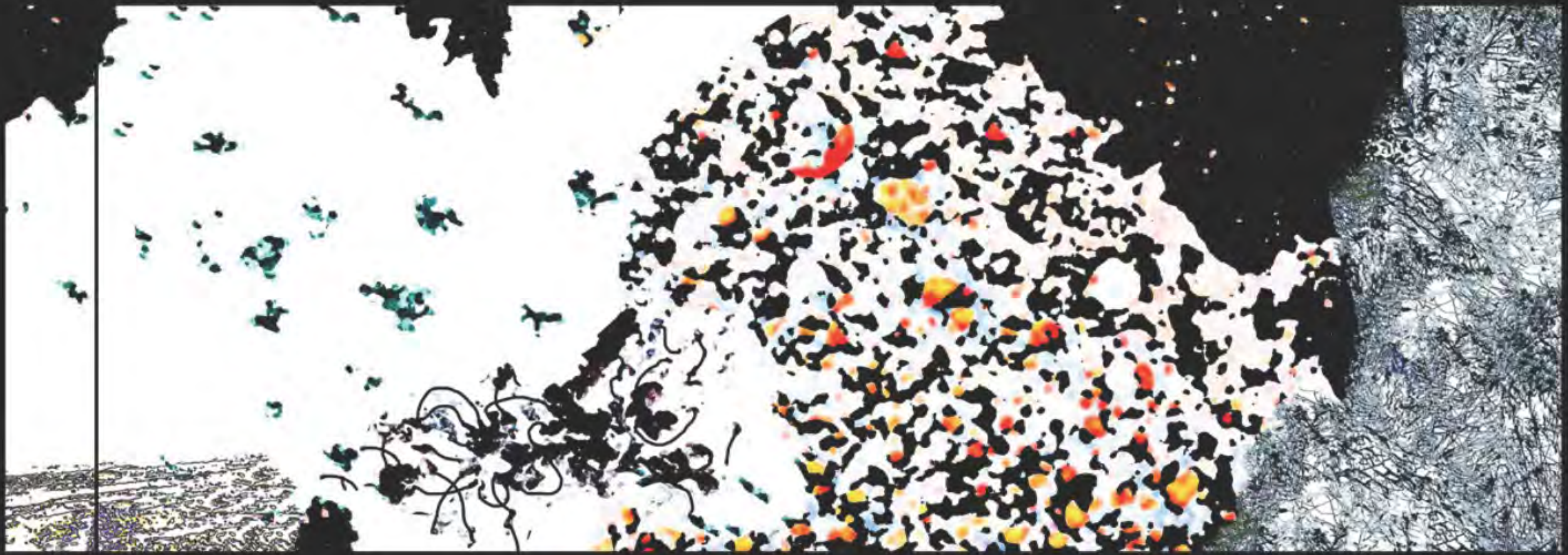
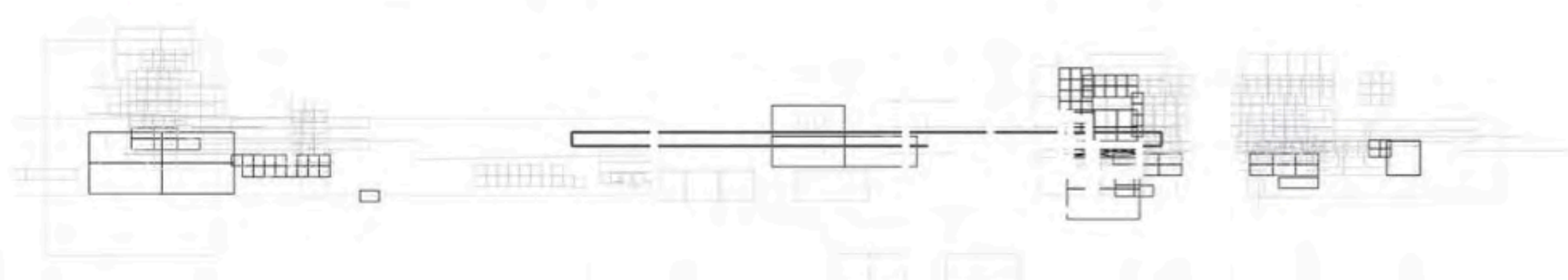
REPRESENTING SOUND WITH COLOUR NOTATION

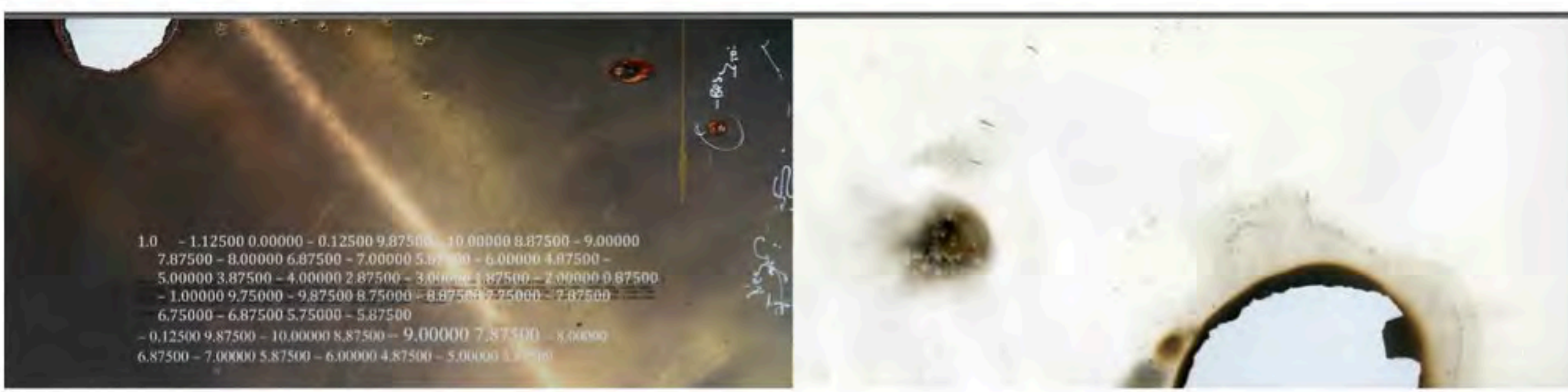
LINDSAY VICKERY



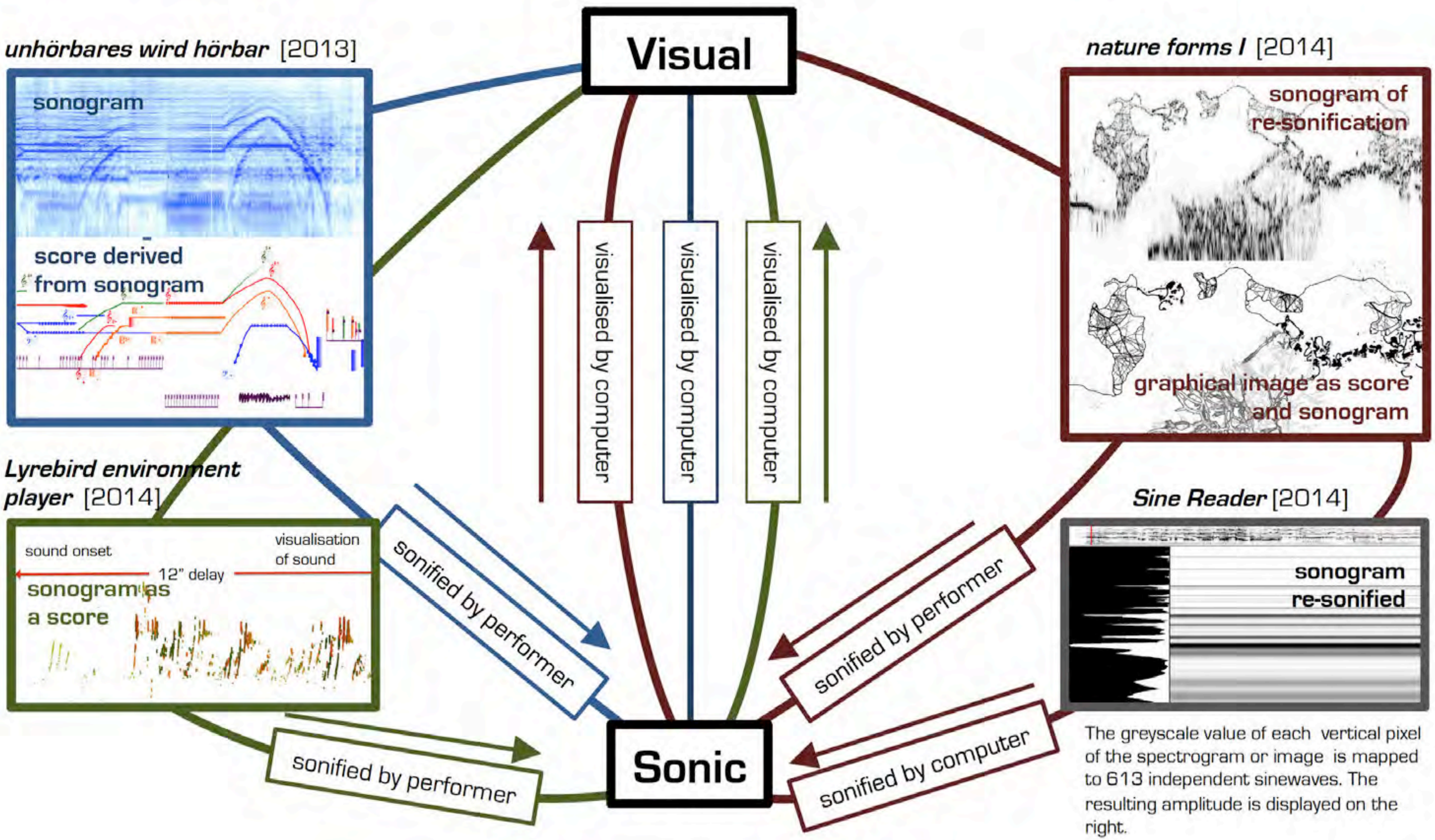
The expansion of the possibilities for the musical score afforded by modern printers and computer screens has provided the opportunity to represent parameters of musical phenomena that were previously poorly captured by traditional Western music notation: most importantly continuously evolving parameters such as timbre and amplitude, and the depiction of complex sound events such as those found in electronic music.

Bil Smith: *String Quartet* (2012)



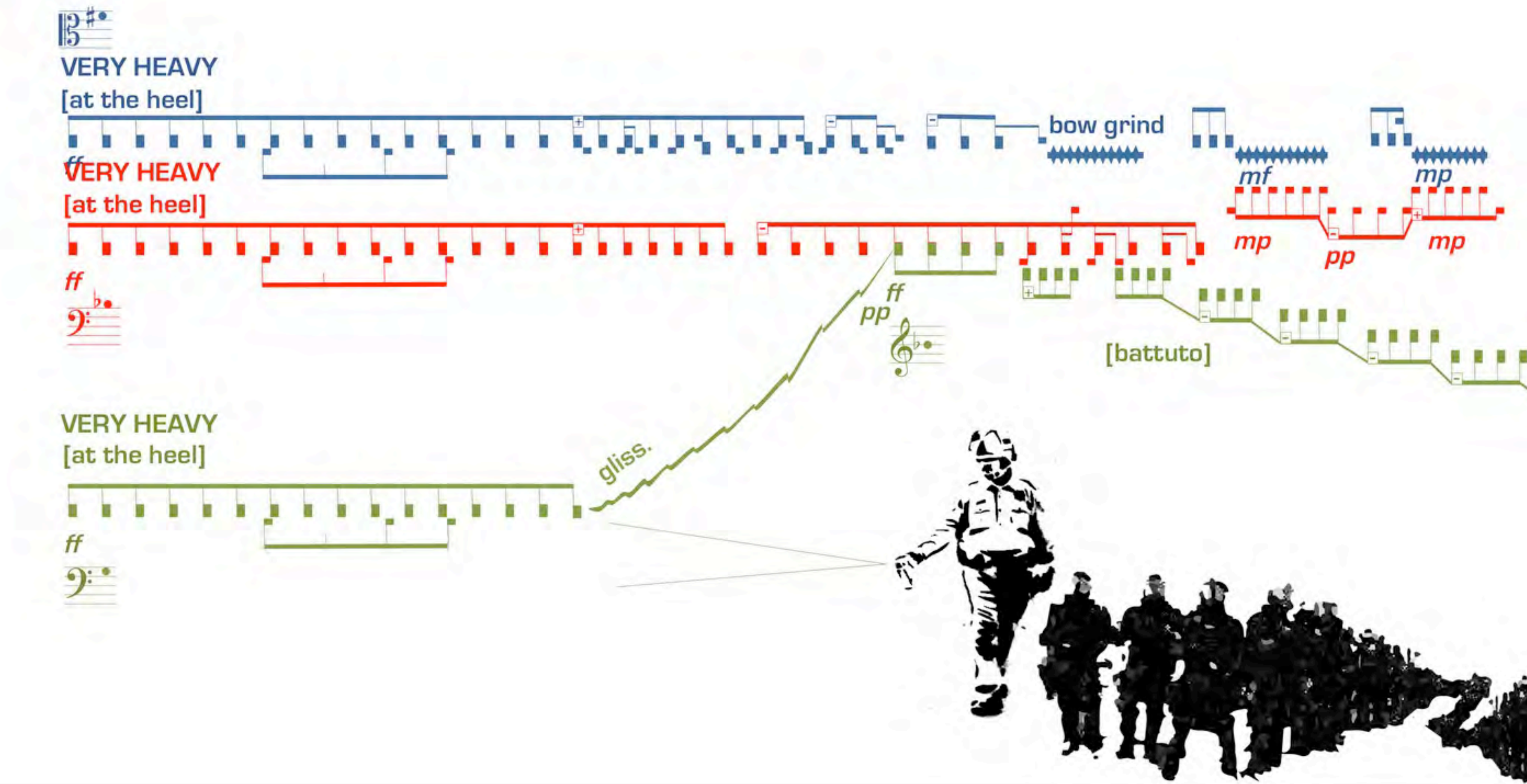


This presentation discusses the role of colour in several projects exploring the visualisation of sound and the sonification of images.



Colour and the Musical Score

The expansion of the possibilities for the musical score afforded by modern printers and computer screens has provided the opportunity to represent parameters of musical phenomena that were previously poorly captured by traditional Western music notation: most importantly continuously evolving parameters such as timbre and amplitude, and the depiction of complex sound events such as those found in electronic music.



Wileman: **Realism continuum**

Spanning: forms of visual representation, spanning colour and then black and white photographs, silhouettes, line drawings, pictographs and text.

Wileman, R. E. (1993). *Visual Communicating*. New Jersey: Educational Technology Publications.

O'Callaghan: **Musical Mimesis**

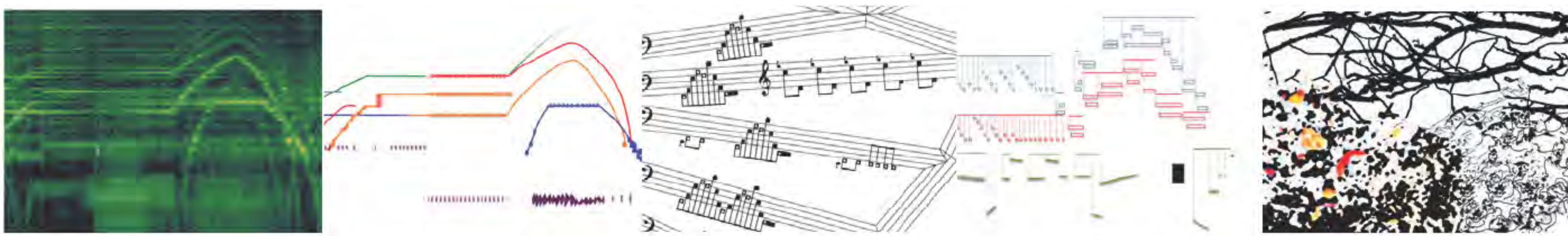
Category 1 transcriptions recognisable as representational of the source sound, and achieving a high level of verisimilitude;

Category 2 some acoustic similarity to the source sound, but distant enough that it requires other extra-musical contexts to identify;

Category 3 relies upon additional outside information, to be interpreted as mimetic

O'Callaghan, J. (2012). Mediated Mimesis: Transcription as Processing. *Proceedings of the Electroacoustic Music Studies Network Conference Meaning and Meaningfulness in Electroacoustic Music*, Stockholm.

Visual forms of musical representation
may also be considered to occupy a continuum, in this case between the spectrogram (a precise frequency/time/amplitude representation of sound), proportional notation, traditional notation, semantic graphical notation, non-semantic graphical notation and text scores that verbally describe the required sound.



spectrogram (a precise frequency/time/amplitude representation of sound),

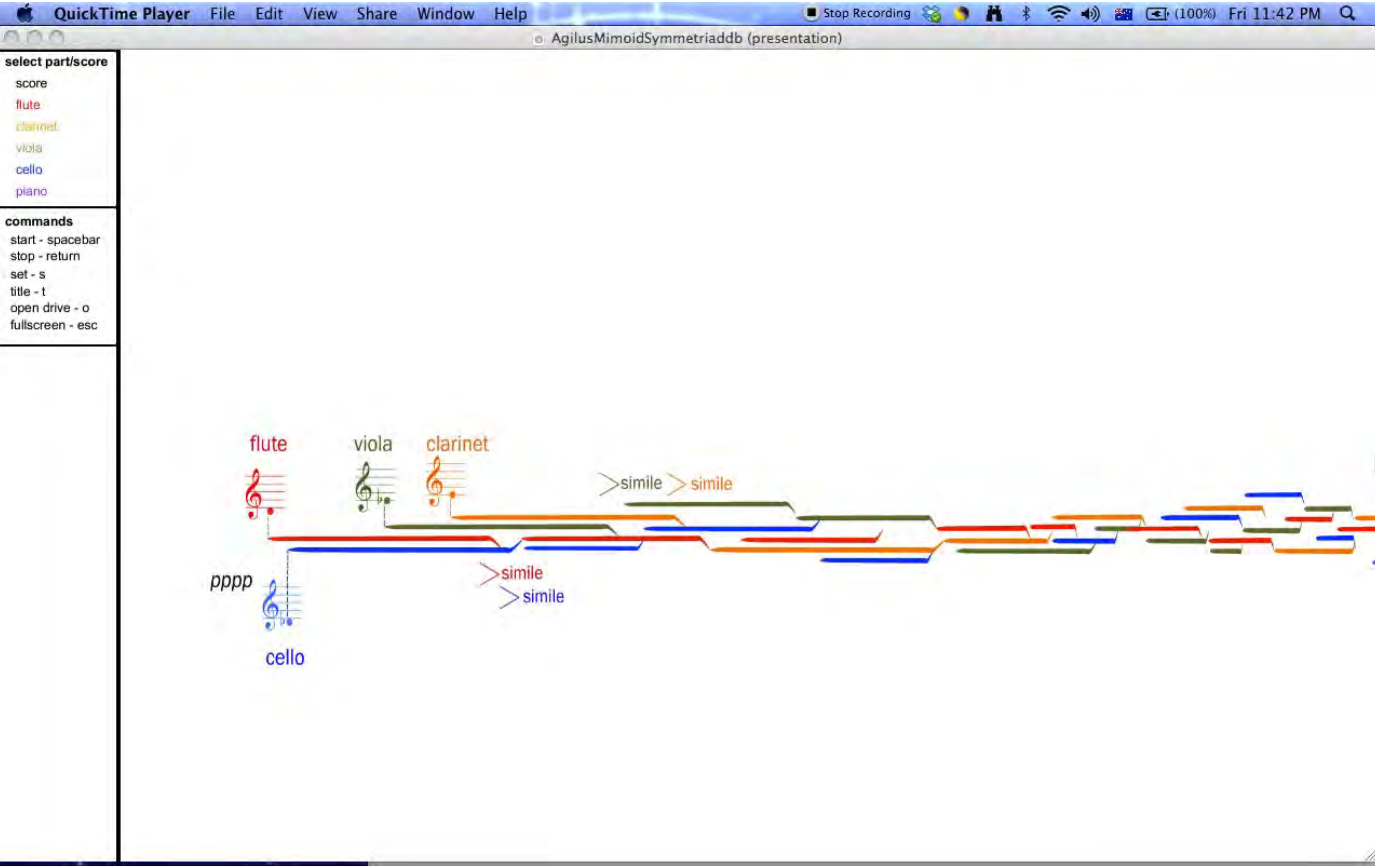
proportional notation

traditional notation

semantic graphical notation,

non-semantic graphical notation

The Decibel Scoreplayer



Screen Scoring Issues

The musical score is a time critical form of visualisation that, in the majority of cases, corresponds to sounds that unfold at a more-or-less defined temporal rate. For this reason there is a strong imperative for scores to employ symbols that signify sonic events with maximal efficiency.

Moody's *Physics of Notations Theory* (Moody 2009) defines a set of principles to evaluate and improve the visual notation, that are pertinent to musical notation.

Cognitive Fit:	use different visual dialects when required.
Semiotic Clarity:	there should be a one-to-one correspondence between semantic constructs and graphical symbols.
Perceptual Discriminability:	symbols should be clearly distinguishable.
Visual Expressiveness:	use the full range and capacities of visual variables.
Complexity Management:	include mechanisms for handling complexity.
Cognitive Integration:	include explicit mechanisms to support the integration of information from different diagrams.
Semantic Transparency:	use symbols whose appearance is evocative.
Graphic Economy:	keep the number of different graphical symbols cognitively manageable.
Dual Coding:	enrich diagrams with textual descriptions.

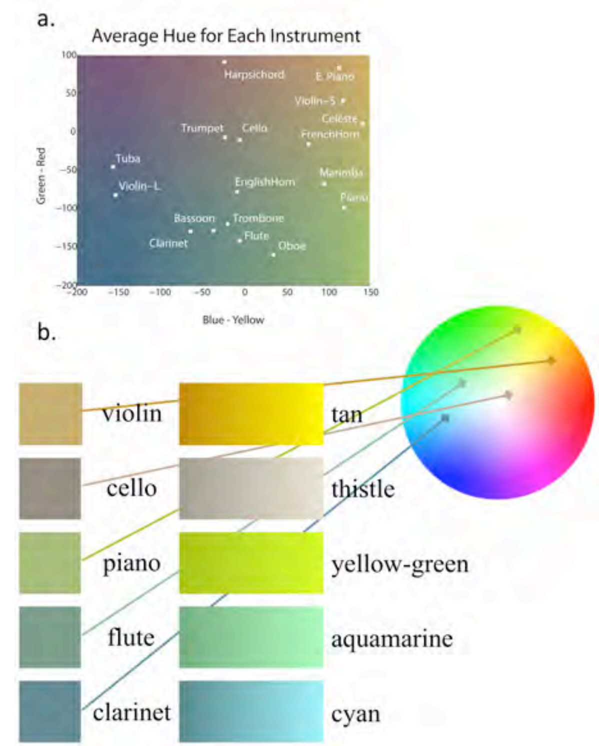
Moody's Physics of Notations theory (as summarized by Genon, et al. 2011:224)

Instrument differentiation

It is necessary for performers to distinguish their own "part".
Instrument colours must be maximally different.

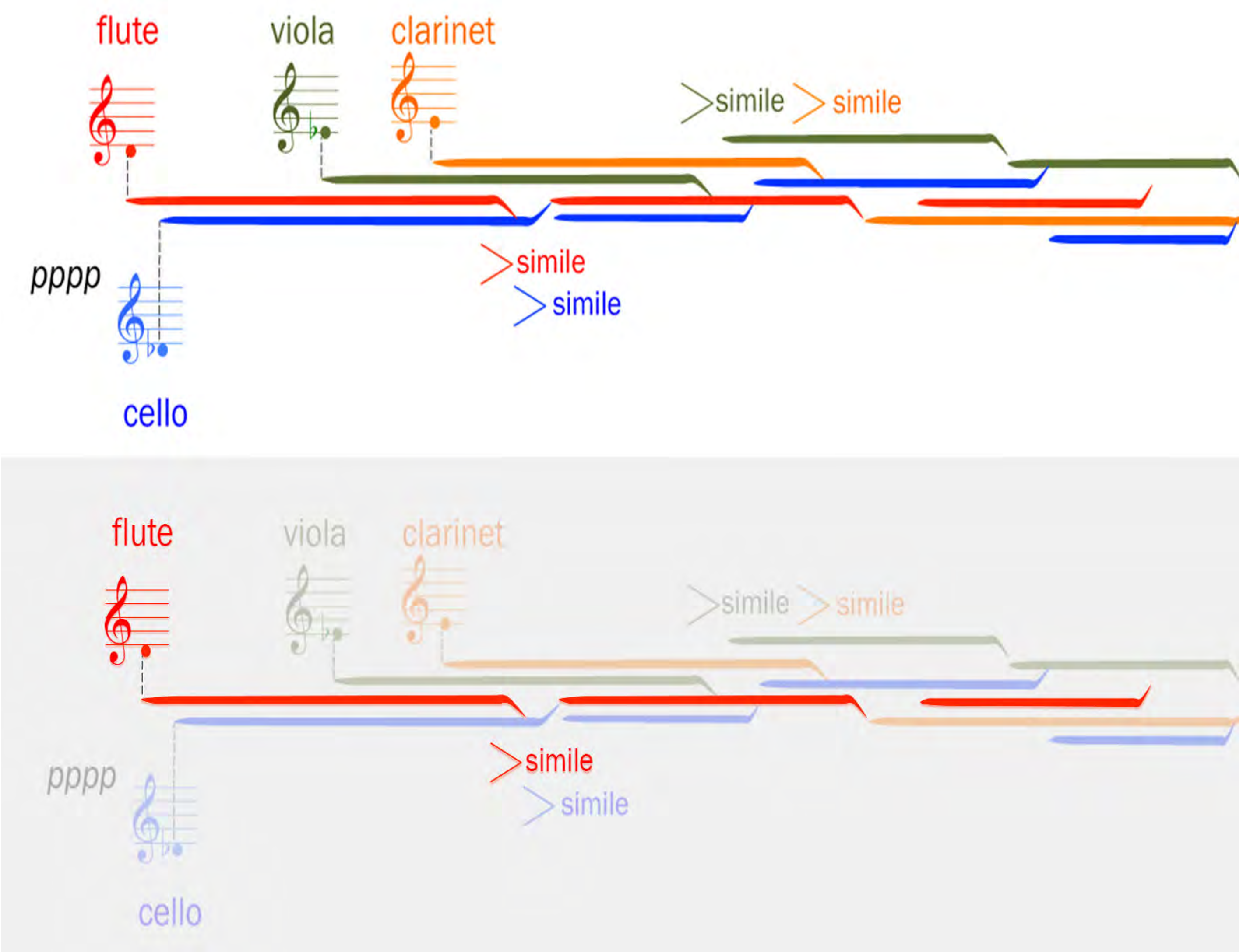
A notional colour spectrum based on human visual perception from white to black (based on CIELAB colour space (Hoffman 2003) and Bruce MacEvoy's Artist's Value Wheel (MacEvoy 2005).

Are there colours that are more "semantically sound"?



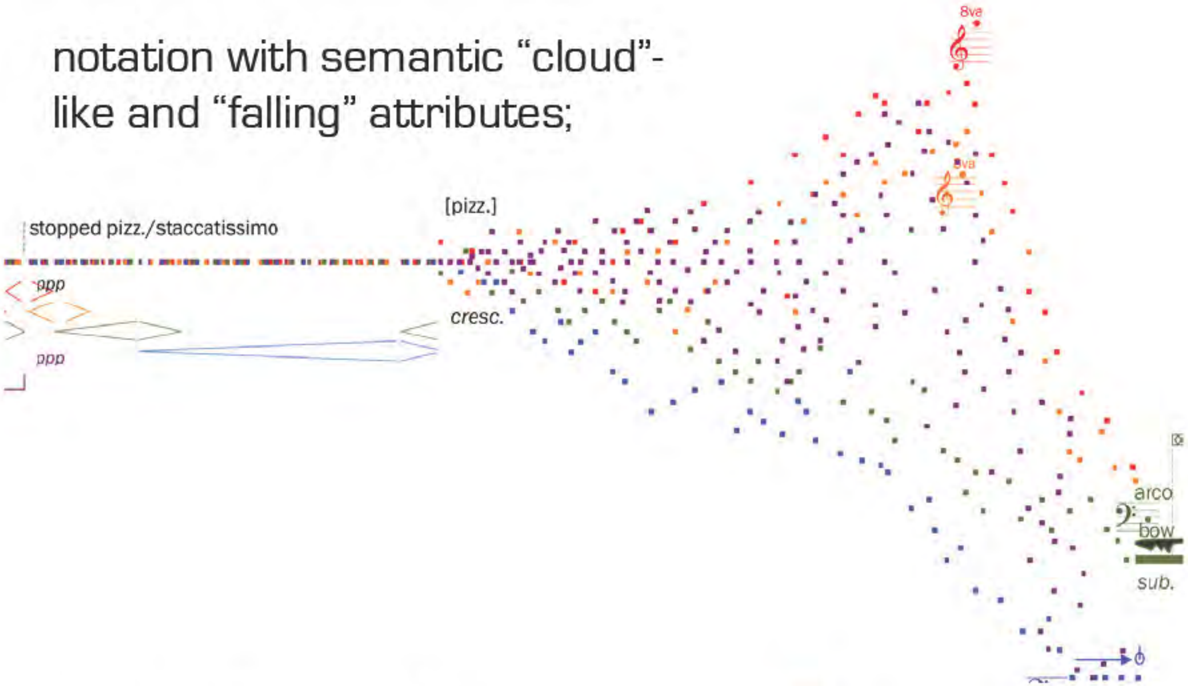
a.) Colour-to-sound associations between instrument timbre and colour (from Grisom and Palmer 2013), b.) Implied "semantically sound" hues for five instruments.

Colour to identify instrumental parts

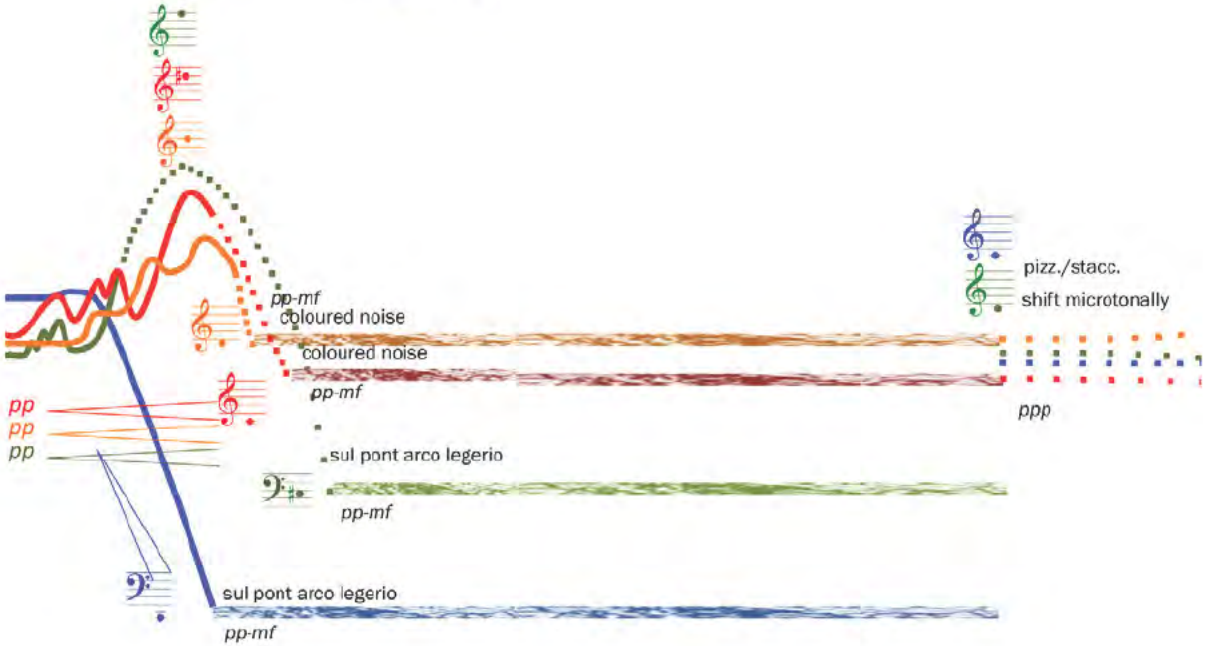


Agilus, Mimoid, Symmetriad (2012b): a. vertically and horizontally proportional notated and score and part view;

notation with semantic "cloud"-like and "falling" attributes;



textured lines used to represent continuously changing "coloured noise" texture.



Reading Issues
Scrolling Rate

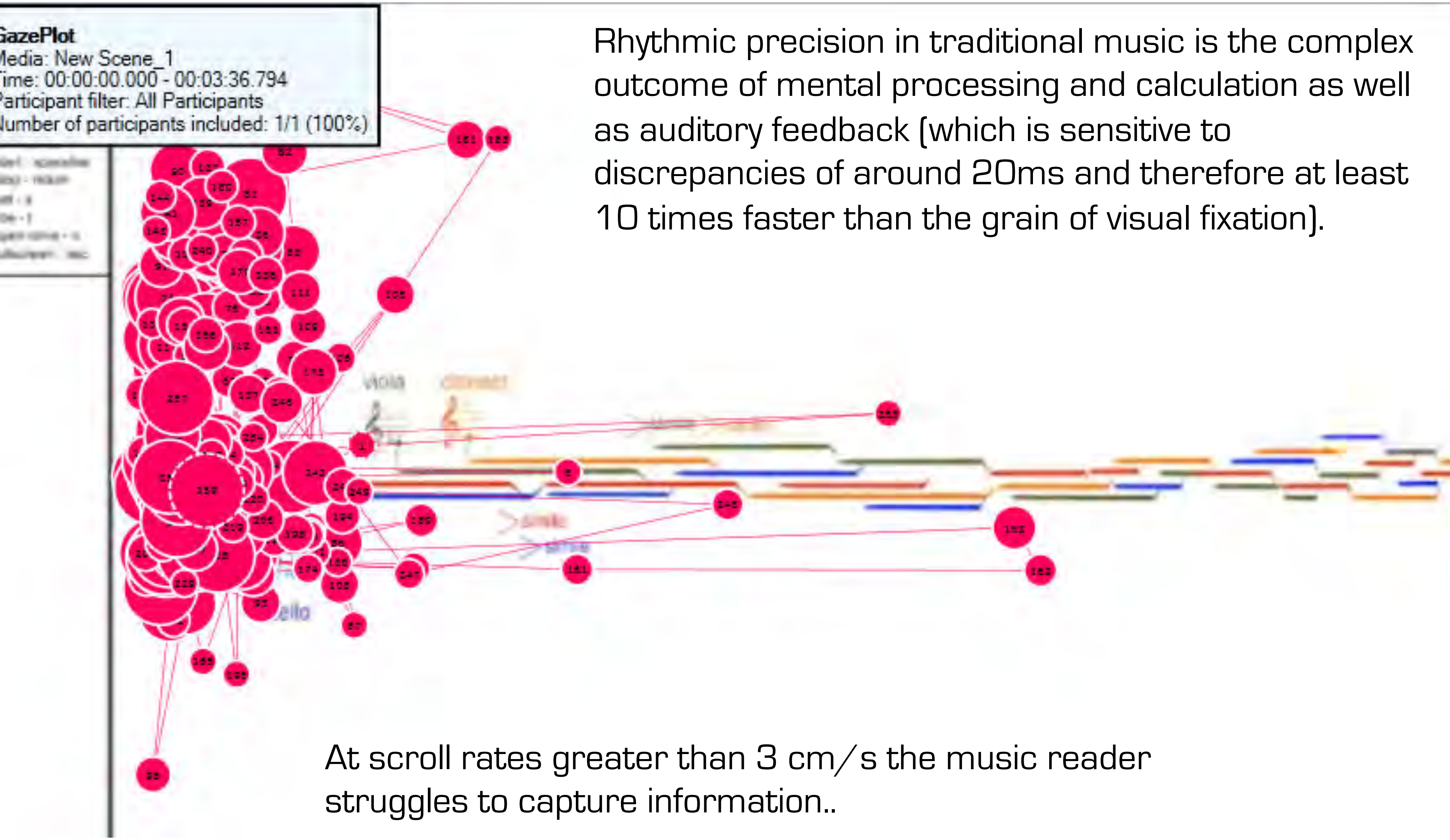
A comparison of the notional average rate at which the score progresses as the performer reads the work: its "scroll-rate". The scroll-rate is calculated by dividing the length of the score by its average duration.

The scrolling score, although highly useful for synchronising musical events in non-metrical music has particular natural constraints based on the limitations of human visual processing.

	work duration (s)	score length (cm)	scroll-rate (cm/s)
Beethoven: The Tempest (1802)	510	1171	2.41/ 0.48
Chopin: Minute Waltz (1847)	120	467	3.89
Ravel: *Pavane* (1899)	360	487	1.35
Debussy: *Voiles* (1909)	240	386	1.61
Hope: *In the Cut* (2009)	431	197	0.46
Hope: *Longing* (2011)	405	109	0.59
Hope: *Kuklinski's Dream* (2010)	490	249	0.51
Vickery: *Agilus, Mimoid Symmetriad* (2012)	574	875	1.52
Vickery: *Silent Revolution* (2013)	560	857	1.53

EYE-TRACKING

Gaze-plot showing all eye fixations made while reading a scrolling score. The size of the circle indicates the duration of the fixation.

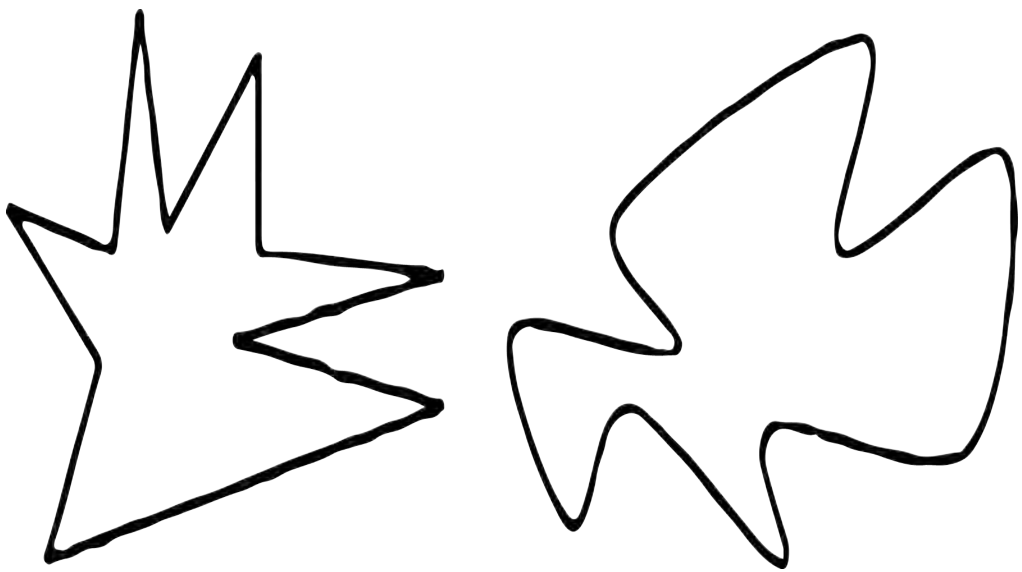


Rhythmic precision in traditional music is the complex outcome of mental processing and calculation as well as auditory feedback (which is sensitive to discrepancies of around 20ms and therefore at least 10 times faster than the grain of visual fixation).

At scroll rates greater than 3 cm/s the music reader struggles to capture information..

SHAPE, COLOUR AND THE SCORE

Synaesthesia, a condition in which an individual experiences sensations in one modality when a second modality is stimulated (Ramachandran and Hubbard 2001:4), has been the subject of scientific enquiry for over two hundred years (Campen 1999:11).



The kiki / bouba effect. “Because of the sharp inflection of the visual shape, subjects tend to map the name kiki onto the figure on the left, while the rounded contours of the figure on the right make it more like the rounded auditory inflection of bouba” *(Ramachandran and Hubbard 2001:19)*.

In 1996 Marks noted that “there are natural correspondences between experiences in different sense modalities, and that these seem to be nothing less than "hard wired." (Marks 1996:61).

This phenonmenon has come to be known as Weak Synaesthesia (Martino and Marks 2001) or simply Crossmodal Correspondence (Deroy and Spence 2013). Martino and Marks differentiate between strong and weak forms of synaesthesia as follows:

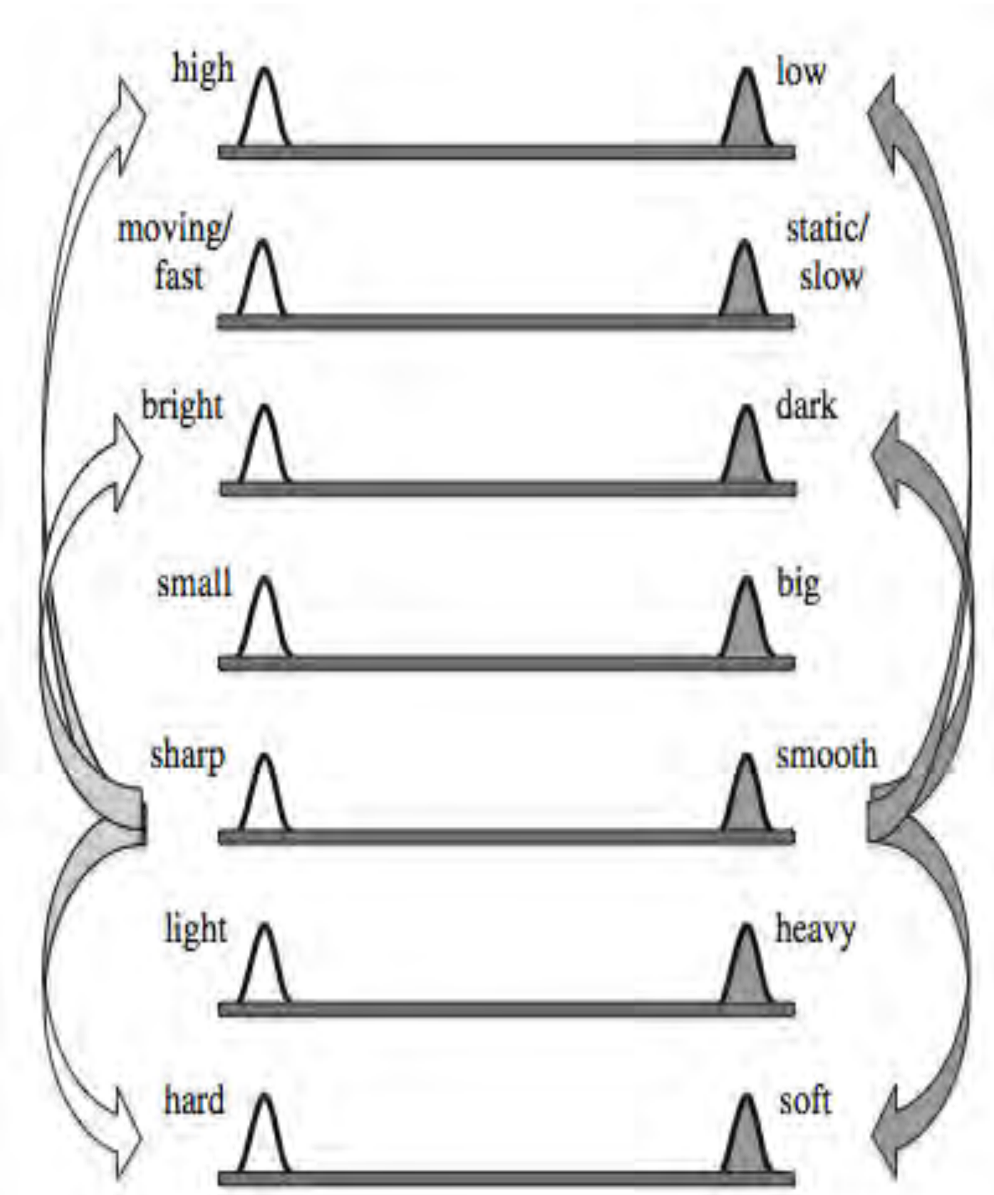
Strong Synaesthesia:

- One stimulus is perceived, the other is experienced as an image;
- the correspondences are both idiosyncratic and systematic;
- the definition of the correspondences is absolute;
- associations are literal and semantic.

Weak Synaesthesia:

- Both stimuli are perceived;
- the correspondences are systematic;
- definition of the correspondences is contextual;
- associations are metaphorical and semantic.

(Martino and Marks 2001:63)

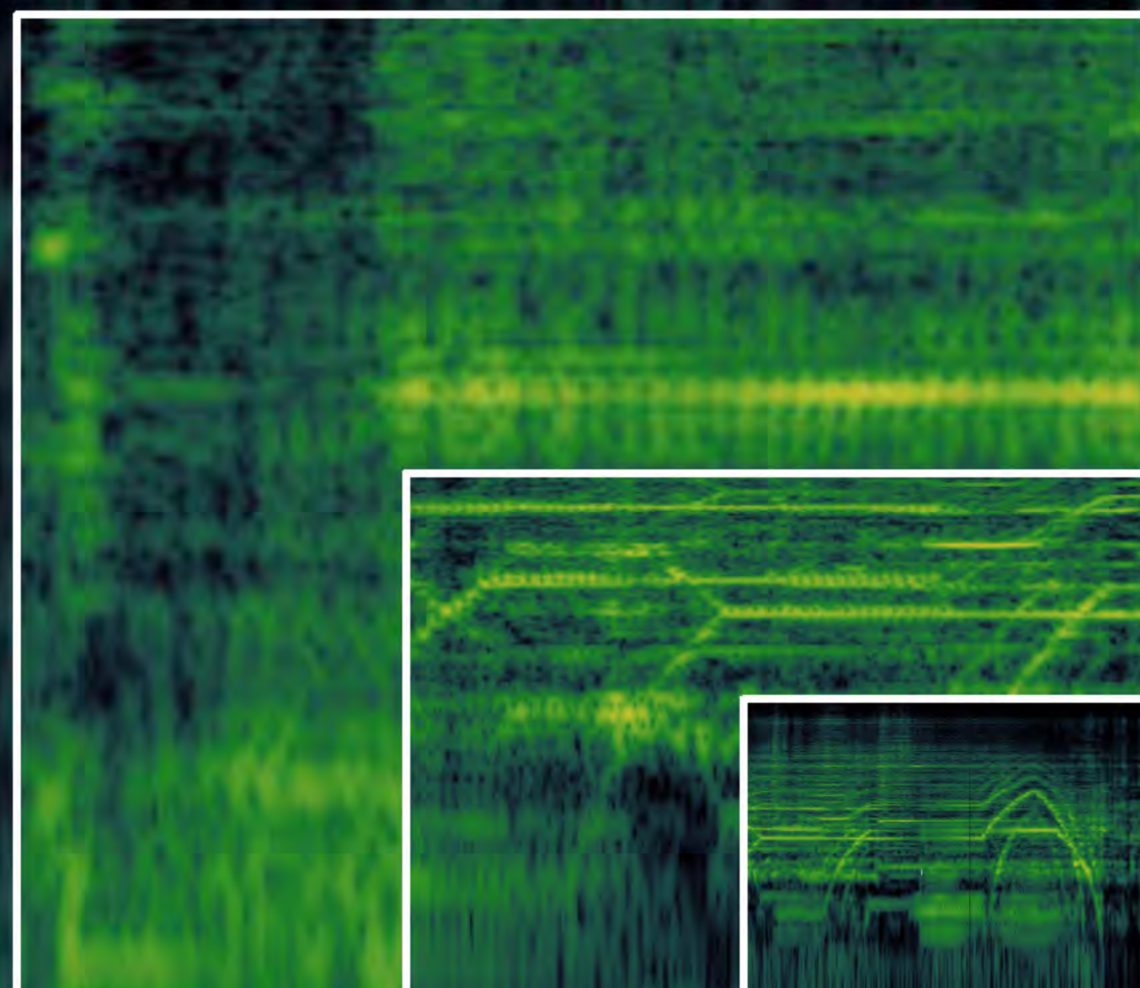


Walker has proposed that cross-modal correspondences are ordered in clusters. Walker claims that "the same core correspondences should emerge whichever sensory feature is used to probe them, confirming that the en bloc alignment of the dimensions is context invariant" (Walker 2012:1806).

Proposed *En Bloc* alignment of cross-sensory features contributing to cross-modal perception (Walker 2012:1793)

PROJECT 1: THE SPECTROGRAM AS A SCORE:

In order to maintain a level of "graphic economy", a resolution of roughly 60ms/px was used for the spectrogram-score. This resolution allows the performer to view elements of the sonogram that represent what Curtis Roads refers to as "basic units of music structure (...) complex and mutating sound events on a time scale ranging from a fraction of a second to several seconds" (Roads 2002:3-4) while at the same time reading at an acceptable scroll rate of 2.35 cm/s (Vickery 2014a).



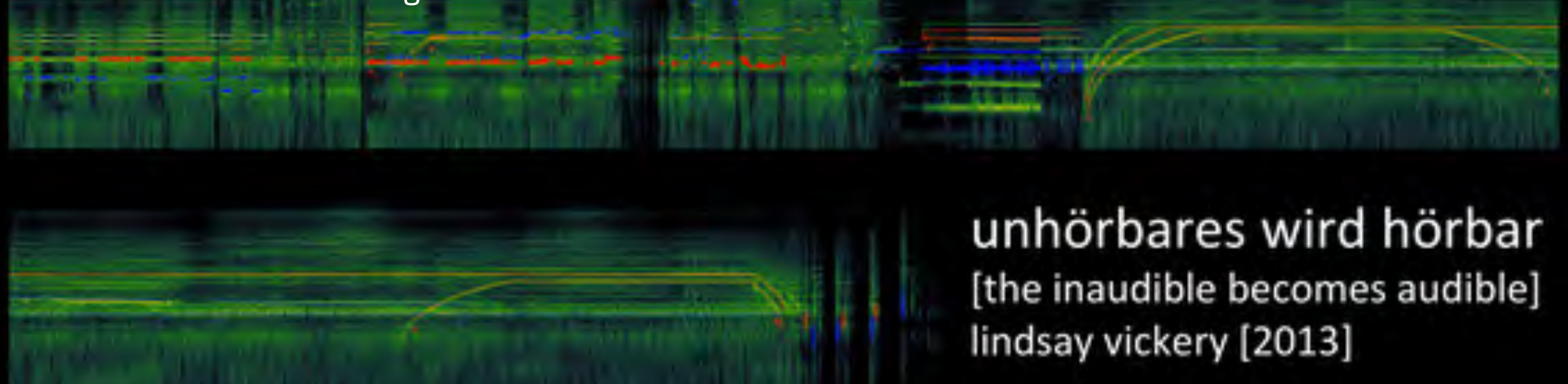
PROJECT 1: THE SPECTROGRAM AS A SCORE:
***UNHÖRBARES WIRD* HÖRBAR (the inaudible becomes audible) [2013]**

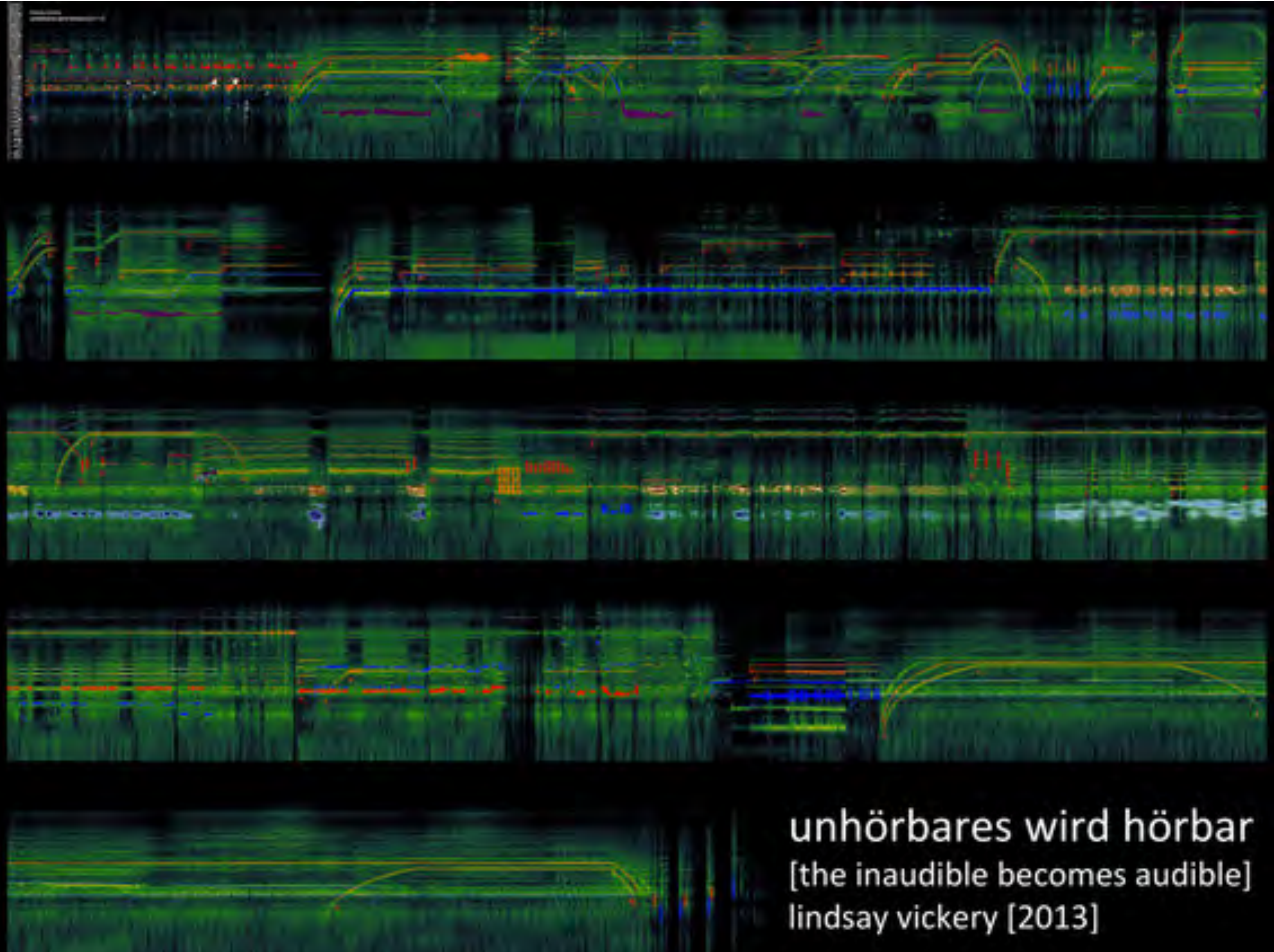
Title is from a 1968 book by Konstantin Raudive detailing his experiments "discovering" Electronic Voice Phenomena (that he describes as "disincarnate voices") through various means.
It uses a spectrogram as the basis for the score.

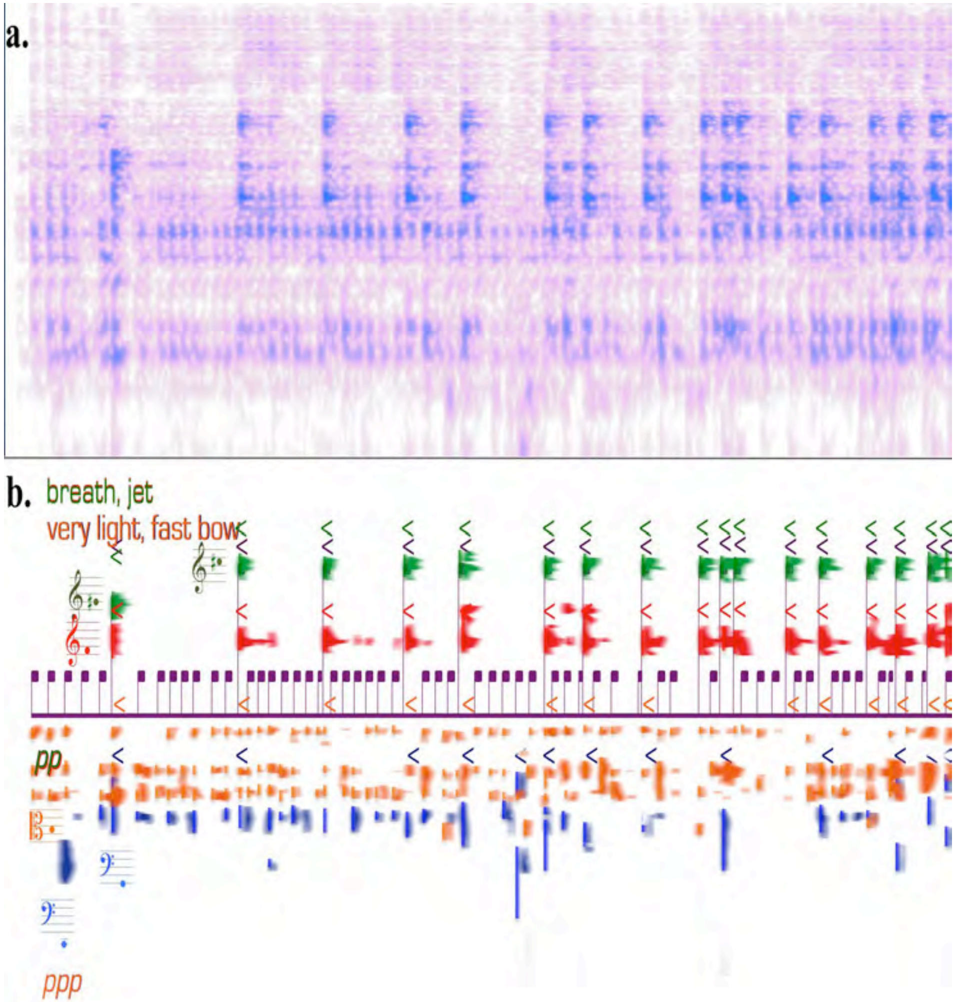
Challenges of this approach: spectrogram "visualizations are highly abstract, lacking a direct relationship to perceptual attributes of sound" (Grill and Flexer 2012).

The resolution available when creating a spectrogram is variable: most detailed in the software used is 190ms x 5hz represented by a rectangle of roughly 6.46 x 0.25 cm. A score this detailed would need to be 19m long and read at 37 cm/s.

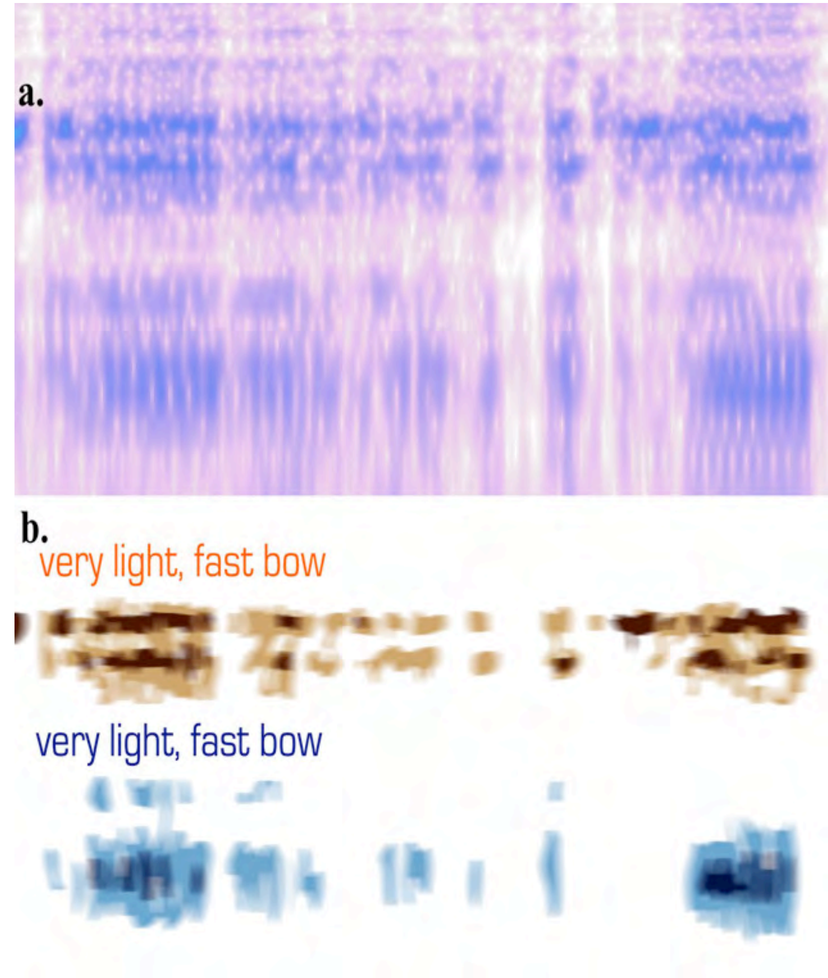
So what is a "reading rate" for a score?




unhörbares wird hörbar
[the inaudible becomes audible]
lindsay vickery [2013]

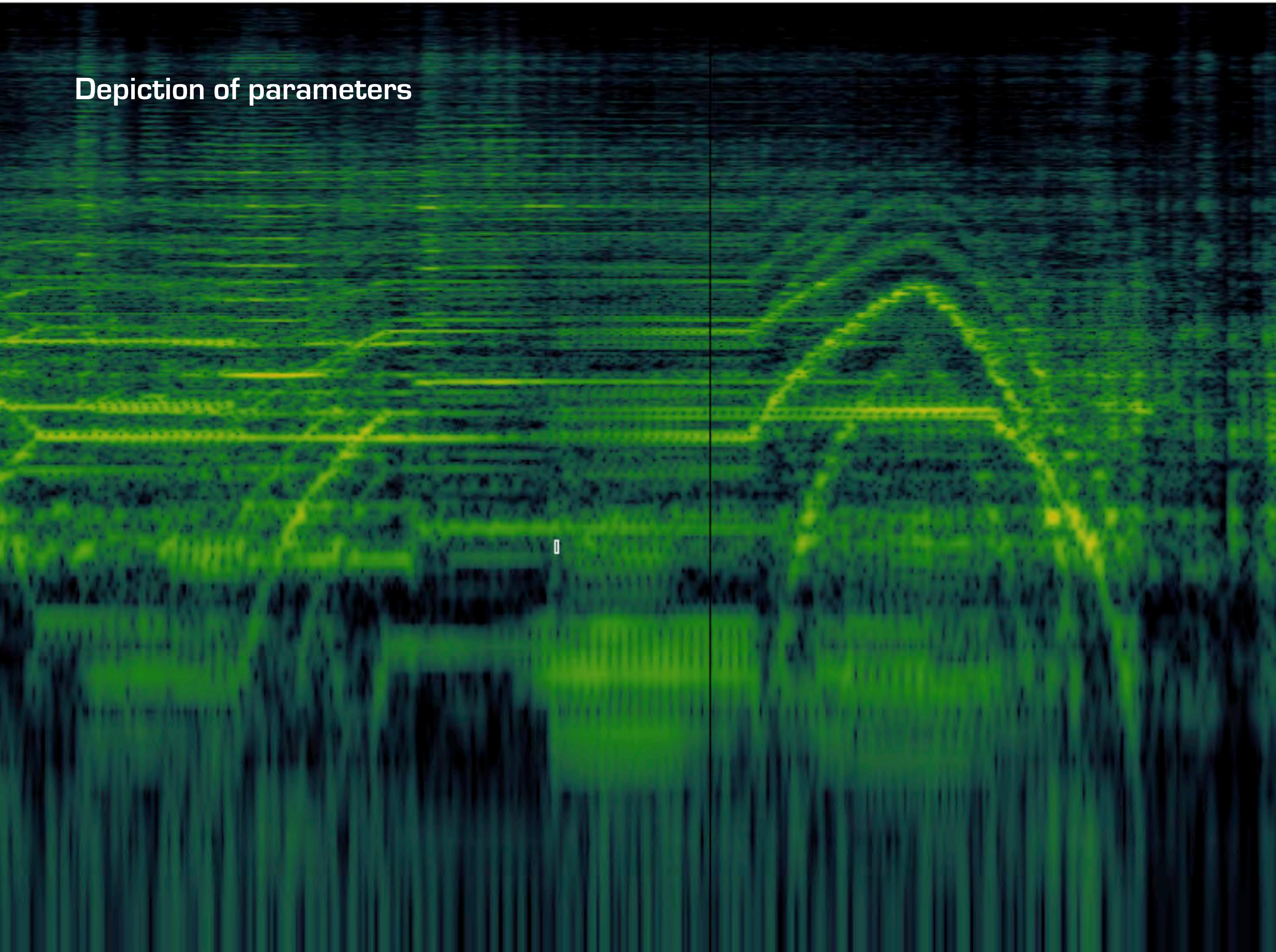


The opening 20 seconds of *unhörbares wird hörbar* [2013]: a.) shows the spectrogram upon which the work is based and b.) shows the score using graphical features

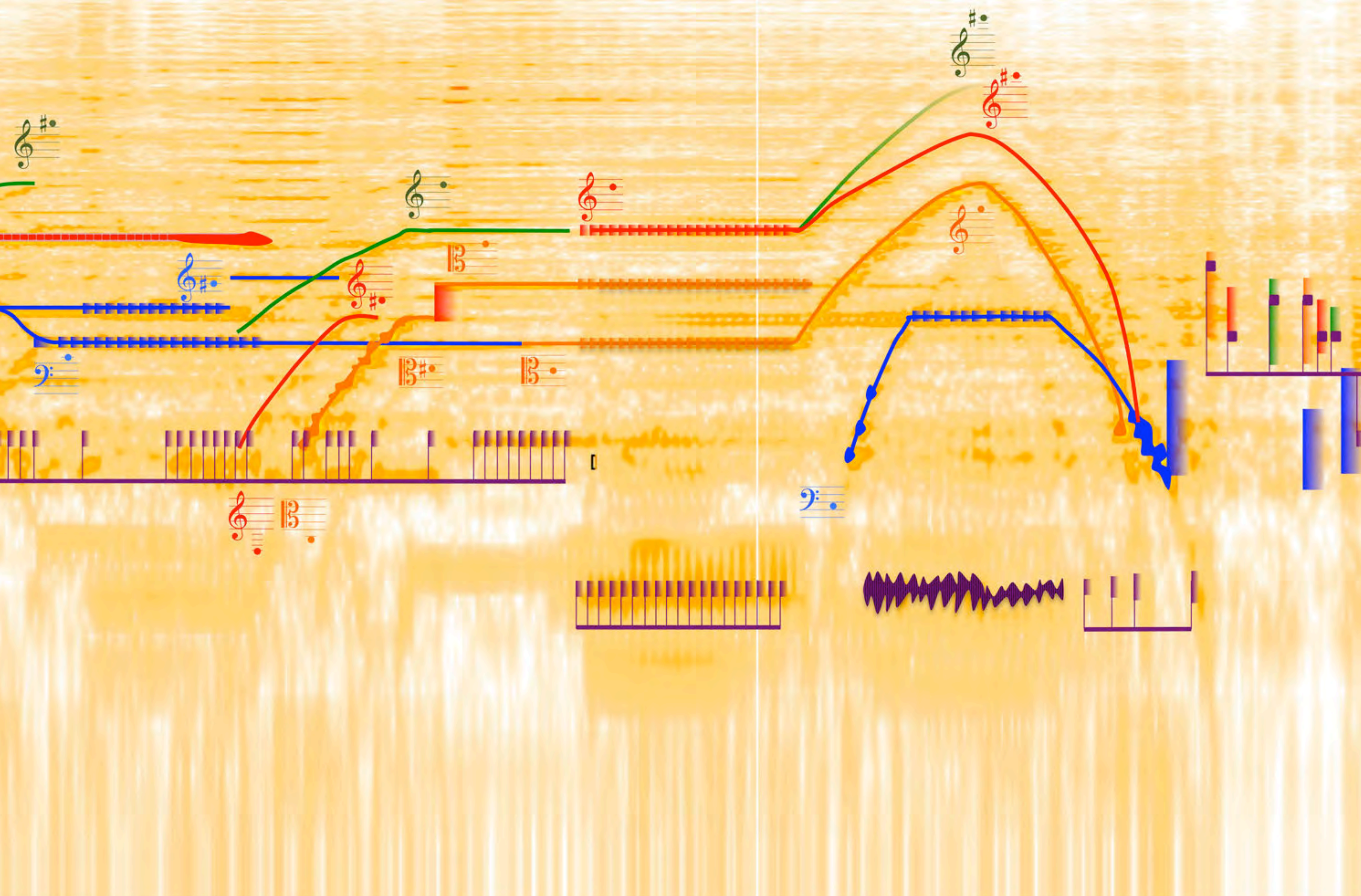


Colour as an indicator of timbral variation in the viola and cello parts of *unhörbares wird hörbar:* a. corresponding spectrogram and b. viola and cello parts.

Depiction of parameters



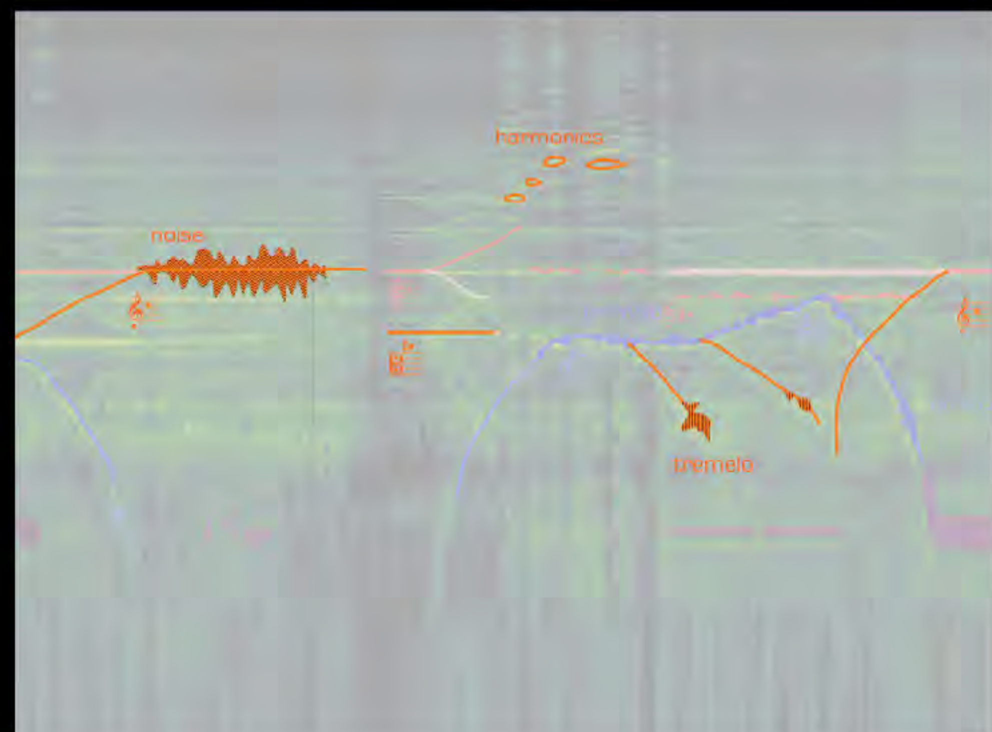
Depiction of parameters



Unhörbares Wird Hörbar (the inaudible becomes audible) [2013]

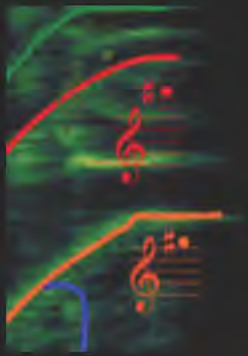
unhörbares wird hörbar is the title of a 1968 book by Konstantin Raudive detailing his experiments "discovering" Electronic Voice Phenomena (that he describes as "disincarnate voices") through various means. This work is spectral trace, in which the prominent features of a spectrogram are "orchestrated" for ensemble by means of a scrolling graphical score. The five instruments are colour coded: flute - green, clarinet - red, viola - orange, cello - blue and percussion - purple. The players are synchronised through reading from networked iPads using the Decibel Scoreplayer app for iPad itunes.apple.com/us/app/decibel-scoreplayer/id622591851?mt=8).

Each player reads from a "part" which consists of their own materials superimposed over the complete, but "greyed-out" score.

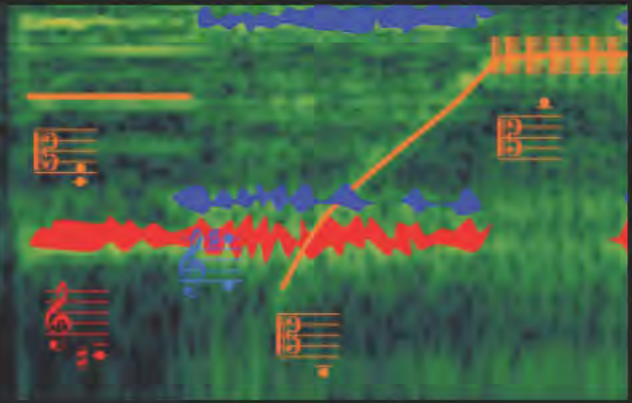


Prominent features of the spectrogram are indicated using:

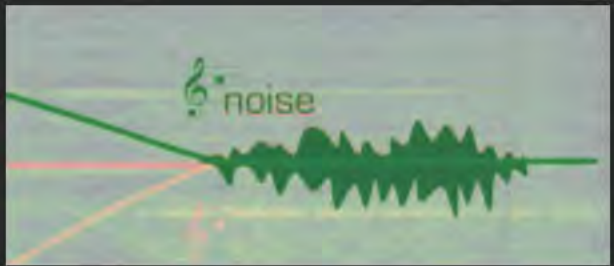
"floating" traditional staff/clef/pitch symbols to specify pitch,



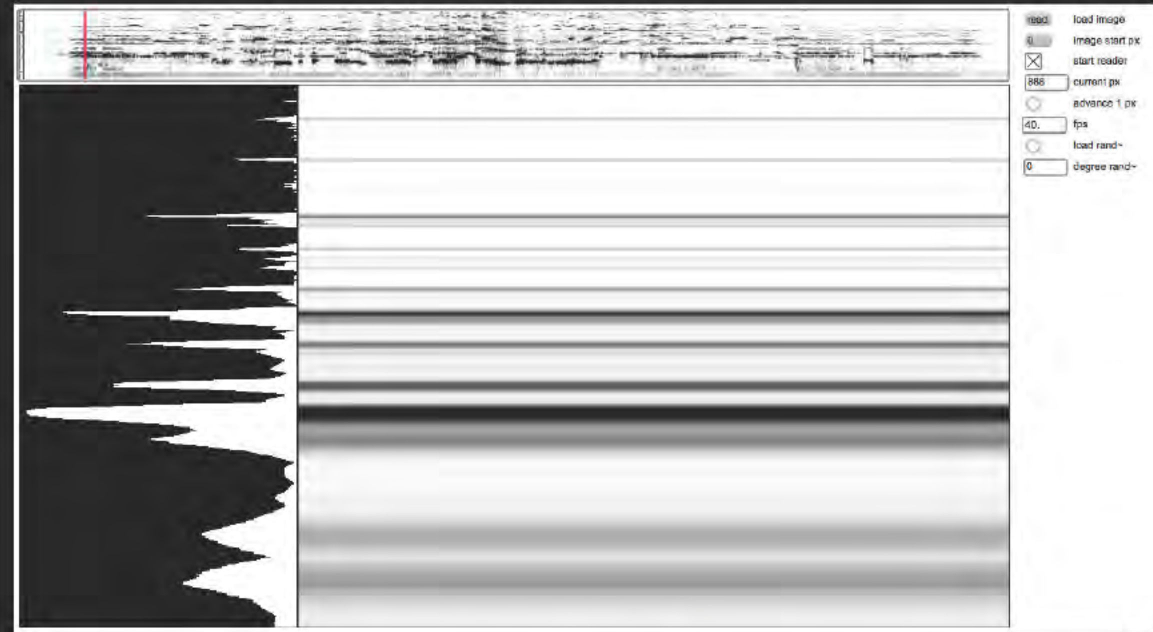
dynamics are indicated by the thickness of each player's line; and



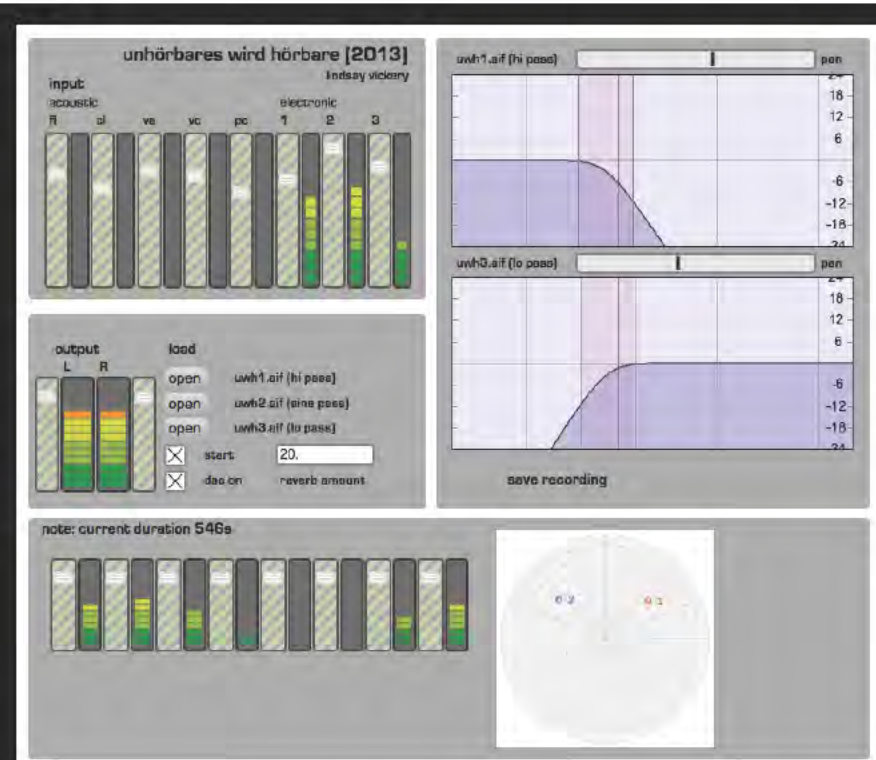
transparency of the line (along with textual indication) is used to denote specific forms of timbral variation, from regular instrumental sound to diffused tones,.



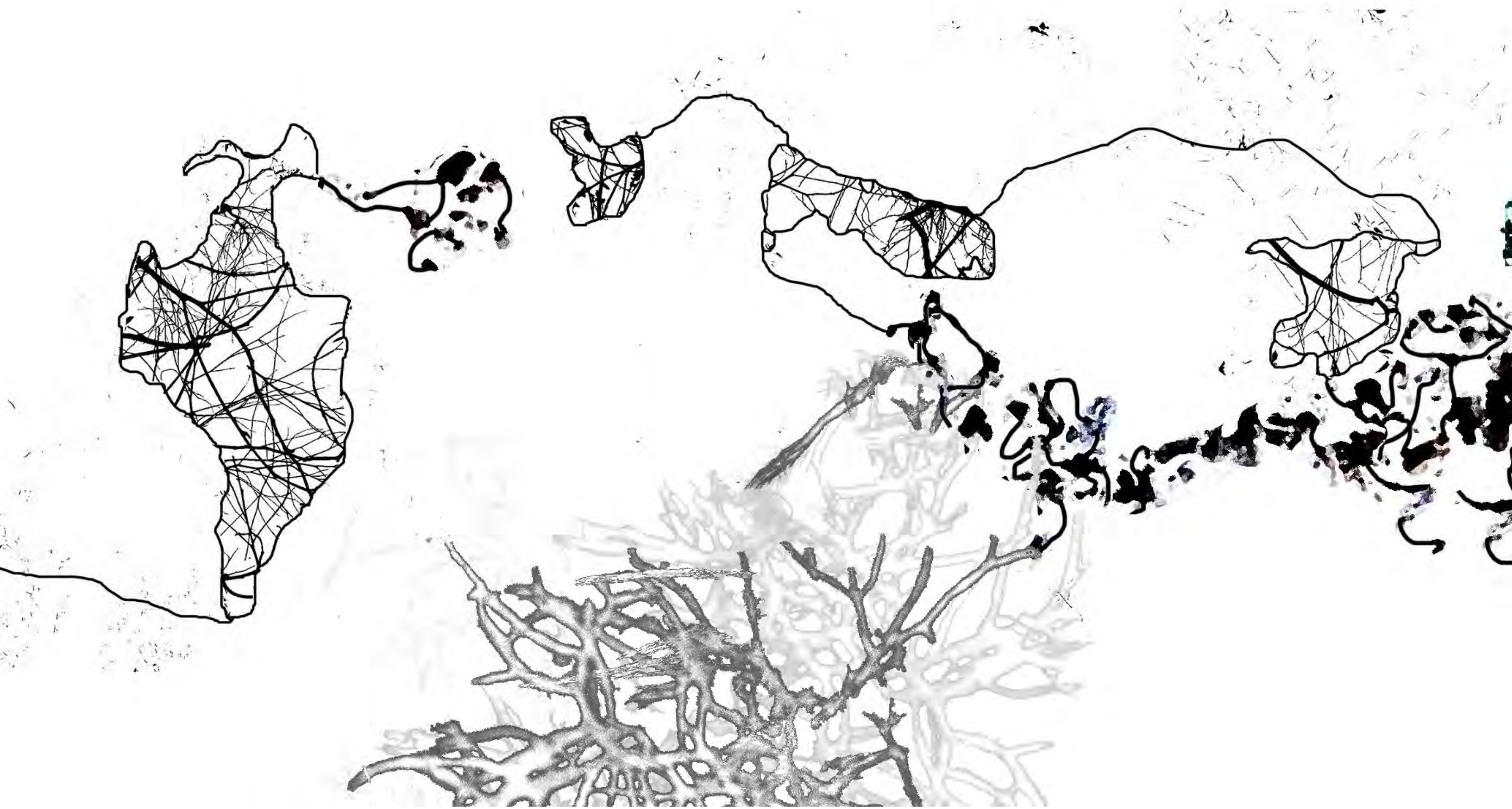
A patch in MaxMSP was developed to map each vertical pixel of a grayscale version of the spectrogram to 613 independent sinewaves at a horizontal rate of 25 pixels per second to create an electronic component.



The recording of the resonified spectrogram is diffused spatially in the performance, effectively "doubling" the instrumental lines. Spatial diffusion was controlled by mapping a realtime analysis of the frequency and amplitude of the third and seventh partial of the recording to the azimuth and distance parameters of an eight speaker array.



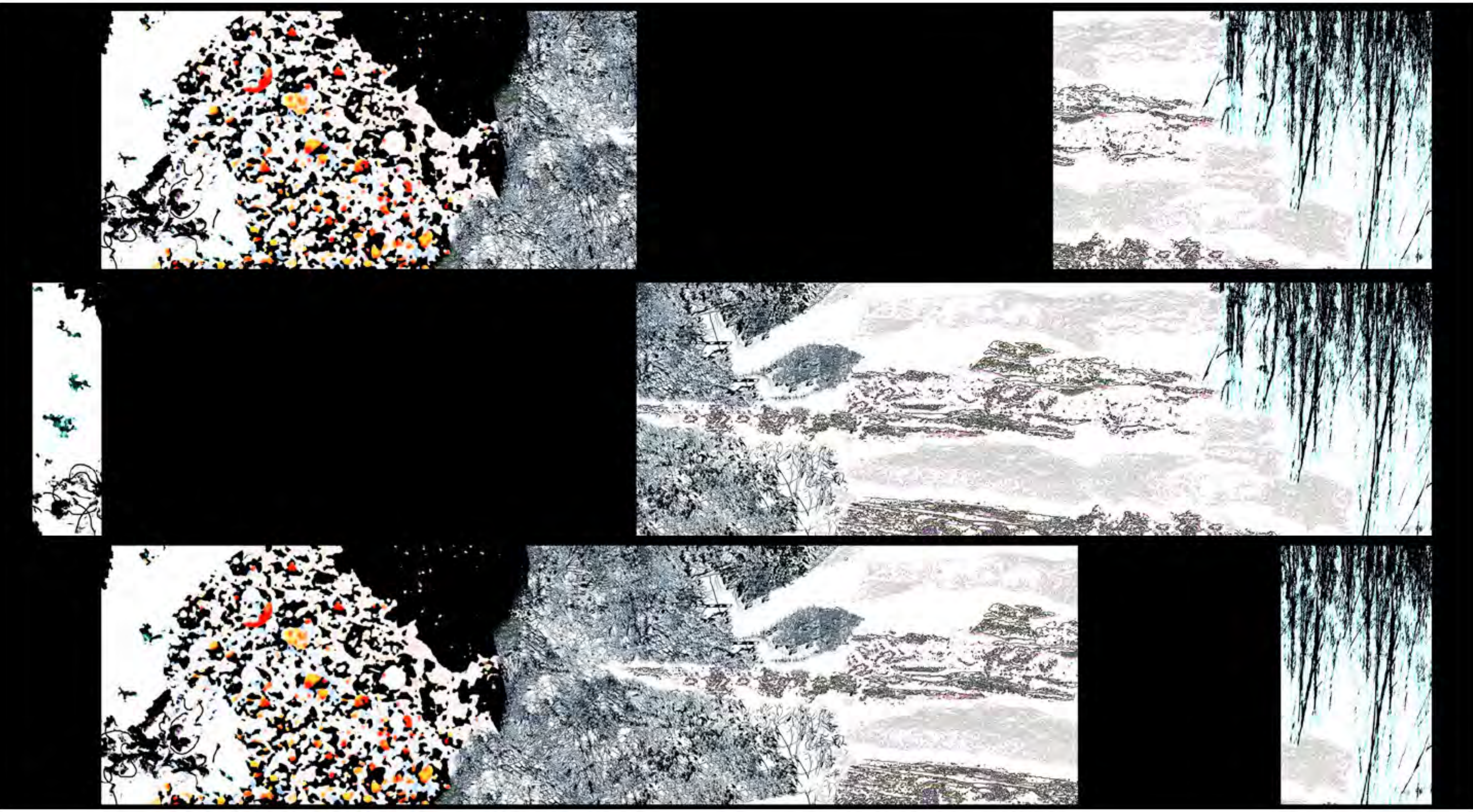
PROJECT 2: NATURAL FORMS AS GRAPHICAL NOTATION



The images were created from photographs of trees, rocks and lichens around the Porongurup range near Albany.

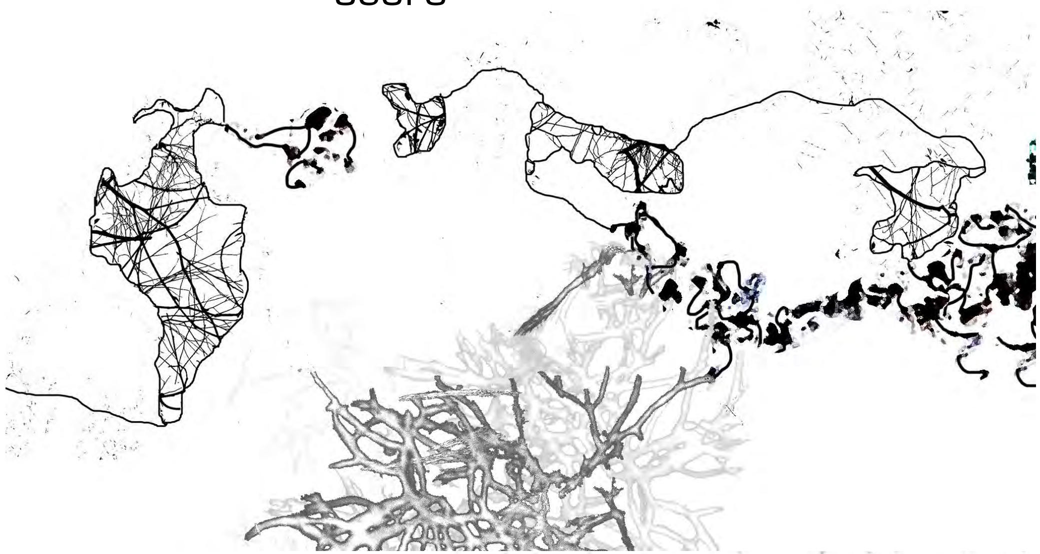
Nature Forms I [2014]

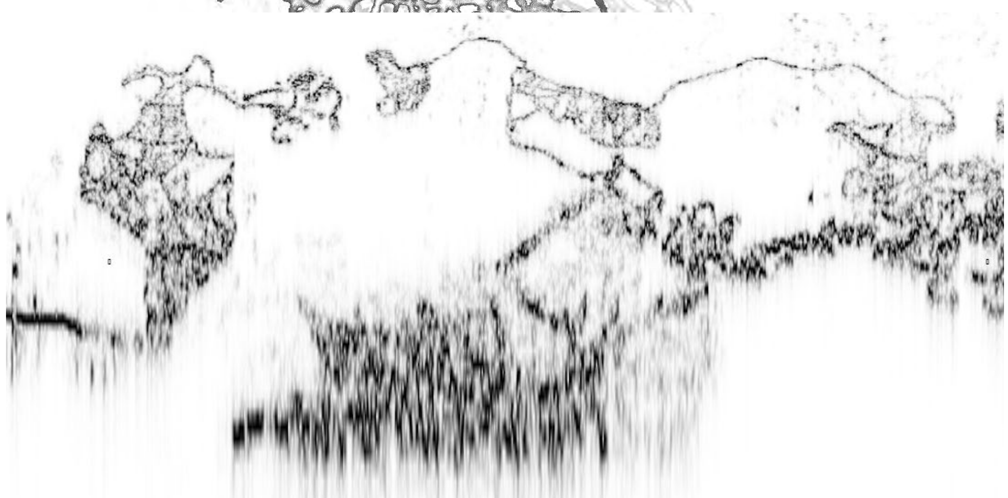
The score is “read” in contrasting ways by three performers and the computer and transformed into sound. The performers read from the same scrolling score semantically, aesthetic or as tablature and each of the scores fade to black indeterminately throughout the performance creating changing combinations of 1, 2 and 3 players.



The notation is simultaneously sonified using frequency, amplitude, brightness, noisiness and bark scale data to control the spatialisation and processing of the sonification data.

score

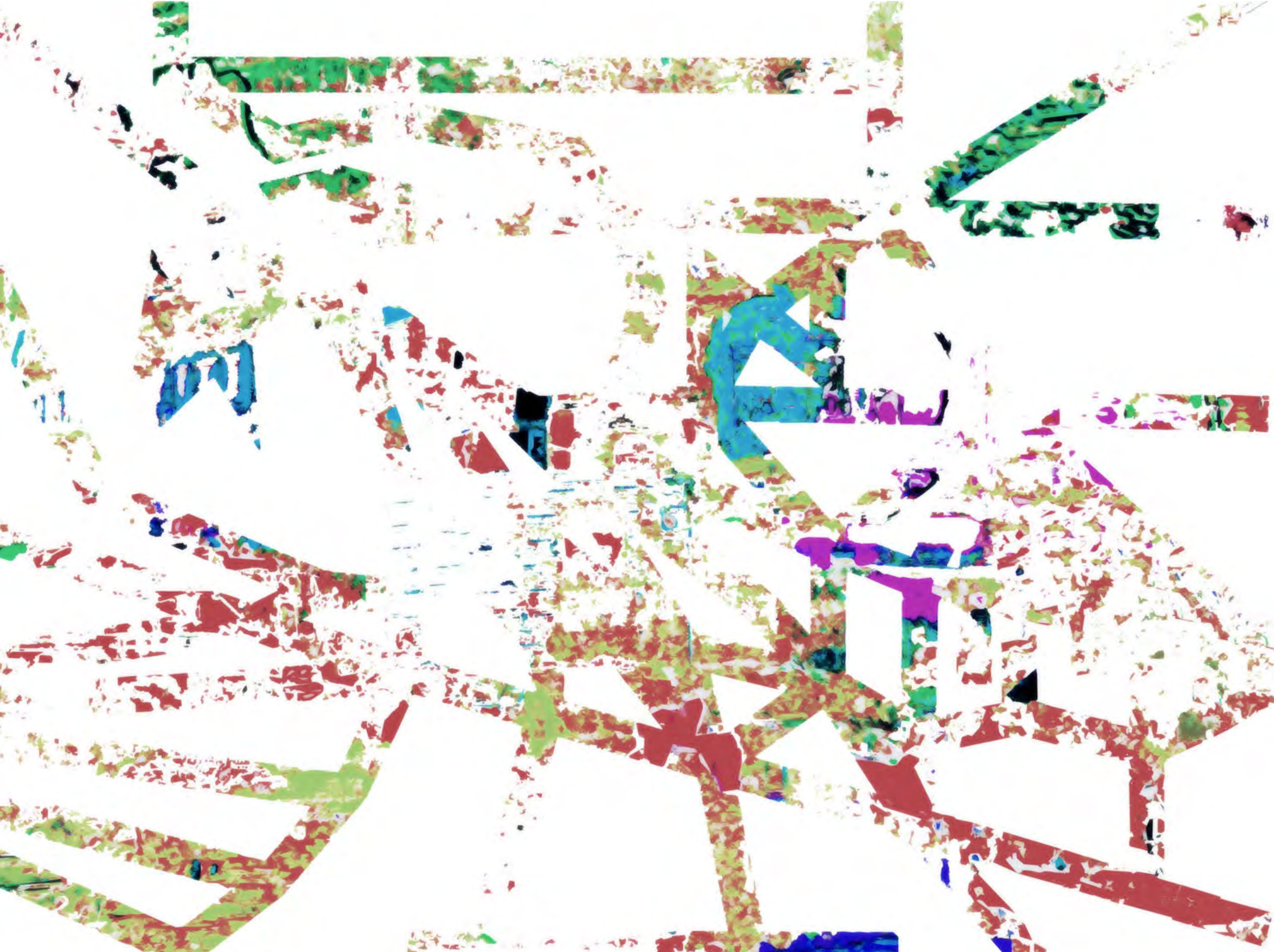


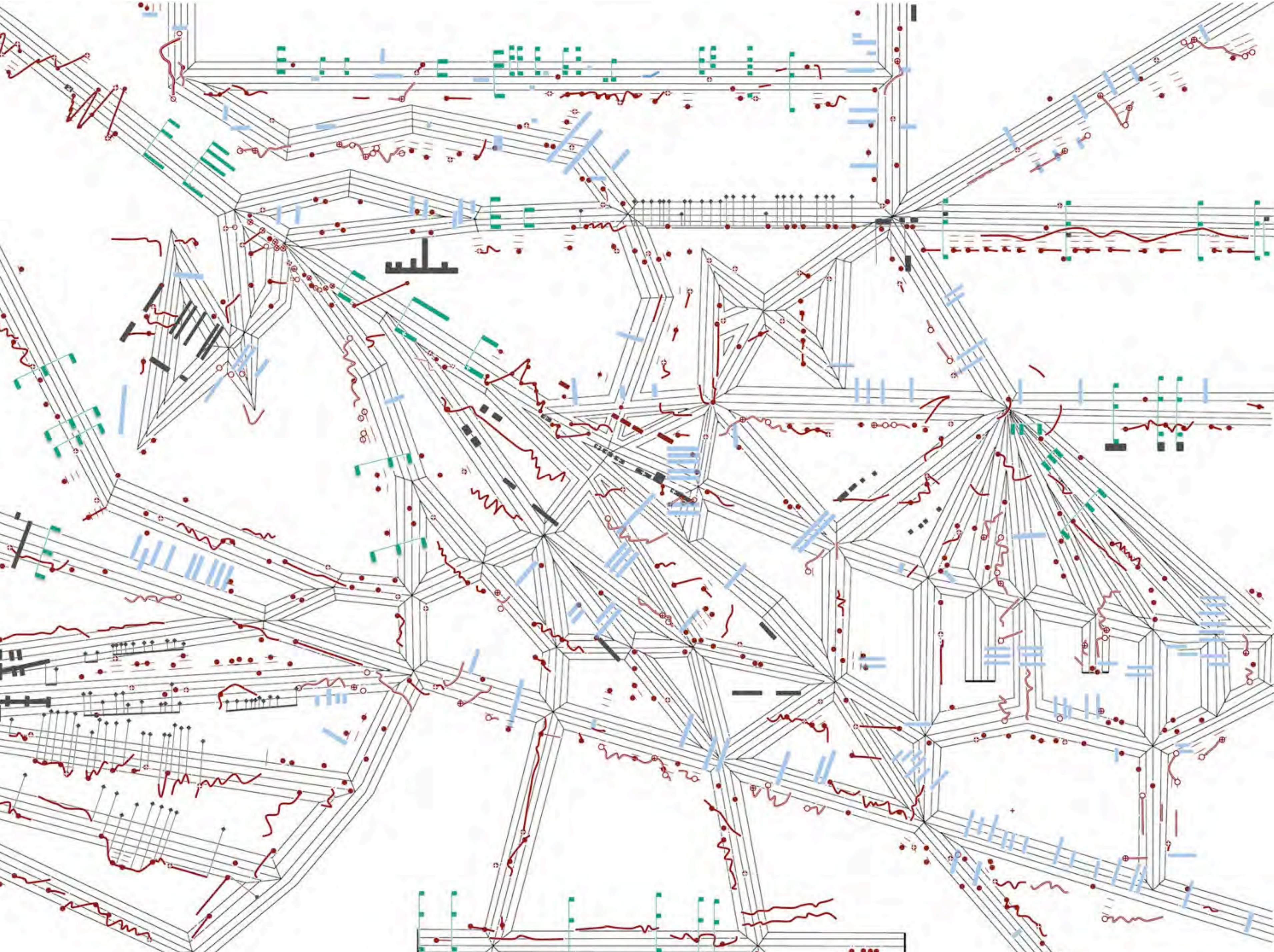


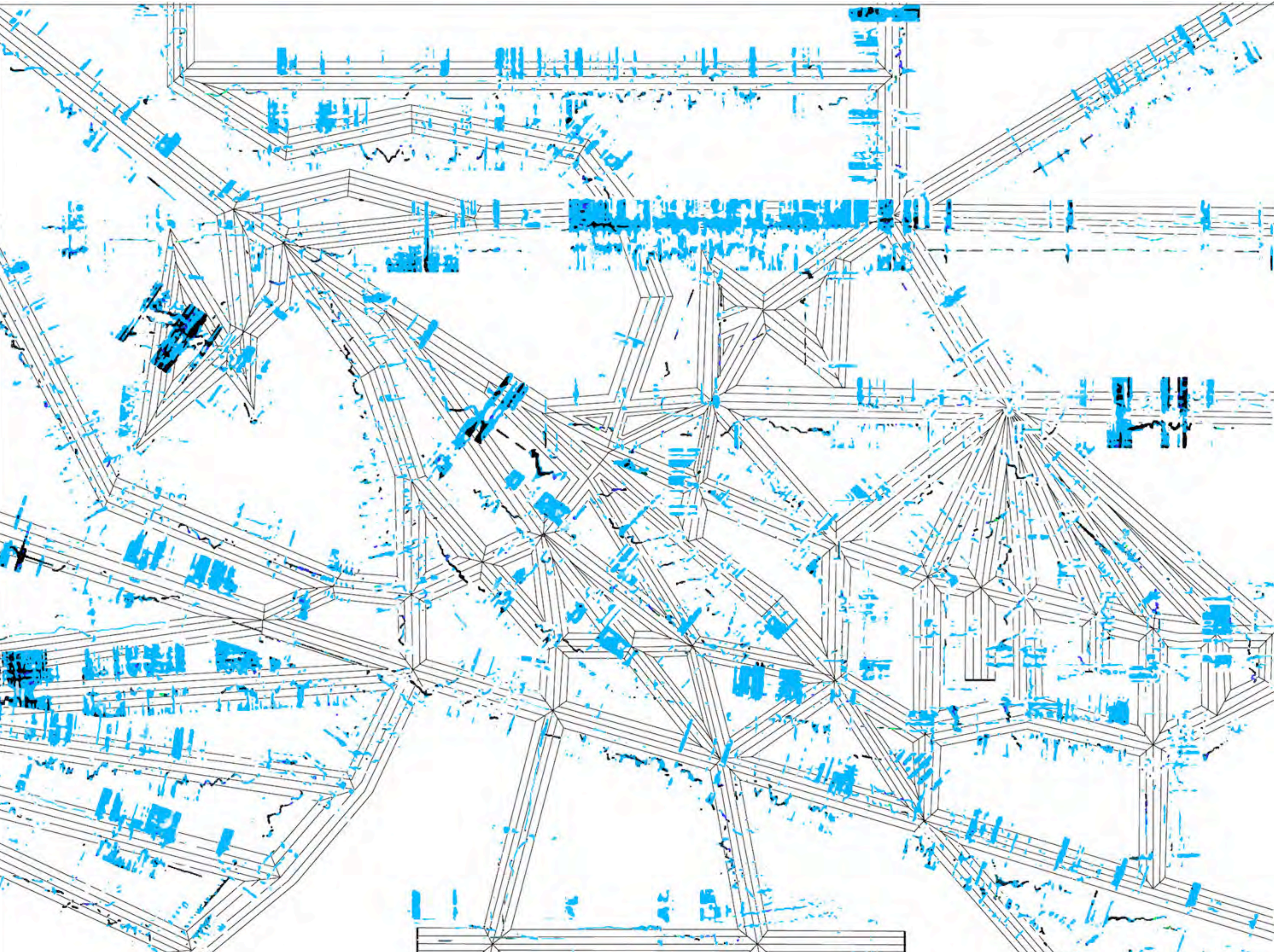
sonogram

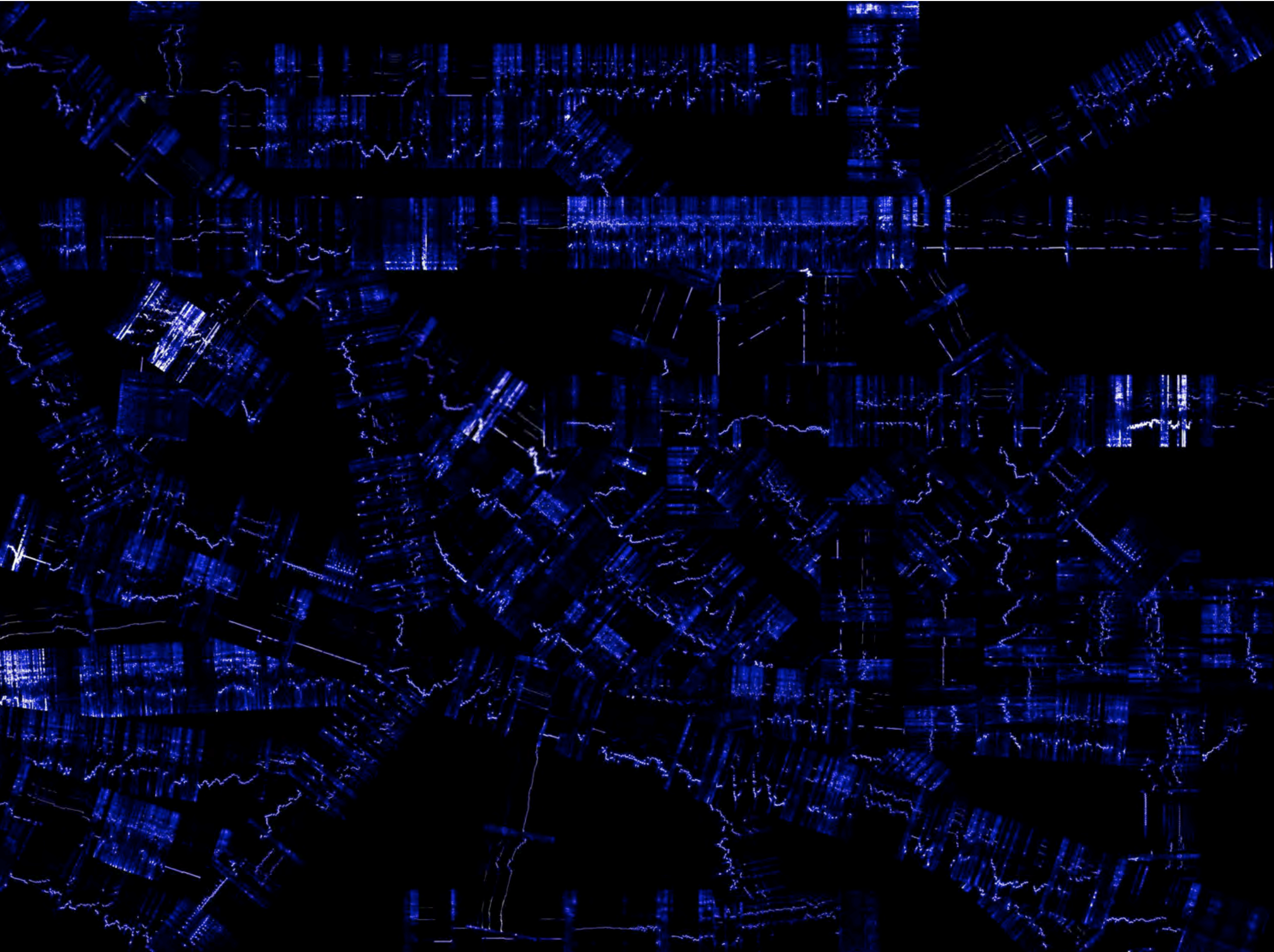
PROJECT 3: FORMS OF NOTATIONAL REPRESENTATION

Sacrificial Zones [2014]

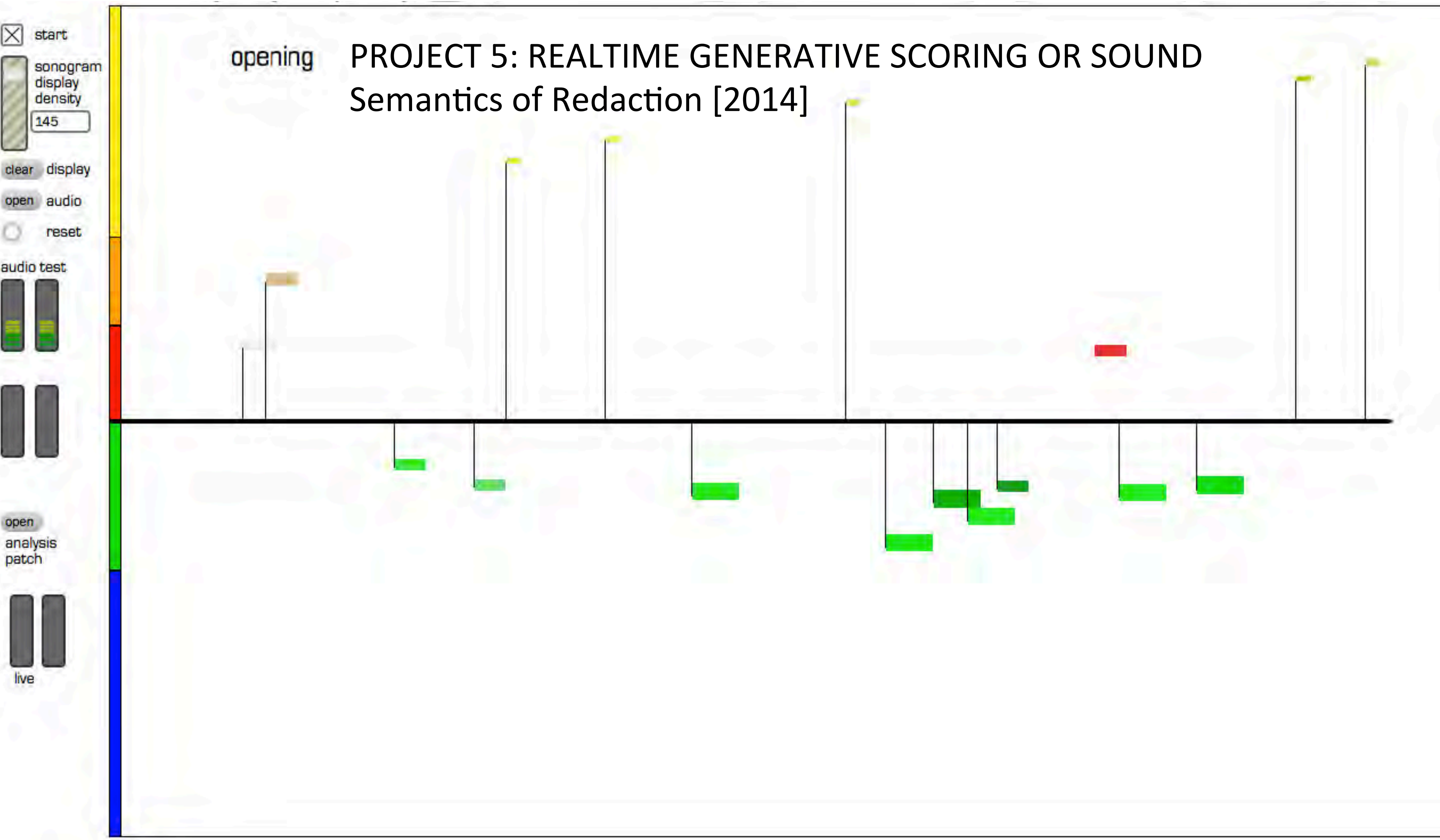








PROJECT 5: REALTIME GENERATIVE SCORING OR SOUND
Semantics of Redaction [2014]

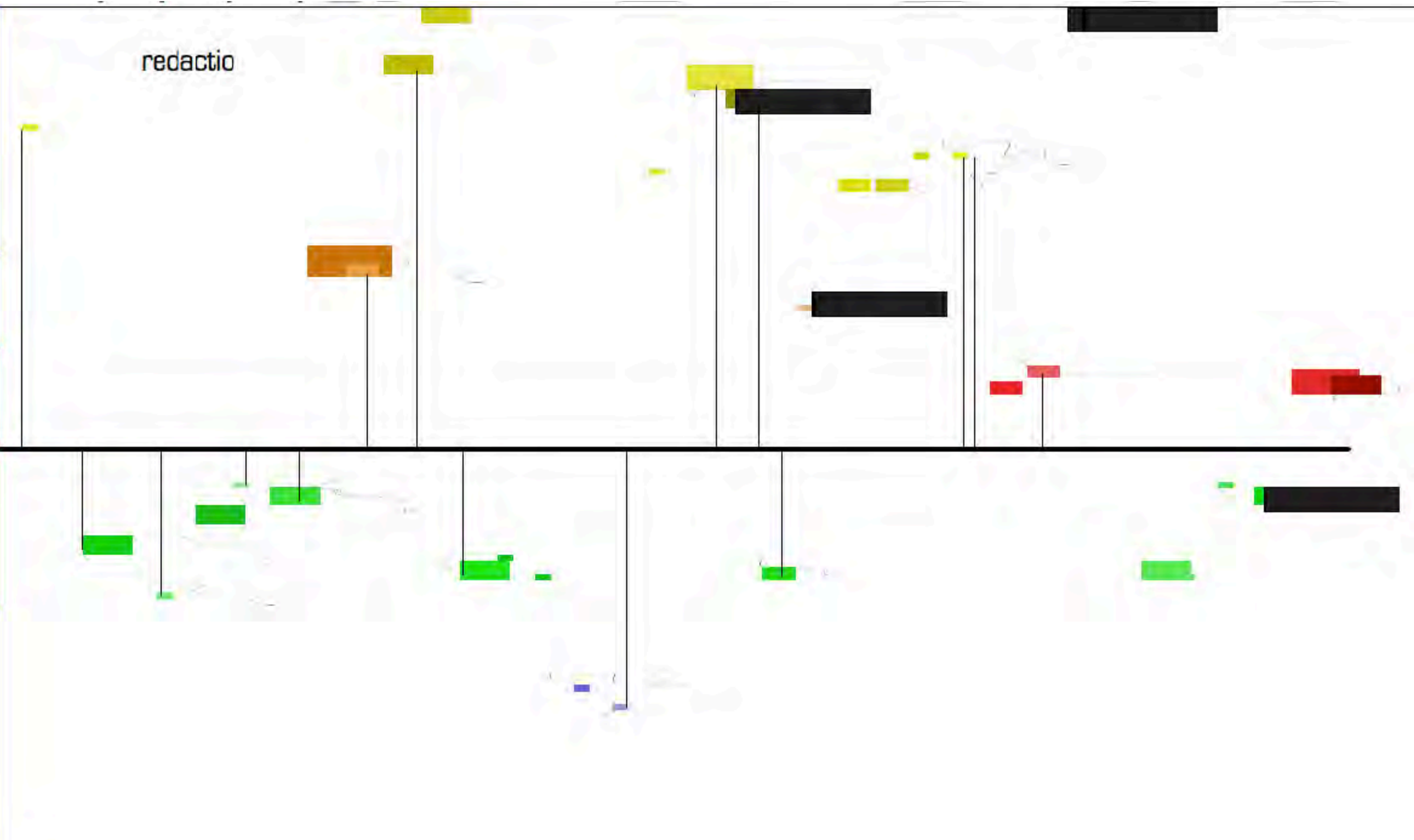


opening

“stems” and “noteheads” represent accents from the recorded speech. Noteheads are colour-coded to represent five instruments or families. Vertical variations (for example between the green noteheads here) can be interpreted as different instruments of timbral shades on a single (or few) instrument(s).

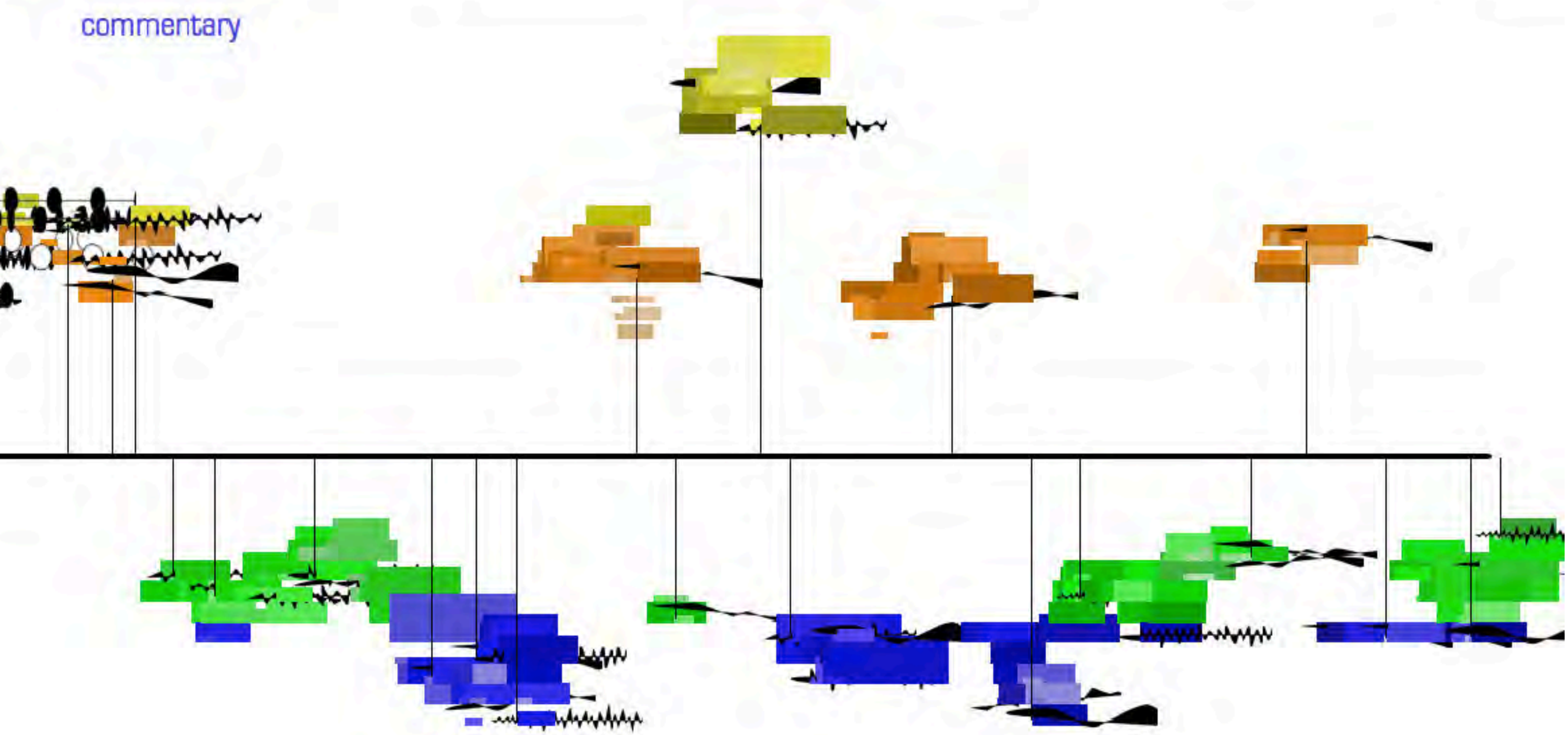
commentary I

The noteheads are extended indicating the "note" should be held proportionally for that duration. The wave-like black lines indicate timbral or dynamic variation of the note that remains constant or widens or narrows .



redactio I

Stems indicate accents. Noteheads without stems are “loose accents”. Black rectangles should be loud enough obscure the electronics. Other graphics indicate gestural flourishes.



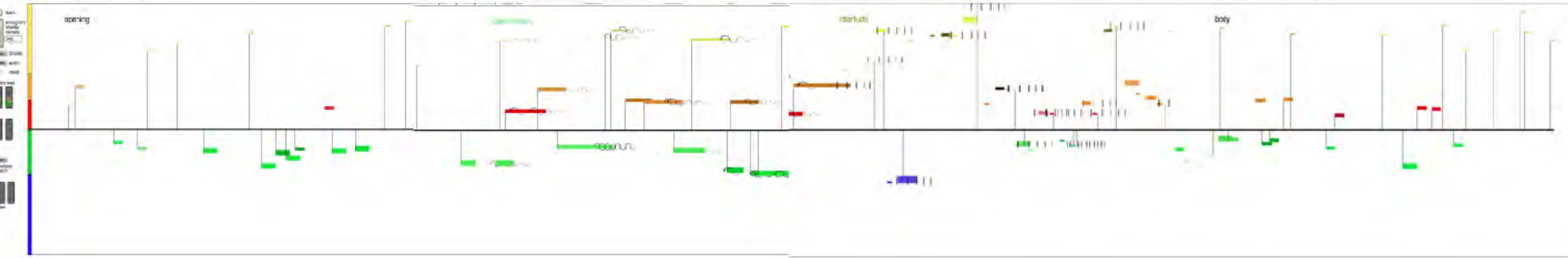
commentary II

More “timbral” colourations, but stems still indicating accents. A range of wave-like graphics.

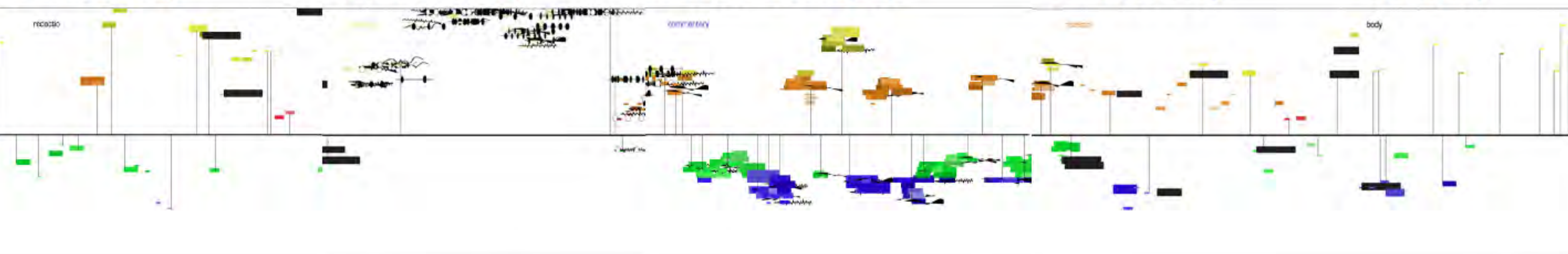
Performance notes: Semantics of Redaction

The formal structure is as follows:

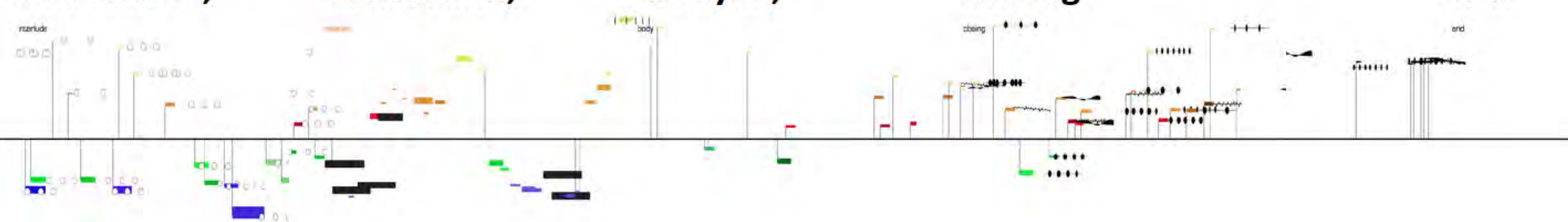
opening, commentary I, interlude I, body I,



redactio I, interlude II, commentary II, redactio II, body II,



interlude III, redactio III, body III, closing end



PROJECT 5: NOTATING THE SONIC ENVIRONMENT
Lyrebird Environment Player [2014]

MODELS FOR THE PRESENT WORK

Alvin Lucier's *(Hartford) Memory Space* (1970) and *Carbon Copies* (1989)

performers imitate the sounds of any indoor or outdoor environment (albeit pre-recorded), "as exactly as possible, without embellishment"

(Hartford) Memory Space

for any number of singers and players or acoustic instruments

Go to outside environments (urban, rural, hostile, benign) and record by any means (memory, written notations, tape recordings) the sound situations of those environments. Returning to an inside performance space at any later time, re-create, solely by means of your voices and instruments and with the aid of your memory devices (without additions, deletions, improvisation, interpretation) those outside sound situations.

When using tape recorders as memory devices wear headphones to avoid an audible mix of the recorded sounds with the re-created ones.

For performances in places other than Hartford, use the name of the place of performance in parentheses at the beginning of the title.

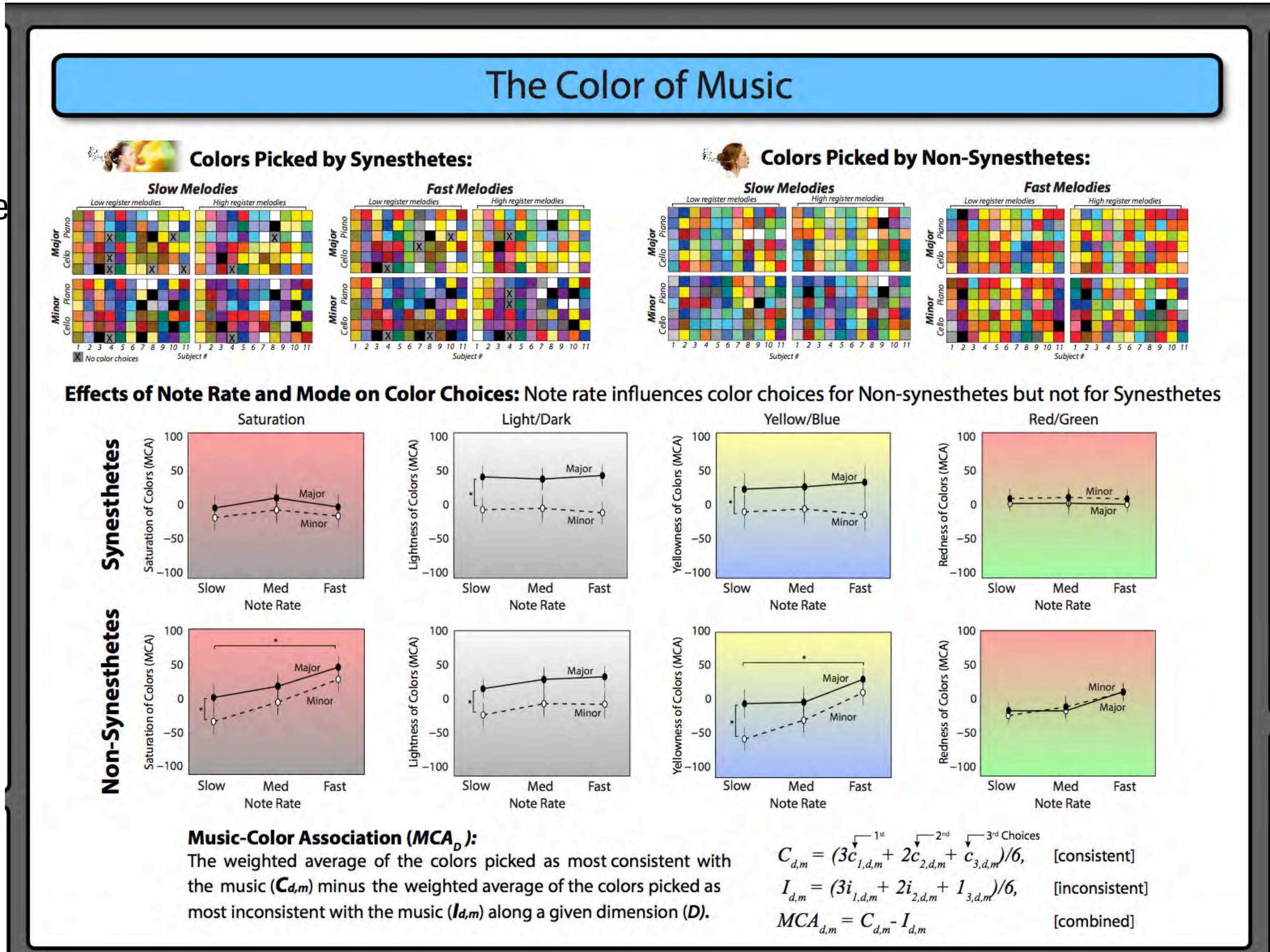
In this project, the objective of interaction between a live performer and environmental sounds was broadened through the addition of a visual representation of the field recording, allowing the performer to see sonic features before they are sounded.

Percussionist Vanessa Tomlinson may use the scoreplayer as a score and/or as an indicator of the sonic features of a recorded environment.

It is envisaged that she will make a field recording and collect objects to play in the vicinity of the performance venue.

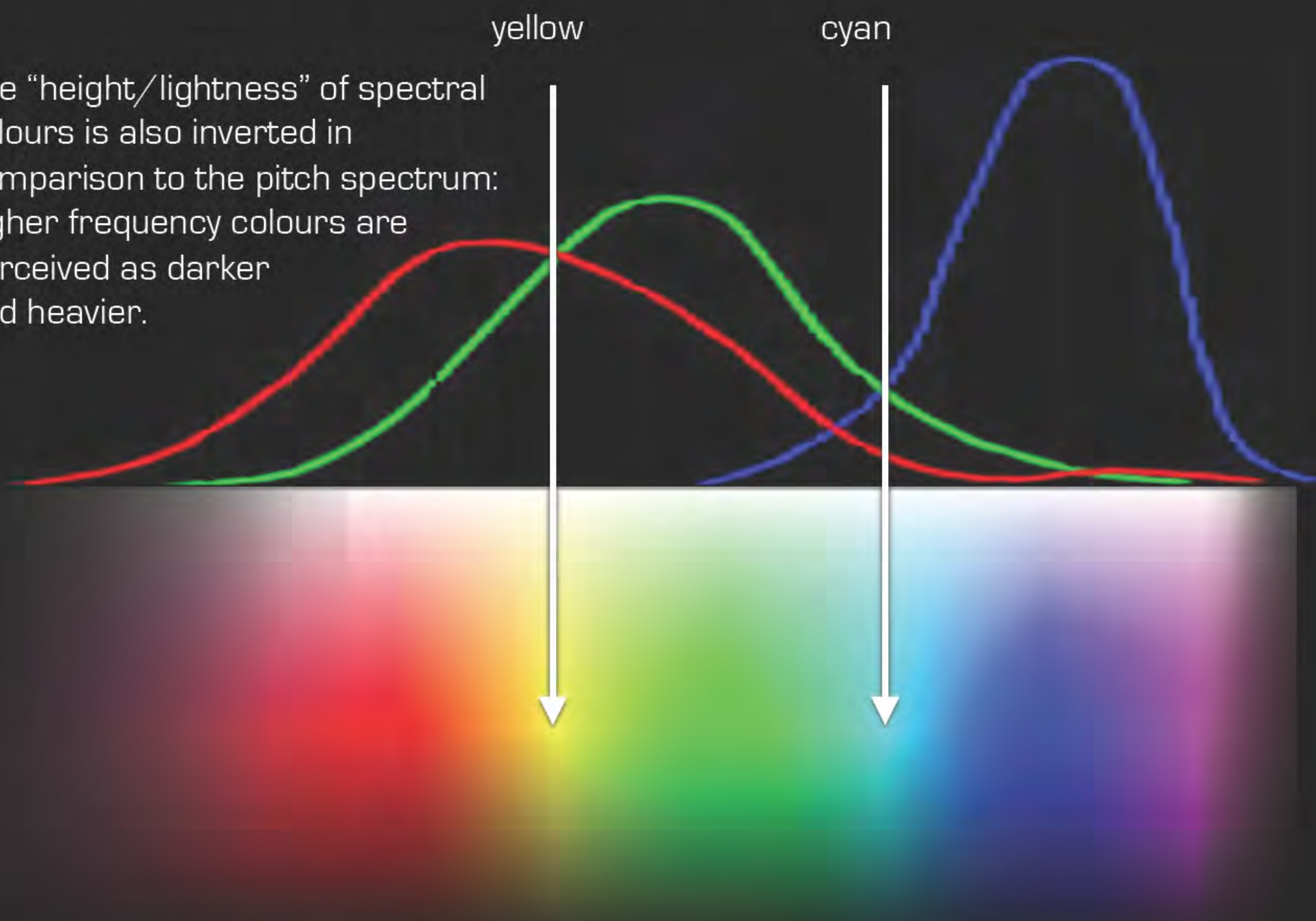
Research at The Visual Perception and Aesthetics Lab at the University of California Berkeley, however, suggests that there is a high degree of correlation between mappings of colour-to-sound in non-synaesthetes.

Griscom and Palmer have proposed that there are systematic relationships between colour and a range of musical phenomena including timbre, pitch, tempo, intervals, triads and musical genres (Griscom and Palmer 2012, 2013).

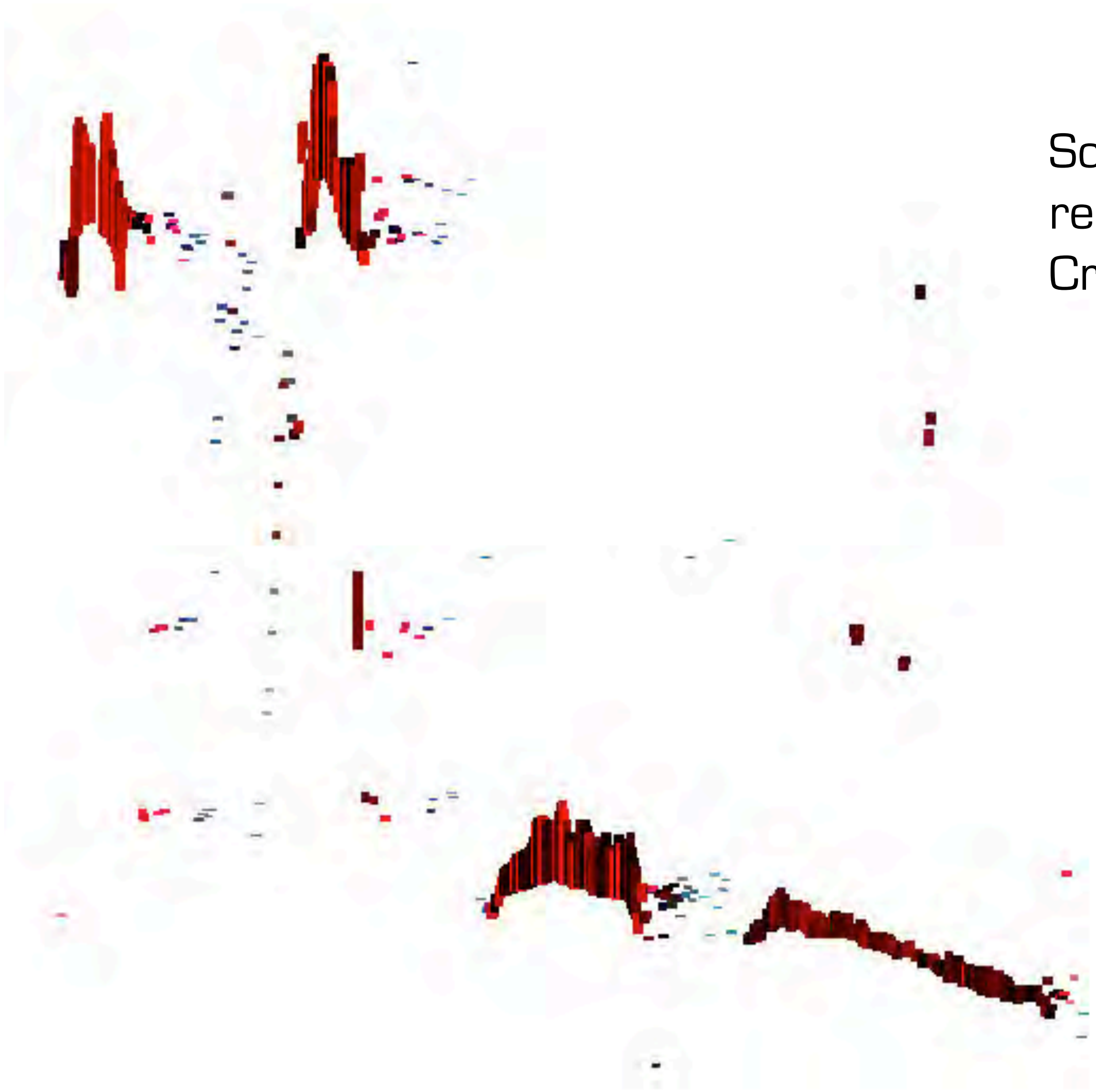


The eye contains only three kinds of colour detecting cone cells.
Colours that fall between them appear perceptually brighter.

The "height/lightness" of spectral colours is also inverted in comparison to the pitch spectrum: higher frequency colours are perceived as darker and heavier.



Pitch is rendered as vertical height.



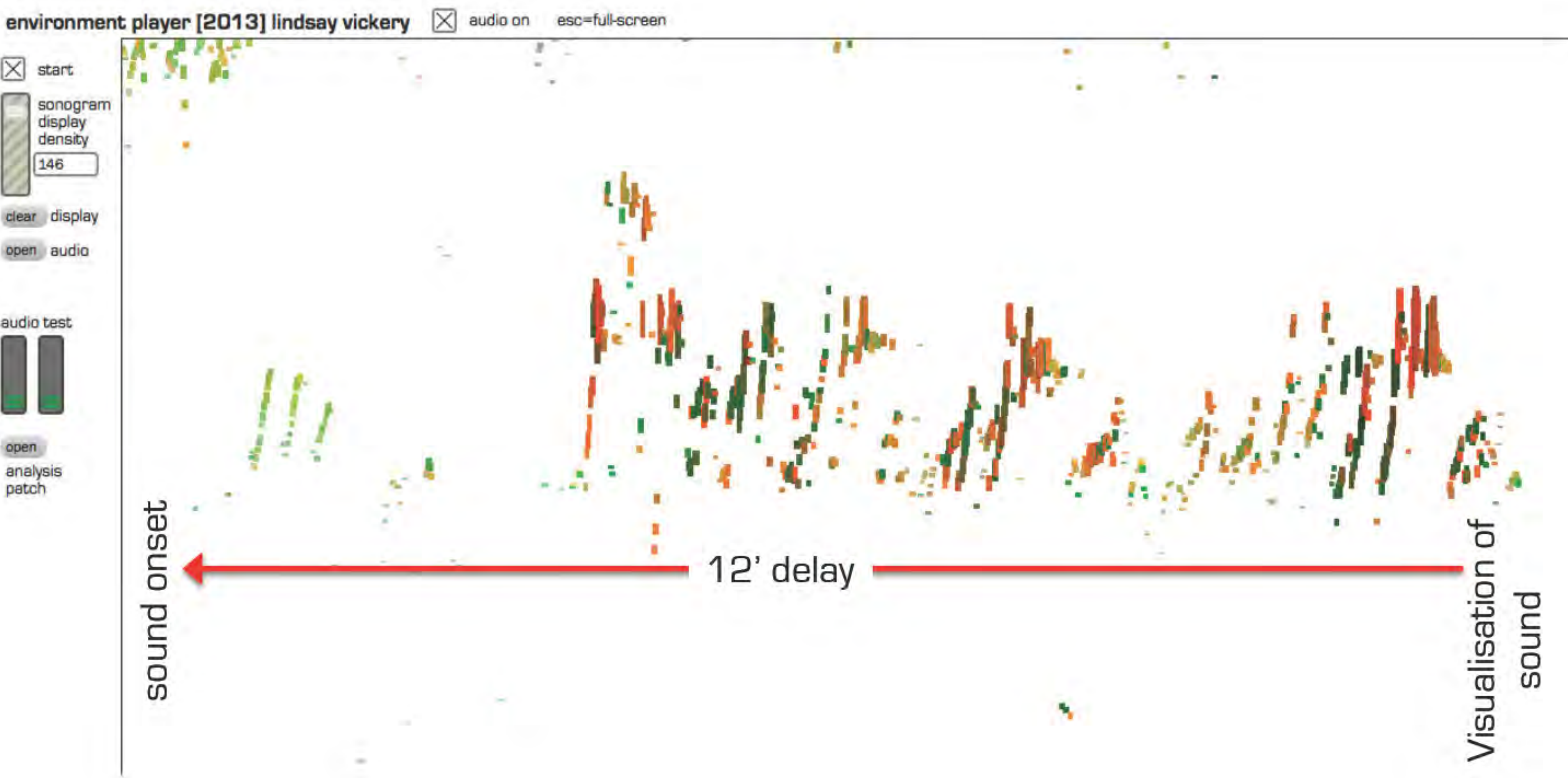
Scoreplayer representation of a Crow Caw

The amplitude of the frequency is represented by the height of the rectangle. The brightness, noisiness and bark scale value of each event determines the shade of the rectangle.

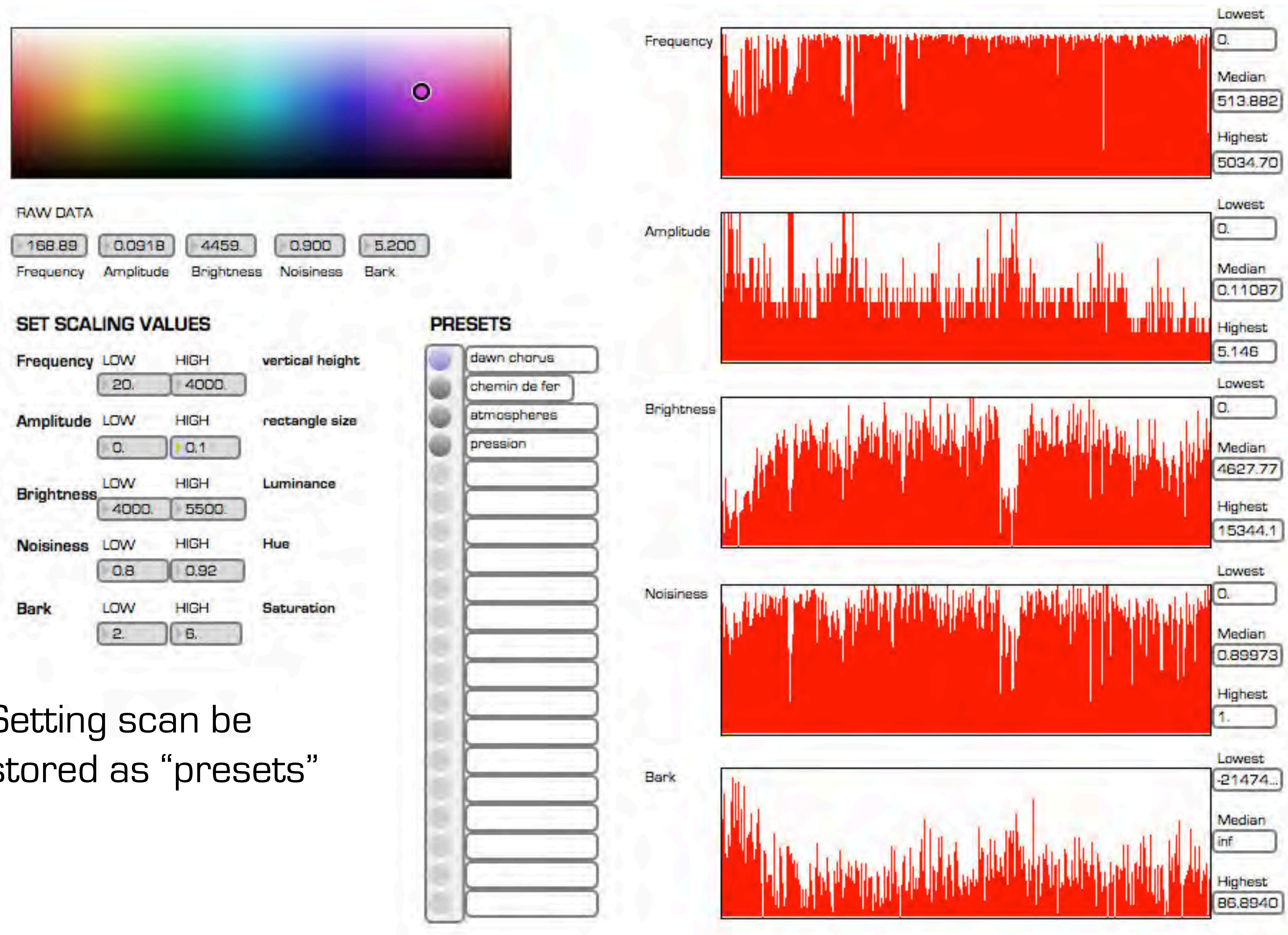
The amplitude of the frequency is represented by the size of the rectangle.

The brightness, noisiness and bark scale value of each event determines the luminance, hue and saturation of the rectangle's shade.

The output is displayed for the performer on the right of the screen and scrolls to the left. The source recording is delayed so that the sound is heard as the visual representation arrives at the "playhead" (the black line of the left of the screen.



The amplitude, frequency, brightness, noisiness and bark scale value of the recording can be scaled via an analysis patch.

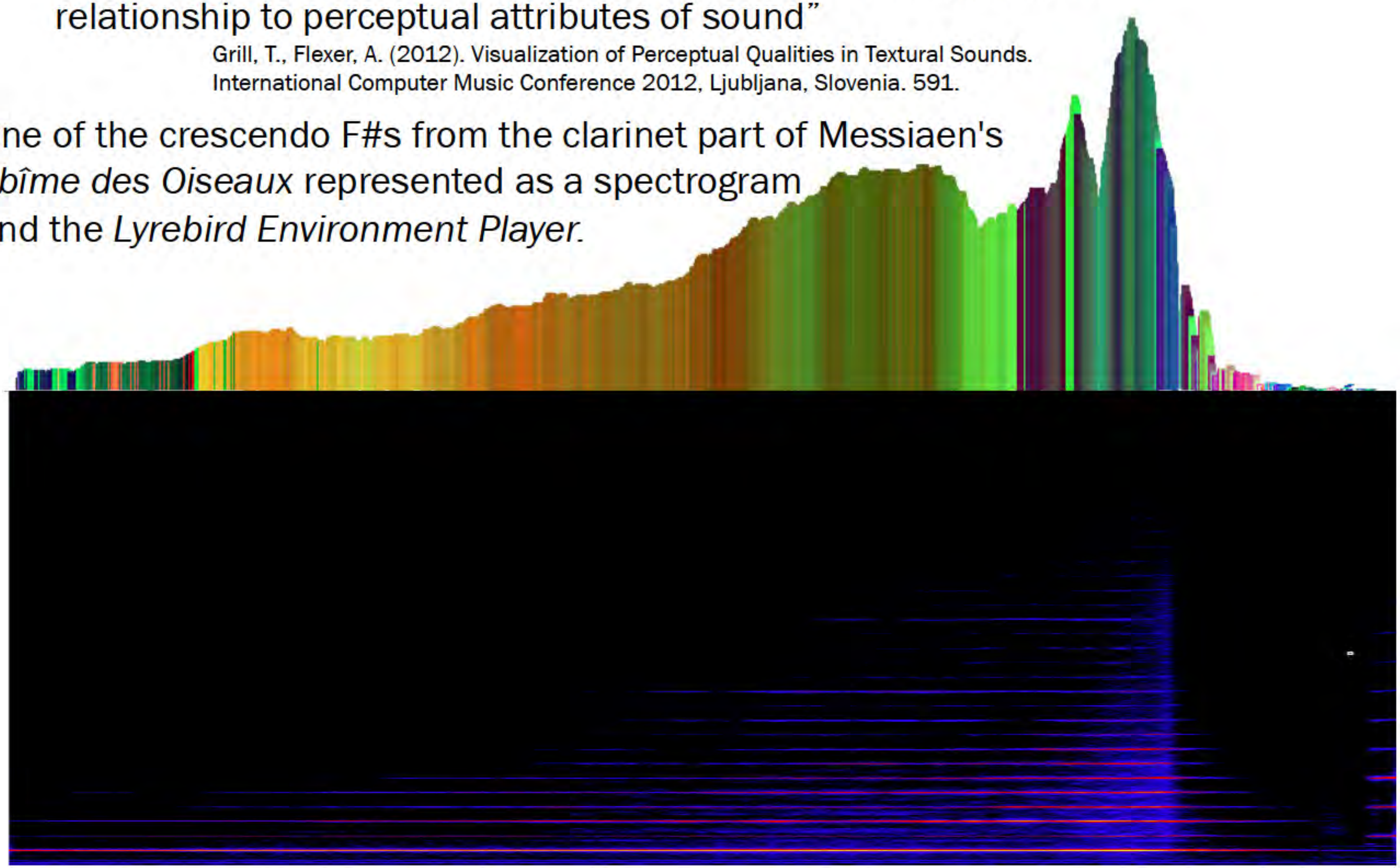


Setting scan be stored as “presets”

The work employs an alternate form of spectrogram in which, rather than visualizing the energy at every sinusoidal peak, only the strongest peak, coloured according to brightness, noisiness and bark scale analysis

> Spectrogram "visualizations are highly abstract, lacking a direct relationship to perceptual attributes of sound"
>
> Grill, T., Flexer, A. (2012). Visualization of Perceptual Qualities in Textural Sounds. International Computer Music Conference 2012, Ljubljana, Slovenia. 591.

One of the crescendo F#s from the clarinet part of Messiaen's *Abîme des Oiseaux* represented as a spectrogram and the *Lyrebird Environment Player.*

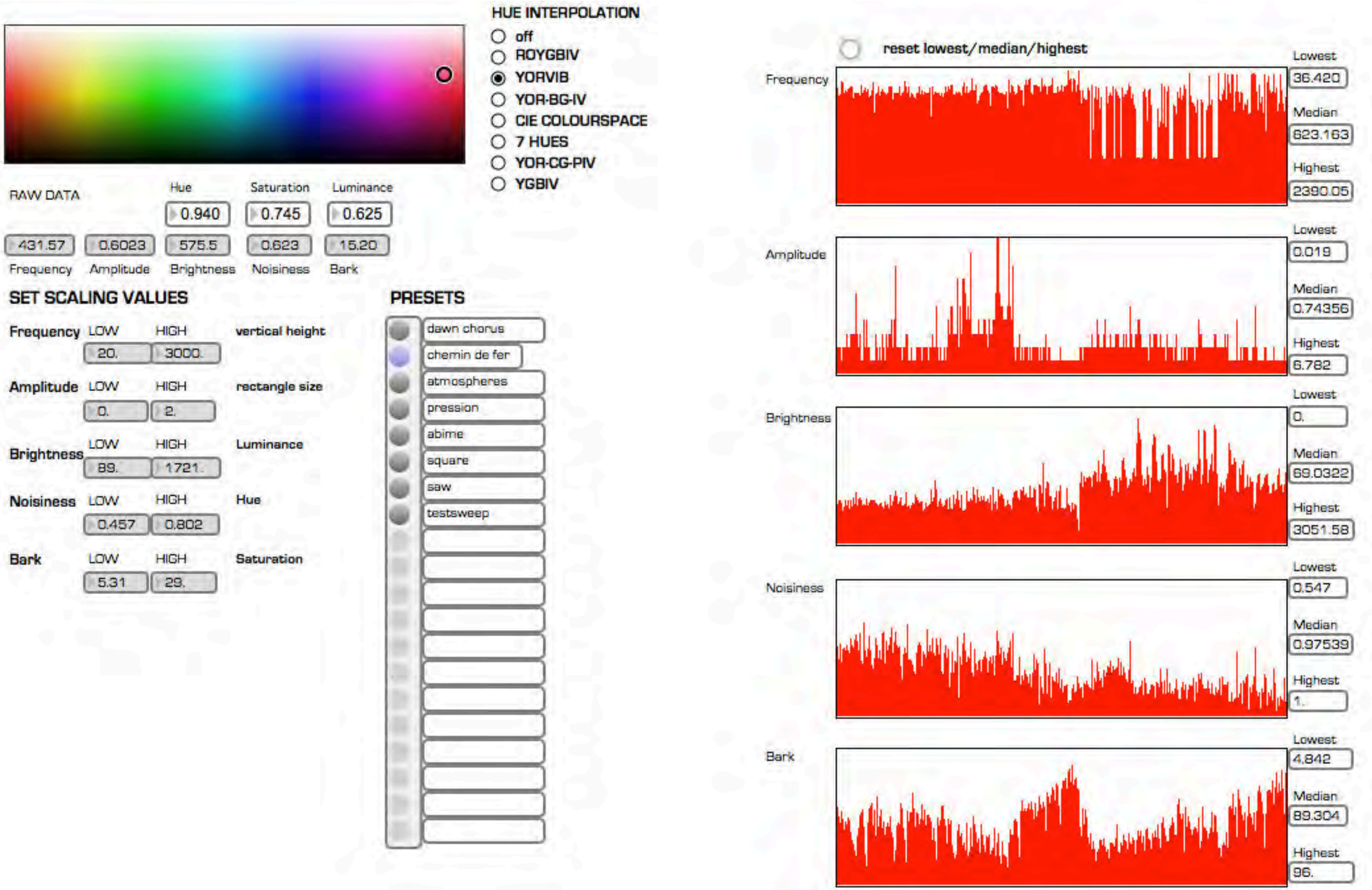


The amplitude of the frequency is represented by the height of the rectangle. The brightness, noisiness and bark scale value of each event determines the shade of the rectangle.

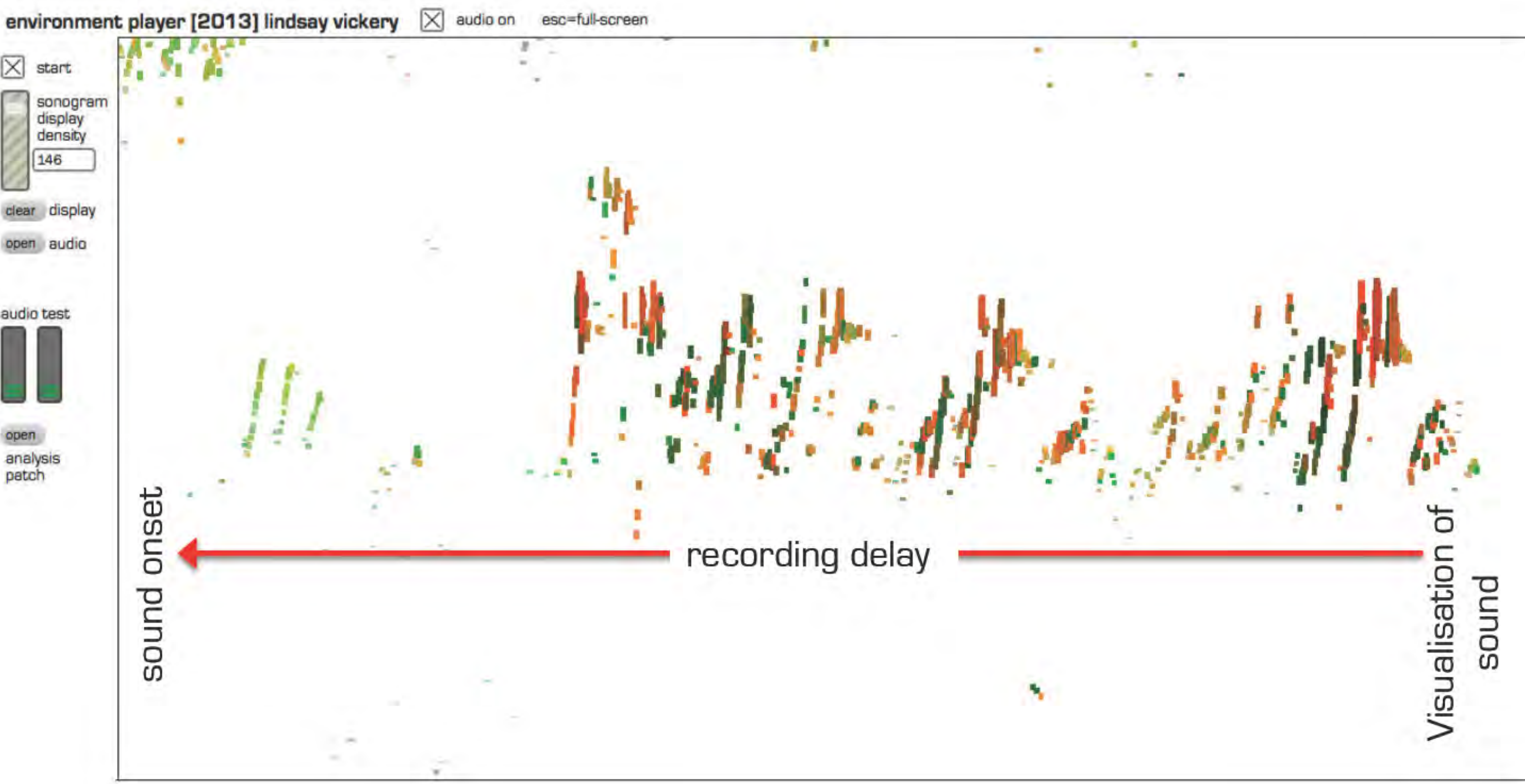
The amplitude of the frequency is represented by the size of the rectangle.

The brightness, noisiness and bark scale value of each event determines the luminance, hue and saturation of the rectangle's shade.

The amplitude, frequency, brightness, noisiness and bark scale value of the recording can be scaled via an analysis patch.

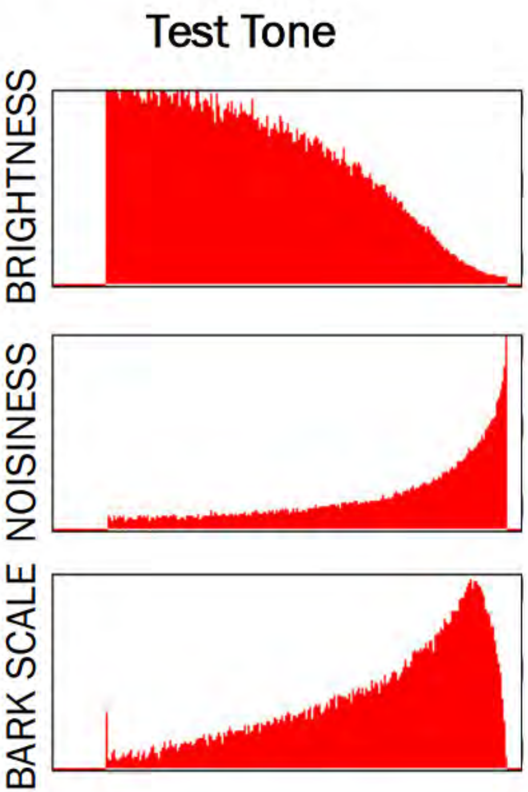


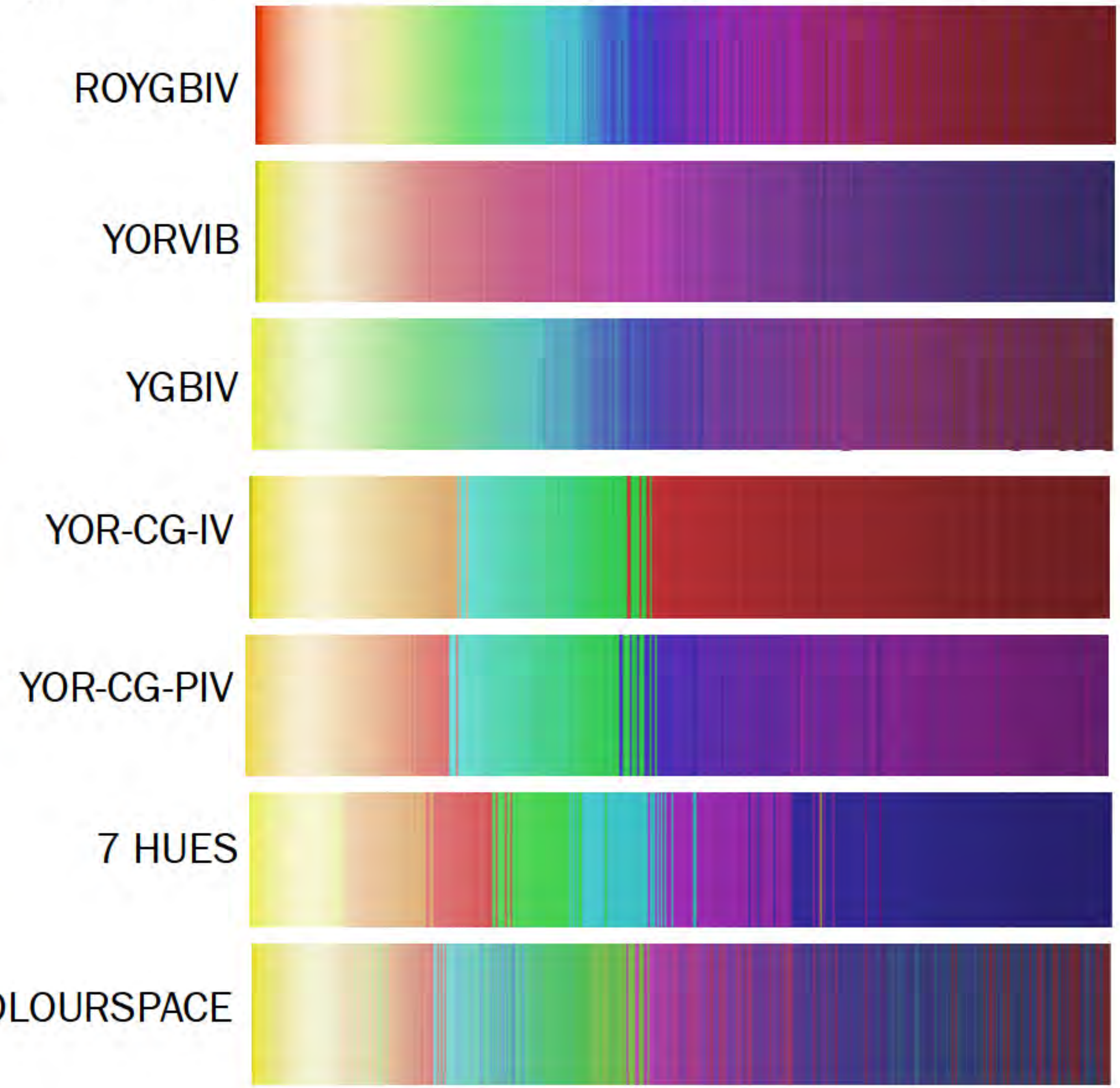
The output is displayed for the performer on the right of the screen and scrolls to the left. The source recording is delayed so that the sound is heard as the visual representation arrives at the "playhead" (the black line of the left of the screen.



Colour Schema

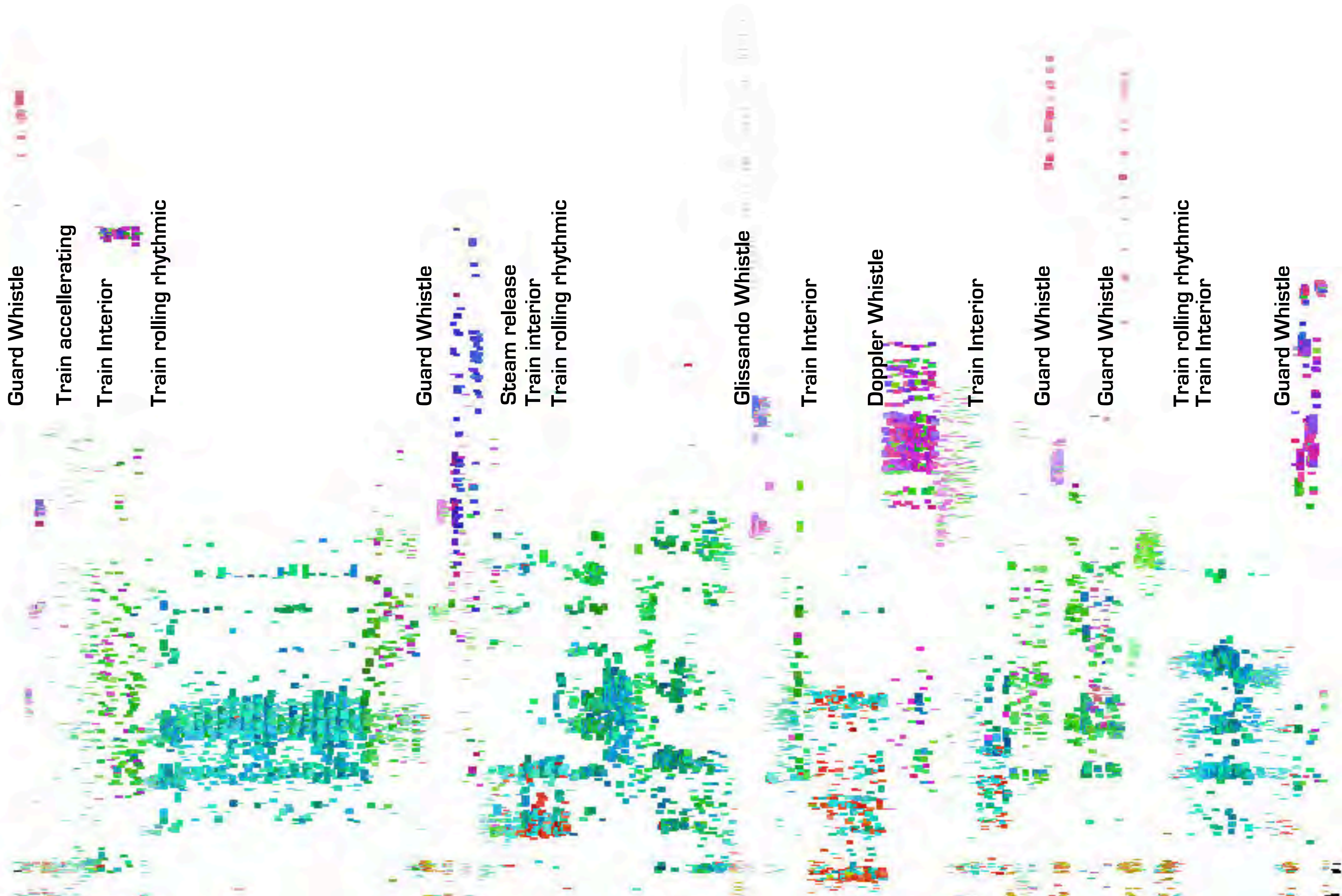
Lyrebird at present allows for the following mappings of timbral brightness to hue. The spectra below depict a test tone of increasing brightness, noisiness and bark scale depicted by a variety of mappings.

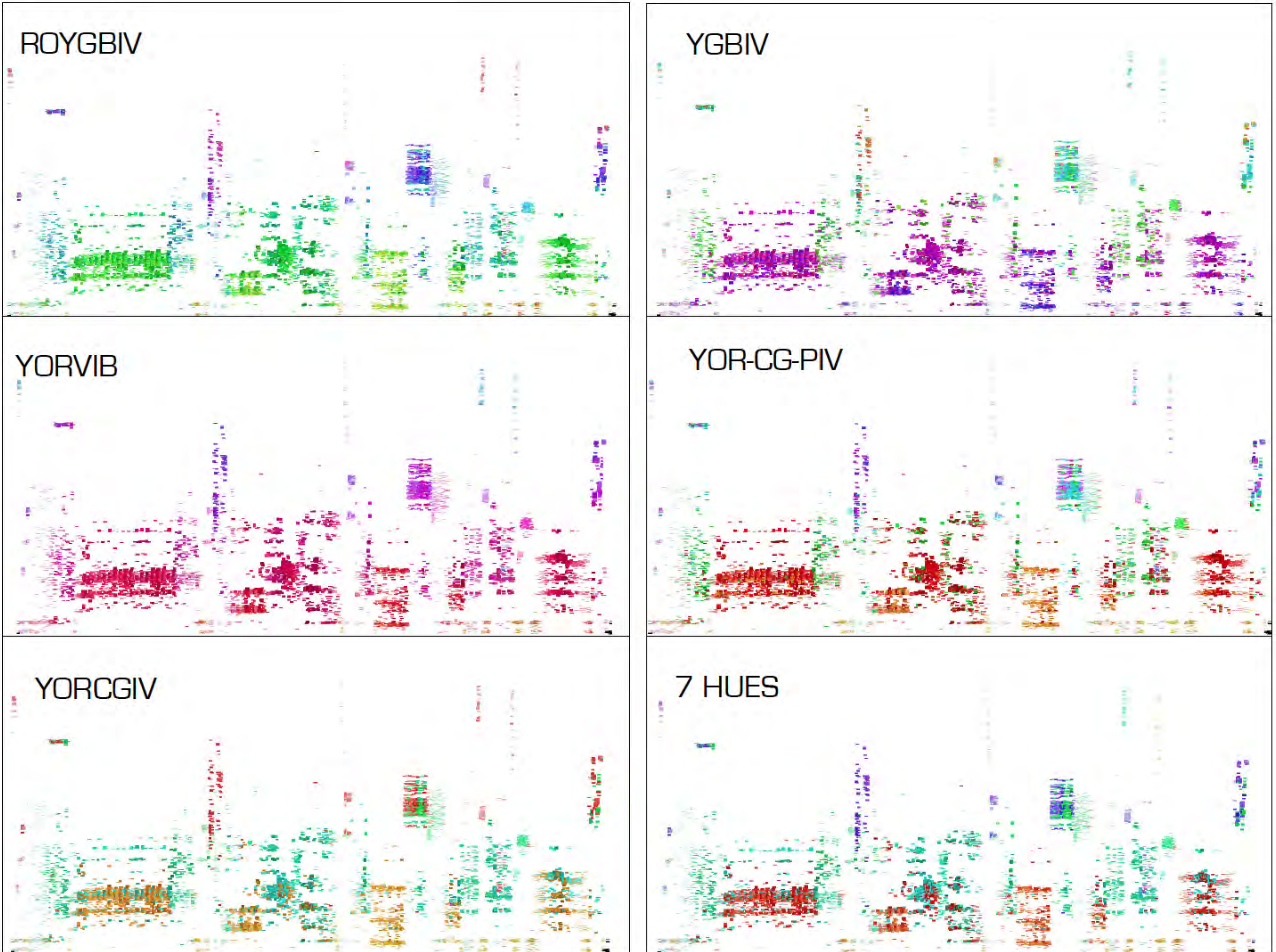


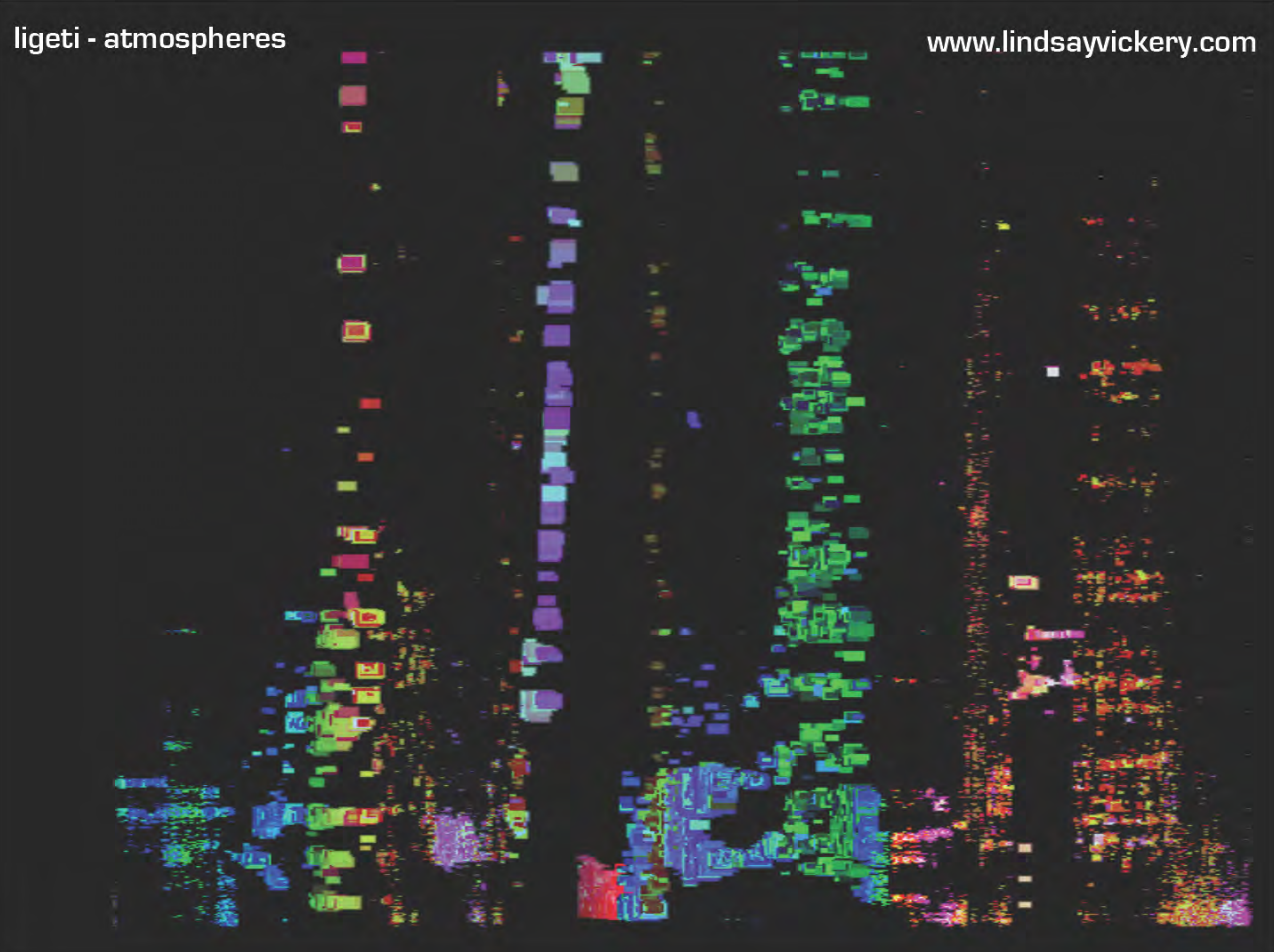


Lyrebird as an analysis tool?

PIERRE SCHAEFFER **ETUDE AU CHEMIN DE FER** CIE COLOURSPACE




ROYGBIV
YGBIV
YORVIB
YOR-CG-PIV
YORCGIV
7 HUES


ligeti - atmospheres
www.lindsayvickery.com