The Sonification of Humans, Their Features and Their Probability of Having a Heart Attack in the Next Ten Years

According to the Framingham Heart Study (Hard Coronary Heart Disease)

Algorithmic Composition

Written Report

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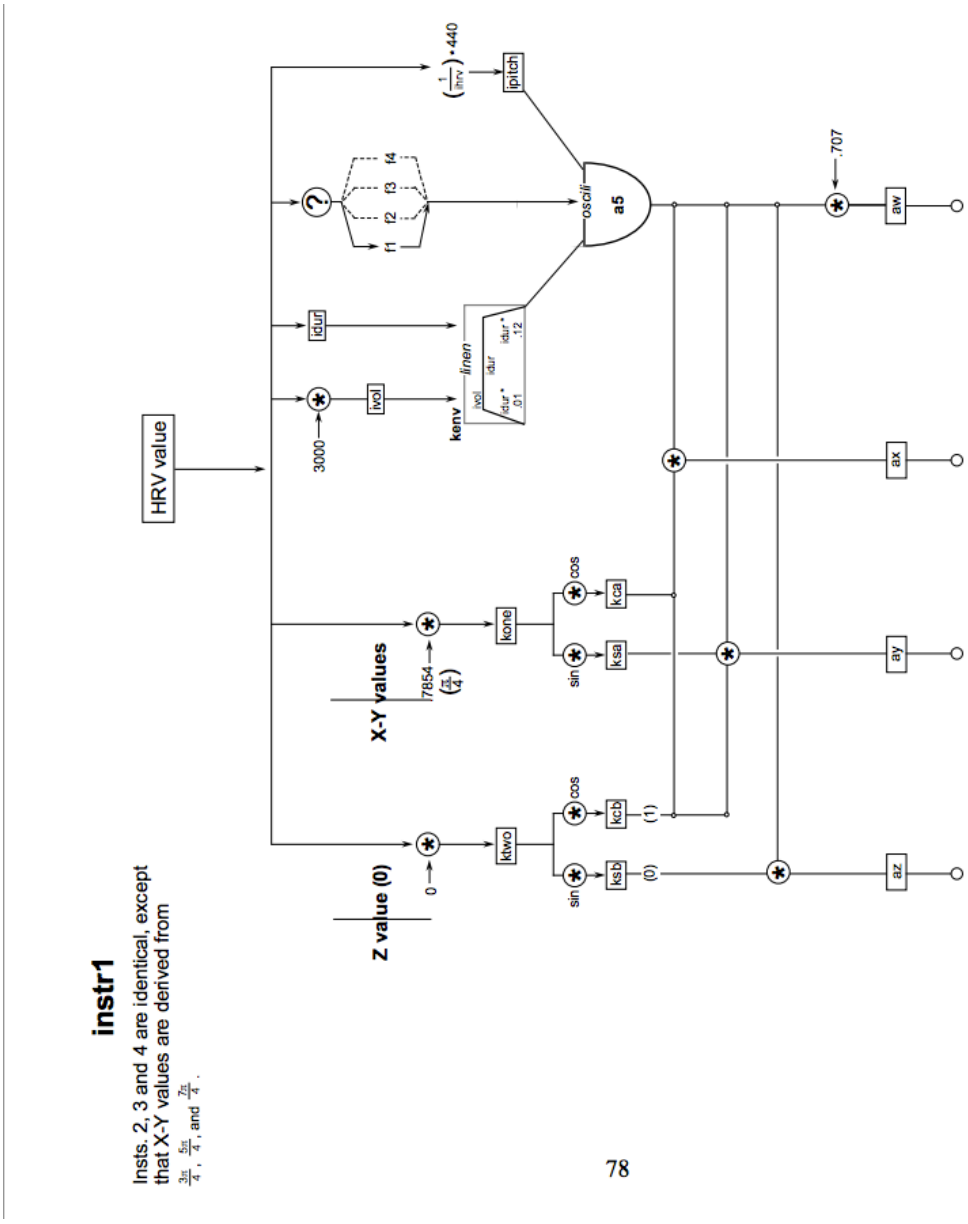
1.0 Composition Overview:

This original algorithmic composition is a structured sonification of humans and their features based upon the specifications within the 'Hard Coronary Heart Disease (10-year Risk)' from the Framingham Heart Study (1), which calculates the risk of a human being (male or female) experiencing a heart attack in the next ten years. The premise of the piece was to control created sound synthesis and effects units according to a human's features e.g. a smoker emits a minor sequence of chords or notes whereas a non-smoker emits a major sequence. Thus enabling the listener to recognize the information associated with these sounds and work out the features of a particular instance of a human such as age, gender, smoker status, total cholesterol level etc.

The concept was inspired by Mark Ballora's insightful TEDx talk, which focused on presenting data through audible means (sonifying information) for the visually impaired (2). Ballora outlines the argument that sound can in some cases be a better tool to comprehend information (as opposed to visually digesting it) and realizations about biological systems, weather patterns or celestial bodies can be made through the humans ability to accurately recognize patterns audible. After deeper research upon the phenomenon of sonification I found Ballora himself had created a utility for physicians to analyze heart rate variability through auditory displays. 'Data Analysis through Auditory Display' (3) is clinically refined in terms of its synthesis creation (fig 1.1), and I feel humbled that my approach has shared similar aesthetics without prior knowledge of this project to creating my own composition (detailed within 'execution of concept' below).

Where Ballora created an auditory tool, I aimed to conceive a sonified algorithmic piece of music. Thus the challenge arose of how to transform static defined information, to control synthesis and present it over time as part of a specific structure or musical form. The learning outcomes set was to understand, evaluate and test the application for sound as a tool for communicating information by manipulating its own paradigms such as rhythm and harmony to convey data that reaches beyond intrinsic musical values.

I found this area of musical composition particularly stimulating because information is always changing across the world, constantly moving and is never still. The applications to use sound as way of representing these changes is a stimulating subject as it allows for simultaneous arrays of information provide an alternative and sometimes superior display of data and demonstrates the potential for algorithmic composition. "Data and their context provide extra-musical 'content' for experimental music and sound-related art projects"(4).



(Fig 1.1 Instrument 1:

Ballora's synthesis defined by HRV (heart rate variability) (5))

(The SynthDefs created within my SuperCollider code echo this formula

as human features instead of HRV determine the pitch, oscillators type, attack etc. of the synth)

Execution of concept:

The most effective way to create new instances of a 'human' was to use classes with getter and setter methods to allow the user to alter features e.g. increase age, change smoker status etc. The ability to be able to keep the human class flexible was paramount to the success of the composition as this inclusion of methods allows for information to be altered over a periods of time (and enables the Elektrokardiogram sound to signal death of a huma). The sonification strategy employed was 'Discrete point data representation' (6) as we are mapping several dimensions of data to parameters of sound events.

The sound design draws parallels from Bollora's inst1 (fig1.1) whereby all sounds were synthesized as opposed to sample based. Sound synthesis and effects were chosen according to the initial idea of basing the piece within the EDM genre. Therefore FM synths and drum machine emulations are used, with deep flexibility in order to successfully represent different human instances.

In order to illustrate how each human is represented, a key is necessary as a reference to explain which features are conveyed by which sounds. See my interpretation of the Framingham's data tables as a musical key (fig 2.1). The user's initial listening period will begin by studying the key and listening simultaneously, in order to process and store the sonification of specific data in their memory. After this period one can run the piece without having to look at the key and realize from the sounds heard, all the features of the human instance(s).

Structure of Composition: (Four Main Sections)

To organize the sonified humans, and to demonstrate their features and risk of heart attack, I chose to keep to a simple, effective structure:

A. The birth of humans. Firstly half the total amount is heard, consecutively one human after the other, to slowly build their patterns up over time. This allows the listener time to clearly distinguish between different instances of humans and denote their individual qualities based upon the provided musical key. Next the second batch of humans follows the same pattern.

B. Heart Risk Calculated. Using my calculation based upon the Framingham's heart study point system, the tempo of the human sounds are determined by their likelihood of having a heart attack in the next 10 years. The higher the risk the faster the tempo controlling their patterns.

A1. Increase age and randomize every feature (except gender) for each human, then run the intro and calculation parts again. This will change the original sounds for each human and those who become too old (80>) die off. Once either all humans have died off or the last one's pattern ends the piece finishes.

Hard Coronary Heart Disease (10-Year Risk) Data Key:

Estimate of 10-Year Risk for Men

Framingham Point Scores	
Age	Points
20 – 34	– 9
35 – 39	– 4
40 – 44	0
45 – 49	3
50 – 54	6
55 – 59	8
60 – 64	10
65 – 69	11
70 – 74	12
75 – 79	13

	point by age				
Total Cholesterol	20 – 39	40 – 49	50 – 59	60 – 69	70 – 79
< 160	0	0	0	0	0
160 – 199	4	3	2	1	0
200 – 239	7	5	3	1	0
240 – 279	9	6	4	2	1
≥ 280	11	8	5	3	1
Nonsmoker	0	0	0	0	0
Smoker	8	5	3	1	1

HDL (mg/dL)	Points
≥ 60	– 1
50 – 59	0
40 – 49	1
< 40	2

Systolic BP (mmHg)	if untreated	if treated
< 120	0	0
120 – 129	0	1
130 – 139	1	2
140 – 159	1	2
≥ 160	2	3

Point Total	10-year risk
< 0	< 1
0	1
1	1
2	1
3	1
4	1
5	2
6	2
7	3
8	4
9	5
10	6
11	8
12	10
13	12
14	16
15	20
16	25
≥ 17	≥ 30

Hard Coronary Heart Disease (10-Year Risk) Data Key:

Estimate of 10-Year Risk for Women

Framingham Point Scores	
Age	Points
20 – 34	– 7
35 – 39	– 3
40 – 44	0
45 – 49	3
50 – 54	6
55 – 59	8
60 – 64	10
65 – 69	12
70 – 74	14
75 – 79	16

point by age					
Total Cholesterol	20 – 39	40 – 49	50 – 59	60 – 69	70 – 79
< 160	0	0	0	0	0
160 – 199	4	3	2	1	1
200 – 239	8	6	4	2	1
240 – 279	11	8	5	3	2
≥ 280	13	10	7	4	2
Nonsmoker	0	0	0	0	0
Smoker	9	7	4	2	1

HDL (mg/dL)	Points
≥ 60	– 1
50 – 59	0
40 – 49	1
< 40	2

Systolic BP (mmHg)	if untreated	if treated
< 120	0	0
120 – 129	1	3
130 – 139	2	4
140 – 159	3	5
≥ 160	4	6

Point Total	10-year risk
< 9	< 1
9	1
10	1
11	1
12	1
13	2
14	2
15	3
16	4
17	5
18	6
19	8
20	11
21	14
22	17
23	22
24	27
≥ 25	≥ 30

Hard Coronary Heart Disease (10-Year Risk) Musical Key:

Male:

Age	Synth Select (& Attack)
20 – 34	Kick (fast attack)
35 – 39	Kick (slow attack)
40 – 44	Cowbell (fast attack)
45 – 49	Cowbell (slow attack)
50 – 54	Snare (fast attack)
55 – 59	Snare (slow attack)
60 – 64	Tom (fast attack)
65 – 69	Tom (slow attack)
70 – 74	Hihat1 or hihat2 (fast attack)
75 – 79	Hihat1 or hihat2 (slow attack)

HDL (mg/dL)	Rhythm
≥ 60	All Straight
50 – 59	Mix of Straight & off Beat/Syncopatio
40 – 49	All off Beat/Syncopated
< 40	Triplet

Total Cholesterol	Delay Time
< 160	0
160 – 199	0.2
200 – 239	0.4
240 – 279	0.6
≥ 280	0.8
Nonsmoker	Distortion
Smoker	No Distortion

Systolic BP (mmHg)	Hits Per Bar	Treated	UnTreated
< 120	3 or less	Reverb	No Reverb
120 – 129	4	" "	" "
130 – 139	7	" "	" "
140 – 159	5	" "	" "
≥ 160	7	" "	" "

Hard Coronary Heart Disease (10-Year Risk) Musical Key:

Female:

Age	Synth Select (OSC Type)
20 – 34	Solo (Sine)
35 – 39	Solo (Saw)
40 – 44	Solo (Square)
45 – 49	Chord1 (Sine)
50 – 54	Chord1 (Saw)
55 – 59	Chord1 (Square)
60 – 64	Chord1 (Triangle)
65 – 69	Chord2 (Sine)
70 – 74	Chord2 (Saw)
75 – 79	Chord2 (Square)

HDL (mg/dL)	Rhythm
≥ 60	All Straight
50 – 59	Mix of Straight & off Beat/Syncopatio
40 – 49	All off Beat/Syncopated
< 40	Triplet

Total Cholesterol	Delay Time
< 160	0
160 – 199	0.2
200 – 239	0.4
240 – 279	0.6
≥ 280	0.8
Nonsmoker	Major chord progression/Melodic Sequence
Smoker	Minor chord progression/Melodic Sequence

Systolic BP (mmHg)	LFO Rate	Treated	UnTreated
< 120	1	Reverb	No Reverb
120 – 129	4	" "	" "
130 – 139	7	" "	" "
140 – 159	10	" "	" "
≥ 160	13	" "	" "

Evaluation / Outcomes:

My initial thesis behind utilizing the heart risk calculations of males and females was to keep them separate and fuse their sound together using match making algorithms such as the stable marriage problem but it proved a harder notion to fulfill than expected. Problems arose with preference and the ability for the stable marriage algorithm to work correctly with homosexual relationships. I feel very satisfied that my algorithm doesn't have sexual bias and allows for any sound male or female to occur simultaneously.

Keeping to the stereotypical qualities of the EDM genre was hard to fully achieve with every iteration. The instruments heard may sometimes individually conform to this genre but within a sonification context where I allowed cross-rhythms and dysfunctional harmony to occur, containing the piece within the genres bounds proved unsuccessful every time.

Overall I am proud with the success of this algorithmic composition. With the vast amount of rhythmic, melodic and chord progression patterns I feel the piece performs to a very high standard and although may not always sound like a consistent piece of EDM music, achieves the role of portraying the features of humans very well.

References

(1) Site Edited by Heather Arruda. (Last updated 2013). *Hard Coronary Heart Disease (10 Year Risk).* Available: http://www.framinghamheartstudy.org/risk/hrdcoronary.html. Last accessed 16th May 2013.

(2) Mark Ballora. (2011). *Opening Your Ears To Data.* Available: http://www.youtube.com/watch?v=aQJfQXGbWQ4. Last accessed 16th May 2013.

(3) Mark Ballora. (2000). *Data Analysis through Auditory Display: Applications in Heart Rate Variability.* Available: http://www.personal.psu.edu/meb26/BalloraDiss.pdf. Last accessed 16th May 2013.

(4) Wilson, Cottle, Collins (2011). *The SuperCollider Book*. Massachusetts Institue of Technology: The MIT Press. 381.

(5) Fig 1.1 Instrument 1 Image
Mark Ballora. (2000). *Data Analysis through Auditory Display: Applications in Heart Rate Variability.* (Page 78)
Available: http://www.personal.psu.edu/meb26/BalloraDiss.pdf. Last accessed 16th May 2013.

(6) Wilson, Cottle, Collins (2011). *The SuperCollider Book*. Massachusetts Institue of Technology: The MIT Press. 384.