SOUND ASLEEP

THE HIDDEN MUSIC OF SLEEP PATTERNS

Milton

Mermikides

BRITISH SLEEP SOCIETY 2015

SOME BACKGROUND

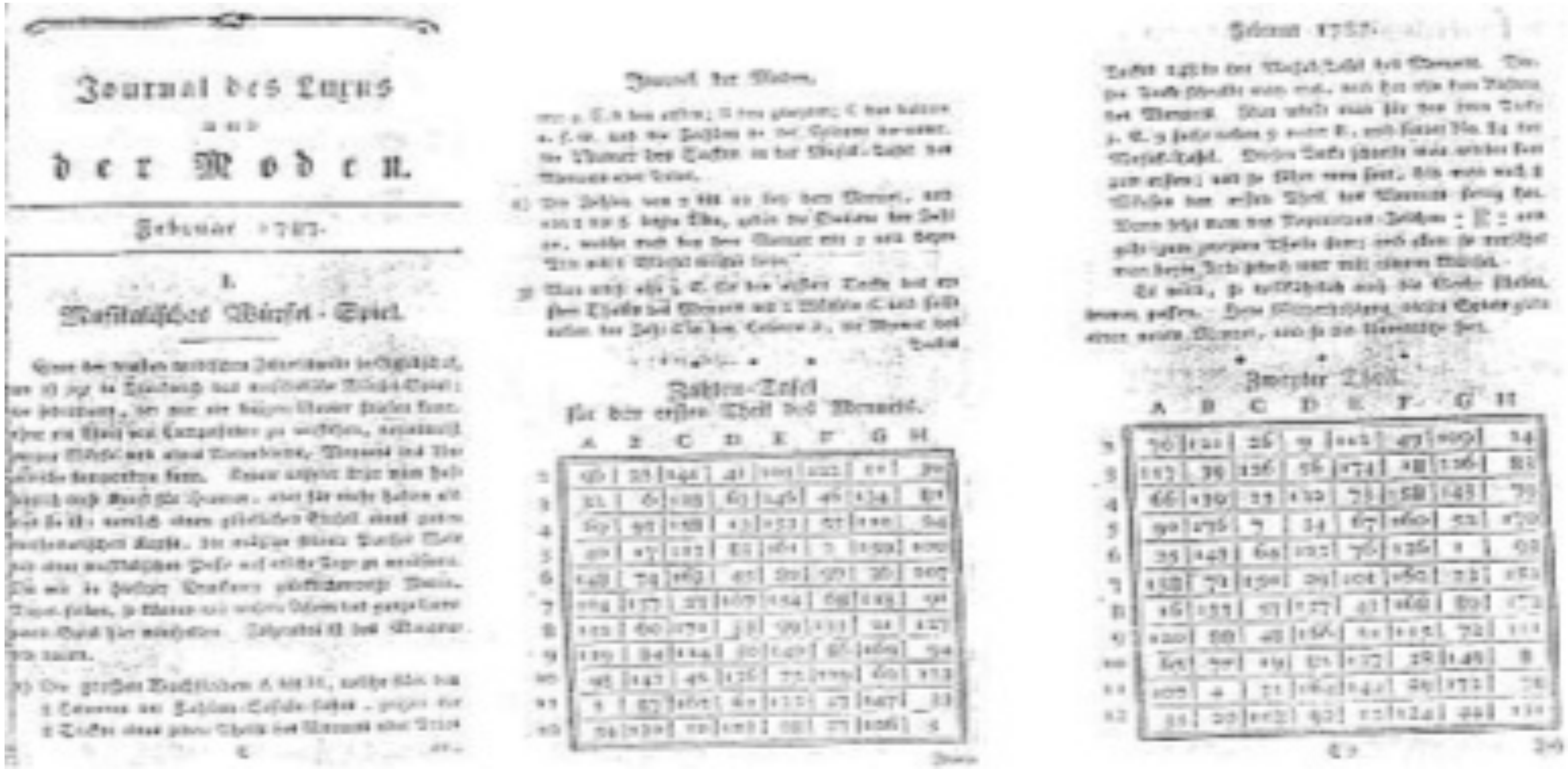
Milton

Mermikides

SOUND ASLEEP

THE HIDDEN MUSIC OF SLEEP PATTERNS

HISTORY OF COMPOSITIONAL DELEGATION


Journal des Luxus und der Moden.

Februar 1787.

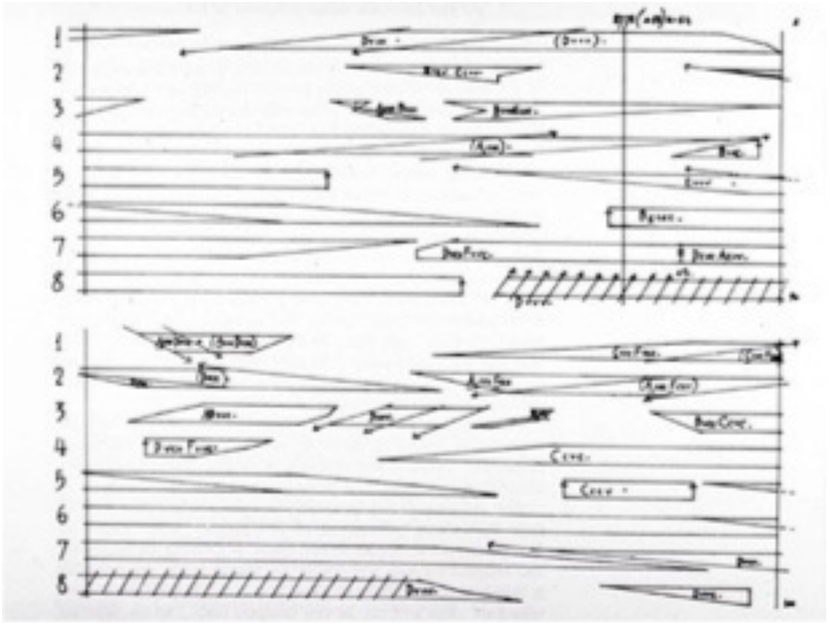
I. Musikalisches Würfel-Spiel.

Zahlen-Tafel für den ersten Theil des Menuets.

Zweyter Theil.

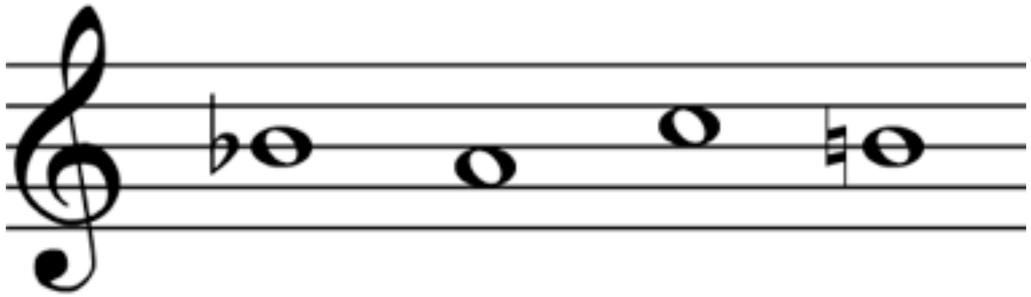
Mozart’s Dice Game (1787)

HISTORY OF COMPOSITIONAL DELEGATION



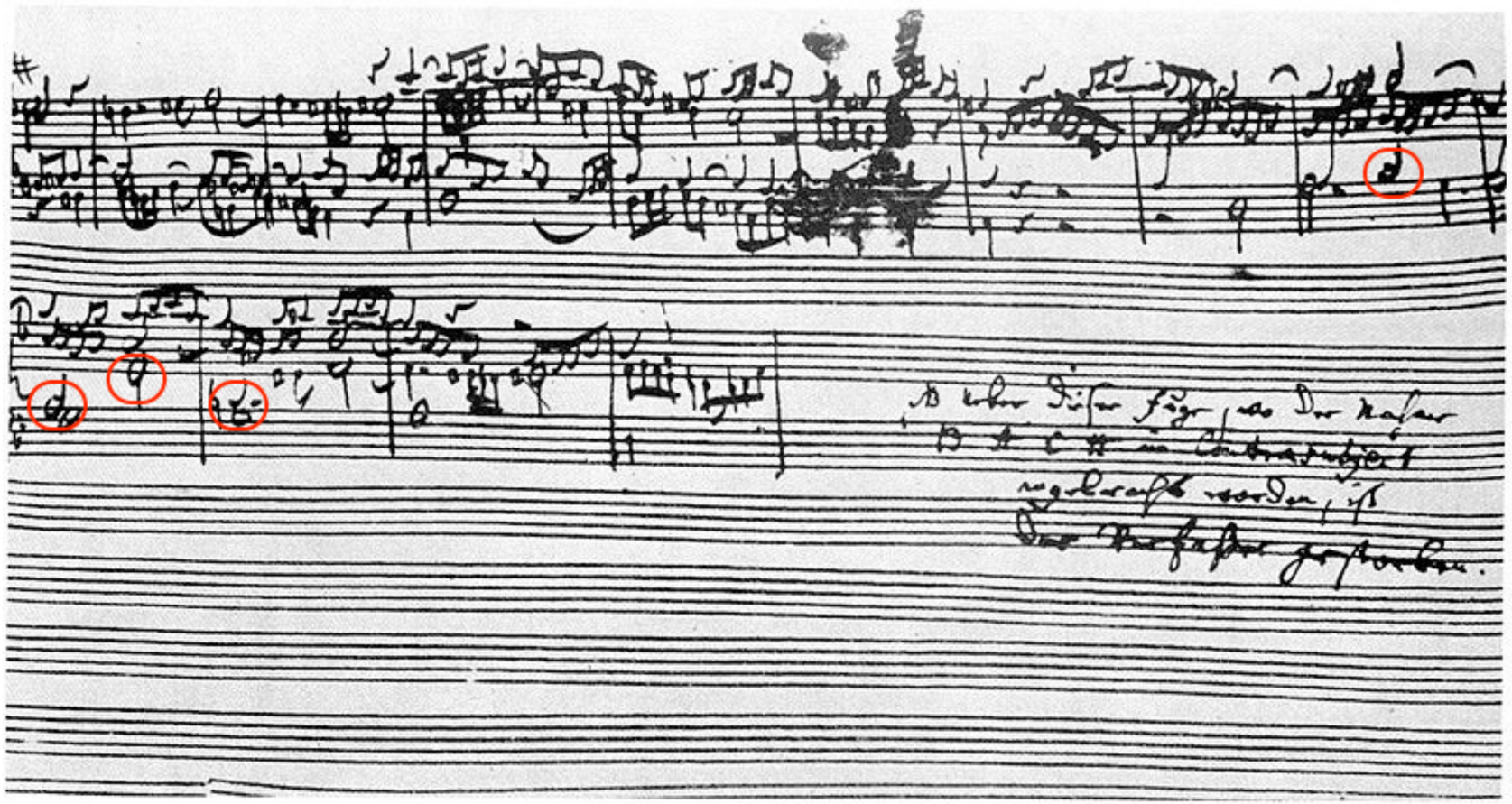
DuChamp (1913) and Cage’s Randomness (1952)

MUSICAL CRYPTOGRAMS



B A C H

MUSICAL CRYPTOGRAMS



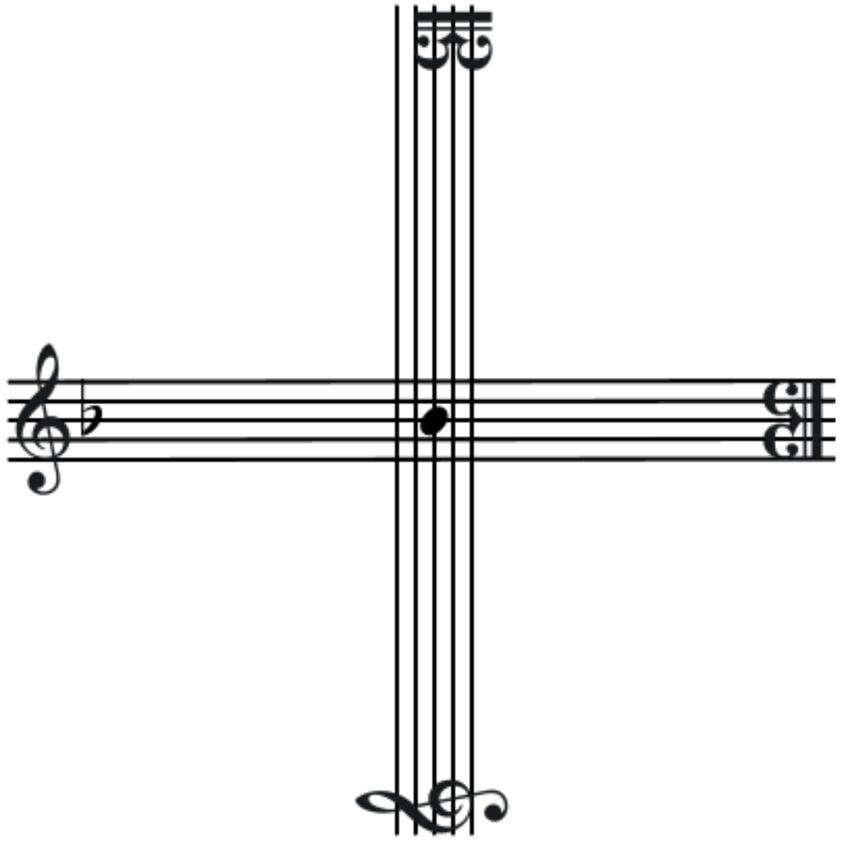
The unfinished Contrapunctus XIV, C.P.E. Bach's note

"At the point where the composer introduces the name BACH [for which the English notation would be B ♭ -A-C-B ♮] in the countersubject to this fugue, the composer died."

MUSICAL CRYPTOGRAMS

Acting as a tribute, or a test of compositional skill,

the Bach motif has appeared in 100s of works since the 17th century, by composers such as Schumann, Liszt, Rimsky-Korsakov, Webern, Brahms, Poulenc and Arvo Pärt



German System

A = A

B = Bb

C = C

D = D

E = E

F = F

G = G

H = B

M = E

L = A

R(e) = D

S (Es) = Eb

T(i) = B

As = Ab

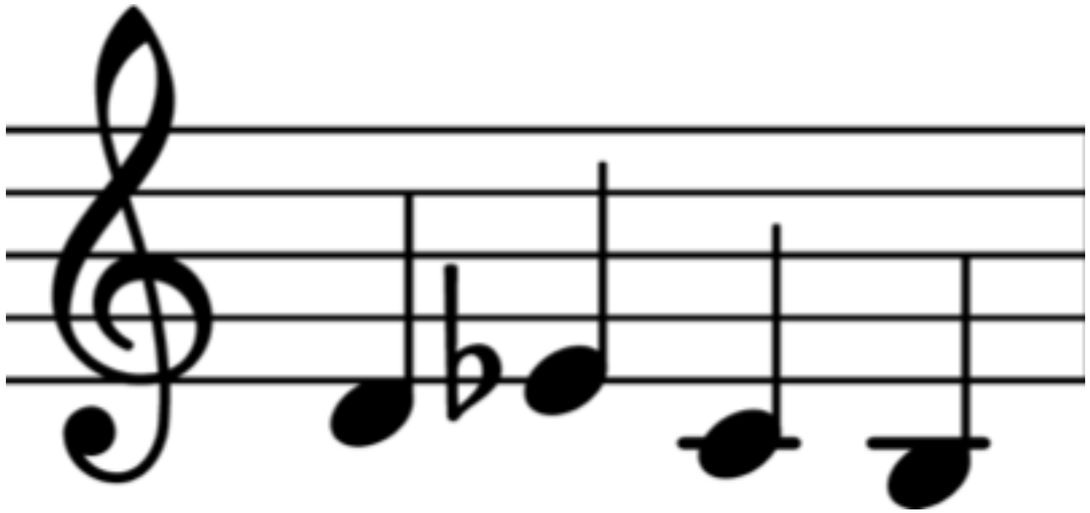
Ignore the rest

French System

A	**B** (or Bb)	**C**	**D**	**E**	**F**	**G**
H (or B)	I	J	K	L	M	N
O	P	Q	R	S	T	U
V	W	X	Y	Z		

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

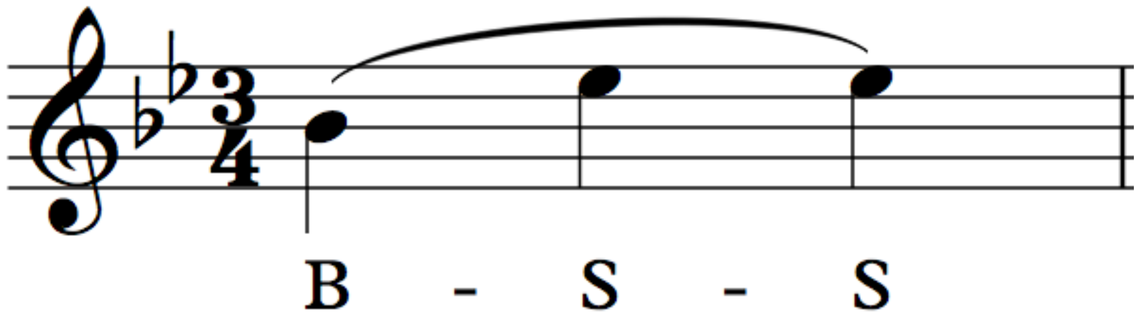
Dimitri Schostakovich



D Eb C B

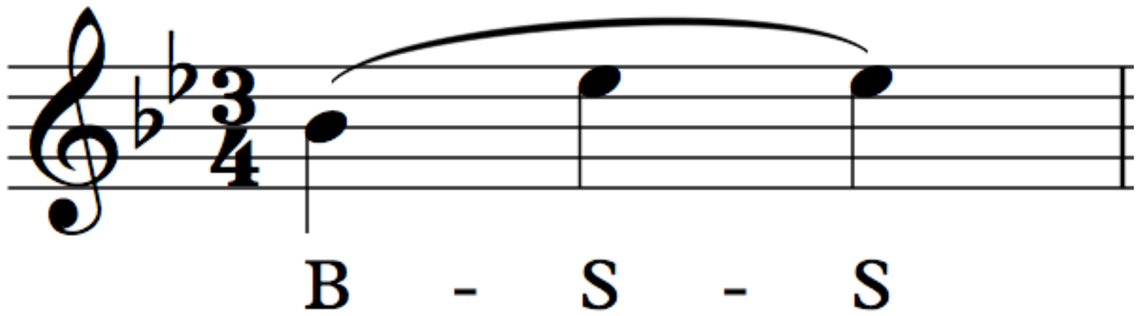
BRITISH SLEEP SOCIETY

BRITISH SLEEP SOCIETY



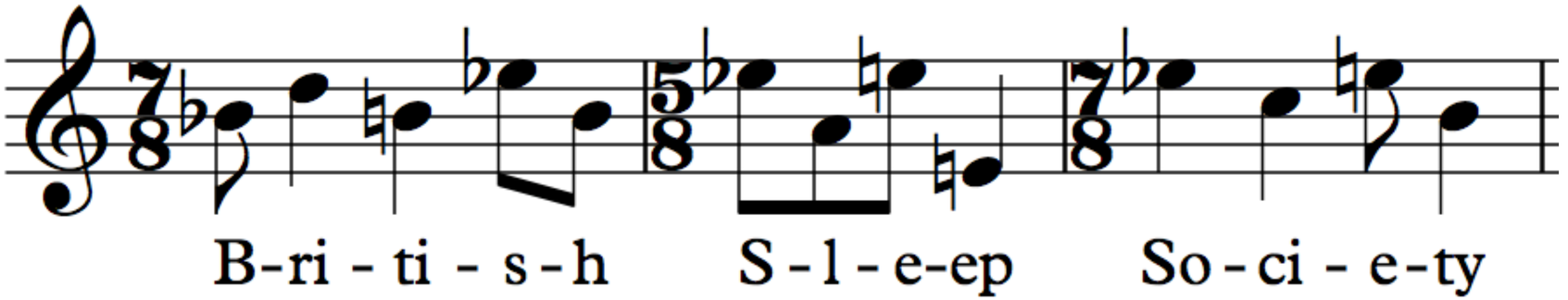
BRITISH SLEEP SOCIETY

(Hollywood Theme)



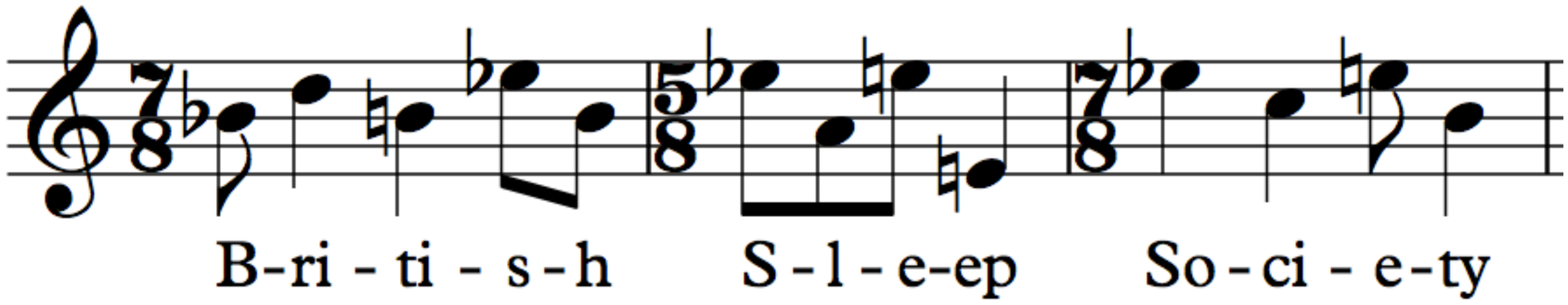
BRITISH SLEEP SOCIETY

BRITISH SLEEP SOCIETY



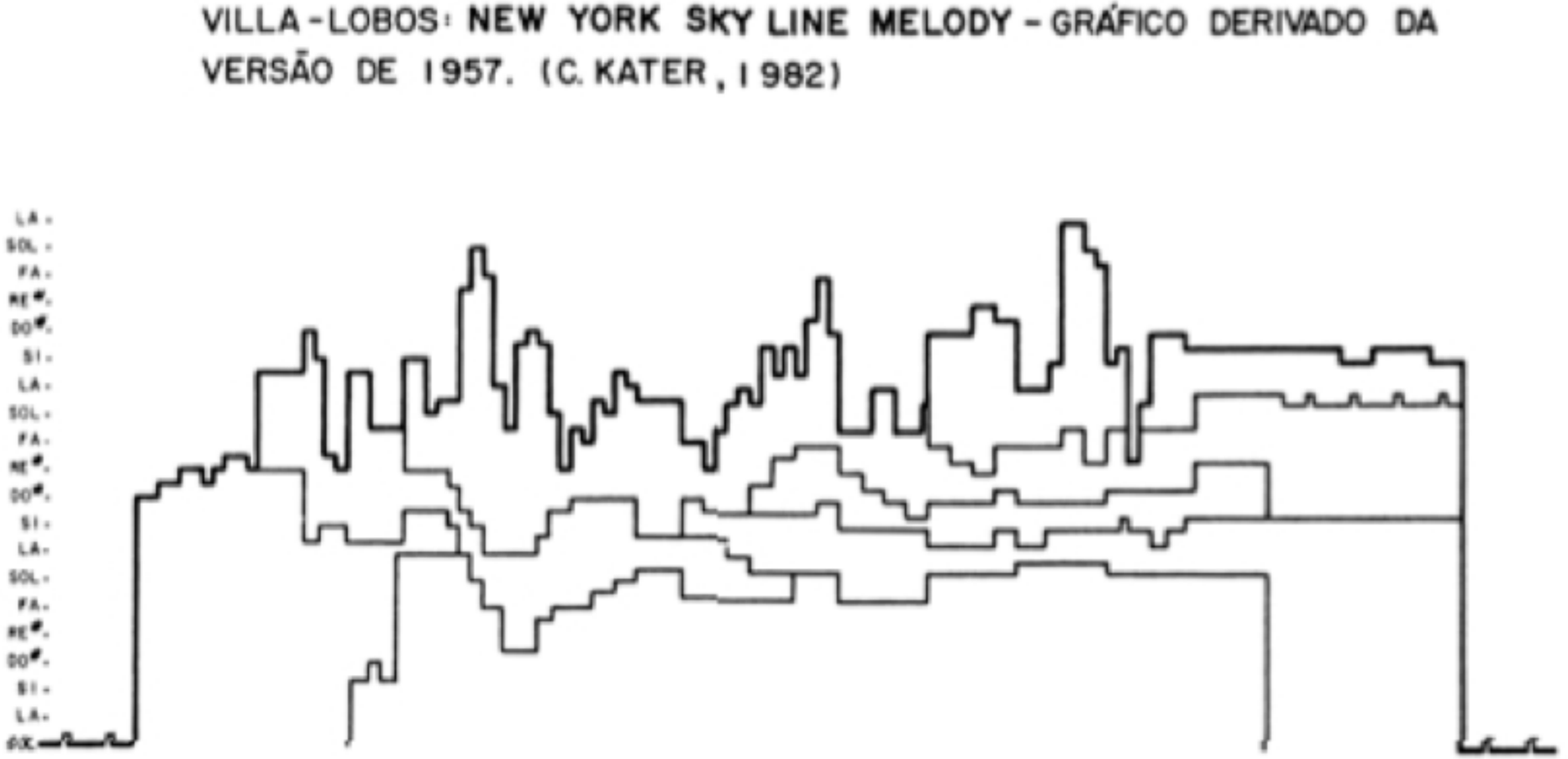
BRITISH SLEEP SOCIETY

(Modernist Interpretation)

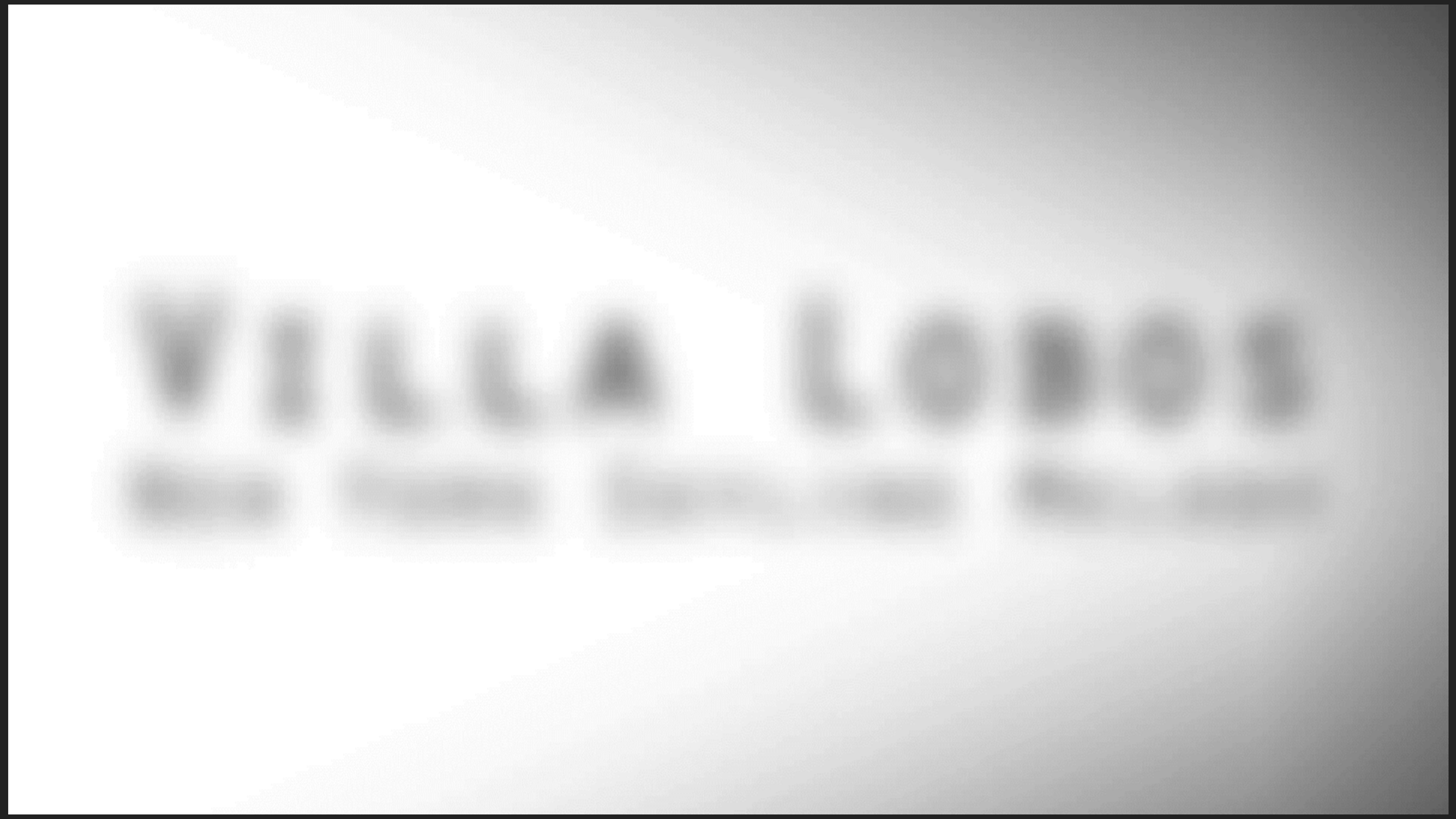


EXTENDING THE CONCEPT

Villa-Lobos
(1887-1959)



New York Skyline Melody (1939)


VILLA LOBOS

DATA SONIFICATION

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)

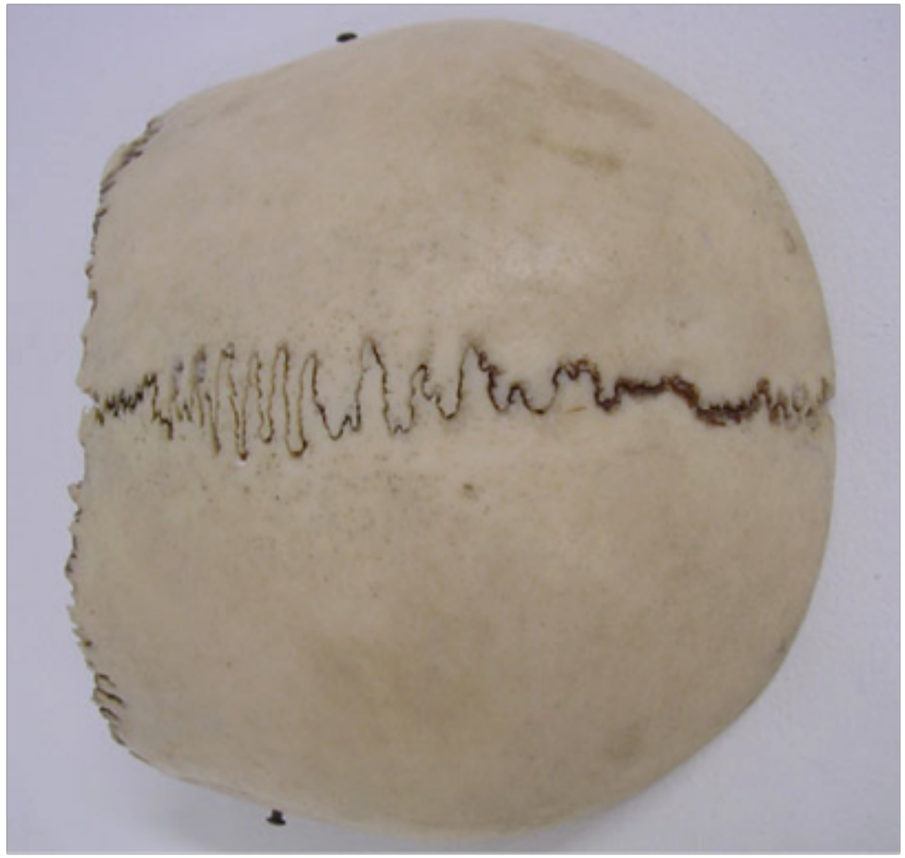
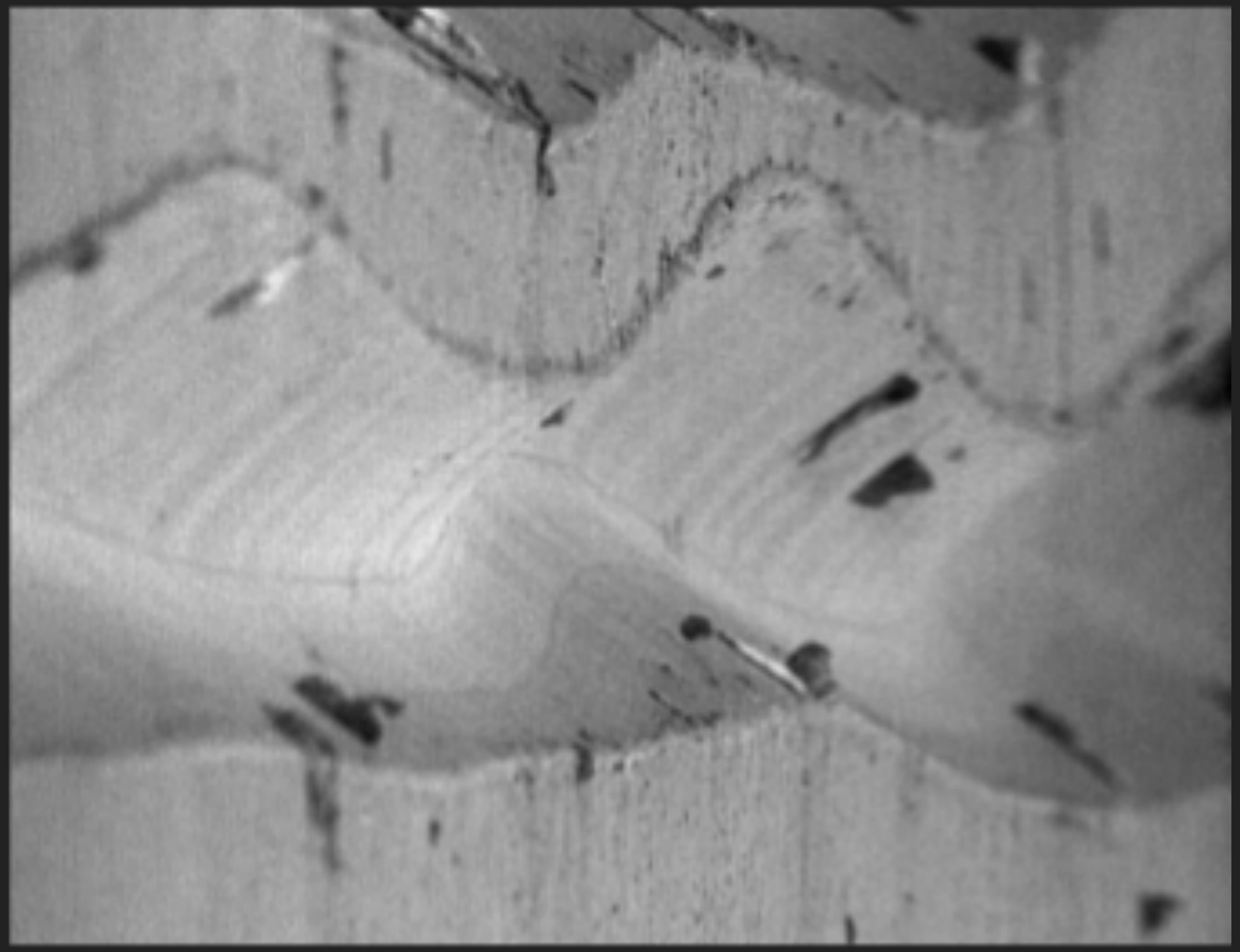
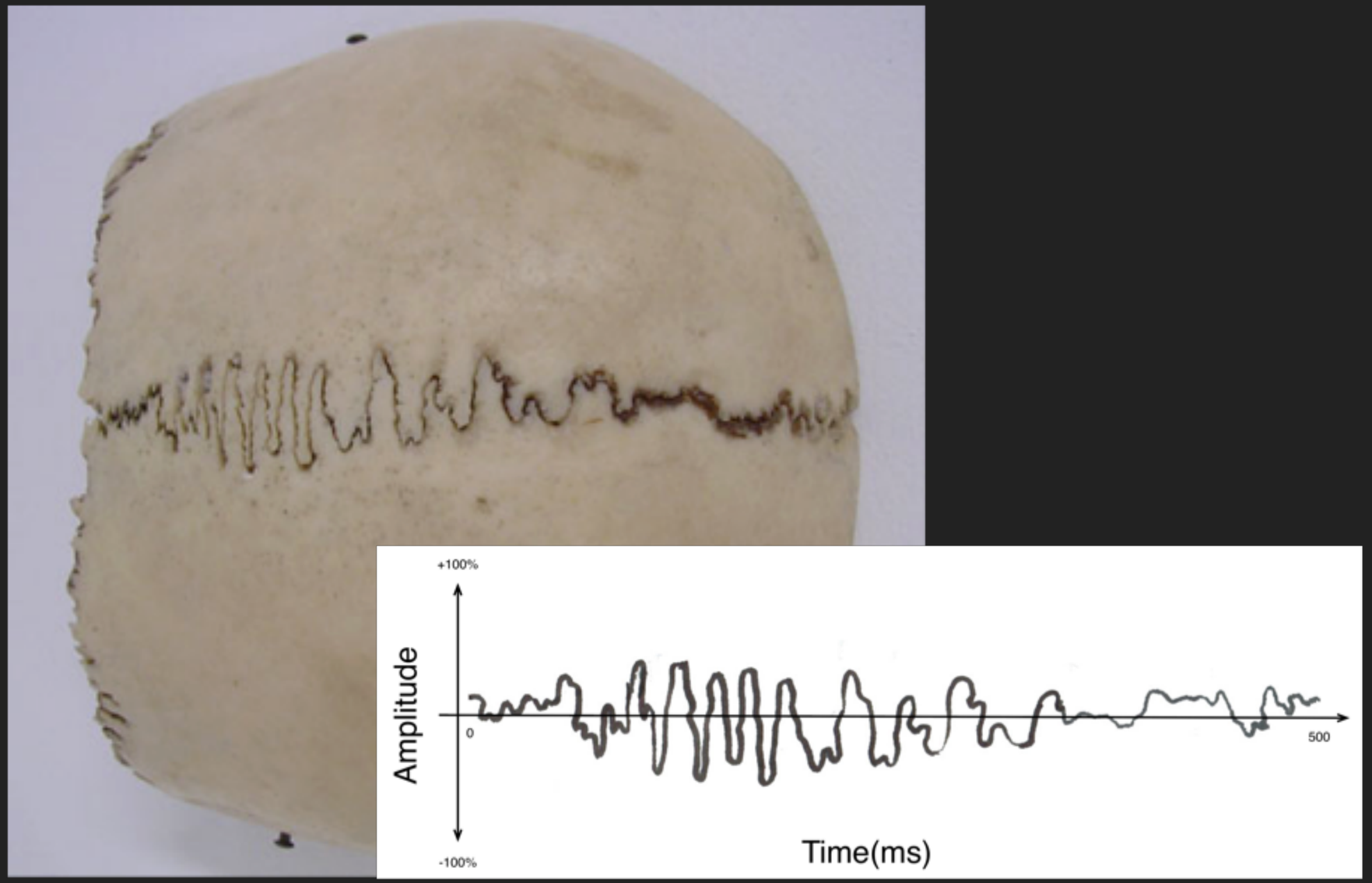
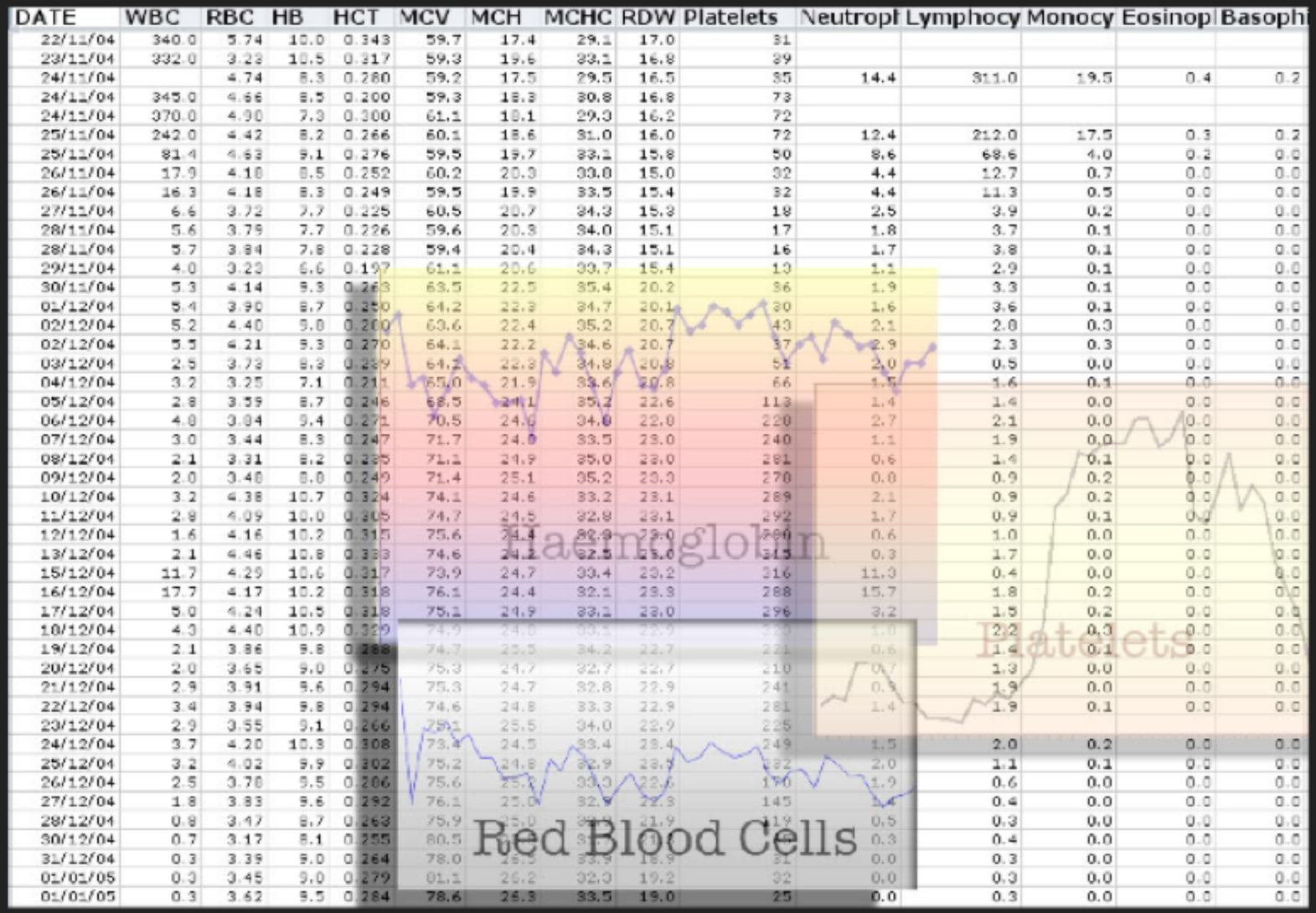


Image ©2004 Palmer




+100%
Amplitude
0
500
-100%
Time(ms)

BloodLines (2004, 2013)



DATE	WBC	RBC	HB	HCT	MCV	MCH	MCHC	RDW	Platelets	Neutrophl	Lymphocy	Monocy	Eosinopl	Basophl
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	5.23	10.5	0.317	59.3	19.6	33.1	16.8	29					
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	0.280	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	19.9	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	3.79	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	0.248	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	22.8	34.7	20.1	30	1.6	3.6	0.1	0.0	0.0
02/12/04	5.2	4.40	9.8	0.280	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	4.8	3.84	9.4	0.271	70.5	24.6	34.8	22.0	220	2.7	2.1	0.0	0.0	0.0
07/12/04	3.0	3.44	8.3	0.247	71.7	24.0	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	3.40	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	2.8	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	32.3	23.0	280	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	315	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	0.330	74.9	24.8	33.1	22.9	325	1.9	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	9.6	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	9.8	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	282	2.0	1.1	0.1	0.0	0.0
26/12/04	2.5	3.70	9.5	0.286	75.6	25.6	33.9	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	33.1	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	25.6	31.8	21.9	83	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	51	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

Haemoglobin

Platelets

Red Blood Cells

DATA SONIFICATION

Systematic Translation of Data into Sound

(Sound design, composition)

Rule-based, Reproducible, Relevant, Recognisable.

QUICK TOUR

VISION TO SOUND

(2015)

SONIC CIRCLES

(2015)

TRANSLATION OF COMPOSITION AND COLOUR IN KANDINSKY'S SEVERAL CIRCLES TO PITCH AND TIMBRE

"Colour is the keyboard, the eyes are the hammers, the soul is the piano with many strings. The artist is the hand which plays, touching one key or another, to cause vibrations in the soul" - Wassily Kandinsky (1911)

SONIC CIRCLES (2015)

(2015)

SEED PODS

HUMAN BEHAVIOUR

(2015)

ANOTHER DAY

(2015)

TRANSLATION OF TRAFFIC MOVEMENT OVER A 24 HOUR PERIOD INTO SOUND

(WATCH THE PARKING SPACES AND BUS STOP)


Chancellors
Chancellors
SOLD
BOSCO

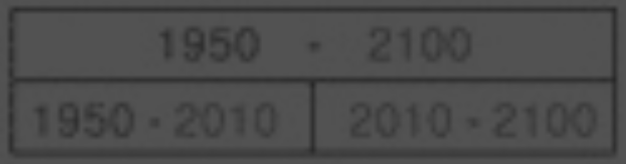
(2015)

BIRTH/DEATH

(2015)

THE RIGHT HAND OF THE PIANO PLAYS AT THE (REAL-TIME) RATE OF BIRTHS IN THE WORLD,
WHILE THE LEFT HAND PLAYS AT THE (SLOWER) RATE OF DEATHS.

AS THE PIECE PROGRESSES, THE WORLD POPULATION GROWS EXPONENTIALLY.



BIOLOGY/CHEMISTRY

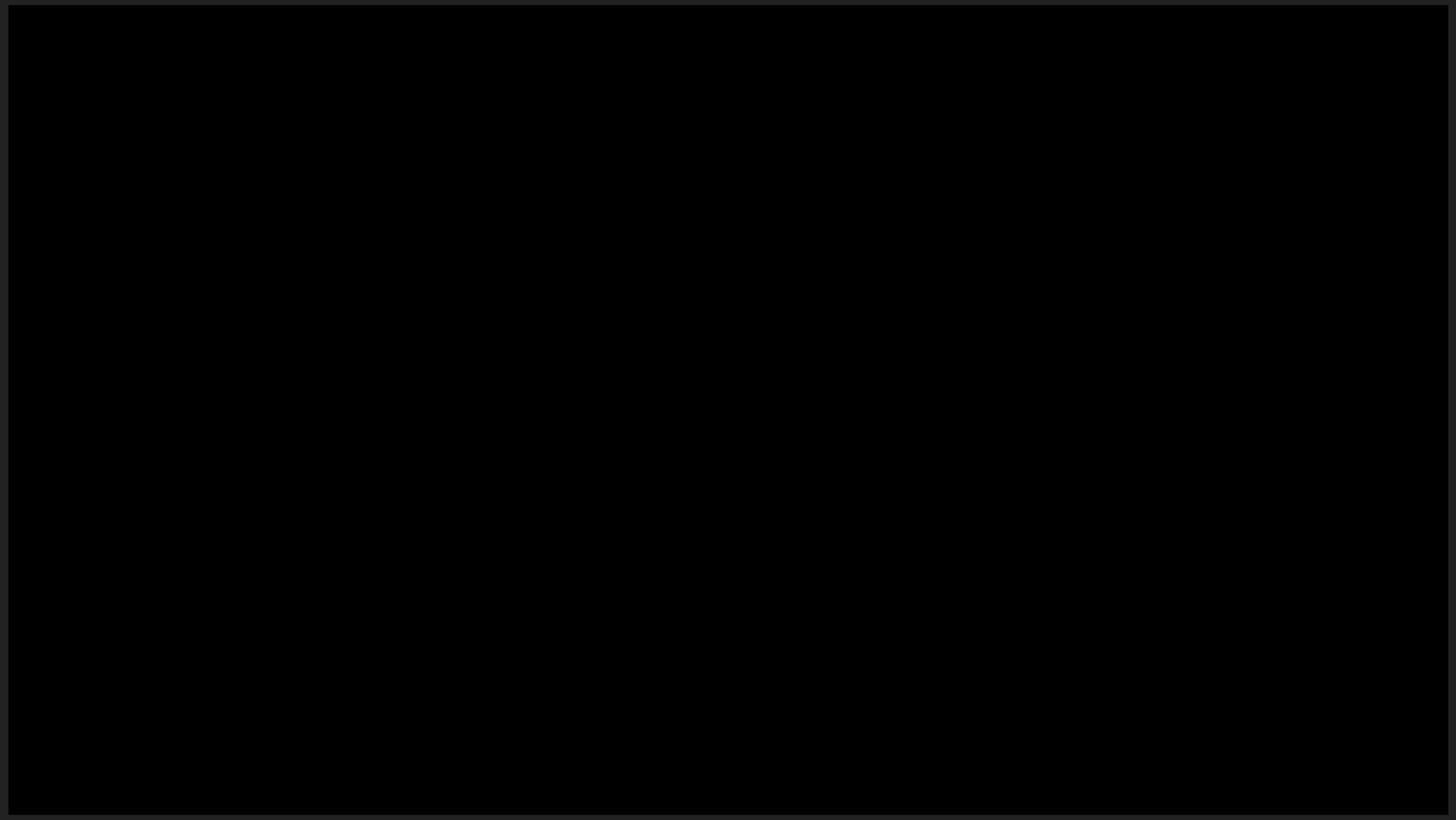
(2015)

CRYSTALS

(2015)

TRANSLATION OF CRYSTAL GROWTH INTO HARMONY AND ARPEGGIO PATTERNS

VIDEO: SIMON PARK



(2015)

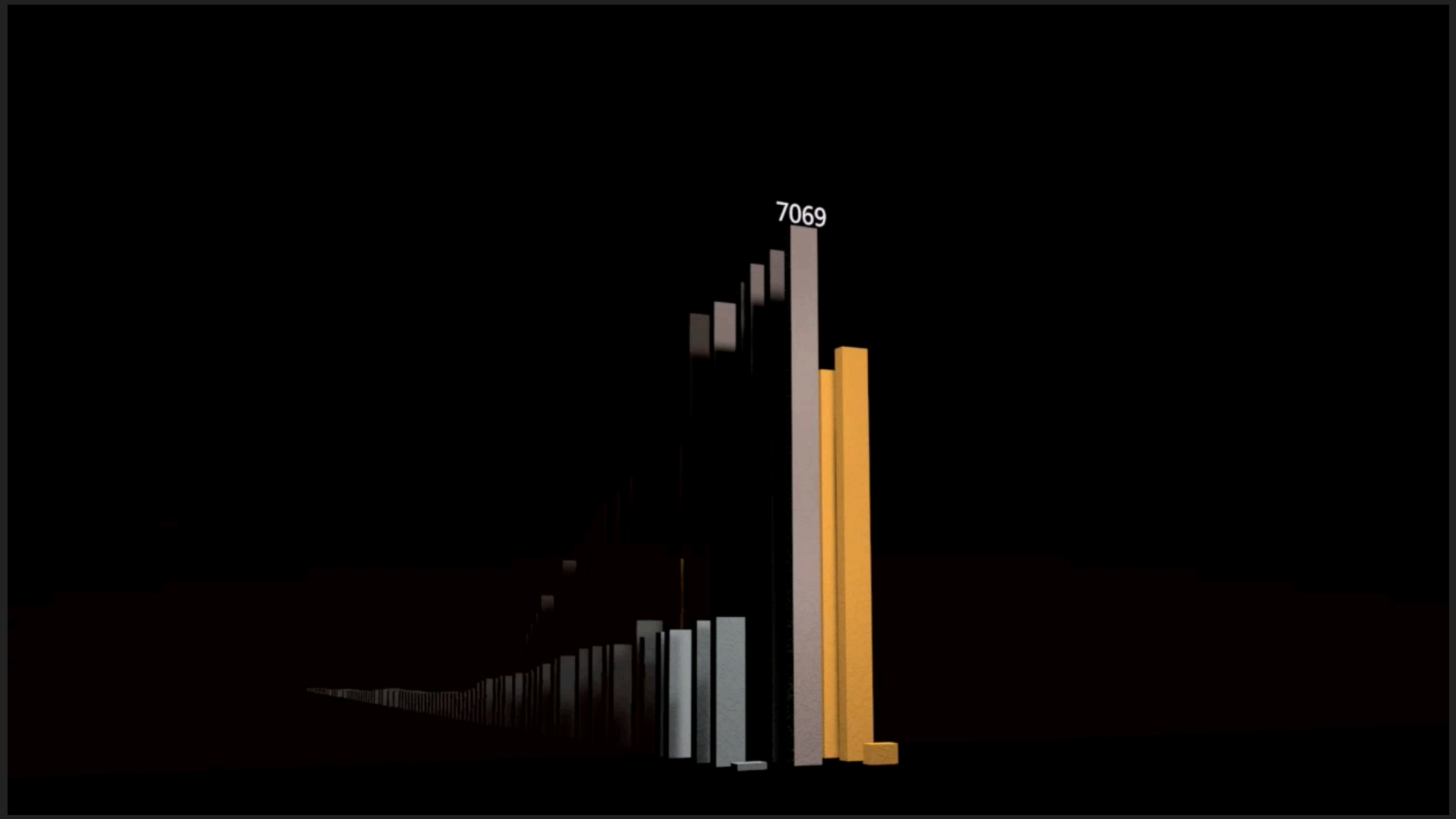
OUTBREAK

(2015)

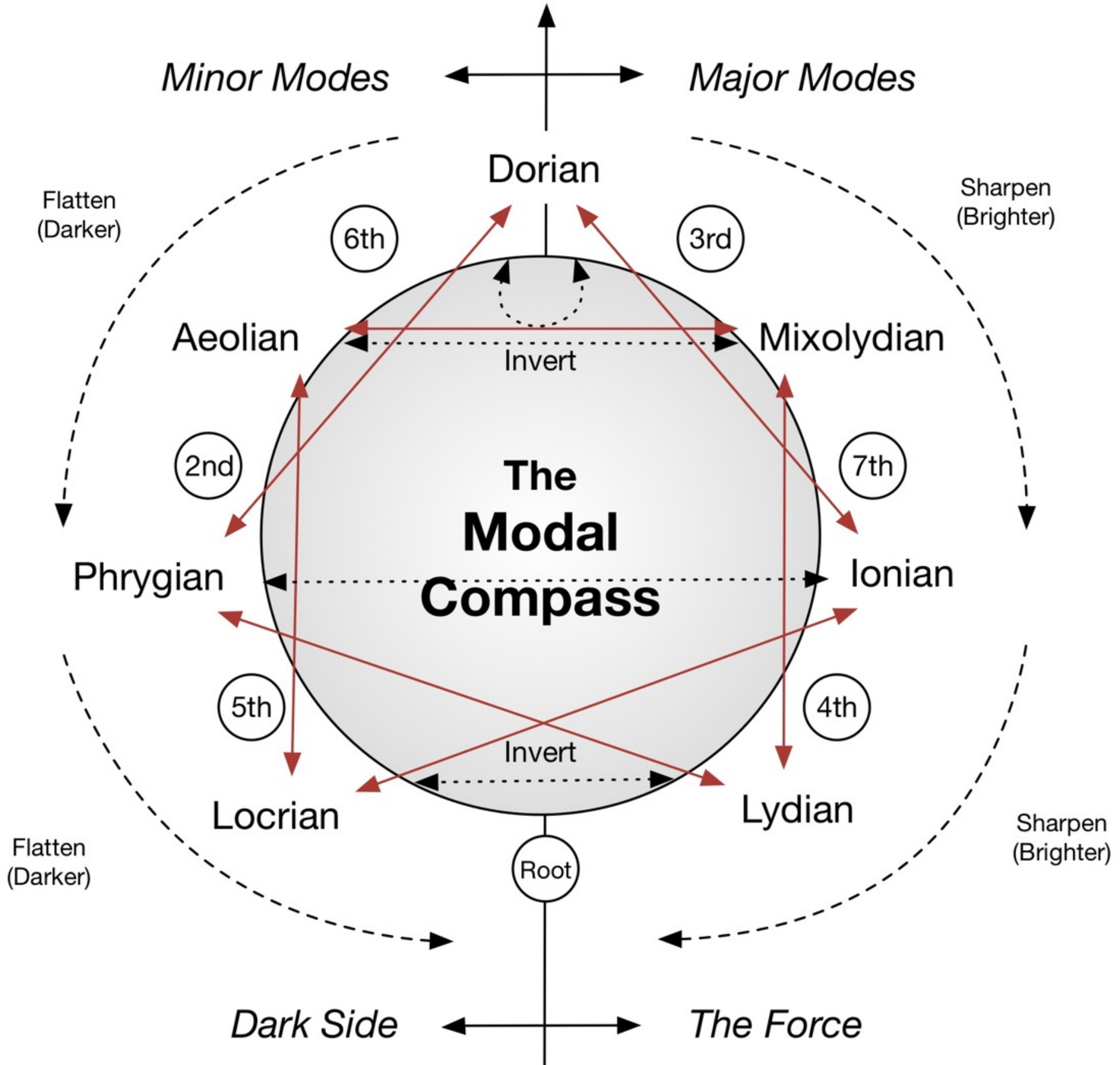
TRANSLATION INTO MUSICAL MOTIFS OF THE DAILY NUMBER OF EBOLA CASES IN SIERRA LEONE, LIBERIA AND GUINEA
(24TH MARCH 2014 TO 5TH JANUARY 2015)

MISSING DATA IS LEFT AS SILENCE


Sierra Leonne
Liberia
Guinea


7069

GEOMETRICAL/
MUSIC THEORETICAL

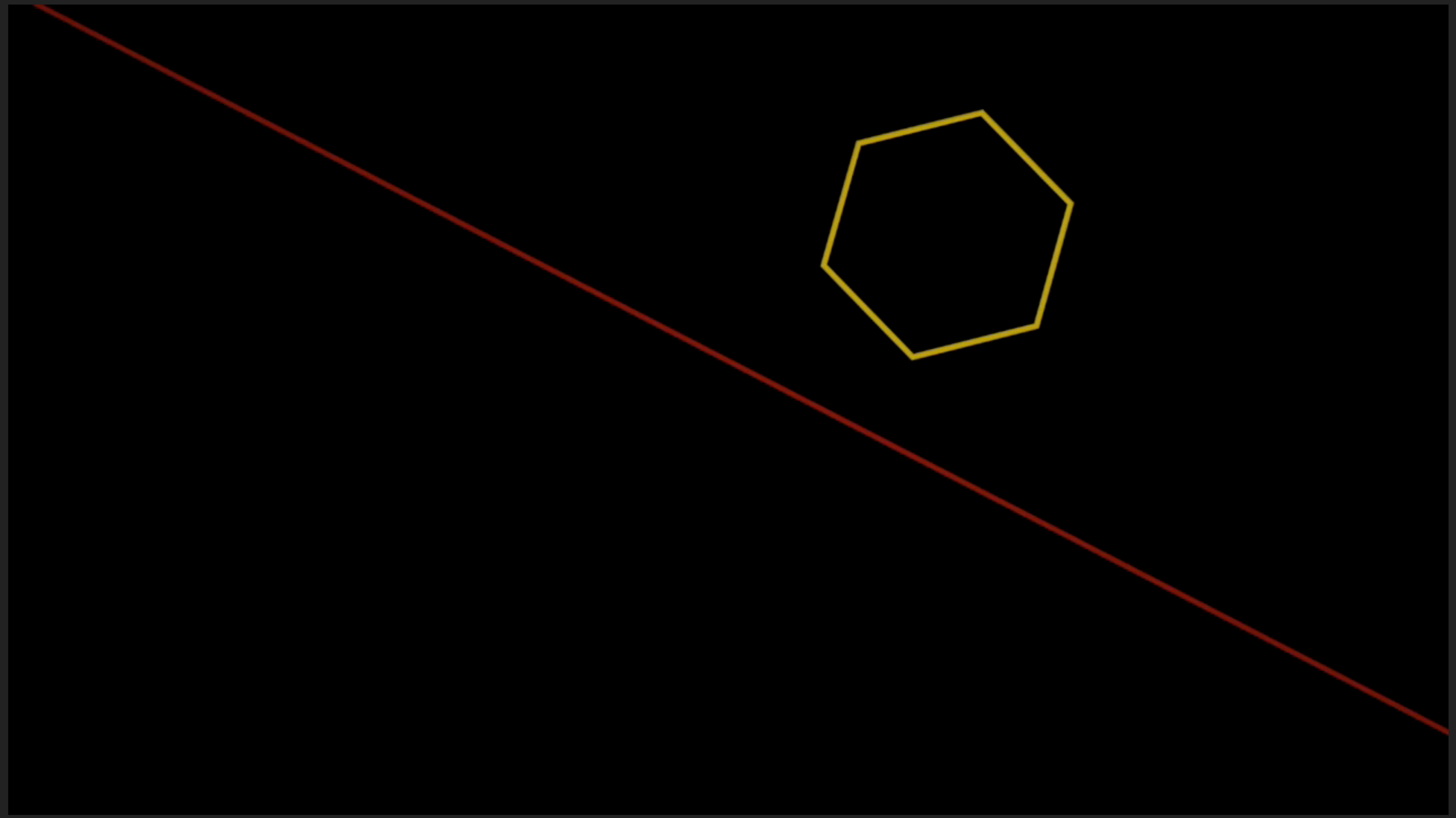

Minor Modes
Major Modes
Dorian
Flatten
(Darker)
Sharpen
(Brighter)
6th
3rd
Aeolian
Mixolydian
Invert
2nd
7th
The
Modal
Compass
Phrygian
Ionian
5th
4th
Invert
Locrian
Lydian
Flatten
(Darker)
Sharpen
(Brighter)
Root
Dark Side
The Force

(2015)

GEOMETUDE NO.3

(2015)

HARMONIC AND MELODIC STUDY FOR DRIFTING HEXAGON AND LINE



COSMOLOGICAL

(2015)

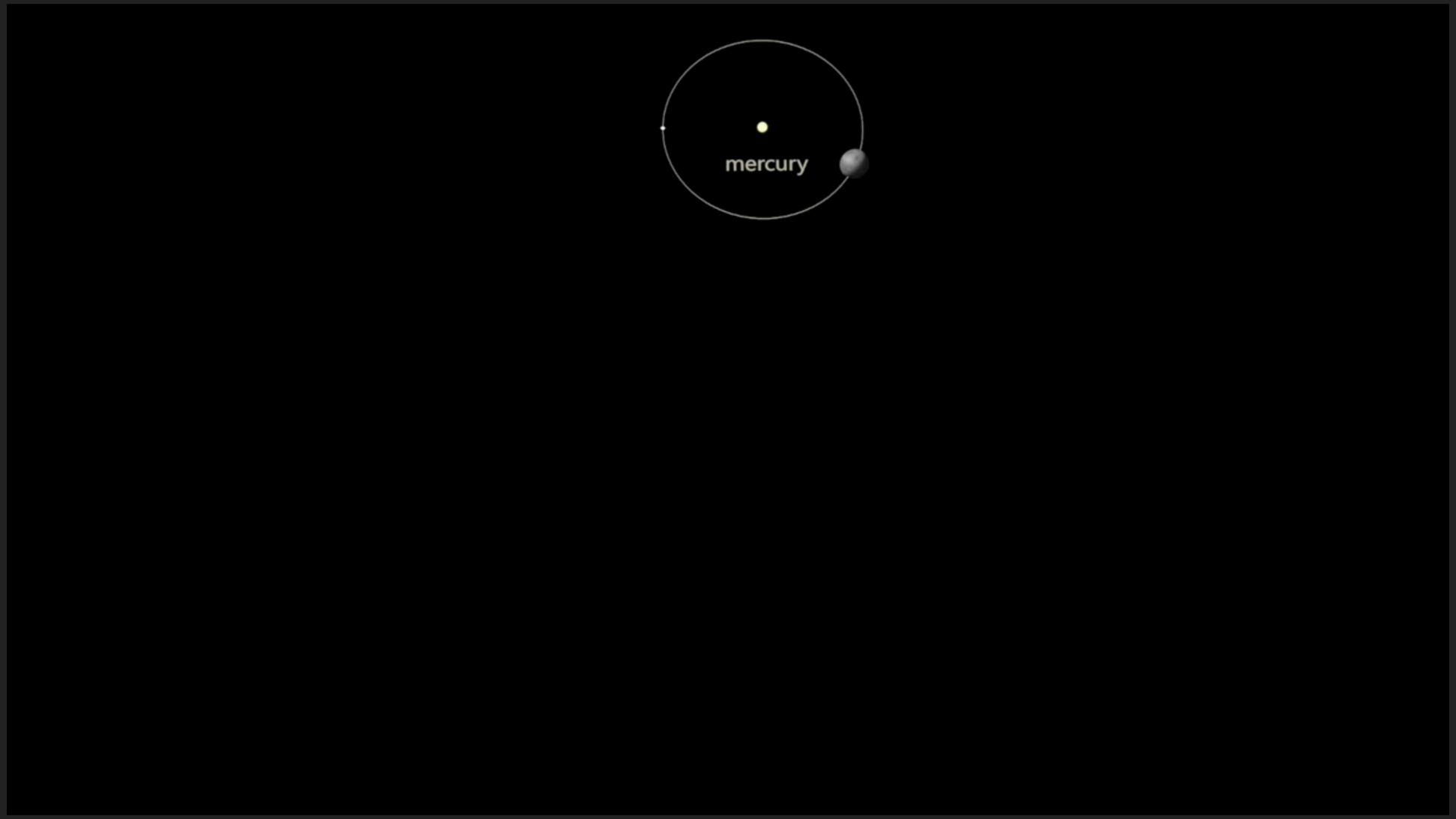
DISTANT HARMONY

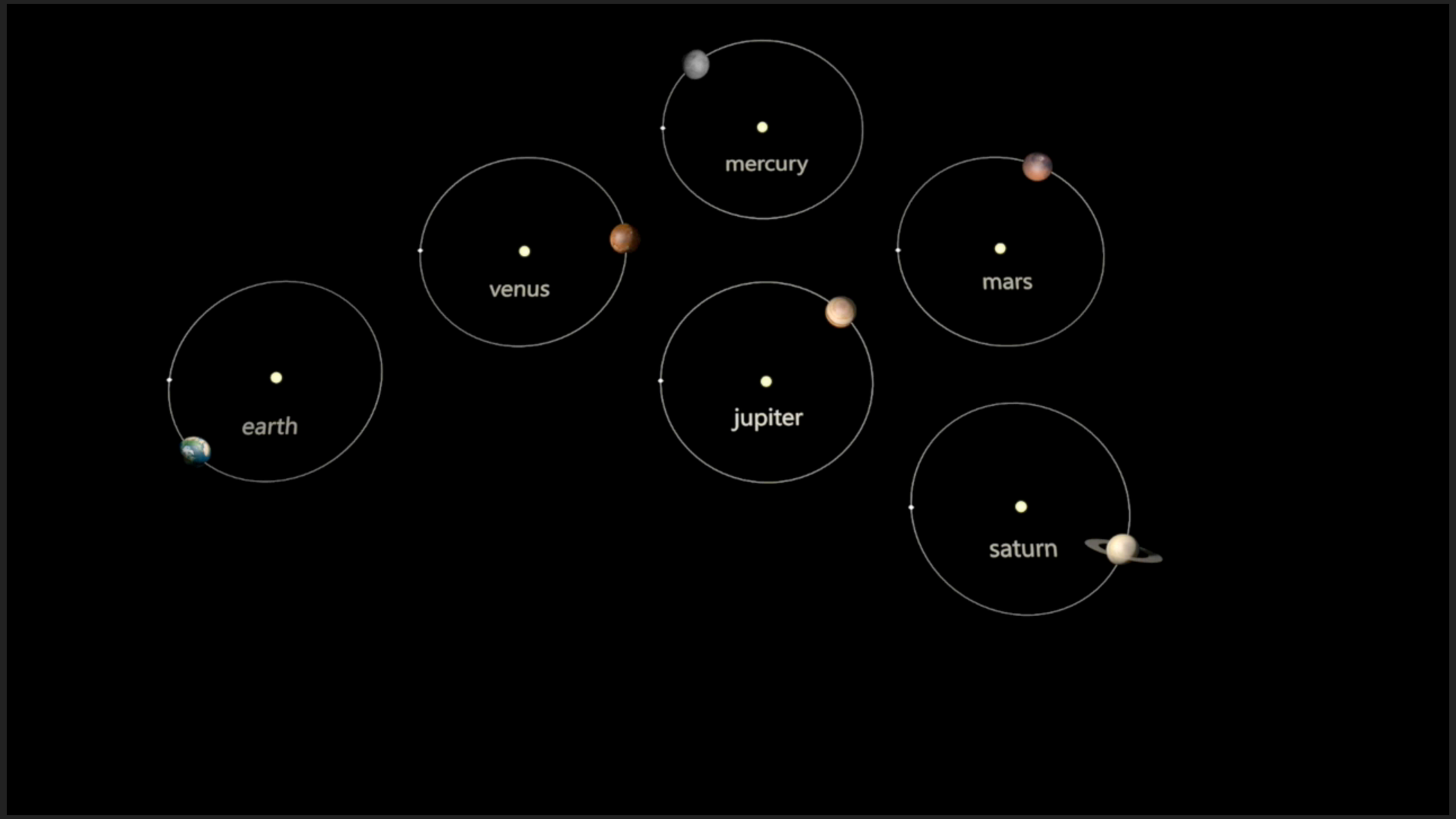
SOLAR

(2015)

THE ORBITAL FREQUENCIES OF THE SOLAR SYSTEM'S PLANETS TRANSLATED INTO RHYTHMS (24 OCTAVES UP) AND PITCHES (35 OCTAVES UP)

THESE ARE PRESENTED AS INDEPENDENT AND
CIRCULAR (RATHER THAN ELLIPTICAL) ORBITS FOR CLARITY


mercury


mercury
venus
mars
earth
jupiter
saturn

WHY SONIFY?

A form of tribute, dedication or signature. Cryptic (or overt) message.

Creative Exercise. Creativity though limitation and collaboration. Spurring new ideas, widening of horizons.

Art/Science/Everything aesthetic.

Catharsis

Link to music theoretical mechanics

The musical revealing of patterns within biological and physical phenomena. A hidden music.

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

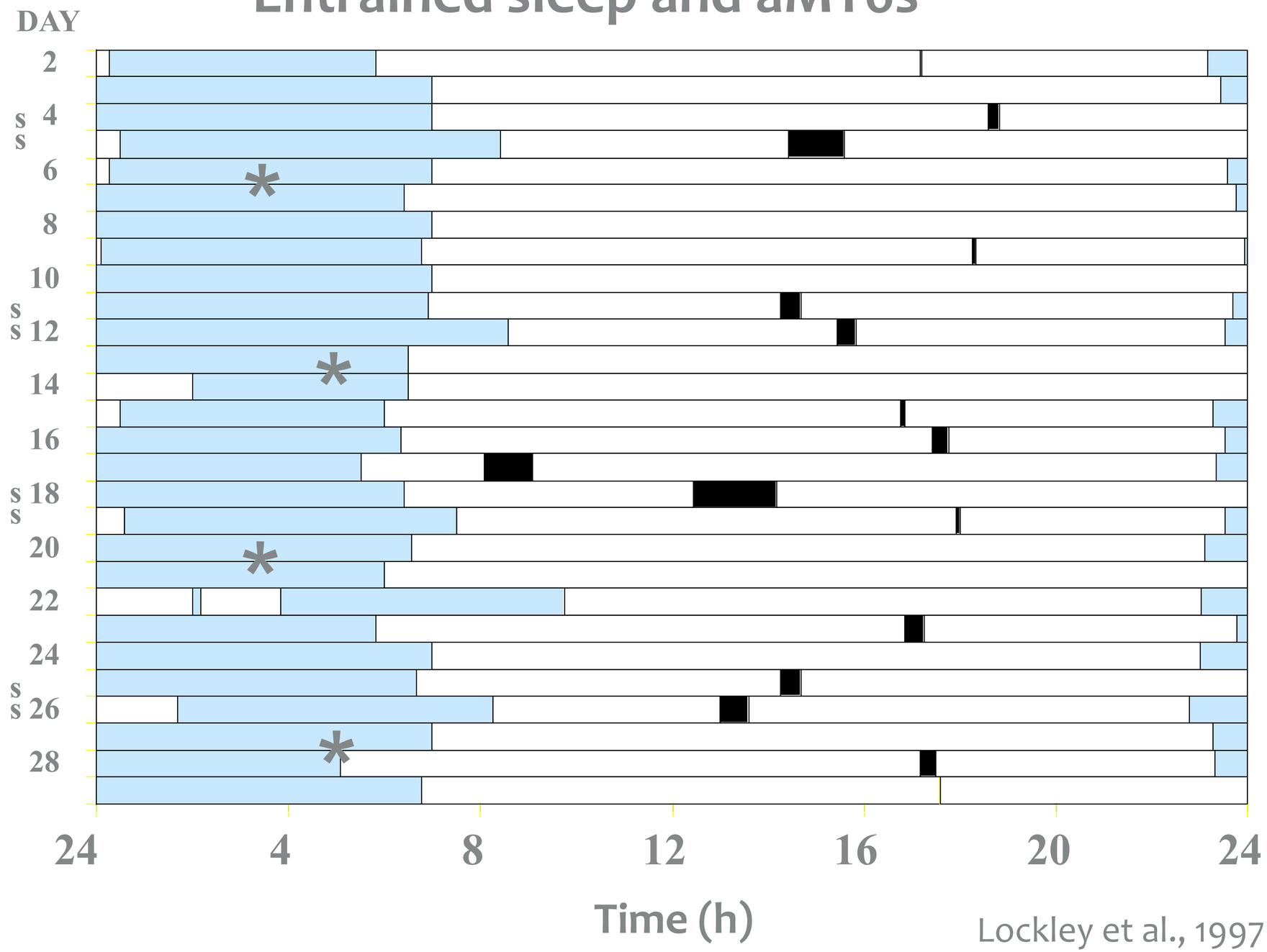
SOUND ASLEEP

MAKING SLEEP VISIBLE TO THE BLIND

Debra J. Skene (University of Surrey)

Milton Mermikides (University of Surrey)

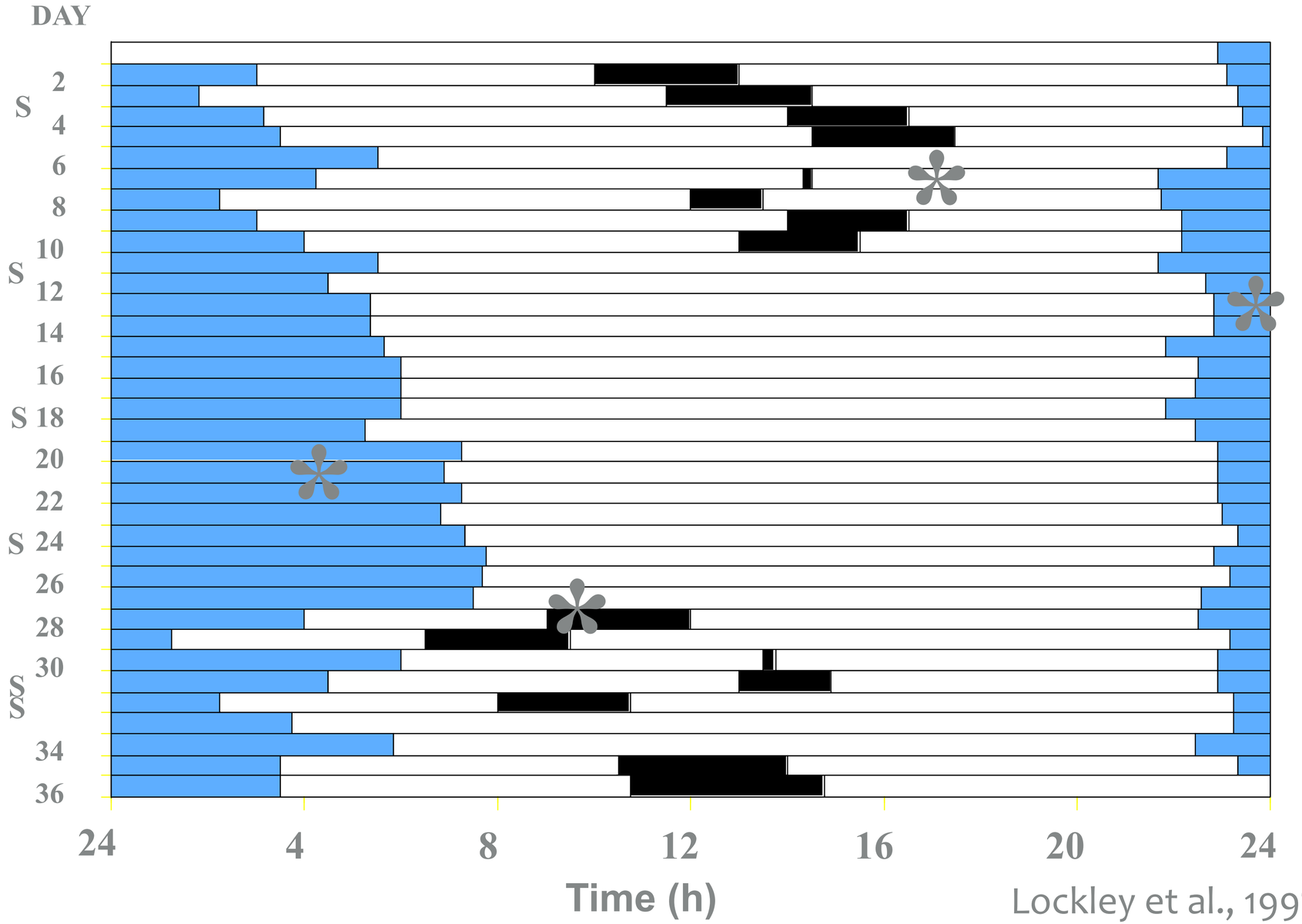
Entrained sleep and aMT6s



Lockley et al., 1997

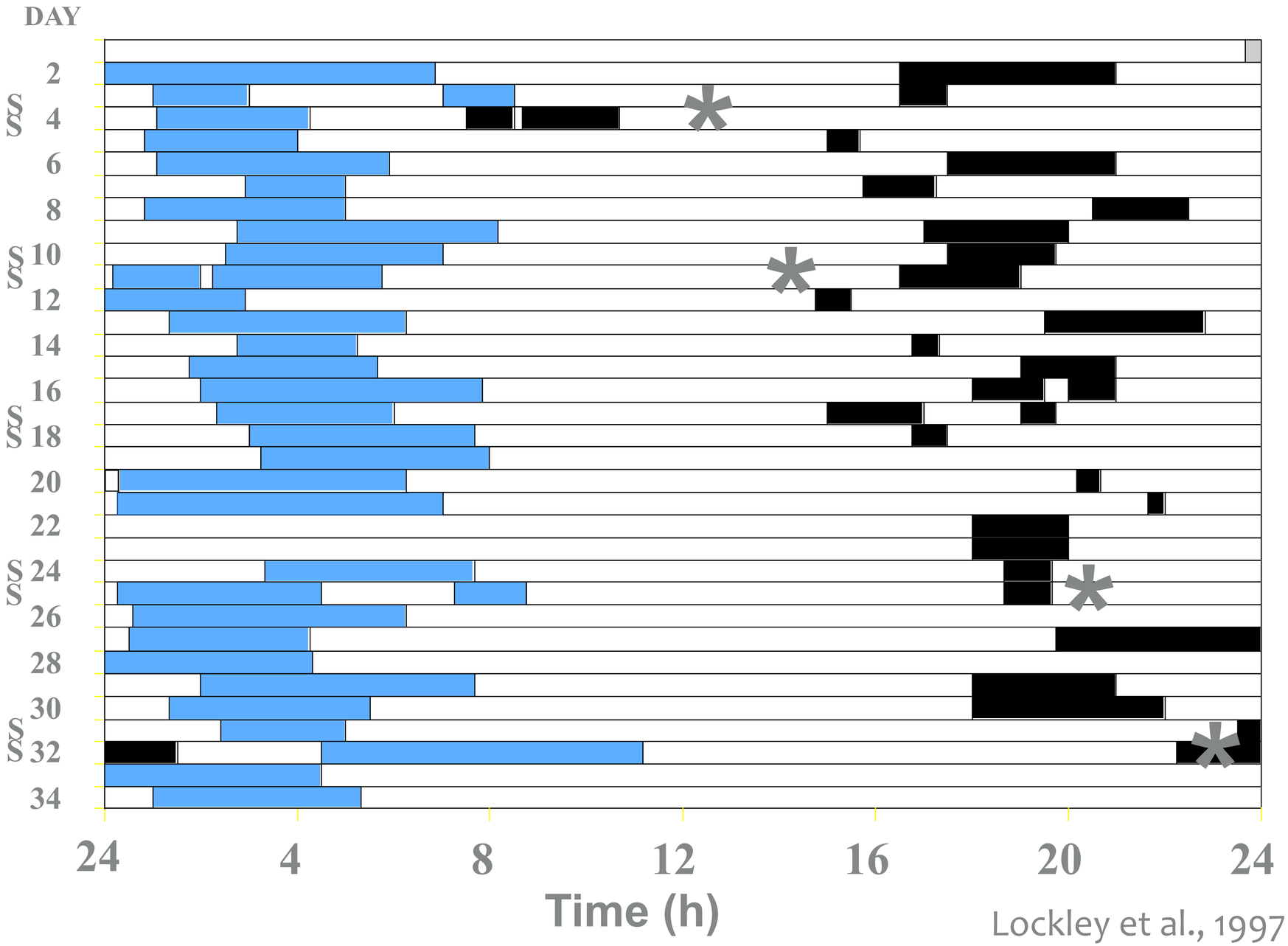
Non 24 h sleep/wake disorder

Abnormal circadian phase – poor sleep – daytime napping



Lockley et al., 1997

Abnormal circadian phase – poor sleep– daytime napping



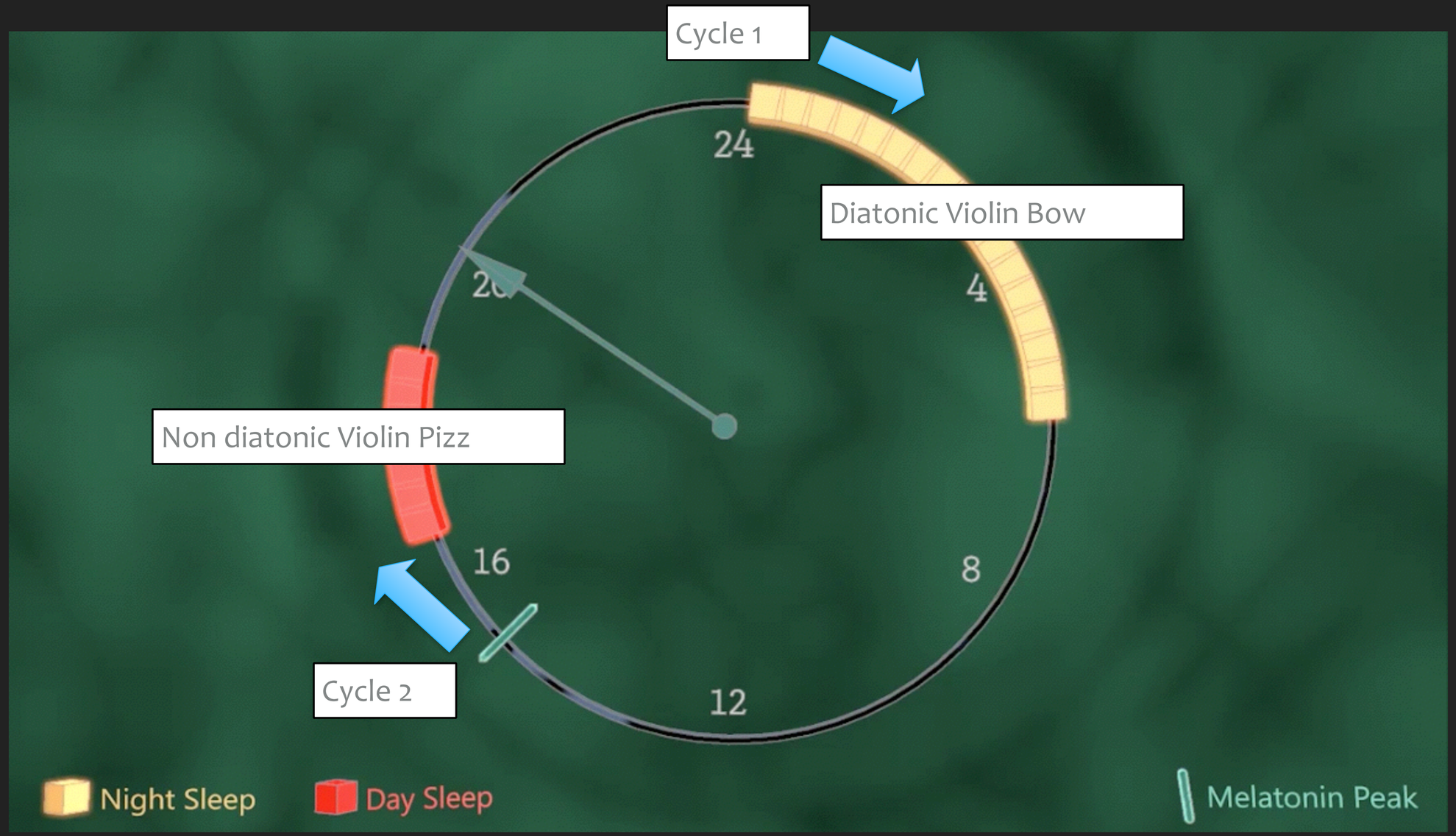
Lockley et al., 1997

MUSICAL ANALOGIES

24-Beat Cycle (Shona Mbira)

Displacement/Phase (West Africa, Steve Reich)

Diatonic/non-diatonic to represent comfort


Cycle 1
24
Diatonic Violin Bow
4
Non diatonic Violin Pizz
16
8
Cycle 2
12
Night Sleep
Day Sleep
Melatonin Peak

VIDEO EXAMPLES

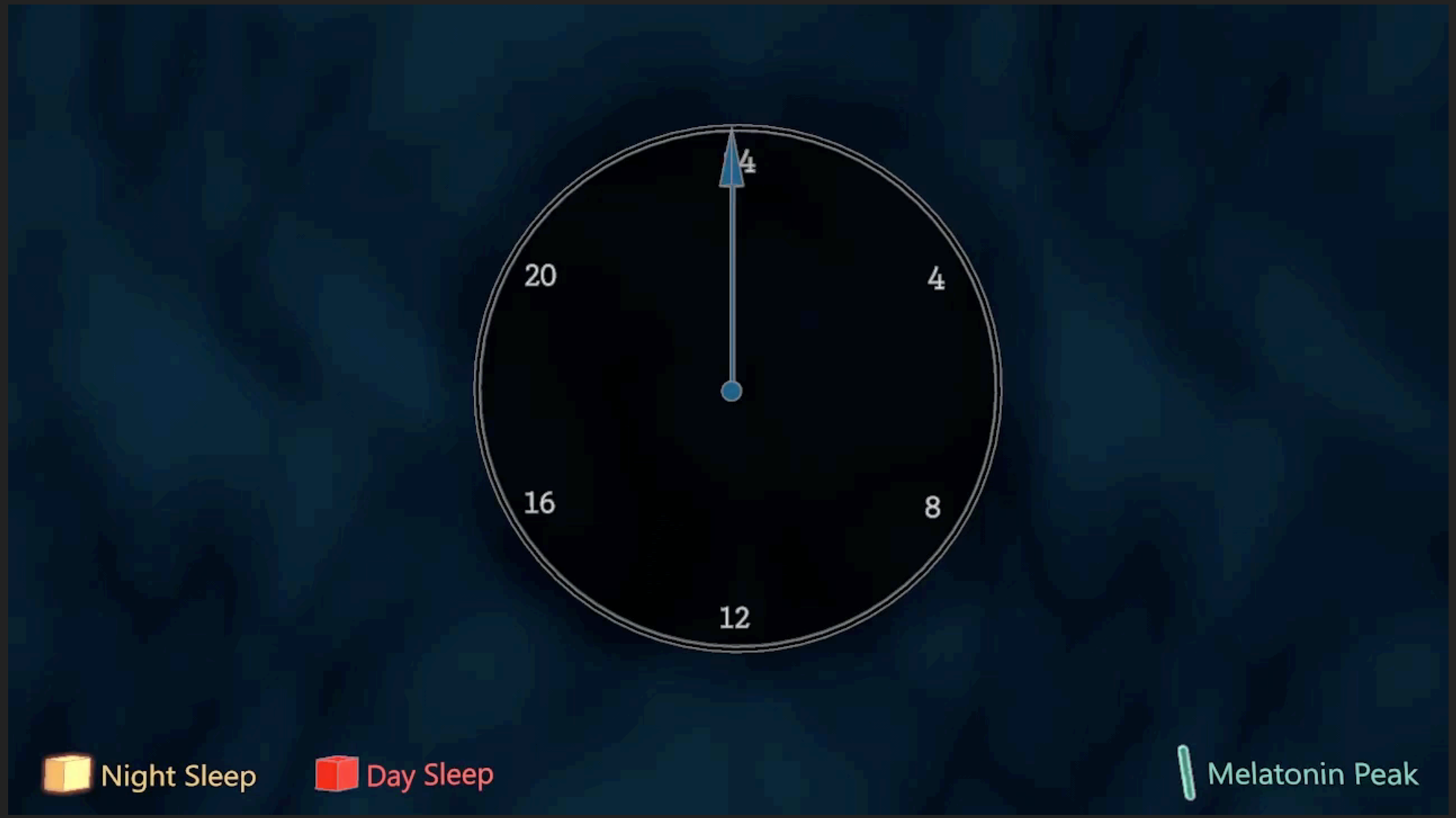
ENTRAINED SLEEP

S12

S12

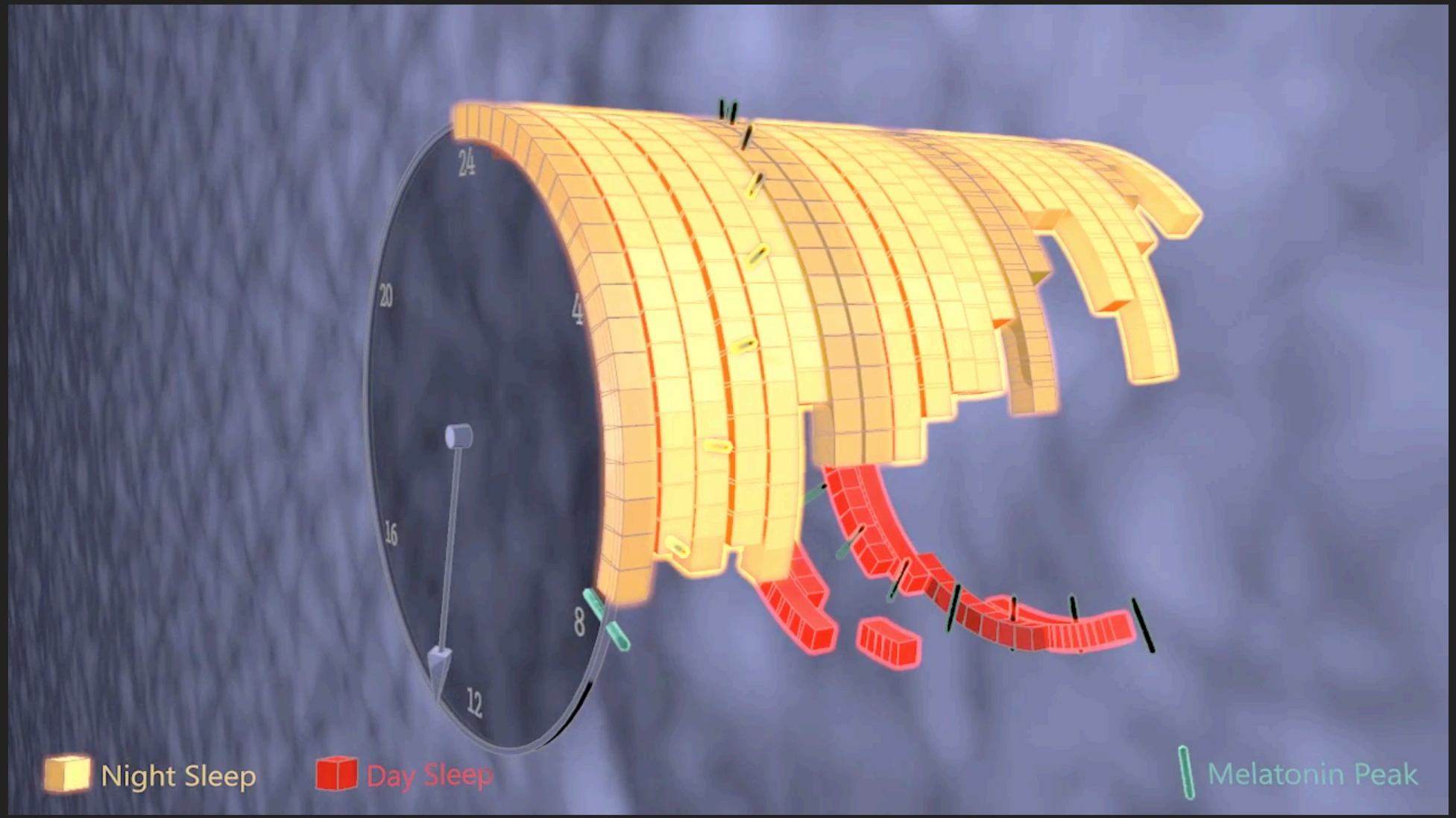
NON 24 H SLEEP/WAKE DISORDER

S20



S20

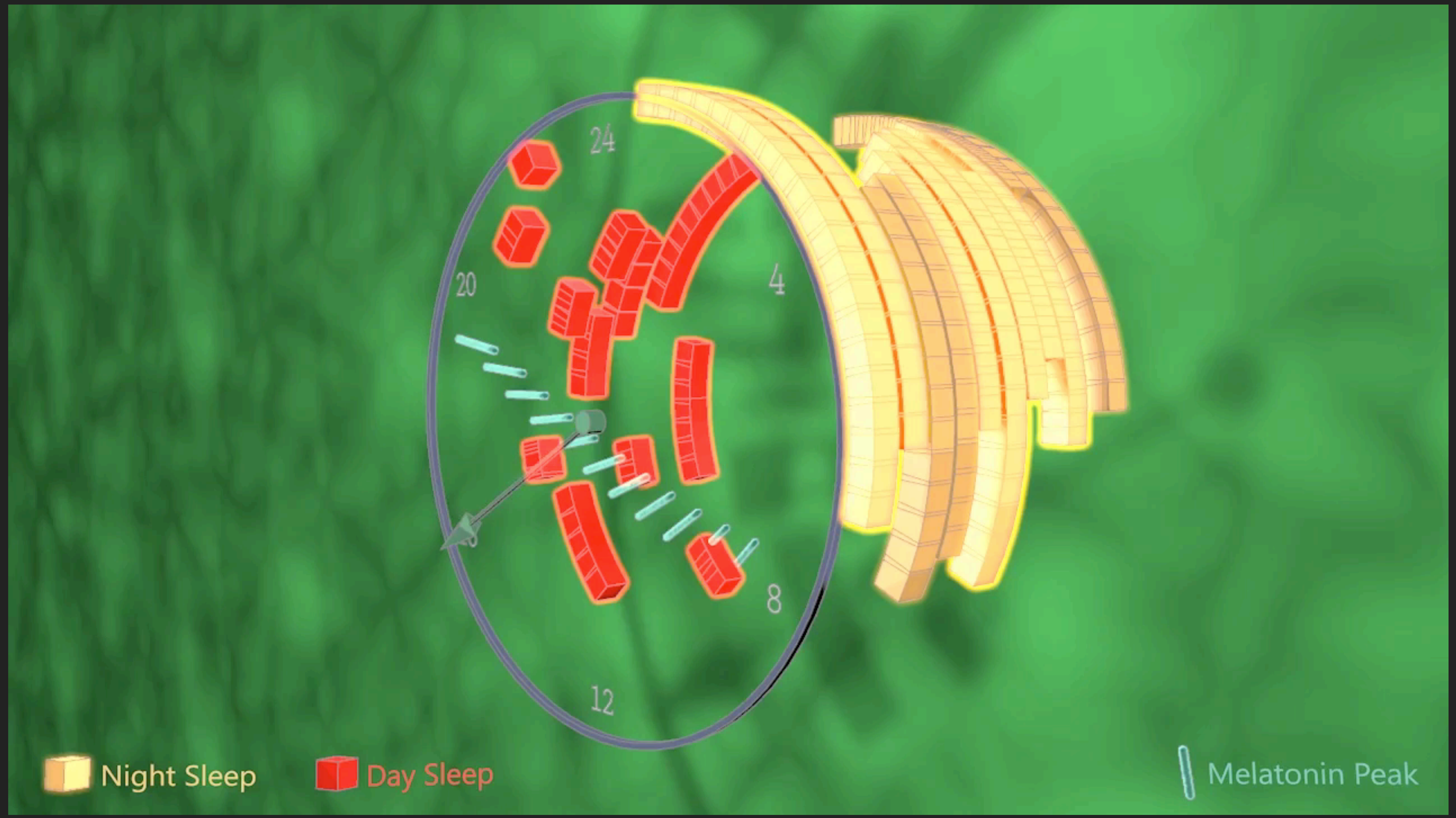
S20



NON 24 H SLEEP/WAKE DISORDER

S23

S23



DATA MAPPING

Diatonic Mapping

‘Good Sleep’ Rising Lydian Mode

‘Bad Sleep’ Minor Key Bleeps

Clock Time Electric piano 24/16

DATA MAPPING

Rhythmic Sensitivity Mapping

Kick Drum on Noon

Snare on Sleep

Cowbell on Napping

DATA MAPPING

Rhythmic Sensitivity Mapping

Kick Drum on Noon

Snare on Sleep

Cowbell on Napping

EXAMPLE 1: FAIRLY GOOD DRUMMER

DATA MAPPING

Rhythmic Sensitivity Mapping

Kick Drum on Noon

Snare on Sleep

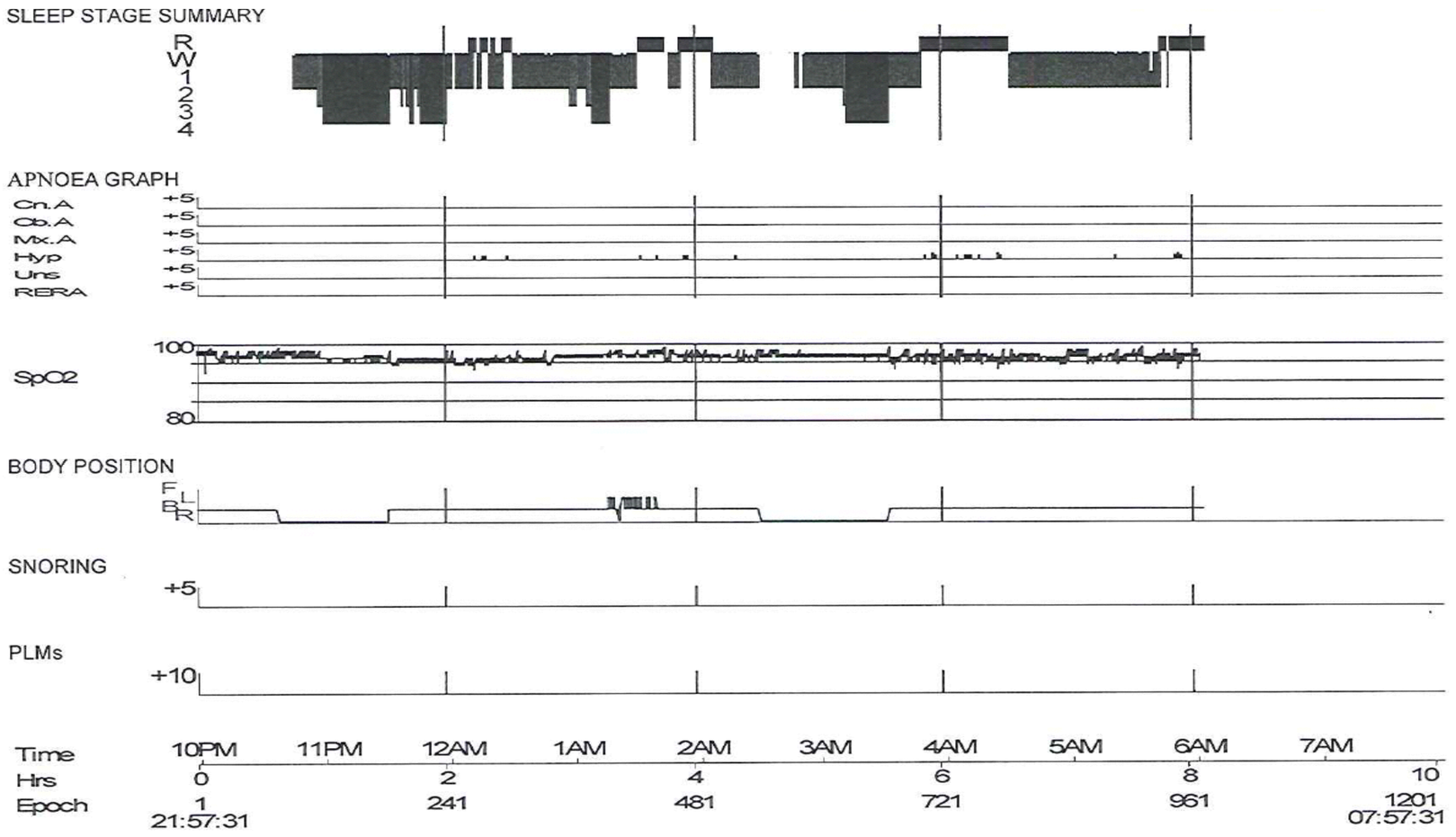
Cowbell on Napping

EXAMPLE 2: TERRIBLE DRUMMER

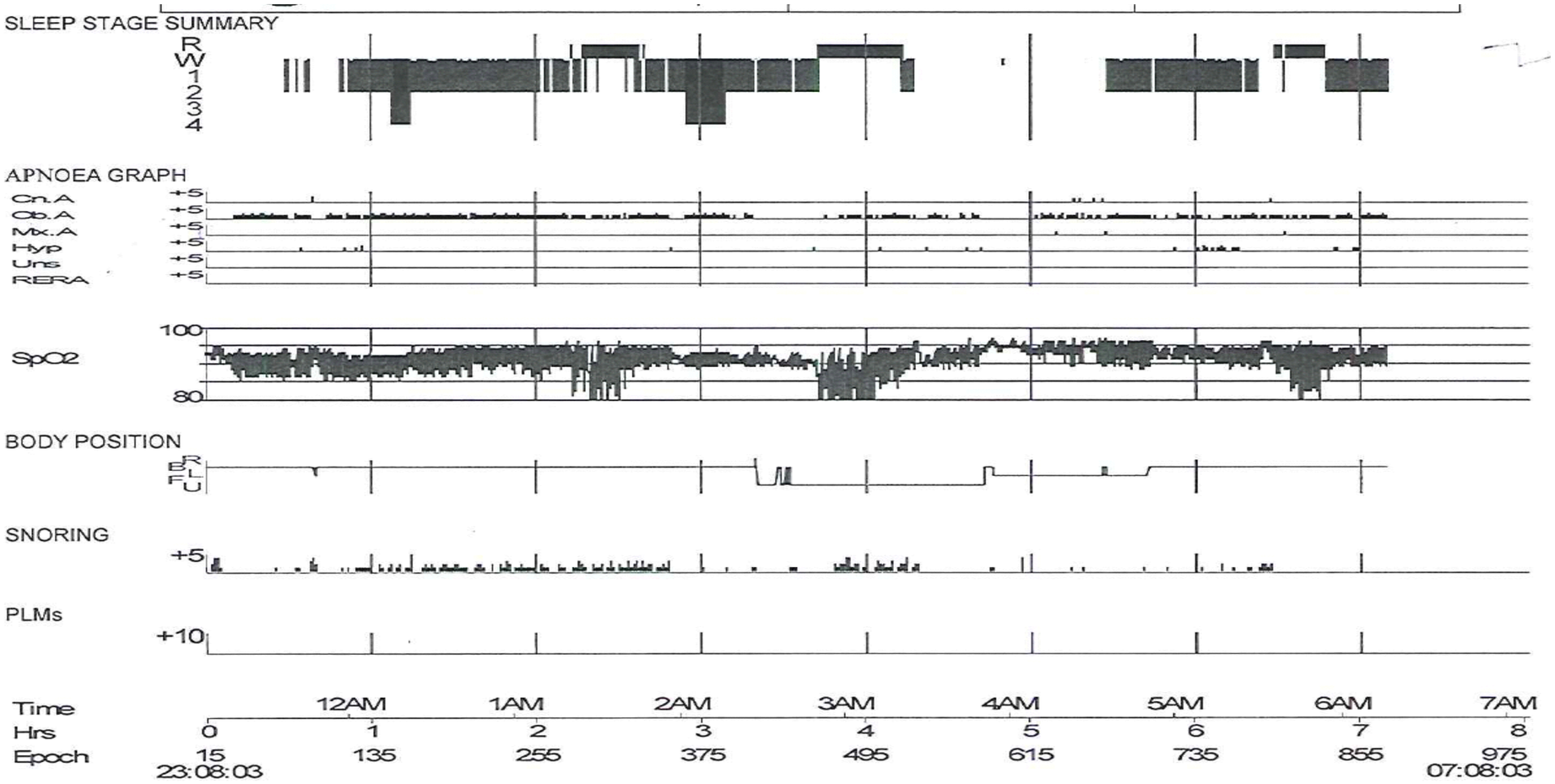
PSG NOCTURNE: CONVERTING PSG DATA INTO MULTI-LAYERED COMPOSITIONS.

Renata L Riha (University of Edinburgh)

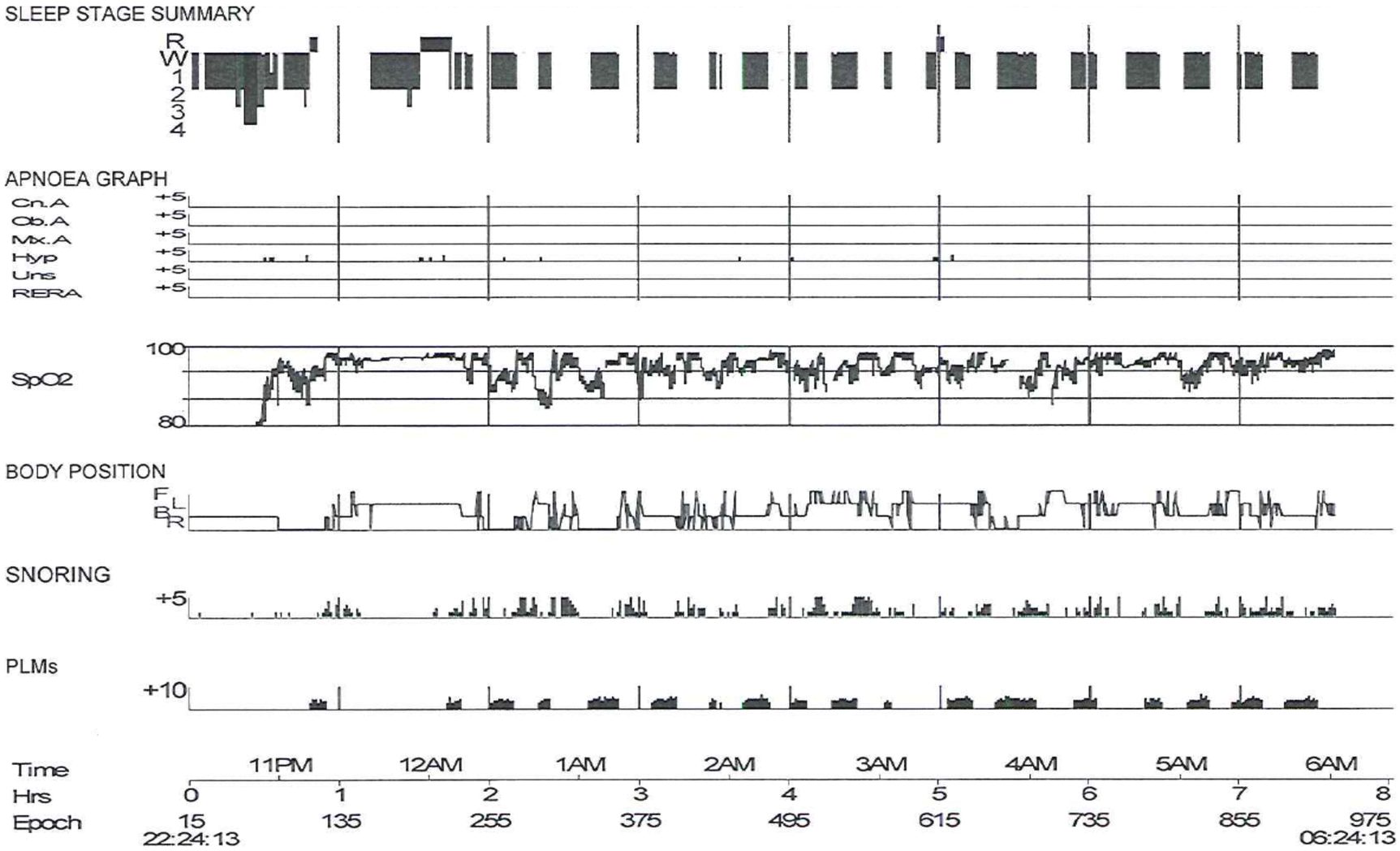
NORMAL PSG


SLEEP STAGE SUMMARY
R
W
1
2
3
4
APNOEA GRAPH
Cn.A
Ob.A
Mx.A
Hyp
Uns
RERA
+5
SpO2
100
80
BODY POSITION
F
L
R
SNORING
+5
PLMs
+10
Time
Hrs
Epoch
10PM
11PM
12AM
1AM
2AM
3AM
4AM
5AM
6AM
7AM
0
2
4
6
8
10
1
241
481
721
961
1201
21:57:31
07:57:31

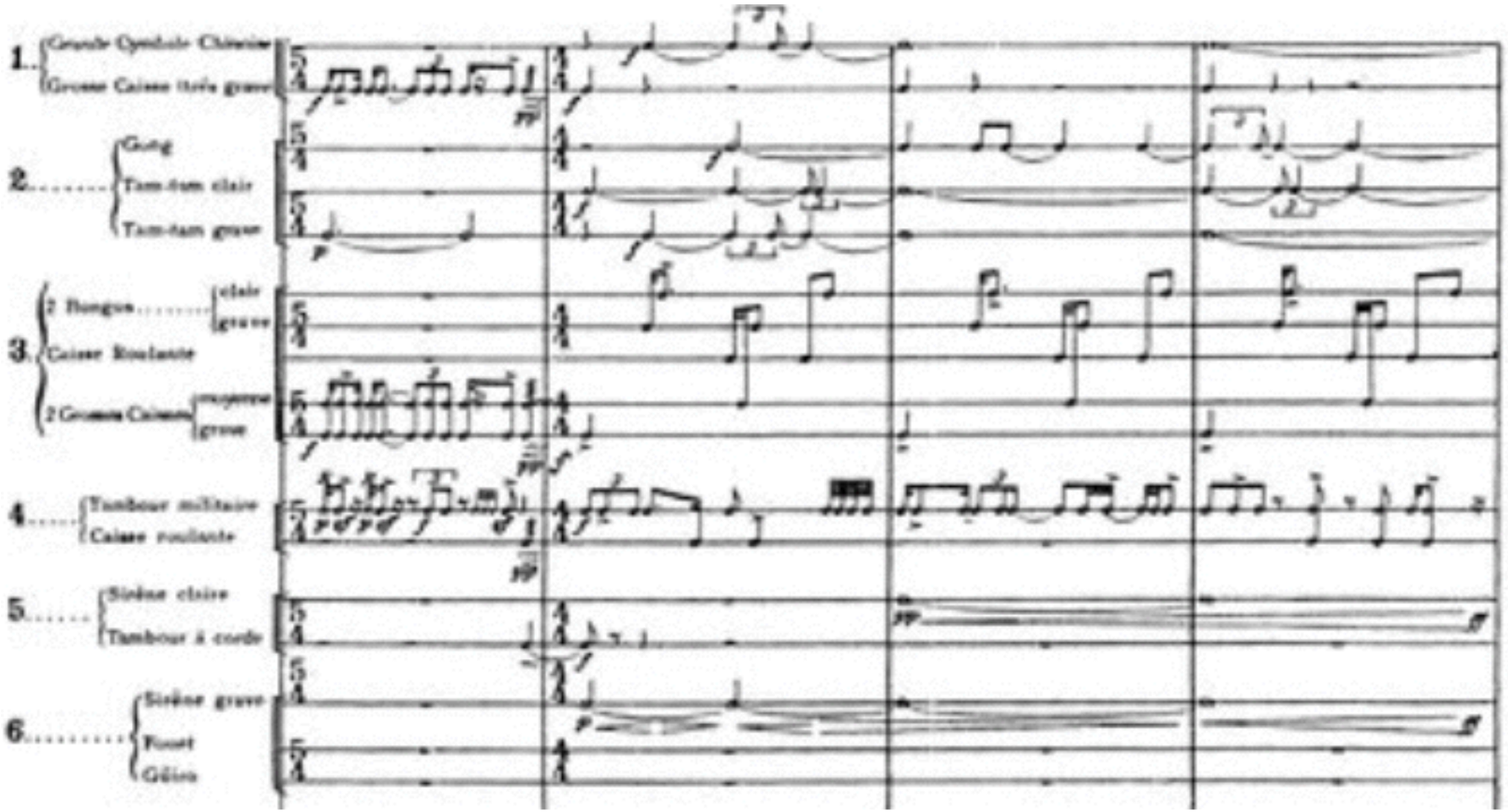
SEVERE SLEEP APNOEA



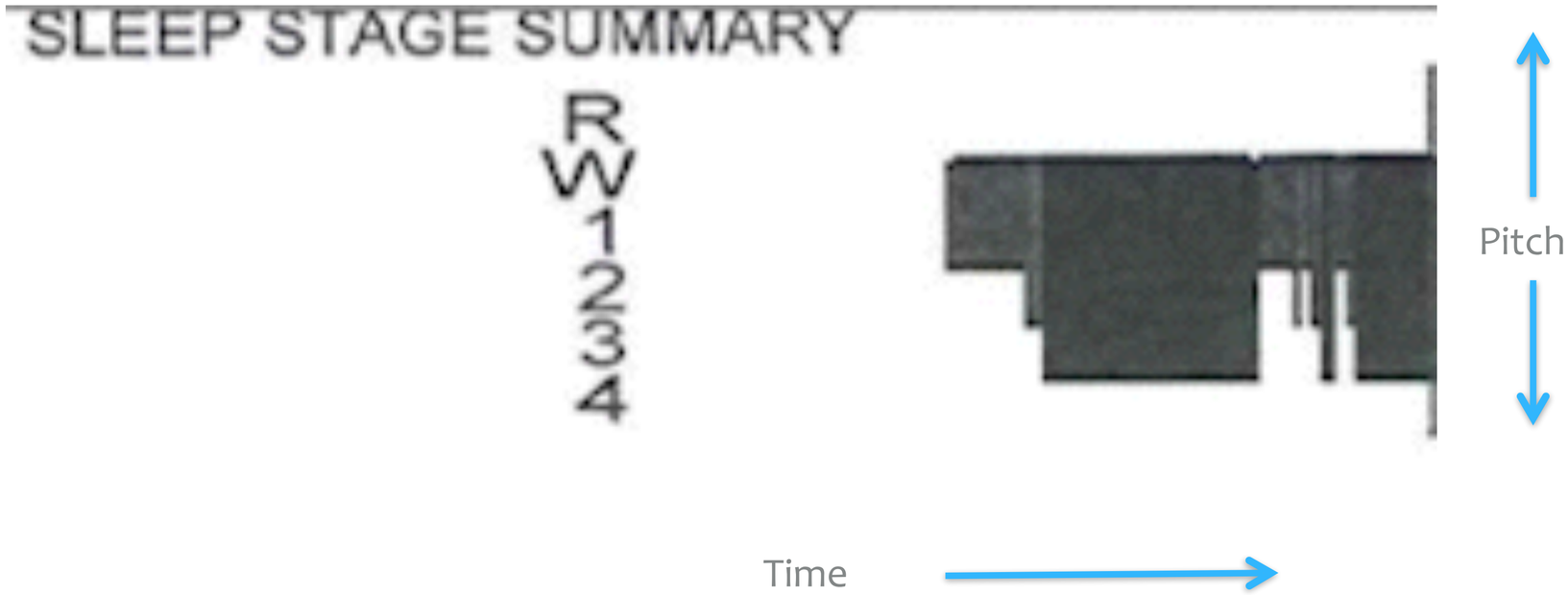
RESTLESS LEG SYNDROME



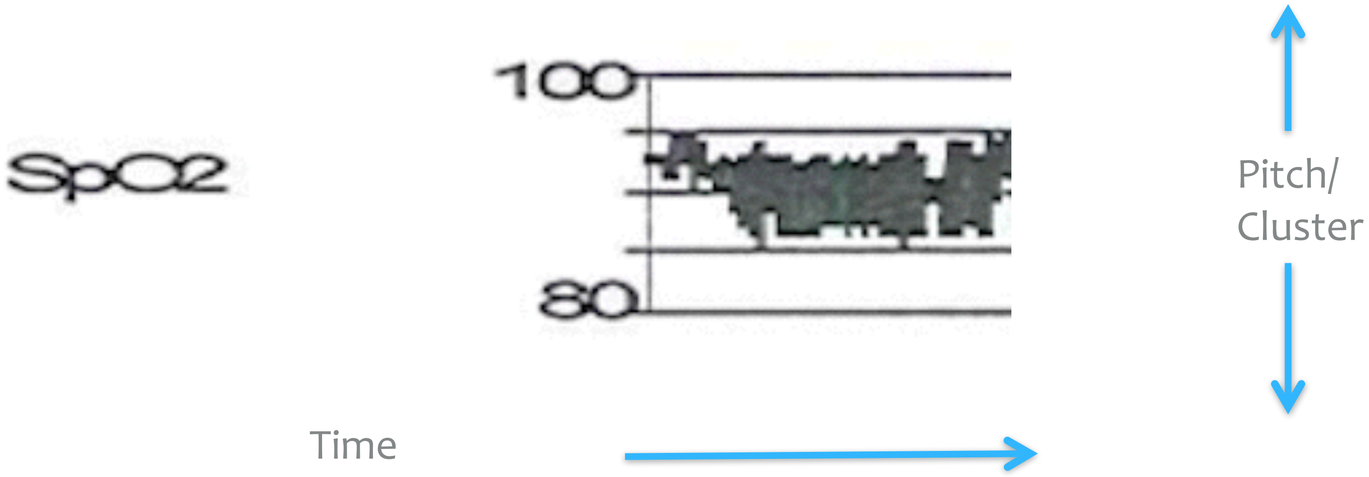
PSG AS SCORE


1.
Grande Cymbale Chinoise
Grosse Caisse très grave
2.
Gong
Tam-tam clair
Tam-tam grave
3.
2 Bongos
clair
grave
Caisse Roulante
2 Grosses Caisses
moyenne
grave
4.
Tambour militaire
Caisse roulante
5.
Sirène claire
Tambour à corde
6.
Sirène grave
Fouet
Gélos

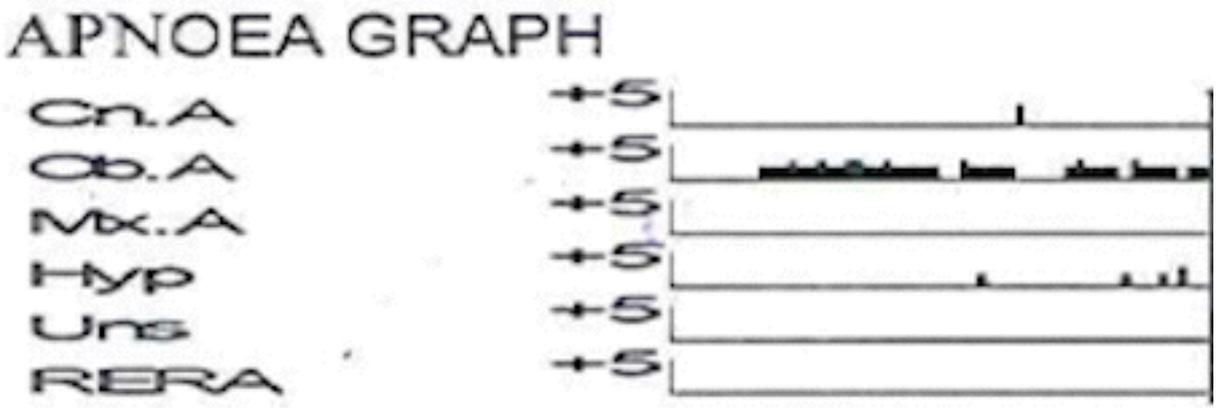
SLEEP FLUTE MELODY



SPO2 TEXTURE/HARMONY



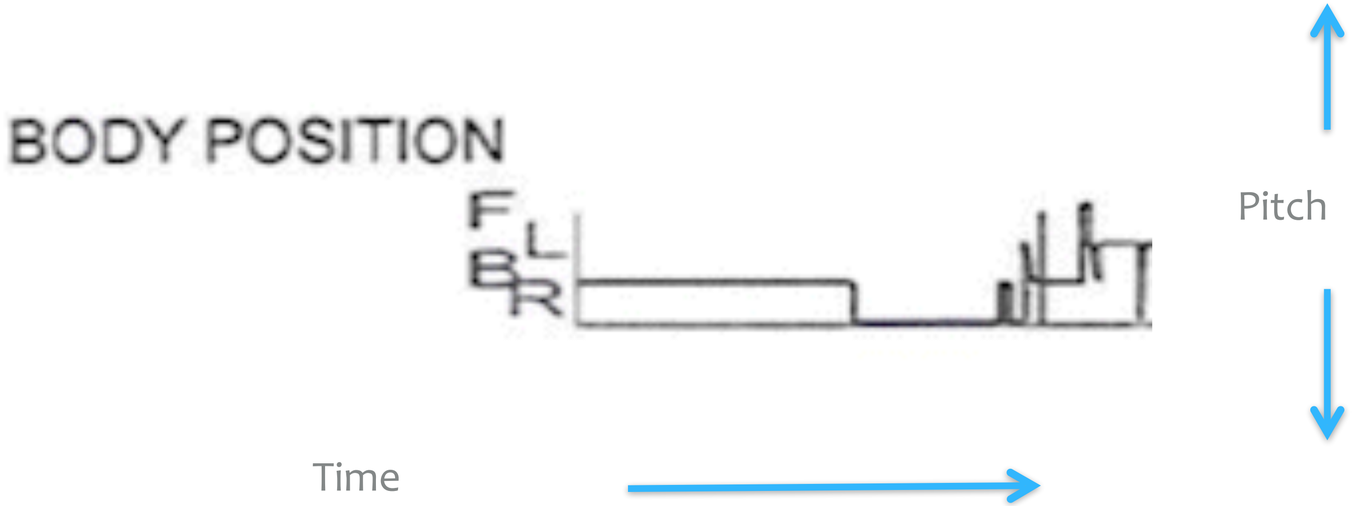
APNOEA PERCUSSION/PIZZICATO



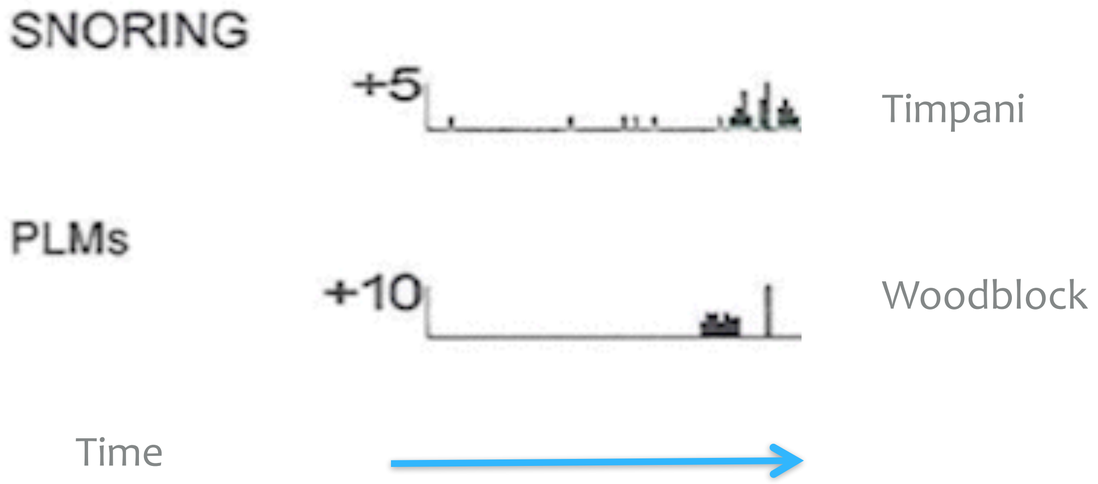
Instrumentation

Time

BODY POSITION BASS-LINE



SNORING AND PLM TIMPANI/WOODBLOCK



NORMAL SLEEP

S9

APNOEA

S11

RESTLESS LEG SYNDROME

S21

THE INNER SOUND OF SLEEP

TRANSLATING EEG DATA TO THE AUDIO SPECTRUM

Vladyslav Vyazovskiy (University of Oxford)

Milton Mermikides (University of Surrey)

WAVES

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

FROM EEG TO AUDIO SPECTRUM

Scaling through Law of Octave Equivalence

Wave	Frequency	Approx. pitch range(4 8ve up)
Gamma	32-100Hz	C2-G3
Beta	14-60Hz	A0-B2
Alpha	8-12Hz 30-50Hz	Eb0-Eb2
Theta	4-8Hz	C-1-C-2
Delta	0.5-3Hz	C-4 G-2

FROM EEG TO AUDIO SPECTRUM

Gamma, Beta and Theta Waves 4 octaves up

You’ll hear the bottom, top and middle of each range in turn, then all together

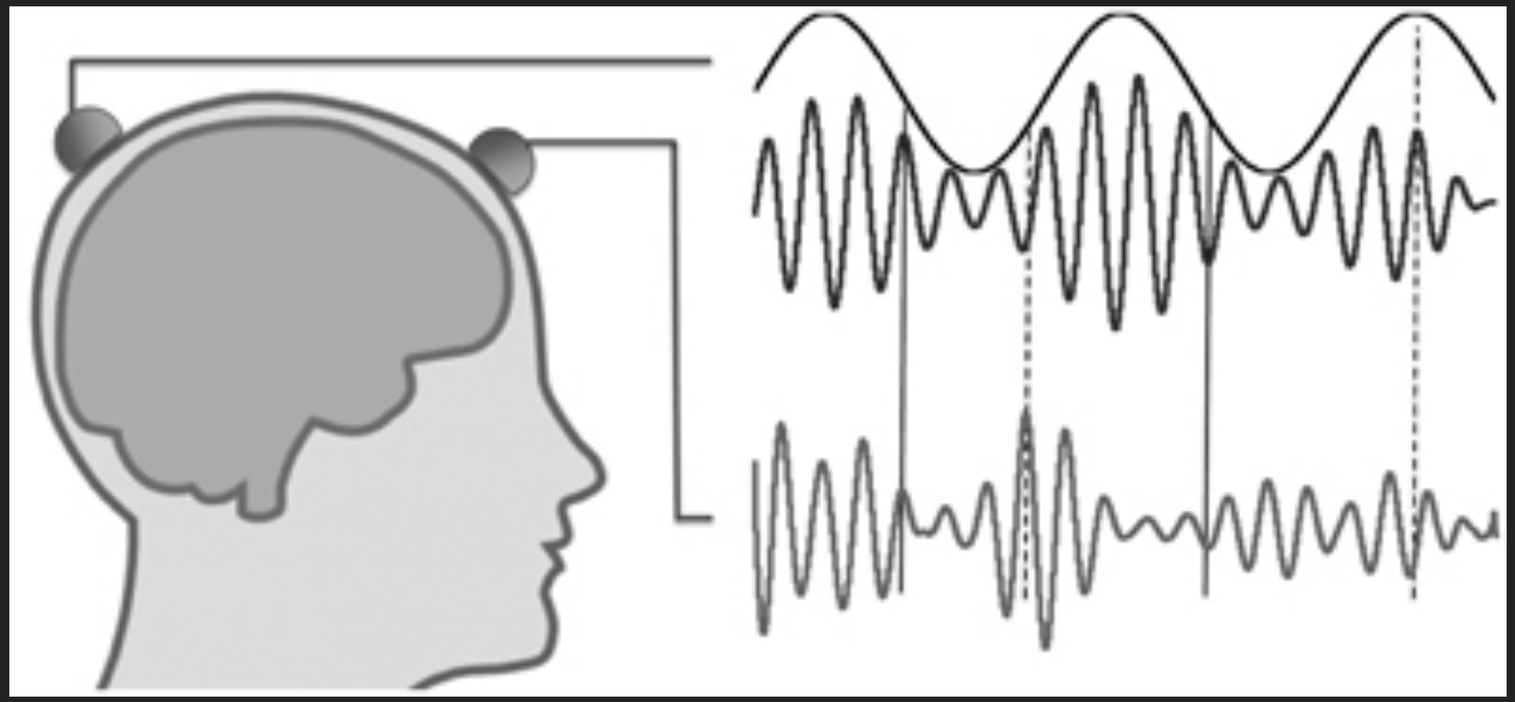
RELATIVE AMPLITUDES

Timbral change through differential amplitudes
in various sleep stages

RELATIVE AMPLITUDES

AUDIO EXAMPLE OF SLEEP
TRANSITION CHORD

PHASE FREQUENCY COUPLING



Monto 2012

LFO — HEARING WAVES WITHOUT SCALING

Musical parameters can be altered in the 0-20Hz range allowing these otherwise inaudible frequencies to be experienced.

LFO — HEARING WAVES WITHOUT SCALING

Held chord with volume altered by wave dropping from Beta to Delta range

SPATIALISATION

Data from neural locations can be spatialised in the audio spectrum, potentially revealing any features of synchronicity.

DISCRETE VS. CONTINUOUS

All this data so far is continuous.

However music perception usually relies on a combination of continuous and discrete events. One can glean discrete events from this data through:

- Selecting/filtering prominent frequencies
- Amplitude triggers/thresholds/gating of frequency bands

AUDIO EXPERIMENT

Amplitude data from one night's sleep.

6 locations:

C3_A2	C4_A1
F3_A2	F4_A1
O1_A2	O2_A1

Beta, Delta, Gamma, ThetaAlpha sampled ever 4 seconds. 15 seconds from various sleep stages were sonified using scaling, amplitude triggers, LFO and spatialisation techniques.

THANKS TO

Sound Asleep Team (Debra, Vlad, Anna, Yurubi, Paul, Renata, Nanyi)
University of Surrey X-Faculty Award
The Royal Society
British Sleep Society

MILTONLINE.COM

SOUNDASLEEP.EU

Milton

Mermikides

miltonline@me.com