SOUND ASLEEP THE HIDDEN MUSIC OF SLEEP PATTERNS

Milton

Mermikides

BRITISH SLEEP SOCIETY 2015

SOME BACKGROUND



Milton

Mermikides

BOUND ASLEP



HISTORY OF COMPOSITIONAL DELEGATION

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Mozart's Dice Game (1787)

10000

HISTORY OF COMPOSITIONAL DELEGATION





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

MUSICAL CRYPTOGRAMS



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."

DAT MAD THILL! Silve fige 1 do Dor Majar D loka larafte more. ANA.

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 = AB = BbC = C $\mathsf{D} = \mathsf{D}$ E = EF = FG = GH = BM = E

L = AR(e) = DS (Es) = EbT(i) = BAs = Ab

Ignore the rest

French System

Α	B (or Bb)	С	D	Ε	F	G	
H (or B)		J	K	L	Μ	N	
Ο	Ρ	Q	R	S	Т	U	
V	W	Х	Y	Z			



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

Dimitri Schostakovich

BRITISH SLEEP SOCIETY

BRITISH SLEEP SOCIETY



BRITISH SLEEP SOCIETY (Hollywood Theme)



BRITISH SLEEP SOCIETY





BRITISH SLEEP SOCIETY

(Modernist Interpretation)



EXTENDING THE CONCEPT





Villa-Lobos (1887-1959)



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



New York Skyline Melody (1939)



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 selfsufficing and existing in nature [...] what would happen? ...

Ur-Geräusch (Rilke 1919)



Image ©2004 Palmer



Image ©2005 Supranowitz



BloodLines (2004, 2013)

DATE	WBC	RBC	HB	HCT	MCV	MCH	MCHC	RDW	Platelets	Neutroph	Lymphocy	Monocy	Eosinop	Basoph
22/11/04	340.0	5.74	10.0	0.343	59.7	17.4	29.1	17.0	31			5		
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	10.1	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	21.2.0	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.B	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	9.3	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	057 10	1,6	3.6	0.1	0.0	0.0
02/12/04	5.2	4.40	9,0	0.200	-63,6	22,4	35.2	20.7	43	2.1	2.0	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	p=\$ 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	12411	3512	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	22,0	220	2.7	2.1	0.0	10.0	0.0
07/12/04	3.0	3.44	8.3	0.247	71.7	24.0	\$3.5	23.0	240	1.1	1.9	0,0	1 V 10.0	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	A 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	Q.0	1 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	A 28.9	22.9	0 0 299	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	CU/82.5	1.123.0	STORIA	LL 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	a/a
17/12/04	5.0	4.24	10.5	0.318	75,1	24.9	33,1	5310	296	3,2	1.5	0.2	0.0	0.0
18/12/04	4.3	4.40	10,9	0.329	74,9	24.0					2.2	0 + 0,3	ot d.o	0.0
19/12/04	2.1	3.86	9.8	0.288	74.7	20,0	34.2	24.1	2.2.1	0.6	11.4	40001	0000.0	0.0
20/12/04	2.0	3.65	9.0	0.275	75,3	29.7	32,7	22.7	210	/ %	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	2.7	0.0	0-0	0.0
22/12/04	3.4	3.94	9.8	0.294	74.6	24.8	83.3	22.9	281	1.4	~1.9	0.1	0.0	0.0
23/12/04	2.9	3.55	9,1	0.266	Kar	25.5	34.0	22,9	225					
24/12/04	3.7	4.20	10.3	0.308	73.4	24.5	1 33.4	23.4	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	1.0	2.0	0.2	0.0	0.0
25/12/04	3.2	4.02	9.9	0.302	75,2	24.8	N 22.9	28.7	282	2.0	1,1	0.1	0.0	0.0
26/12/04	2.5	3.78	9.5	0.206	75.6	25.8	1 33/3	(X2.p	190	V 12.9	0.6	0.0	0.0	0.0
27/12/04	1.8	3.83	9.6	0.292	1 76.1	25.0	32.9	22.3	145	2,4	0.4	0.0	0.0	0.0
28/12/04	0.8	3.47	8.7	0.263	75.9	Do	AD.	101	Dd da	110 0.5	0.3	0.0	0.0	0.0
30/12/04	0.7	3.17	8.1	0.255	80.5	NE	U D	100	JUUE	115 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	83.9	18.9	SI OC	0.0	0.3	0.0	0.0	0.0
01/01/05	0.3	3.45	9,0	0.279	81.1	25.2	32.3	19,2	32	0.0	0.3	0.0	0.0	0.0
01/01/05	0.3	3.52	9.5	0.284	78.6	25.3	33.5	19.0	25	0.0	0.3	0.0	0.0	0.0

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)





(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 8 Guinea



GEOMETRICAL/ MUSIC THEORETICAL



(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







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





MAKING SLEEP VISIBLE TO THE BLIND

Debra J. Skene (University of Surrey)

Milton Mermikides (University of Surrey)



Non 24 h sleep/wake disorder Abnormal circadian phase – poor sleep – daytime napping





Abnormal circadian phase – poor sleep– daytime napping

MUSICAL ANALOGIES

24-Beat Cycle (Shona Mbira) Displacement/Phase (West Africa, Steve Reich) Diatonic/non-diatonic to represent comfort





ENTRAINED SLEEP







NON 24 H SLEEP/WAKE DISORDER







NON 24 H SLEEP/WAKE DISORDER





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 RSTNOA



APNOEA GRAPH

n A	+5	1	1	 	
	+5				
	+5				
-	+5			 	
iyp Inc	+5				
	+5				





Time	10PM	11PM	12AM	1AM	2AM	3AM	4AM	5AM	6AM	7AM
Hrs	6		2		4		6		8	10
Epoch	1 21:57:31		241		481		721		961	1201 07:57:31

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SEVERE SLEEP APNOEA



RESTLESS LEG SYNDROME



Cn.A	+5			
Ob.A	+5			
Mx.A	+5			
Hyp	+5	1.00		
Uns	+5			
RERA	+5			









PLMs



Time		11PM	12AM	1AM
Hrs	Ó	1	2	
Epoch	15 22:24:13	135	255	3



PSG AS SCORE





SLEEP FLUTE MELODY

SLEEP STAGE SUMMARY





SP02 TEXTURE/HARMONY







APNOEA PERCUSSION/PIZZICATO

APNOEA GRAPH Cn.A OD.A MX.A Hyp Uns RER



BODY POSITION BASS-LINE

BODY POSITION





SNORING AND PLM TIMPANI/WOODBLOCK

SNORING

PLMs











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)

32-100Hz Gamma

14-60Hz Beta

Alpha 8-12Hz to 30-50Hz

Theta 4-8Hz

0.5-3Hz Delta

FROM EEG TO AUDIO SPECTRUM Scaling through Law of Octave Equivalence

Wave	Frequency
Gamma	32-100Hz
Beta	14-60Hz
Alpha	8-12Hz 30-50Hz
Theta	4-8Hz
Delta 0.5	5-3Hz

Approx. pitch range(4 8ve up)

C2-G3

A0-B2

Eb0-Eb2

C-1-C-2

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
- bands

Amplitude triggers/thresholds/gating of frequency



Amplitude data from one night's sleep.

6 locations: C3_A2 C4_A1 F3_A2 F4_A1 O2_A1 O1_A2

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

AUDIO EXPERIMENT

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



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