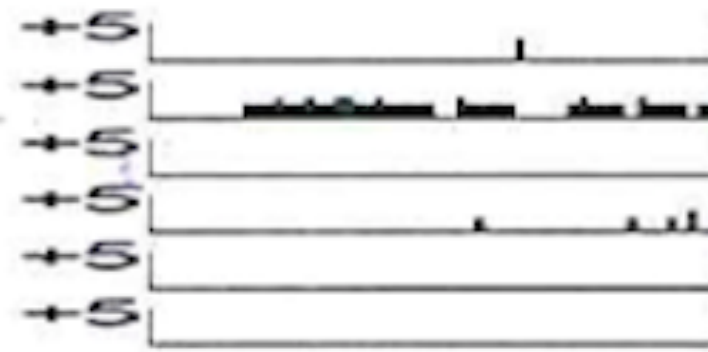
SPO2 TEXTURE/HARMONY



APNOEA PERCUSSION/PIZZICATO

APNOEA GRAPH

Ch.A
Ob.A
Mx.A
Hyp
Urs
RERA



Instrumentation

Time



BODY POSITION BASS-LINE

BODY POSITION



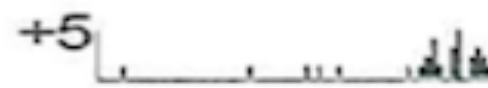
Pitch

Time



SNORING AND PLM TIMPANI/WOODBLOCK

SNORING



Timpani

PLMs



Woodblock

Time



S9

NORMAL SLEEP

S11

APNOEA

S21

RESTLESS LEG SYNDROME

THE INNER SOUND OF SLEEP

TRANSLATING EEG DATA TO THE AUDIO
SPECTRUM

Vladyslav Vyazovskiy (University of Oxford)

Milton Mermikides (University of Surrey)

WAVES

Pitch Domain



Gamma	32-100Hz
Beta	14-60Hz
Alpha	8-12Hz to 30-50Hz
Theta	4-8Hz
Delta	0.5-3Hz

WAVES

Gamma 32-100Hz

Beta 14-60Hz

Alpha 8-12Hz to 30-50Hz

Theta 4-8Hz

Delta 0.5-3Hz

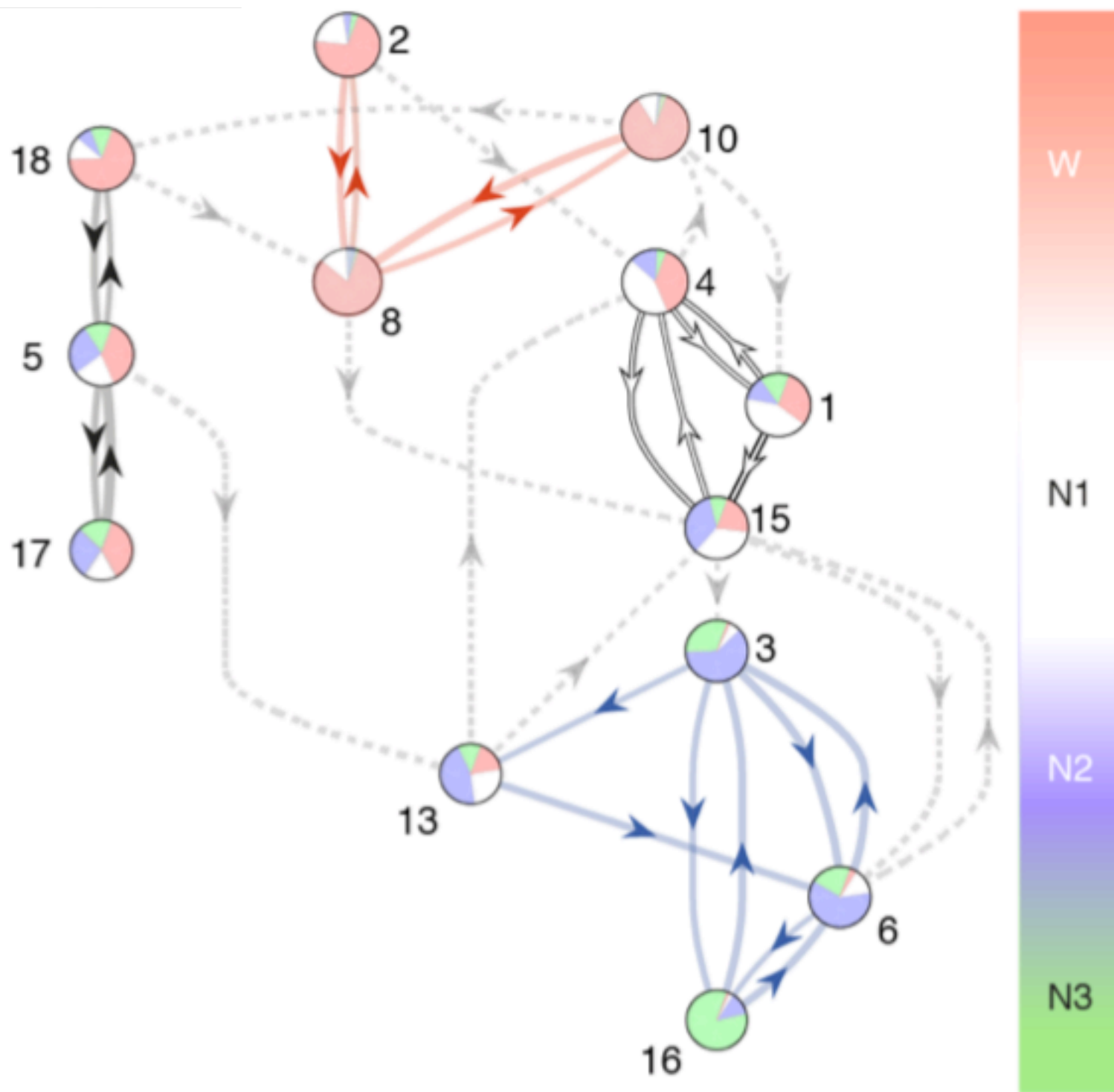


Rhythmic Domain

[Morten
HMM]

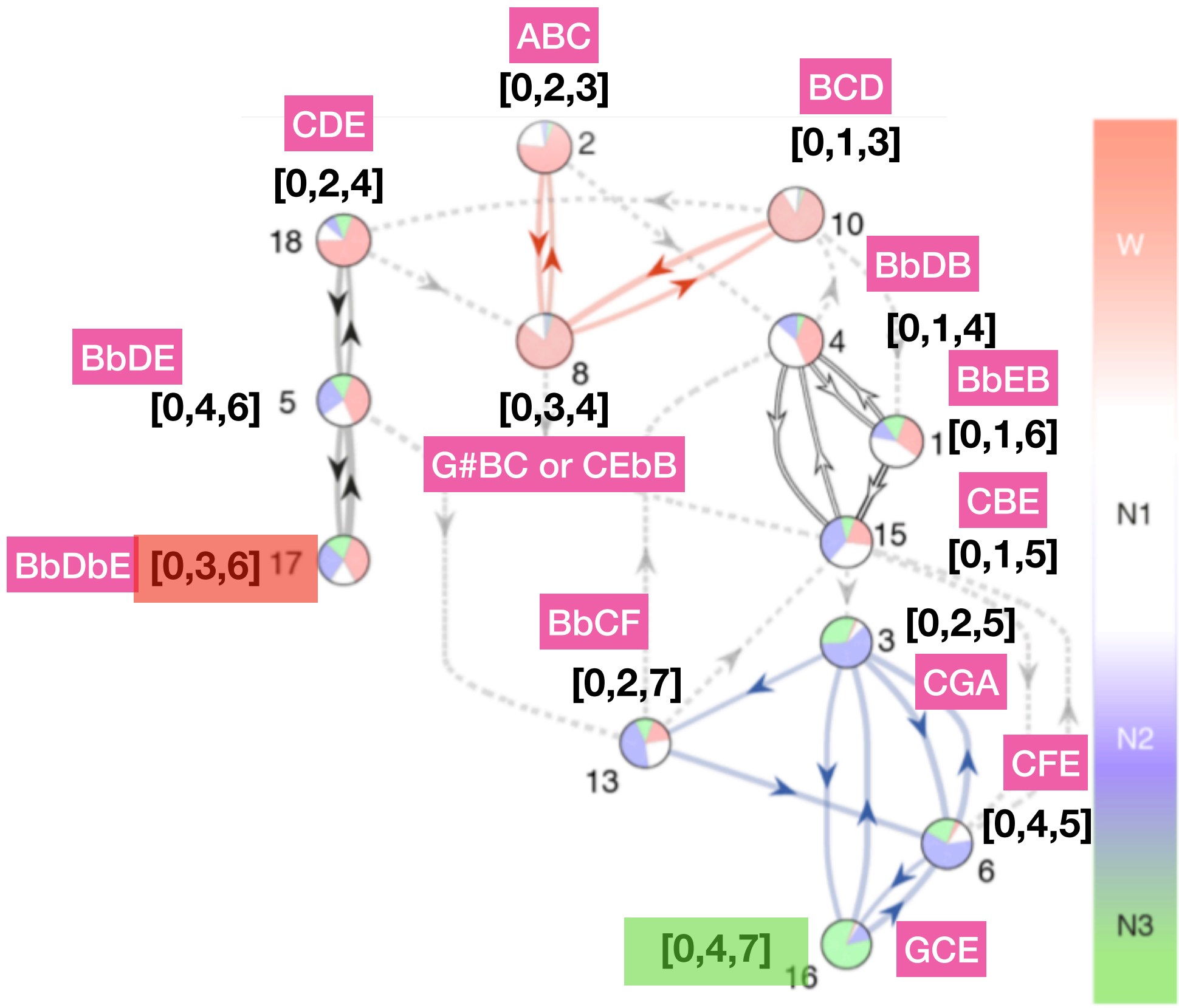
Network as Consonance/Dissonance Vectors

Transition map



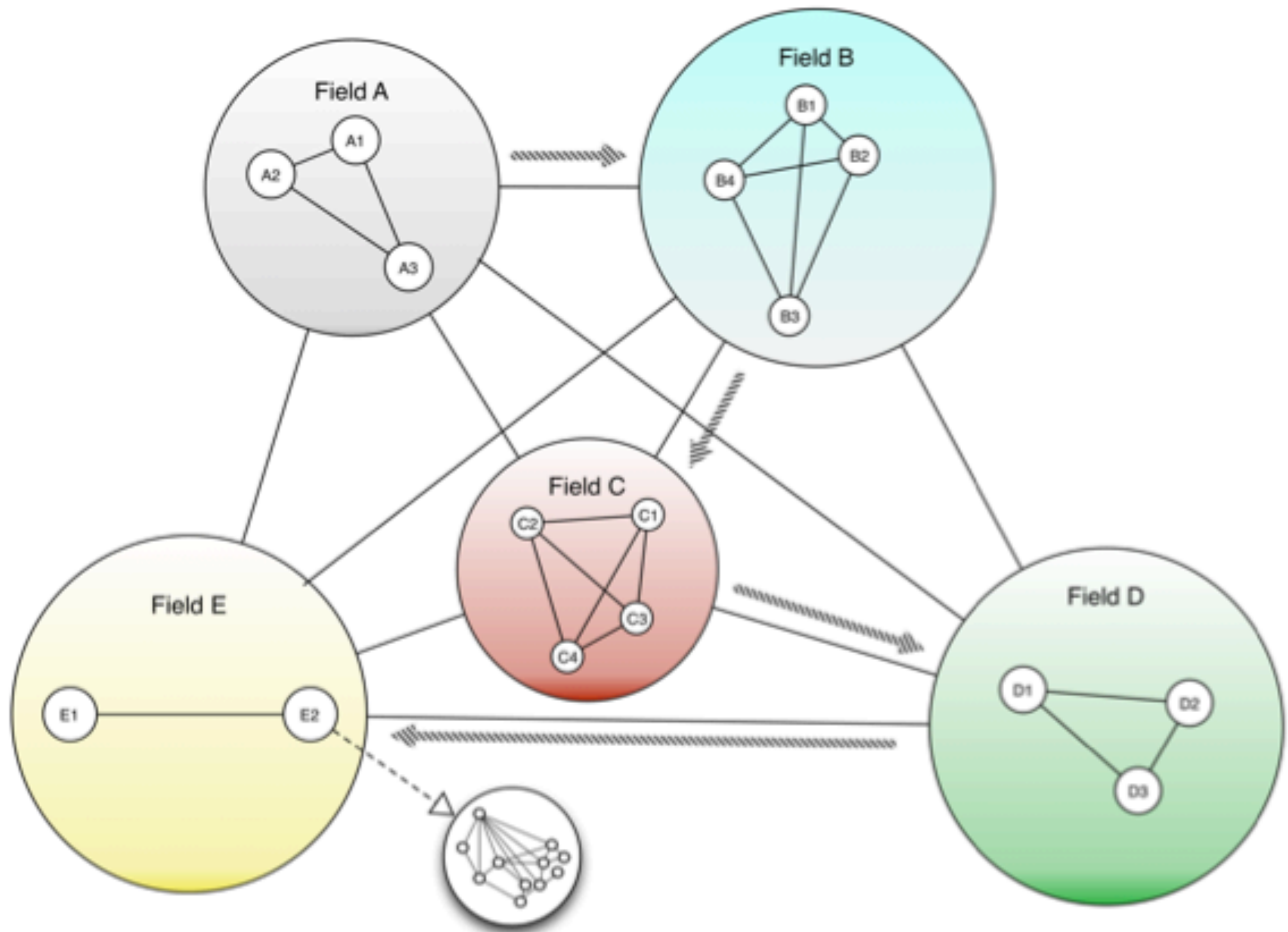
1	3-1	[0,1,2]	<2,1,0,0,0,0>	Cluster
2	3-2A	[0,1,3]	<1,1,1,0,0,0>	Soft Cluster A (Phrygian)
3	3-2B	[0,2,3]		Soft Cluster B (Aeolian)
4	3-3A	[0,1,4]	<1,0,1,1,0,0>	Hijaz A
5	3-3B	[0,3,4]		Hijaz B: Twilight
6	3-4A	[0,1,5]	<1,0,0,1,1,0>	Desert
7	3-4B	[0,4,5]		Sun
8	3-5A	[0,1,6]	<1,0,0,0,1,1>	Viennese A
9	3-5B	[0,5,6]		Viennese B
10	3-6	[0,2,4]	<0,2,0,1,0,0>	Whole Tone Cluster
11	3-7A	[0,2,5]	<0,1,1,0,1,0>	Blues trichord A (Soul)
12	3-7B	[0,3,5]		Blues trichord B (Trane)
13	3-8A	[0,2,6]	<0,1,0,1,0,1>	Italian 6th A
14	3-8B	[0,4,6]		Lydian
15	3-9	[0,2,7]	<0,1,0,0,2,0>	Sus chord
16	3-10	[0,3,6]	<0,0,2,0,0,1>	dim. chord
17	3-11A	[0,3,7]	<0,0,1,1,1,0>	minor chord
18	3-11B	[0,4,7]		major chord
19	3-12	[0,4,8]	<0,0,0,3,0,0>	Aug. chord

Trichord Interval Vectors



Trichord category and Interval Components

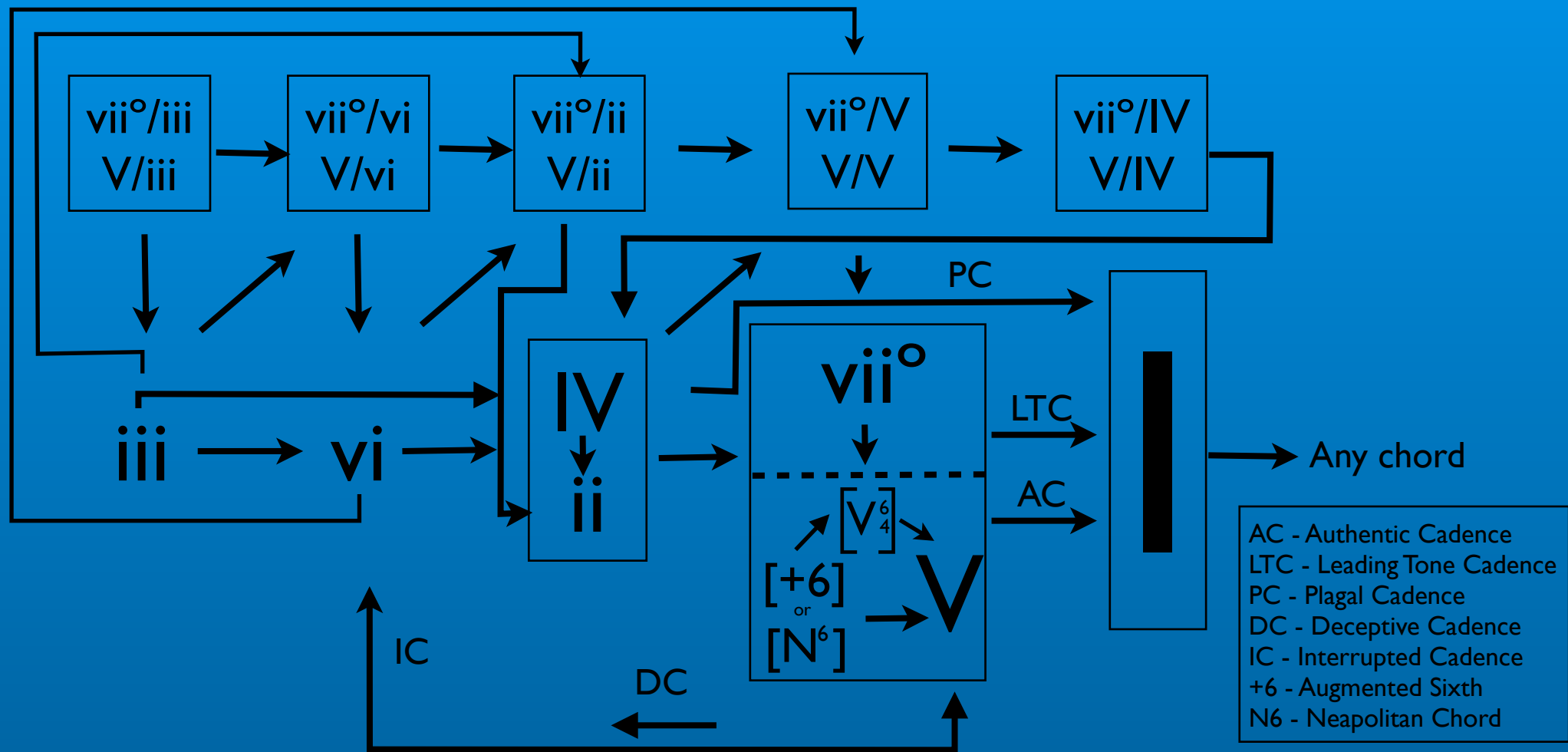
Network as Musical Proximity



Multi-level hierarchical units

Network as Harmonic Function

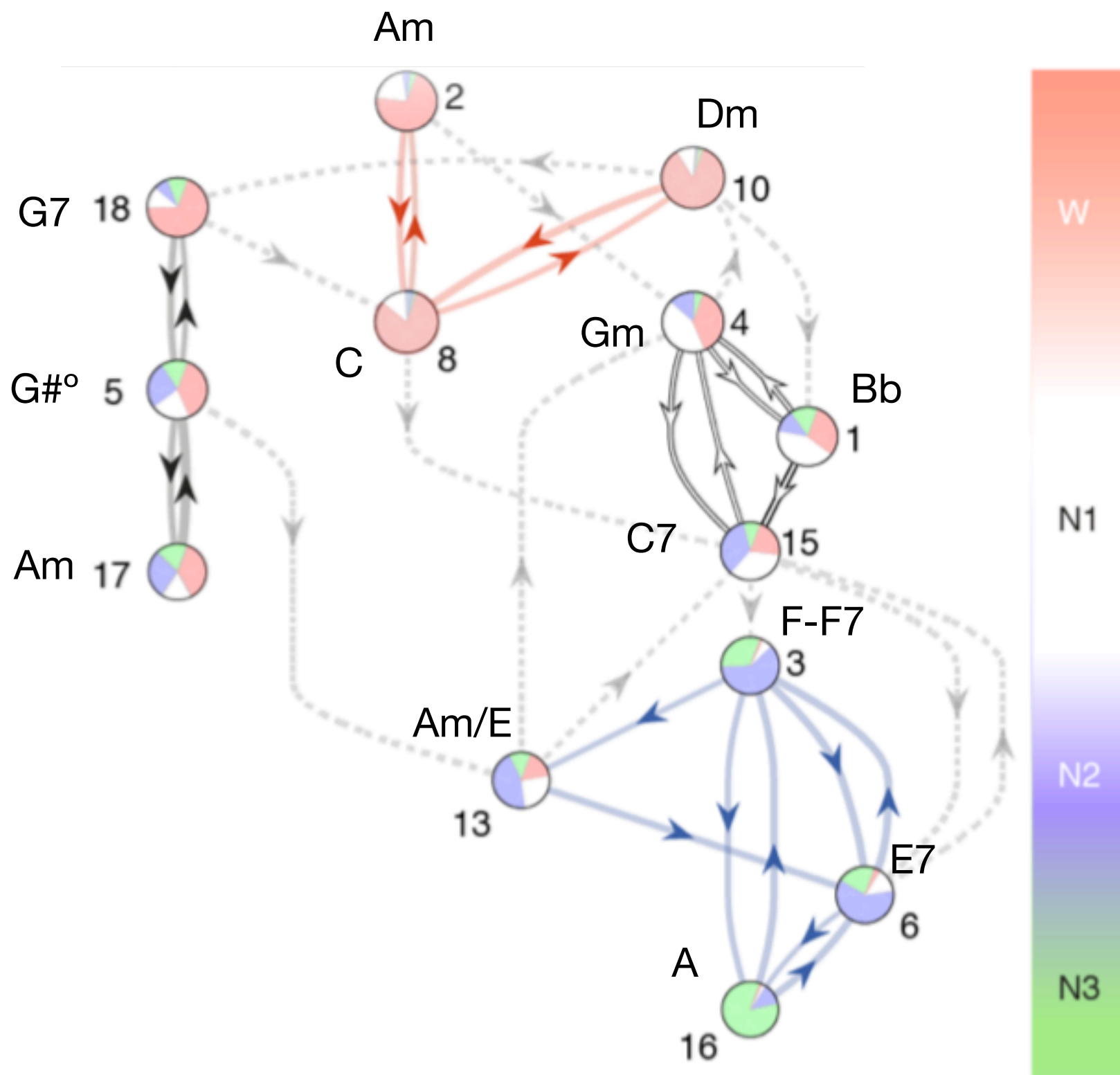
Tonal Harmony Flow Chart... for Common Progressions in a Major Key



These triads (particularly V & vii°) may be freely extended to 7th chords

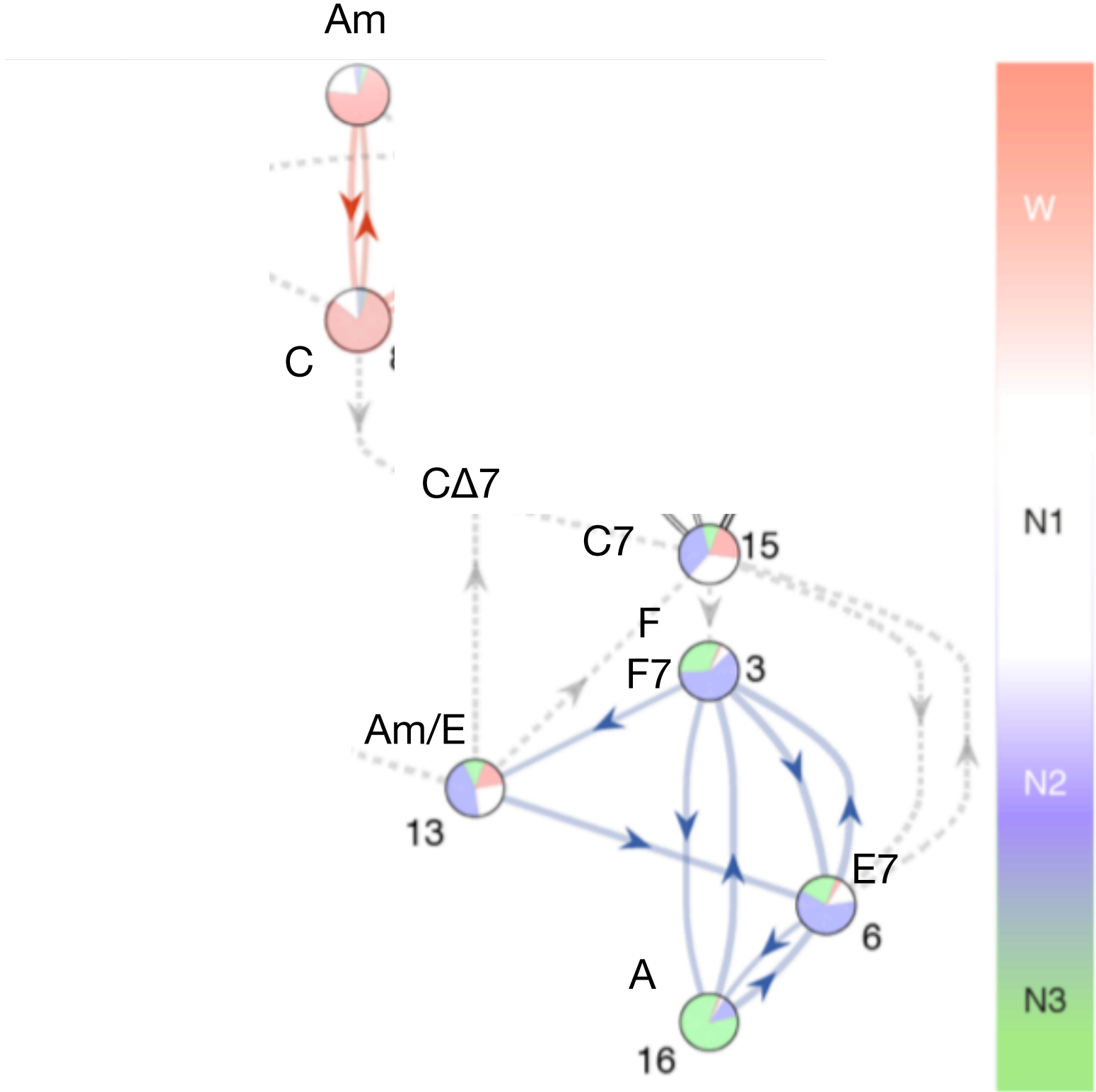
@miltonline

Tonal Devices



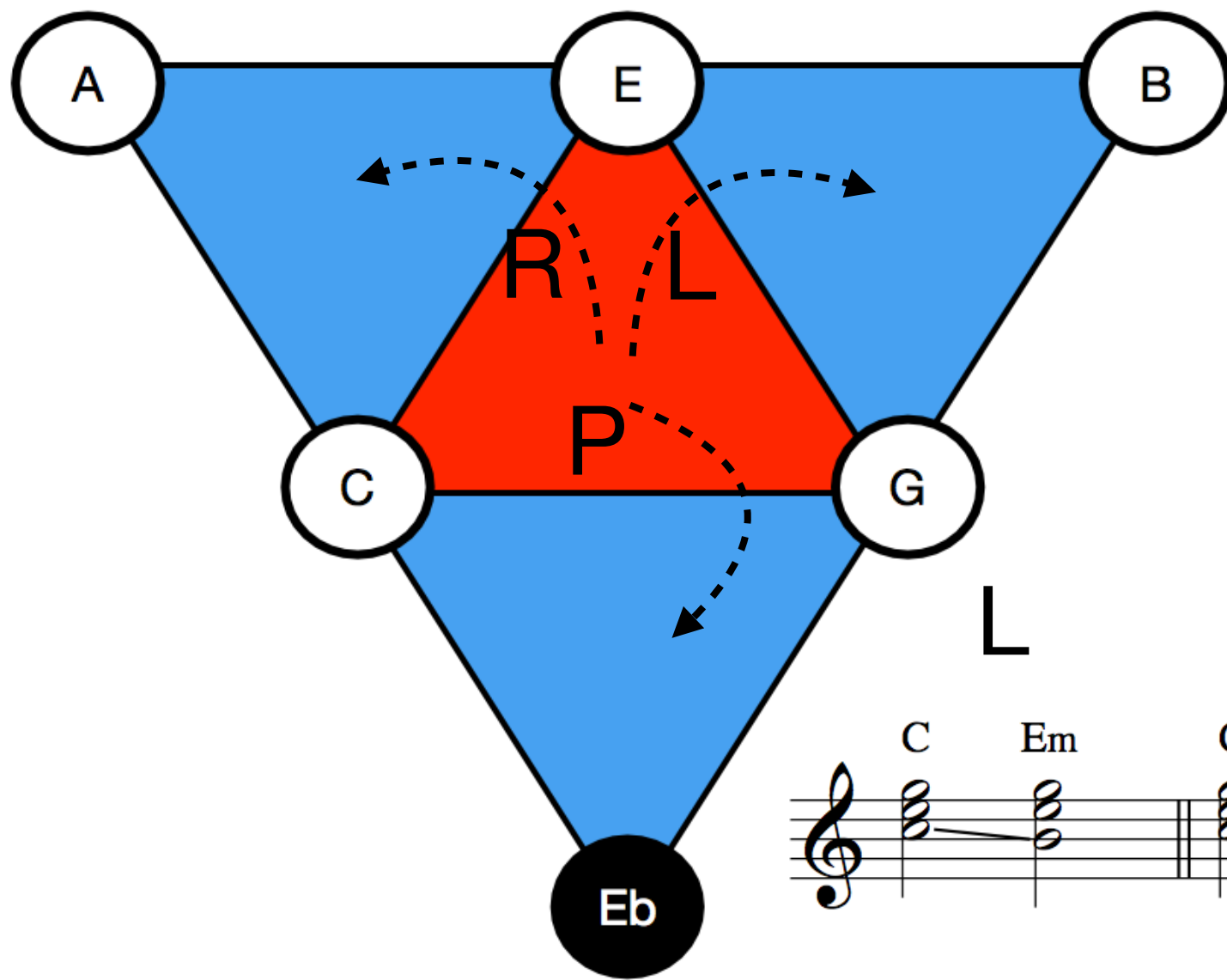
Harmonic Tonal Devices: key areas/directionality

Tonal Devices



Harmonic Tonal Devices: key areas/directionality

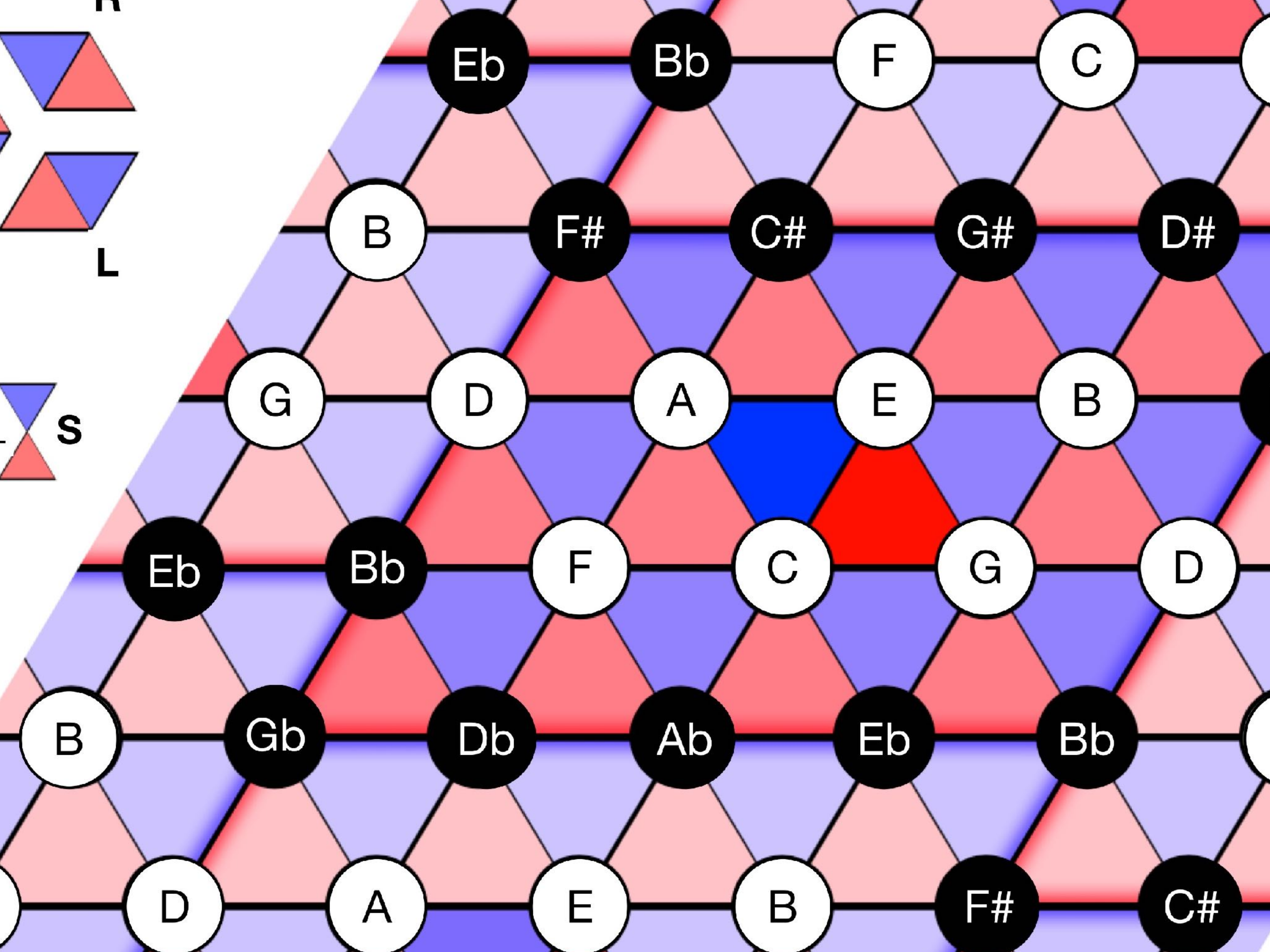
Network as Harmonic Transformation

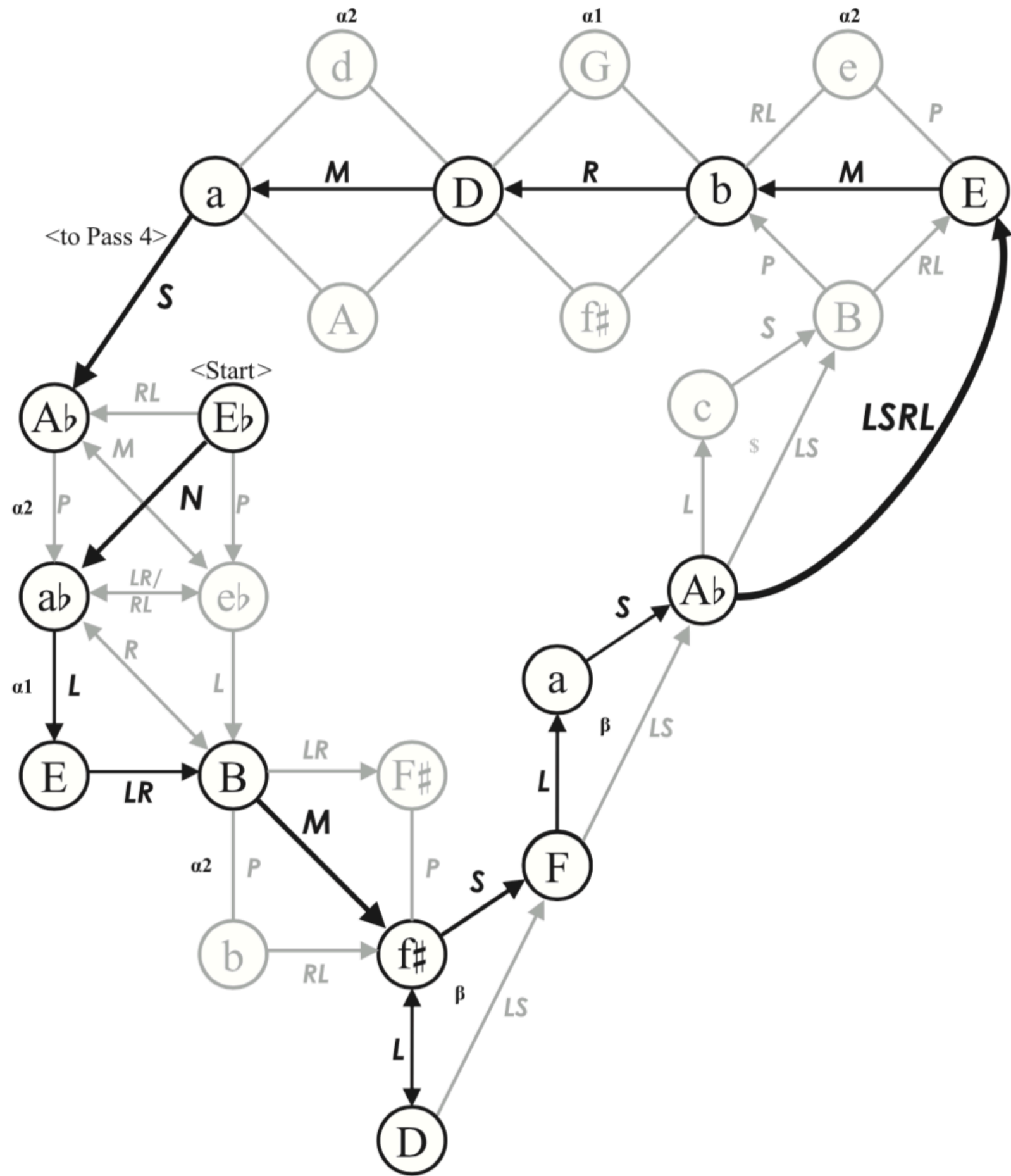


L R P

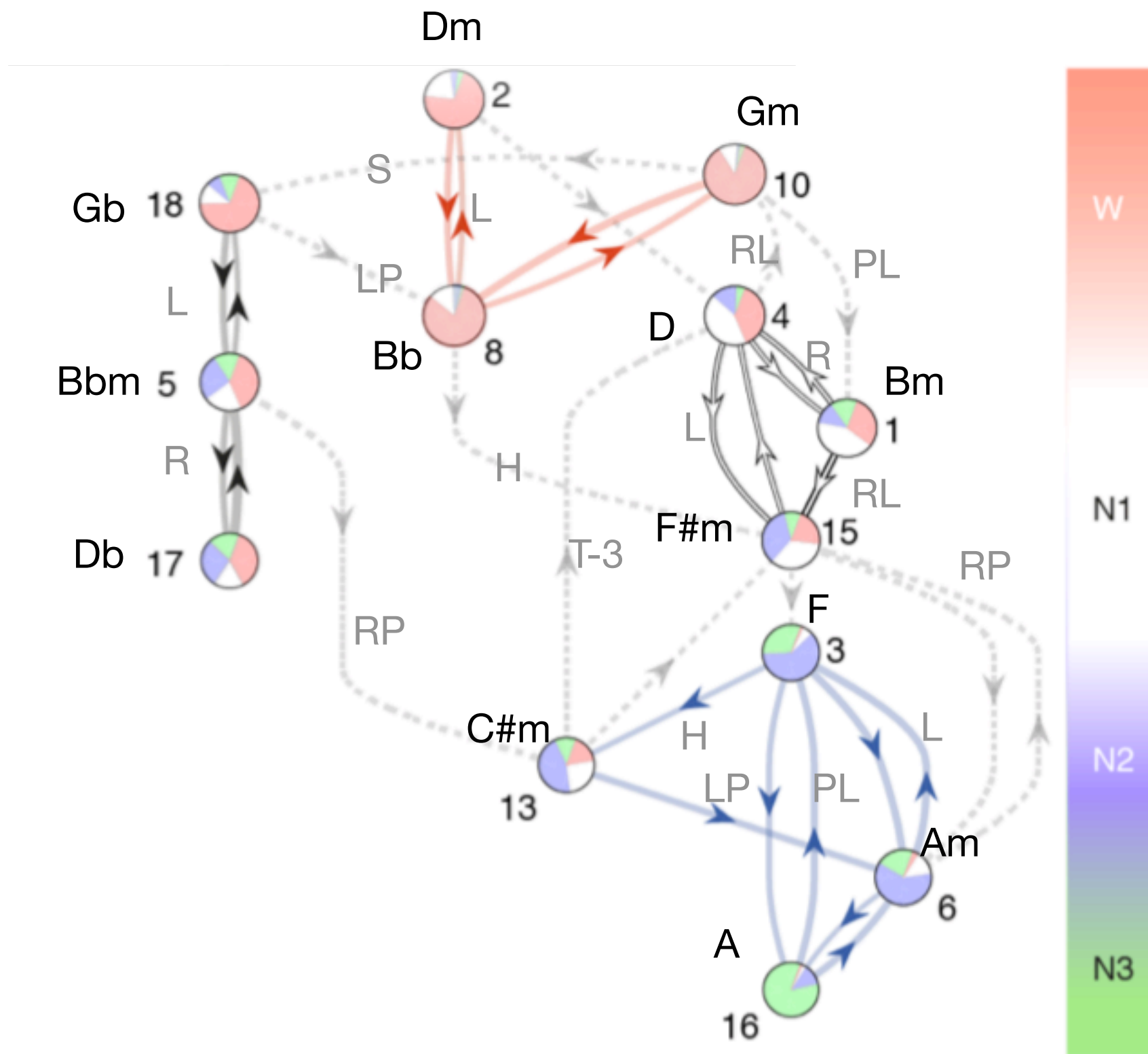
C Em C Am C Cm

The musical staff shows a sequence of chords: C, Em, C, Am, C, and Cm. The chords are written on a single staff with a treble clef. The chords are connected by lines, indicating a sequence. The chords are: C (C4, E4, G4), Em (E4, G4, Bb4), C (C4, E4, G4), Am (A3, C4, E4), C (C4, E4, G4), and Cm (C4, E4, Gb4). The fingerings L, R, and P are indicated above the chords.

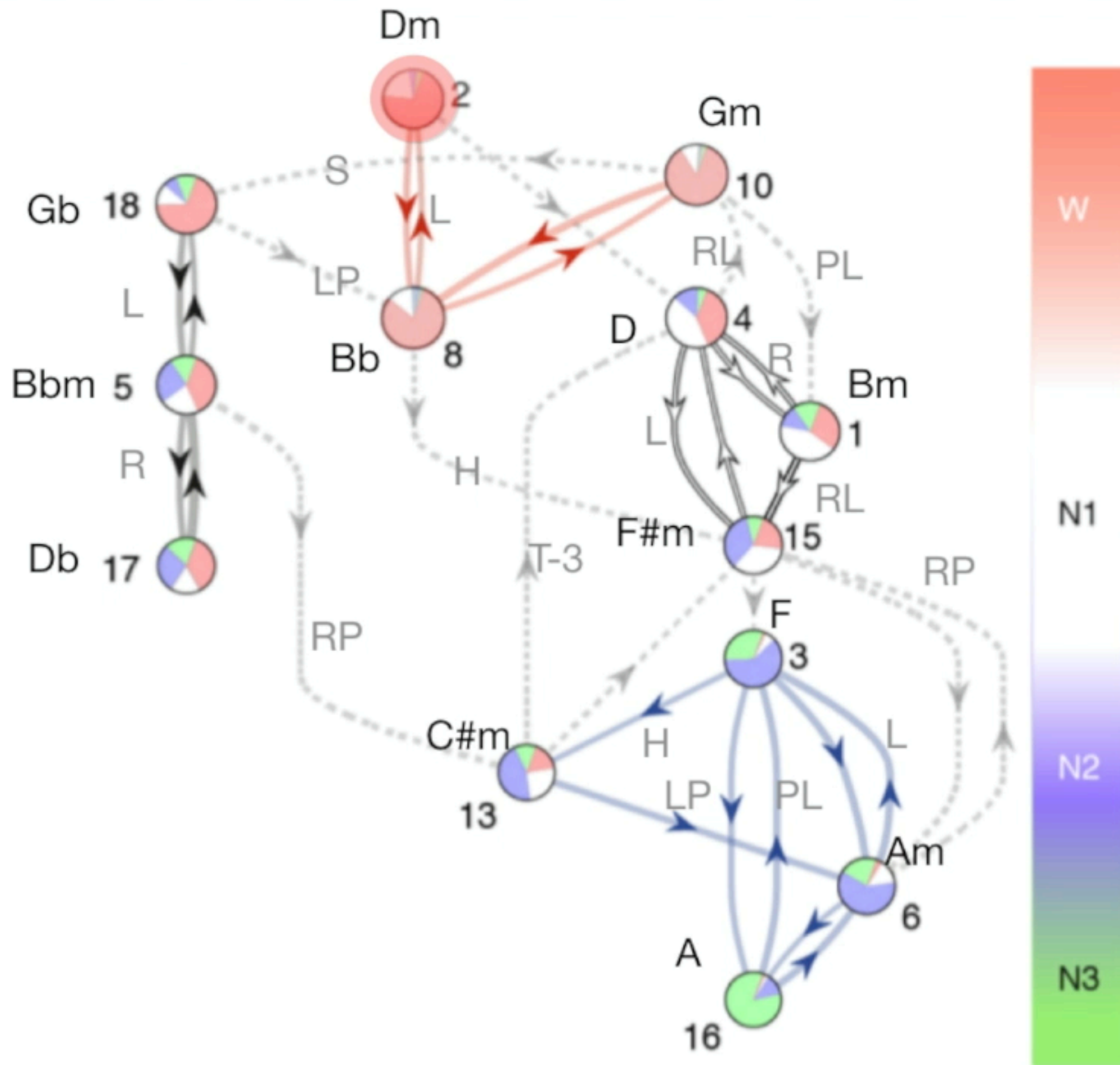




Neo-Riemannian Transformational Network



**Pathways denote
Number of common tones/intervallic proximity**



CODA

Thanks