2010

The analysis of composition techniques in utp_: Synthetic composition for electroacoustic ensembles

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Honours Dissertation

Bachelor of Music (Honours)

The analysis of composition techniques in *utp_*: synthetic composition for electroacoustic ensembles

Submitted 4th November 2010

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Bachelor of Music: Music Technology

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USE OF THESIS

Abstract

This thesis attempts to analyse and describe a number of spectrally oriented composition techniques for composing music for electroacoustic ensemble. These techniques aim to achieve a synthetic approach to combining electronic and acoustic sound sources in live performance. To achieve this, an in-depth analysis of *utp_* (2008) by Alva Noto and Ryuichi Sakamoto in collaboration with Ensemble Modern is conducted. *utp_* utilises a large acoustic ensemble, live electronic processing, pre-recorded electronic sound and video projections in performance.

The discussion also queries the possible problems of electroacoustic performance, and examines ways to resolve the most prevalent issues. This involves a discussion of the materials of electroacoustic works, timbral differences in acoustic and electronic sounds and liveness in electroacoustic music performance. The analysis involves using spectral and score analysis to identify composition techniques. The final section describes the way these composition techniques are applied in my own work for electroacoustic ensemble, *lucidity*.

Declaration

I certify that this thesis does not, to the best of my knowledge and belief:

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(ii) contain any material previously published or written by another person except where due reference is made in the text; or

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Acknowledgements

Thanks firstly and most importantly to my supervisor Dr. Cat Hope, who has provided amazing guidance and support over many years. Thanks to my composition teacher Lindsay Vickery for enthusiasm in the project and wealth of knowledge. Thanks to my teachers throughout my studies, Dr. Malcolm Riddoch and Stuart James for their expertise and dedication.

Many thanks to the incredible and generous performers who helped create and develop my work, Ben Hamblin, Lindsay Vickery, Tristen Parr, Lyndon Blue, Stina Thomas, Christopher de Groot, Callum Moncreiff and James Paul, this project would not have been possible without your assistance.

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Introduction

*utp_* is a collaborative multimedia work between the artists Alva Noto (aka Carsten Nicolai, b. 1965, Germany), Ryuichi Sakamoto (b. 1952, Japan) and contemporary music ensemble Ensemble Modern (formed 1980, Germany). The work creates unique sound spectra and textures through the combination and juxtaposition of electronics and acoustic instrumentation, utilizing an ensemble of eleven acoustic instruments, live processing, pre-recorded sound, video synchronisation and video projections. The *utp_* CD package contains the audio recording, full score booklet, additional materials booklet (containing diagrams, reviews, pictures and liner notes) and DVD (containing video of the performance and workshops).

This thesis aims to define and describe techniques for the combination of electronic and acoustic sounds, through structural and spectral analysis of the work *utp_*. Selected composition techniques will then be transformed and absorbed into my own compositional style in my work *lucidity*. It is the goal of this thesis to identify ways in which acoustic and electronic sound sources can be synthetically combined.

Definitions and Terms

The term composition refers to both the process and the product of organising materials in order to create music.[1] This is achieved through any means, such as the notation of parts, constructing improvisation directions, computer programming and specification of recording and amplification techniques. Improvisation is defined as any performer decisions at the point of performance.[2] I will be using the term electroacoustic to describe any music that employs electronic and acoustic sound sources in a live performance.[3] The term texture is used to describe the layering of sound timbres and the combination of multiple sound sources at any given moment.[4] The term spectra refers to the *visualisation* of overtones present at any given moment. While both texture and spectra refer to the overall sound quality at any given time, texture accounts for the perception of sound, while spectra refers to the scientific

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[1] Stephen Blum, "Composition," Oxford Music Online, http://0-www.oxfordmusiconline.com.library.ecu.edu.au/subscriber/article/grove/music/06216 (accessed October 23, 2010).
[2] Bruno Nettl et al., "Improvisation," Oxford Music online, http://0-www.oxfordmusiconline.com.library.ecu.edu.au/subscriber/article/grove/music/13738 (accessed October 23, 2010).
[3] This term is primarily used to describe live applications in the writings of Karlheinz Stockhausen. This spelling of electroacoustic has been adopted rather than any other permutation due to its exclusive use in these writings, see Karlheinz Stockhausen and Jerome Kohl, "Electroacoustic Performance Practice," *Perspectives of New Music* 34, no. 1 (1996).
[4] Brian Newbould, "Texture," Oxford Music Online, http://0-www.oxfordmusiconline.com.library.ecu.edu.au/subscriber/article/opr/t114/e6743 (accessed October 23, 2010).

analysis and empirical data present.[5] Synthetic composition is a term that has been used by many composers, musicians and writers that alludes to the combination of musical parts to create a new, greater substance.[6] Synaesthesia refers to the neurological condition in which cross linking of senses occurs. This is thought to allow for metaphorical thought due to forming abstract connections between the senses, e.g. hearing and vision.[7]

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[5] Robert Cogan, *New Images of Musical Sound* (Cambridge, Mass. ; London: Harvard University Press, 1984), 6-12.
[6] Tristan Murail, "The Revolution of Complex Sounds," *Contemporary Music Review* 24, no. 2/3 (2005): 5.
[7] V. S. Ramachandran, *A Brief Tour of Human Consciousness : From Imposter Poodles to Purple Numbers* (New York: Pi Press, 2004), 60-82.

Chapter One

1. Electroacoustic Music

1.1. A Brief History of Live Electroacoustic Music.

Electroacoustic music can be seen as forming a "metagenre"[8] of electronic music, which as defined by Joanna Demers, encompasses institutional electroacoustic works that derive themselves from academia and trace a lineage back to Edgar Varèse (b. 1883, France) and Karlheinz Stockhausen (b. 1928, Germany).[9] This is largely due to the development of many compositions in or around academic institutions such as the *Institute de Recherche et Coordination Acoustique/Musique* (IRCAM, France) and the *Groupe de Recherches Musicales* (GRM, France). At these government subsidised institutions technological developments are paired with creative uses, forging the path of music technology.[10] Stockhausen and Varèse were among the first composers to call for the use of electronic sound in their music, using electronics in performance along with acoustic instruments as early as 1955 with Varèse's *Deserts* for orchestra and tape,[11] and Stockhausen's *Kontakte* (1958-60) for electronic sounds with optional piano and percussion.[12]

Early experiments involved the use of pre-recorded tape sounds that would be played back through loudspeakers in a concert setting, in addition to the instrumental sound. In the case of *Deserts*, the orchestra would not sound at any time the tape was playing, but was composed to demonstrate similar musical elements in the electronic and acoustic sounds.[13] Tape music flourished with *musique concrète* led by Pierre Shaeffer (b. 1920, France), music that explores 'the sound object' through the recording and manipulation of found sounds and acousmatic playback over loudspeakers. Iannis Xenakis (b. 1922, Greece) is credited with developing the first granular synthesis techniques at this time, by splicing pre-recorded tape into short samples and then layering them into thick, continuous sound, as used in works such as *Concret PH*

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[8] Joanna Teresa Demers, *Listening through the Noise : The Aesthetics of Experimental Electronic Music* (Oxford ; New York: Oxford University Press, 2010), 6.
[9] Ibid.
[10] Ibid., 142.
[11] Thom Holmes, *Electronic and Experimental Music : Technology, Music, and Culture*, 3rd ed. (New York: Routledge, 2008), 338.
[12] Ibid., 67-68.
[13] Ibid., 338.

(1958).[14] The manipulations and editing of recorded sounds that occurred during this time opened a new world of possibilities for composers, as changing sounds with reverb, compression, overdrive, ring modulation and filters became a part of electronic music language. At the same time, the *Elektronische Musik* school in Germany, led by Stockhausen, created sounds using synthesis techniques and tape manipulations. The generation of sound using synthesis and the manipulation of pre-recorded material forms the basis of electronic music's ability to create almost any sound imaginable, and to bring to fruition Varèse's call to "compose with the sounds themselves and not composing only *with* sounds".[15]

During the mid-1960s, Stockhausen developed several works for live instruments and live electronic manipulations. These include *Mixtur* (1964) for orchestra and four ring modulators, *Mikrophonie I* (1964) for tam-tam and filters, and *Mikrophonie II* (1965) for twelve singers, four ring modulators, hammond organ and tape.[16] These early works utilise live performers on electronics that manipulate the timbre of the live instruments and were some of the earliest works to involve the live combination of acoustic instruments and electronics. Stockhausen also used electronic instruments in live concert performances such as the hammond organ, the use of electronic instruments being heavily popularised by rock and blues bands during the mid-1960s. Up to this point in history, most of the areas of electroacoustic composition have already been developed. Stockhausen later explains in a lecture in 1991 that the techniques of electroacoustic performance practice form six key areas: recording technique, amplification technique, transformation technique, pre-formed music technique, adoption of electronic musical instruments and finally, the combination of all electroacoustic possibilities.[17] Here he outlines how understanding, experimentation and creativity using these techniques can lead to a "liberated music" or a "synthesis" of all the aspects of electroacoustic performance practice. *utp_* makes use of all of these areas of electroacoustic music.

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[14] Ibid., 340-41.

[15] Jean-Claude Risset, "The Liberation of Sound, Art-Science and the Digital Domain: Contacts with Edgard Varese," *Contemporary Music Review* 23, no. 2 (2004): 31-33.

[16] Holmes, *Electronic and Experimental Music : Technology, Music, and Culture*, 351.

[17] Stockhausen and Kohl, "Electroacoustic Performance Practice," 99-100.

Computers in Music

Microprocessor chips and sound cards became readily available in the early 1970s and have grown to the point today where computers influence all genres of music, far beyond its original home in academia.[18] This evolution of digital technology has had a strong effect on electronic and electroacoustic music. As technology has developed and personal computers and laptops have become commonplace they have become the preferred choice of electronic music device. Today, anyone with a desktop or laptop computer has access to a digital audio workstation. Software programming environments such as Max/MSP[19] provide a modular, real-time environment for sound synthesis, sound processing and programming,[20] effectively fulfilling the roles of multiple analog devices with a single program. It is now much easier to be able to incorporate all areas of electroacoustic music into a single composition than anytime in the past.

With this development in technology, the roles of digital processes in music have significantly expanded. In his book *Electronic and Experimental Music* (2008), Thom Holmes defines some of these roles as: computer composition and scoring, computer synthesis of sounds and computer sampling of audio input.[21] Perhaps most importantly, the development of computer hardware and software has enabled composers of electronic music to be able to create unique programs for specific purposes. The power of these machines also allows extremely complex calculations to be made in real-time, enabling the performers to treat the computer as an instrument and direct the device in real-time to perform musical applications.[22]

*utp_* draws from academic electroacoustic music, but is also informed by many other areas of music, in particular 'glitch', or microsound, and electronica.[23] As time has progressed, more and more performers and composers have used the combination of electronic and acoustic sound sources in their music, and many have made these transformations in real-time during live performances. Examples of this can be seen in live performances by the band Radiohead (formed 1985, UK) who perform live

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[18] Holmes, *Electronic and Experimental Music : Technology, Music, and Culture*, 320.
[19] This thesis will not discuss the specific programming or implementation of digital materials but assumes the capabilities of common processes to be implemented using one or more of the available software platforms.
[20] Jean-Claude Risset, "Fifty Years of Digital Sound for Music," *Proceedings SMC'07* 4(2007).
[21] Holmes, *Electronic and Experimental Music : Technology, Music, and Culture*, 260.
[22] Flo Menezes, "For a Morphology of Interaction," *Organised Sound* 7, no. 3 (2002): 305.
[23] Demers, *Listening through the Noise : The Aesthetics of Experimental Electronic Music*, 6-7.

electronic manipulations to vocals and instruments. Other artists such as Christian Fennesz (b. 1962, Austria) have taken the exploration of acoustic and electronics in combination as their primary impetus. Fennesz uses computer processing of guitar sounds to create washes of noise and manipulated sounds that greatly extend the instrument. Some artists have also used the inherent sounds and functions of digital devices as the audio material of their work such as Ryoji Ikeda (b. 1966, Japan) whose compositions consist of digital glitches, white noise and rapid mechanical rhythms. The openness of electronic music today has allowed for the incorporation of techniques generally used only in electronica to become used in electroacoustic music. *utp_* takes influence from music created both inside and outside of academia, and uses the sounds of digital glitches, pulsing rhythms and washes of white noise in combination with classical orchestration, synergistically combining areas of electronic and acoustic sound.

1.1.1. Liveness and Successful Electroacoustic Works

Denis Smalley (b. 1946, New Zealand) states that electronic music has the capability to access "all sounds, a bewildering sonic array ranging from the real to the surreal and beyond",[24] and that this surreal world of sound often disconnects listeners from the physical act of sound making, and can remove the traditional frame of performance.[25] According to Demers, much electronic music, and in particular acousmatic music, blocks the natural connection of sound to source by signifying sound objects that are detached from their origins. However, electroacoustic performances generally involve live performers playing acoustic instruments in addition to electronic sound and/or live manipulations. These performances involve both the sonic and the gestural, the combination of senses can provide a logical, transparent relationship between source and result.[26] The advantage of these electroacoustic performances over acousmatic or solely electronic performances is that it places emphasis on the liveness of the performers, while also creating sounds that are "extending and transforming traditional sounds in well-nigh visionary ways".[27]

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[24] Denis Smalley, "Spectromorphology: Explaining Sound-Shapes," *Organised Sound* 2, no. 02 (1997): 107.
[25] Ibid.
[26] Demers, *Listening through the Noise : The Aesthetics of Experimental Electronic Music*, 39.
[27] Arnold Whittall, "Electroacoustic Music," Oxford Music Online, http://0-www.oxfordmusiconline.com.library.ecu.edu.au/subscriber/article/opr/t114/e2223 (accessed September 23, 2010).

Liveness is used here to denote the live performance interaction between electronics and acoustic performers.[28] In some listening scenarios, audiences are immediately deterred by playback of recordings that have been created prior to performance. Yet on the other end of the spectrum, John Croft (b. 1971, UK) explains that performances that rely heavily on manipulation of a musical motif played live and then manipulated by electronic means display a one-to-one relationship that is "tedious",[29] the technology bringing "the procedure into the foreground".[30]

Theorists such as Croft argue for "aesthetic liveness"[31] or a situation in which, as Croft states, "aesthetically meaningful differences in the input sound are mapped to aesthetically meaningful differences in the output sound". This includes the use of prerecorded or predetermined sound, as long as it creates this meaningful difference. The treatment of liveness in works for electroacoustic ensemble requires that not only the individual instruments be treated as extended instruments, but that the entirety of sound of the acoustic instruments is extended via manipulation or playback. From the analysis of *utp_*, I identified that the live combination of electronics and acoustic sounds successfully achieves liveness when:

1) the electronic manipulations avoid obvious procedures of recording and playback to form a time-based relationship with the live acoustic sounds (either no delay between recording and playback or sounds played back at a later time)

2) the sound of the ensemble is augmented, i.e. altered in real-time (the electronics able to change the spectra of acoustic sound and output immediately)

3) the electronic sounds create meaningful difference in the timbral relationships to the acoustic sound (in particular predetermined sound needed to make direct timbral connections or distinctions when combined with the acoustic sources)

In *utp_* the multiple layers of manipulation and pre-recorded sound create coherent relationships with the acoustic sounds. The pre-recorded electronic sounds either maintain an electronic identity with sine tones, computer glitches or low frequency sound, or provide similar timbres to the acoustic sounds, such as manipulated pre-recorded ensemble sounds. *utp_* utilises manipulations that extend the instruments'

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[28] John Croft, "Theses on Liveness," *Organised Sound* 12, no. 01 (2007): 59-60.
[29] Ibid.: 61.
[30] Ibid.
[31] Ibid

spectra in real time, or create complex layering and repetitions via sampling. The electronics augment the acoustic sounds whilst creating their own identity, generating sounds that cause complex interplay with the acoustic sounds, and allowing the entirety of the sound to remain the focus.

1.2. Analysis of Electroacoustic Music

1.2.1. Spectral Analysis History and Uses

Spectral analysis refers to the analysis and deconstruction of spectrogram images.[32] These images display the amplitude of each frequency present in a recorded sound, mapped to time. On each spectrogram, time forms the x-axis, frequency the y-axis, and amplitude is shown by depth of colour, or the z-axis. Robert Cogan (b. 1930, USA) first described spectrograms as a tool for musical analysis in 1984, with his book *New Images of Musical Sound*. Cogan uses spectrograms to illustrate the ways that different styles of music performance utilise the frequency spectrum, from the performance techniques of singers such as Billie Holiday (b. 1915, USA), the rich orchestration found in compositions by Alban Berg (b. 1885, Austria) and the shifting densities of electronic music works by composers such as Jean-Claude Risset (b. 1938, France).

1.2.2. Viewing Spectrograms

Spectrograms contain a significant amount of information, but in order to be used as an analysis tool their shapes must be "interpreted and reduced to perceptual essentials".[33] Cogan describes five main areas revealed by spectrograms:[34]

1) Sound waves (clearly illustrated contours of melodies or changing pitches)
2) Musical space (defining the human hearing range and viewing how musical material occupies this space)
3) Musical time (duration represented horizontally, displays the time scales of music and illustrates musical form)
4) Spectra (the complexity and richness of musical tone, timbre and texture displayed in vertical patterns and structures)

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[32] Also known as sonograms or spectrum photos. Here spectrogram is used due to its use in the Sonic Visualiser software used to create the images seen in this paper.
[33] Smalley, "Spectromorphology: Explaining Sound-Shapes," 108.
[34] Cogan, *New Images of Musical Sound*, 6-14.

5) Register (sounds occurring in different octave frequency bands appear to be of different qualities, in particular low frequency sounds require greater amplitude to achieve the same perceived volume)

An understanding of the frequency makeup of sounds is essential in analysing spectrograms. While spectrograms arbitrarily show the amplitude content at each frequency, the human ear and brain are able to reduce an enormous amount of information into single events, e.g. a single tone heard from a musical instrument consists of multiple harmonics but is grouped together and heard as a single sound. The intensity, number and frequency of harmonics account for the difference in tone or timbre between different sounds,[35] and therefore different instruments. Figure 1 illustrates the visual representation of a range of timbres, from the computer-generated extremes of sine waves (all energy at a single frequency) and white noise (equal amount of all frequencies). Exact replication of these sounds is only possible with electronics, although acoustic instruments can share some of their timbral characteristics.

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[35] Hermann von Helmholtz and Alexander John Ellis, *On the Sensations of Tone as a Physiological Basis for the Theory of Music*, 2nd English ed. (New York: Dover Publications, 1954), 65-69.

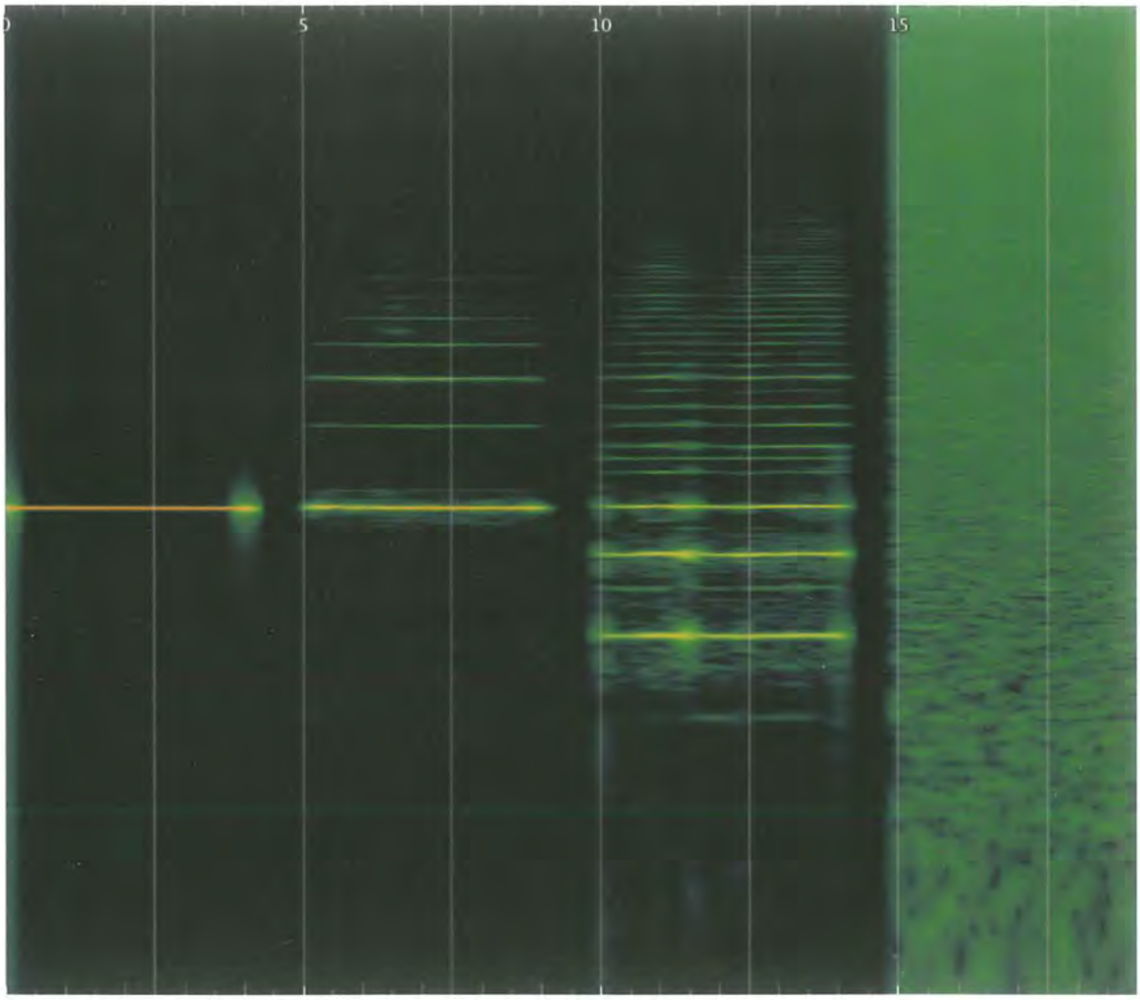

Figure 1 – Spectrogram showing examples of four timbrally different sounds, a computer-generated sine wave, a clarinet note, a cello note and computer-generated white noise.

1.2.3. Sonic Properties

The timbre, tone or quality[36] of individual sounds can be characterised by the oppositions of sonic properties that make up the overall characteristic of the sound. In *New Images of Musical Sound*, Cogan uses a table of oppositions, which lists thirteen different properties of sound, each ranging from low to high energy. The properties that Cogan discusses can be seen in Figure 2.

[36] Ibid., 24.

− +	a	b	c	d
grave/acute	∓	∓	+	−
centered/extreme	+	−	+	+
narrow/wide	+	+	−	−
compact/diffuse	∓	∓	∓	−
non-spaced/spaced	+	−	−	−
sparse/rich	+	+	+	+
soft/loud	Ø	Ø	Ø	Ø
level/oblique	−	−	−	−
steady/wavering	−	−	−	−
no-attack/attack	−	−	−	−
sustained/clipped	∓	∓	∓	−
beatless/beating	+	+	+	+
slow beats/fast beats	∓	∓	+	−
Neutral (Ø)	1	1	1	1
Negative (−)	3	5	5	9
Mixed (±)	4	4	2	0
Positive (+)	5	3	5	3
Totals	(-7 +9) +2	(-9 +7) -2	(-7 +7) 0	(-9 +3) -6

Figure 2 – Table of oppositions for Babbitt, *Ensembles for Synthesizer*, Introduction,[37] showing Cogan's framework for analysing sonic properties.

Cogan analyses the spectrograms with this table of properties and uses it as a comprehensive framework for describing sound. Cogan uses this table to show that what is perceived as a heightened intensity in sound can be described as the movement of multiple properties from low to high energy. I will use four of the sonic properties described by Cogan in my analysis:

1) grave/acute: indicates the majority of frequency content, grave refers to the lower portion of the frequency spectrum, while acute refers to the upper.
2) narrow/wide: the distance between outer spectral elements. A more widely spread band will tend to be of more irregular shape and sound noise-like[38]
3) sparse/rich: the total amount of frequencies present.
4) no-attack/attack: attack refers to a noticeable difference in the onset and continuation of spectral elements.

This provides a method of categorising individual sounds from instruments according to defined properties, and then comparing these properties to other sounds.

[37] Cogan, *New Images of Musical Sound*, 127.
[38] Ibid., 135.

The somewhat fixed overtone structure of acoustic instruments[39] compared to the near-limitless potential of electronic sound means that the two will not always cover the same sonic territory, but within the inevitable overlap lay many interesting effects when manipulating sonic properties. The above four properties are used to identify a continuum of sonic properties for acoustic and electronic sound sources as a way of negotiating the timbral differences found in each.

I believe that spectrograms are particularly important in the analysis of electroacoustic music, (an area which Cogan does not cover) due to their ability to illustrate the differences and similarities in timbre between electronic and acoustic sounds.[40] This means they can be used to show how pre-recorded and manipulated sound interacts with acoustic sources in time, a concept termed "spectromorphology".[41]

1.2.4. Spectrally Informed Synthetic Composition

"Synthetic composition" is a term coined by Tristan Murail (b. 1947, France) in his paper *The Revolution of Complex Sounds*, in which Murail calls for a new method of composition that uses "new organizing principles that do not exclude one or more categories *a priori*, but integrate the totality of sonic phenomena". Murail here speaks of the integration of complex techniques into the language of music.[42] These techniques are often derived from electronic techniques; echo, loops, reverberation, inharmonic and harmonic spectra, and the integration of complex sounds and noise. Murail's explanation of synthetic composition as a theory of organisation places varieties of sounds into a complex whole. This provides an approach for the combination acoustic

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[39] Acoustic instruments that use vibrating strings or columns of air have particular acoustic properties, and follow a harmonic overtone structure, this refers to overtones that fall within whole number ratios of the fundamental. The reinforcement of frequency ratios aids the aesthetically pleasing nature of combinations of sounds as harmony, see Hermann Helmholtz, *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (London: Longmans, Green, and Co., 1875), 22-23.

[40] While spectral analysis is able to provide many useful insights into the properties of sound, there are some important limitations when working with this approach. The spectrograms can only be produced from recorded sound, in order to create this data there must be a conversion from vibration to electronic or digital material. This means that the quality of the spectrogram is dependent on a particular recording of the piece. The spectrograms here are from single channel mixes of each recording. It is important that the recordings used be considered the best possible indication of their intent. The spectrograms used can be displayed in either logarithmic or linear frequency scale, the former has been used due to the way it more naturally articulates the octaves of musical instruments, as the octaves are shown with equal spacing. The viewing range of the spectrograms has been altered to best indicate the desired properties. In some cases the spectrograms illustrate the sonic nature and structure of an entire piece and a time range of several minutes. In other examples the spectrogram shows interplay between specific sounds and lasts only a few seconds. In each example the duration will be indicated in the below caption. The amplitude of signals shown has also been normalized so that each spectrogram illustrates the difference in amplitude levels for that individual image and cannot be accurately compared to other spectrograms. All spectrograms created using Sonic Visualiser software, see Sonic Visualiser Ver. 1.7.1, University of London, London.

[41] Smalley, "Spectromorphology: Explaining Sound-Shapes," 107-08.

[42] Murail, "The Revolution of Complex Sounds," 5.

and electronic sounds. The aim here is the *results*, the sound spectra and sonic textures created, rather than a hierarchical, pre-determined organisation. This has proved a large influence upon the study of *utp_* and the creation of my own work, *lucidity*.

Spectrograms and audio frequency spectrums have been used in Western Music since the French spectral school. Murail and Gérard Grisey (b. 1946, France) use spectrograms of recorded sounds to identify the partials and overtone structure, and then use these overtone ratios to influence structural properties, or as notated parts for acoustic instruments. Perhaps the clearest example of this technique is Grisey's *Partiels* (1975), which reconstructs the overtones of a trombone note, from the double bass upward, beginning low and muted and moving to bright and dissonant in the upper tones. This method of composition pays close attention to the fundamental nature of sound and its construction on a microscopic level, rather than imposed sets of rules as in traditional harmony and counterpoint. This ties the harmonic make-up of the pieces in with the scientific logic of sound synthesis and helps to tie together the electronic and acoustic sounds.

During the composition process of creating *lucidity*, spectrograms and frequency spectrum visualisers were used as a tool to identify the sound's spectra. This helped to visualise and identify the relationships between acoustic and electronic sounds. Use of spectral analysis assured the implementation of the composition techniques described in the 2nd and 3rd chapters.

Chapter Two

2. *utp_*

2.2. Background

*utp_* is an audio/visual work developed by Alva Noto and Ryuichi Sakamoto in collaboration with Ensemble Modern, for the 400th anniversary of the city of Mannheim. The work builds upon Alva Noto and Ryuichi Sakamoto's previous electroacoustic recorded works *Vrioon* (2002), *Insen* (2005) and *Revep* (2005) that feature compositions of electronics and piano. The artists describe their work as a "synergetic mixture of electronic and natural sounds"[43]. Their approach is expanded by working with the acoustic instrumentation of Ensemble Modern. The formal structure of the work is derived from a rasterised city map of Mannheim, built in the seventeenth century as an 'ideal city'.[44] Composed for a large ensemble of instruments, prerecorded electronics, live sound processing and visuals, the work takes on an unusual form, described by the artists as "having no model".[45] The musicians view a display screen with a timer and the projected visuals in addition to a musical score.

2.2.1. Background of Involved Artists

The involved artists in this work cover significant territory and an understanding of these backgrounds helps to explain how they arrive at such a synergistic work. Alva Noto is the performing name used by German sound and visual artist Carsten Nicolai. Nicolai has released an extensive discography on his own label *raster-noton*, his music is generally categorised as 'glitch'.[46] Nicolai's recorded works feature, on the most part, minimal rhythmic structures applied to computer tones, he has stated that his music is more informed by scientific and mathematic processes than by musical logic.[47] Ryuichi Sakamoto is a composer who has won numerous awards for film scores and instrumental music. He gained significant popularity in Japan in the late 1970s with the synth-pop group Yellow Magic Orchestra, but has since gained a reputation for his work with film scores and his use of electronics in his composition.[48] The main

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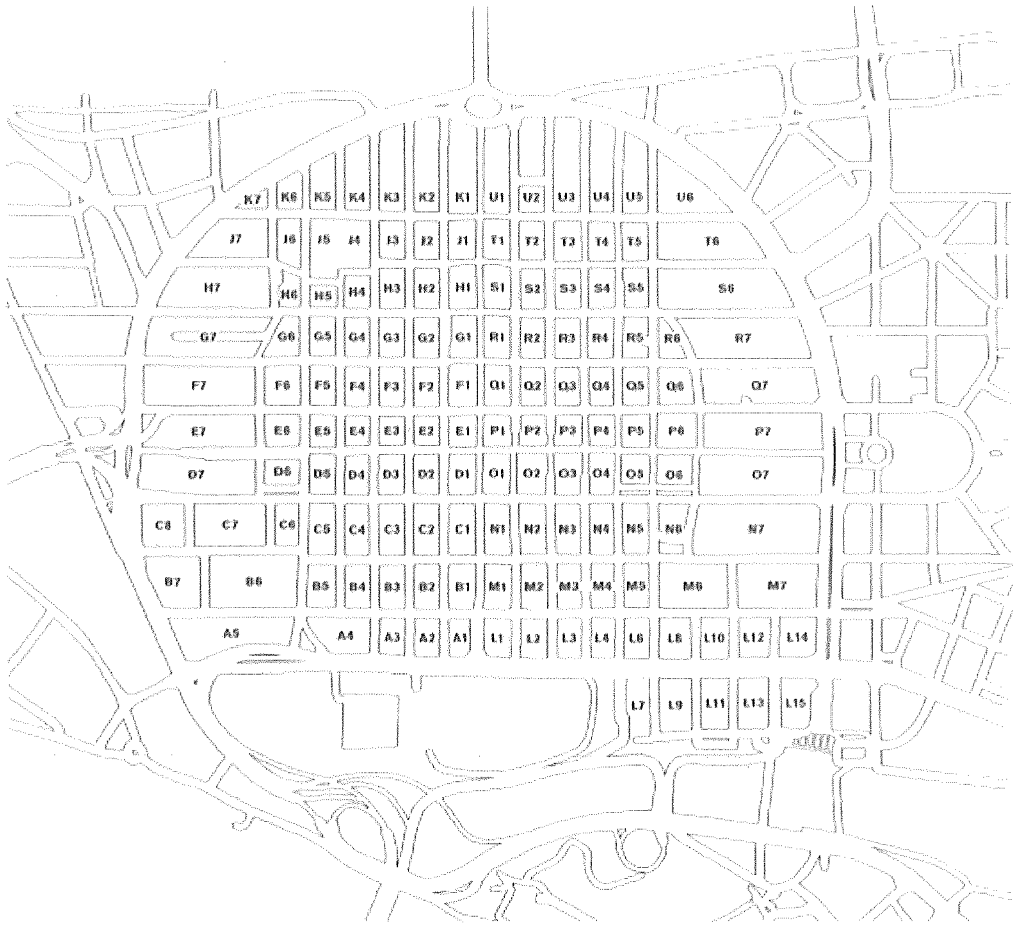
[43] raster-noton, "Archiv Für Ton Und Nichtton," http://www.raster-noton.net/main.php (accessed October 23, 2010).
[44] Ibid.
[45] Alva Noto and Ryuichi Sakamoto, *Utp_ Dvd Material* (Mannheim: raster-noton, 2008), DVD Audiovisual Material.
[46] Kim Cascone, "The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music," *Computer Music Journal* 24, no. 4 (2000): 16.
[47] Carsten Nicolai, "Carsten Nicolai Official Website," http://www.carstennicolai.de/ (accessed October 25, 2010).
[48] Ryuichi Sakamoto, "Ryuichi Sakamoto Official Website," http://www.sitesakamoto.com/ (accessed October 25, 2010).

performers in *utp_*, Ensemble Modern, are one of the world's leading contemporary music ensembles. The group regularly invites composers to form co-operative ventures – resulting in collaborations with such artists as Frank Zappa (b. 1940, USA), Anthony Braxton (b. 1945, USA) and György Ligeti (b. 1923, Hungary).

2.2.2. Structural Map and Layout of Work

*utp_* is arranged into twelve sections, each given a title that refers to the focus of sound used in that section (*attack*, *grains*, *particle*) or the structural direction or movement (*transition*, *broken line*, *plateaux*). The work is composed to be 72 minutes in length, the exact size of an audio CD.[49] From this overall length, the city map of Mannheim is used to allocate amounts of time to each section, creating a distinctive fixed structure.

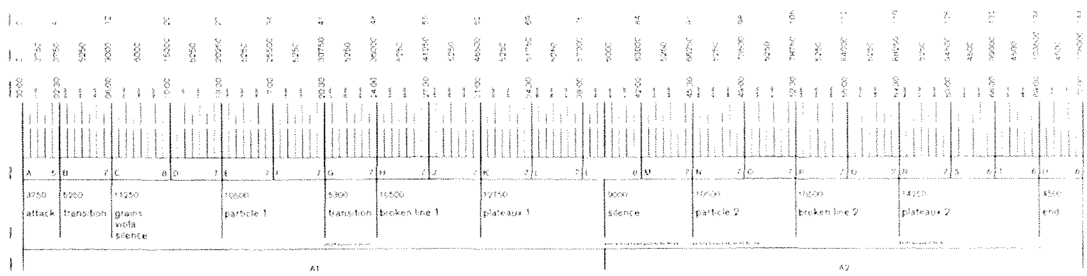
[49] Noto and Sakamoto, *Utp_ Dvd Material*.



street plan of the inner city of mannheim

Figure 3 - Diagram of street plan of the inner city of Mannheim, showing the city layout from which the *utp_* structure is derived, from *utp_* additional materials booklet, p. 9.

The blocks in the Mannheim city plan are allocated letters and numbers. These are tallied and allocated to each section; there are 144 sections across twelve letters. Therefore each block equals thirty seconds of musical time, for example, there are five A blocks so the A section in *utp_* has a set duration of 2:30, section B has seven blocks and a duration of 3:50 and so on. This method of structure means that the overall timing of the work is fixed and takes on an architectural form, locked in to specific durations.



composition timeline

Figure 4 - Composition timeline, showing lengths and order of sections, from *utp_* additional materials booklet, p. 4.

2.2.3. Notations

Most notations used in *utp_* allow the performers to choose some aspect of their playing within a controlled texture. The use of instructions and very few tempo-based notations allows each section to explore a particular texture by restricting the range of sounds, while still allowing the performers some amount of rhythmic, dynamic or melodic freedom. All notations used throughout *utp_* create specific sonic textures by using combinations of the following:

1) **tone sets or performer choices**: sets of notes are provided to the performers to choose from. These range from tonal to chromatic, hinting at specific harmonic chords without stating them fully.

2) **written performance instructions**: instructions for the performer to utilise particular sounds. These also call for improvising random rhythms, referencing the parts of other players or the electronic sound.

3) **graphic notation**: notations that fall outside of traditional nomenclature, all symbols reference a particular sound. These are used when players are asked to play unusual sounds (e.g. grain like sounds) or for electronic parts that evoke a particular symbolic notation.

4) **proportional notation**: ranges of dynamics, lengths or articulations that notes are to be performed within. Some examples include “mop-up”, “each note must be played very long” and “with very slow attack”.

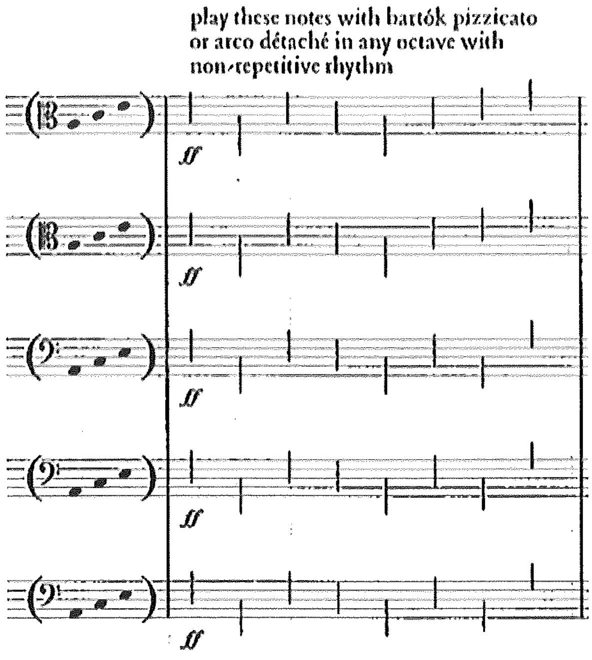


Figure 5 - Score excerpt of *attack/transition*, showing combination of tone set, written instructions and graphic notation, from *utp_* score booklet, p. 2.

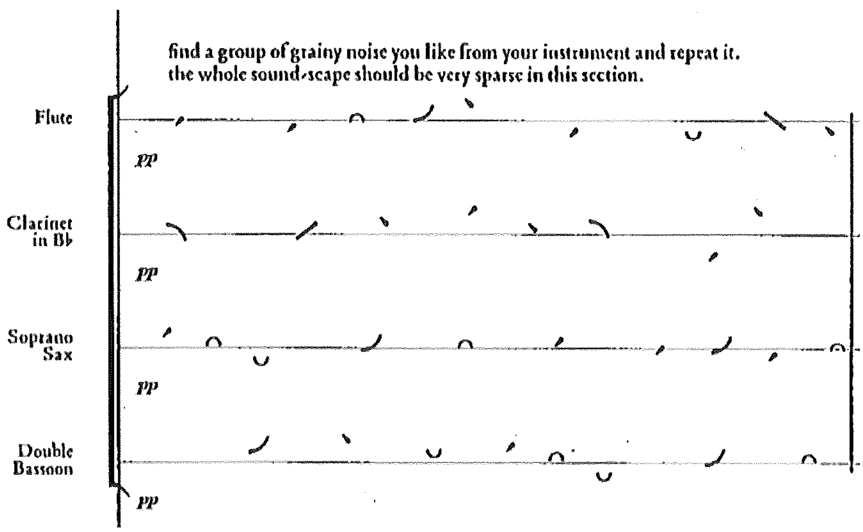


Figure 6 - Score excerpt from *grains*, showing combination of written descriptions and graphic notation, from *utp_* score booklet, p. 4.

The electronics use similar notational tools but are generally more descriptive of the sounds that are created. Volumes, triggers of sound and descriptions of what each sound is are shown, but rarely are frequency or rhythm articulated.

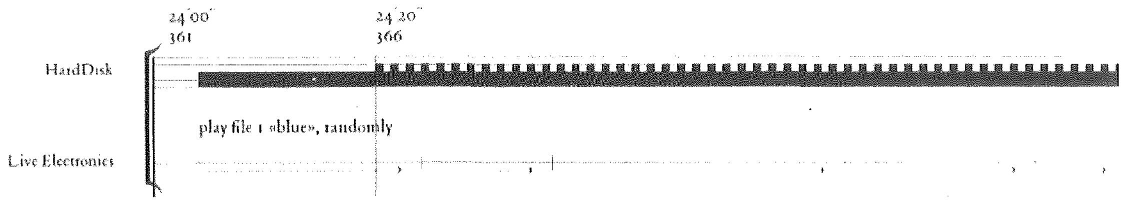


Figure 7 – Score excerpt from *broken line 1*, showing notation of pre-recorded and live electronic parts using symbols and descriptions of sounds, from *utp_* score booklet, p. 10.

2.3. Composition Techniques

From the analysis and study of *utp_*, I identified a number of spectrally informed composition and synchronisation techniques. These are broken down into four areas, each of which will be described in detail: 1) continuum of sonic properties, 2) utilisation of the frequency spectrum, 3) augmentation of instrumental sound and 4) video scoring and synchronisation.

2.3.1. Continuum of Sonic Properties

Opposing sonic properties can reveal the similarities or differences found in individual sounds and this information is used as a method of contrasting acoustic or electronic sounds. The combination of acoustic and electronic sounds can be used to reinforce a particular texture, or to draw the sound together in subtle ways. For example, a *col legno battuto* string sound produces irregular, noisy spectra that is wide, diffuse and rich. Its spectrogram shows that this tone has many partials, each at weak strengths, which cover a large number of frequencies of varying ratios from the fundamental. This sound could be contrasted with electronically generated white noise, where the spectra share similar properties.

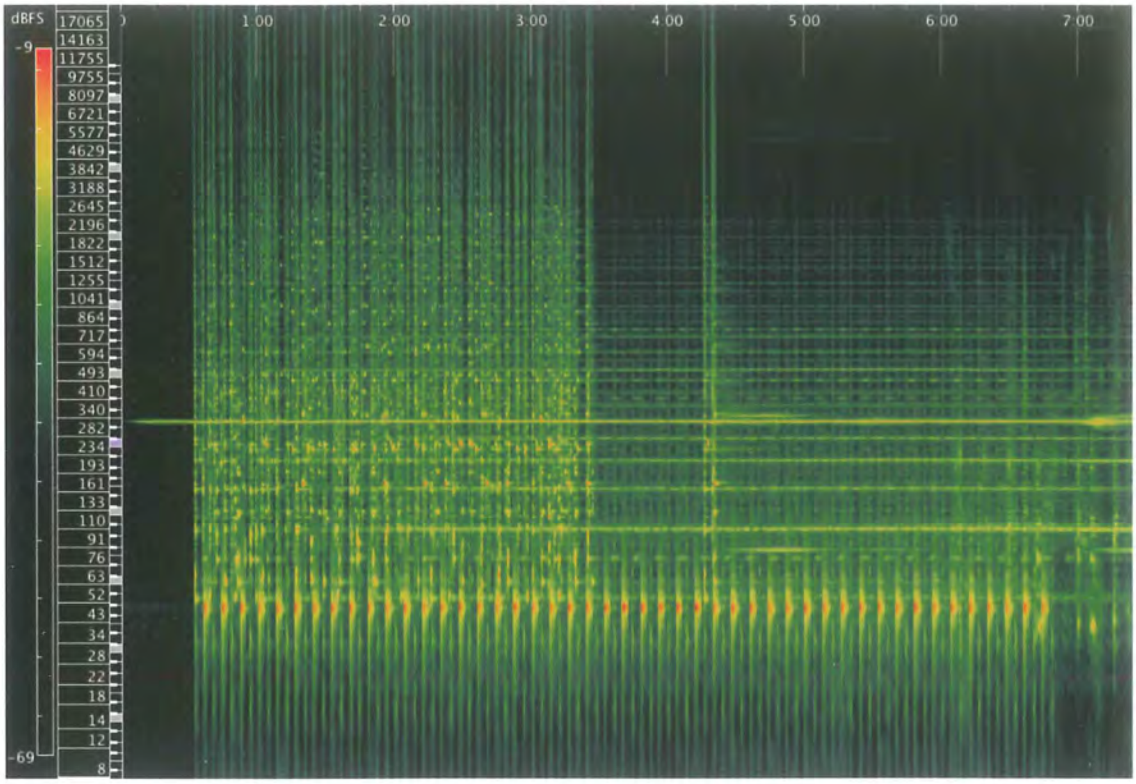


Figure 8 – Spectrogram of *attack/transition*, showing the use of white noise and noisy string techniques in combination at 0:30-3:30. Total duration 0:00-7:24.

Although the electronic sound is able to create white noise to a much more exact degree, the combination of the two sounds contrast each other and prove to be an engaging combination, making the electronic and acoustic sounds difficult to distinguish aurally.

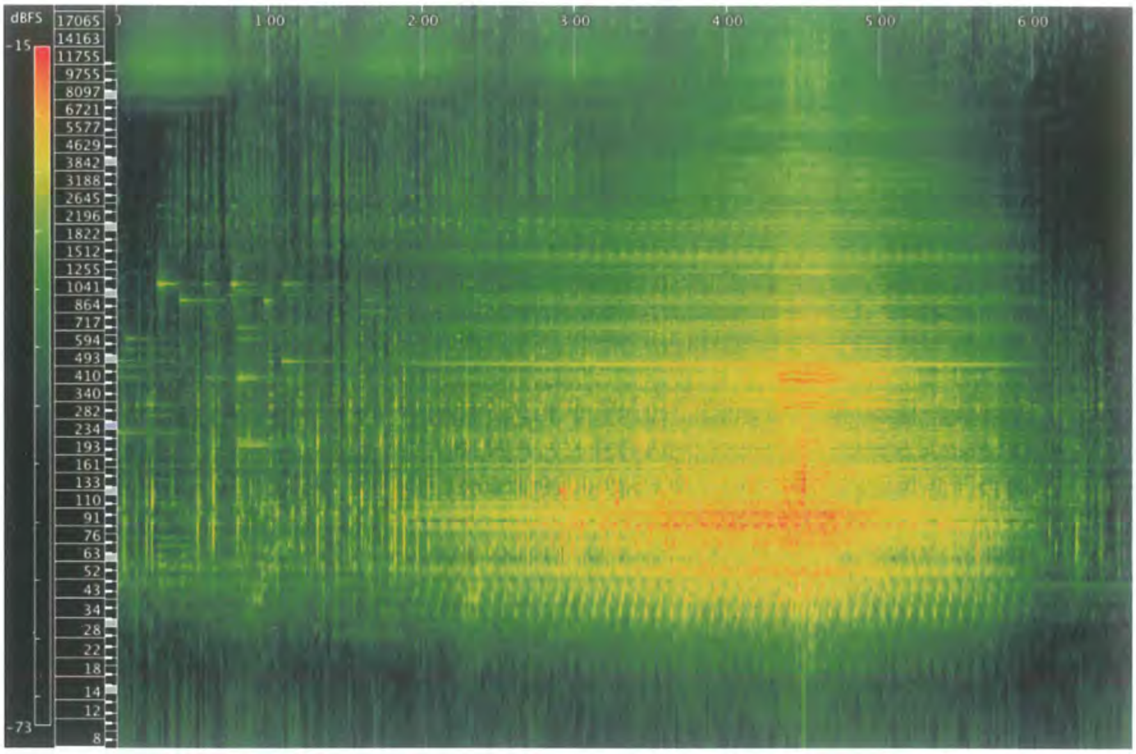


Figure 9 – Spectrogram of *particle 1*, showing a wide, diffuse and rich spectra created by noisy acoustic instrument techniques. Duration 0:00-7:00

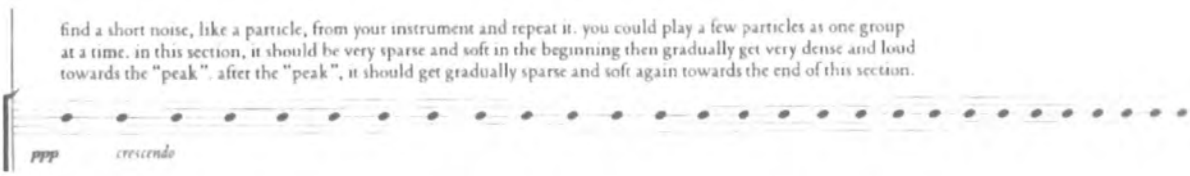


Figure 10 – Score excerpt from *particle 1*, showing instructions for each performer to find a short particle of noise and repeat, with a crescendo towards a peak at 4:30, from *utp_* score booklet, p. 6.

In *particle 1*, acoustic instruments are instructed to play noisy particles of sound to create an overall texture of noise, which spans a full frequency spectrum at its peak, similar to electronically created white noise.

2.3.2. Utilisation of the Full Range of the Frequency Spectrum

The capabilities of electronic sound extend to the far reaches of the frequency spectrum and are often far more complex than acoustic instruments are capable of. Electronically generated sounds can intermingle with acoustic tones to create psychoacoustic and timbral effects, including the interference of tones at similar frequencies to create beat frequencies, or the augmentation of timbre via electronic manipulation of the live sound. By using widely spread frequencies to cover almost all the hearing range, or by focusing closely on a very specific frequency range, complex musical effects can be created that place the electronic and acoustic sounds in close interplay.

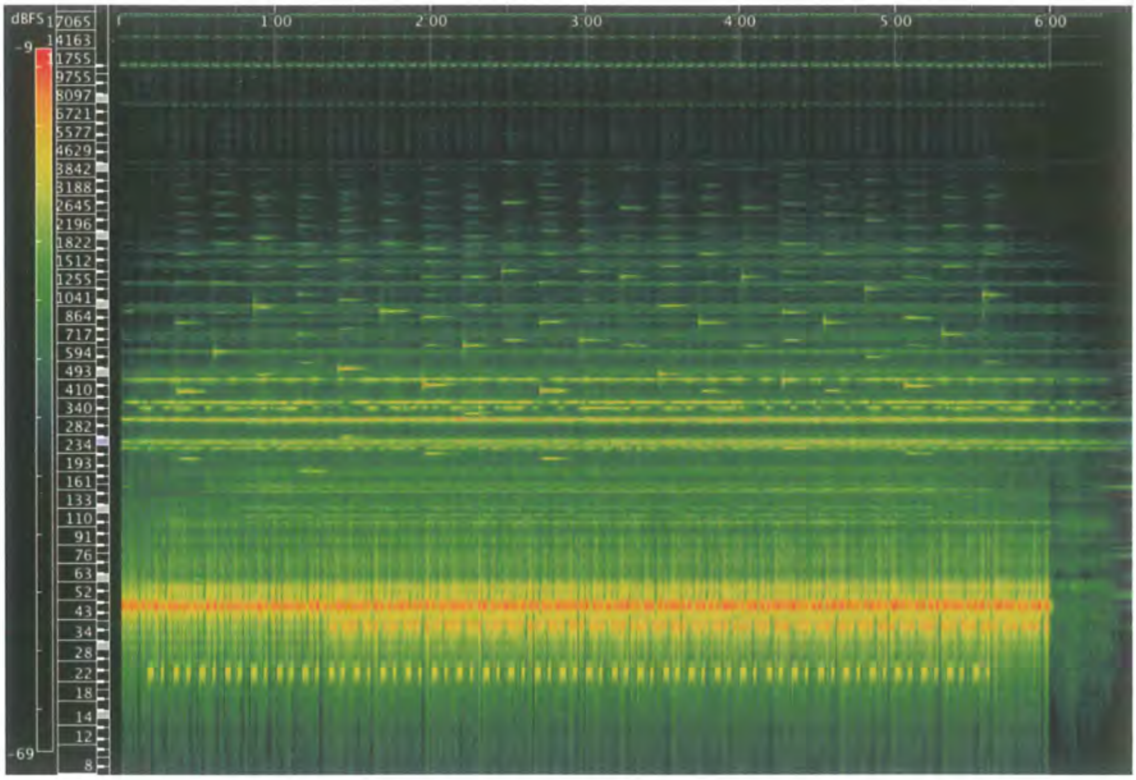


Figure 11 - Spectrogram of *broken line 1*, showing electronic sounds operating below 120Hz and above 10kHz. Duration 0:00-6:29.

One clear example of widening can be found in *broken line 1* where the electronic repeated rhythmic elements are placed below and above the acoustic instruments' frequency range, featuring prominently at both below 50Hz and above 10kHz. As can be seen in Figure 11, the instrumental sounds operate between 180-3500Hz, while the electronic sound dominates the frequencies above and below this range. Electronic bass pulses and glitches fill the frequency range between 20-120Hz and high pitched synthesised chime sounds create clearly defined rhythms in the range of 10-18kHz. This use of the frequency spectrum creates a sense of space within the texture. Elements of electronic and acoustic sounds each operate in their own frequency domain: each being heard as individual parts. The perceived result is that of sounds moving in separate directions, their evolution not directly linked to one another. This further enhances the polytextural aspect of the music by allowing repetitive pulsing parts to continue below and above the frequency range of the developing instrumental part.

2.3.3. Augmentation of Instrumental Sounds

As previously discussed, digital processing allows for the real-time manipulation of sounds in a way that can alter the perception of the instrument's sonic output. The augmentation or alteration of sounds proves to be a key composition technique in combining electronic and acoustic tools in that it allows the sound to seem acoustic and electronic simultaneously.

One example of this can be found in *attack/transition* where the string instruments are playing in short stabs of *col legno*, *arco detache* or Bartók pizzicato[50]. Some of these sounds are processed by the computer to add a significant reverb tail, greatly altering their role in the current sound world from being a short sound with a sharp dynamic to becoming a longer held tone. This also makes the texture more layered by increasing the amount of sounds that are heard concurrently.

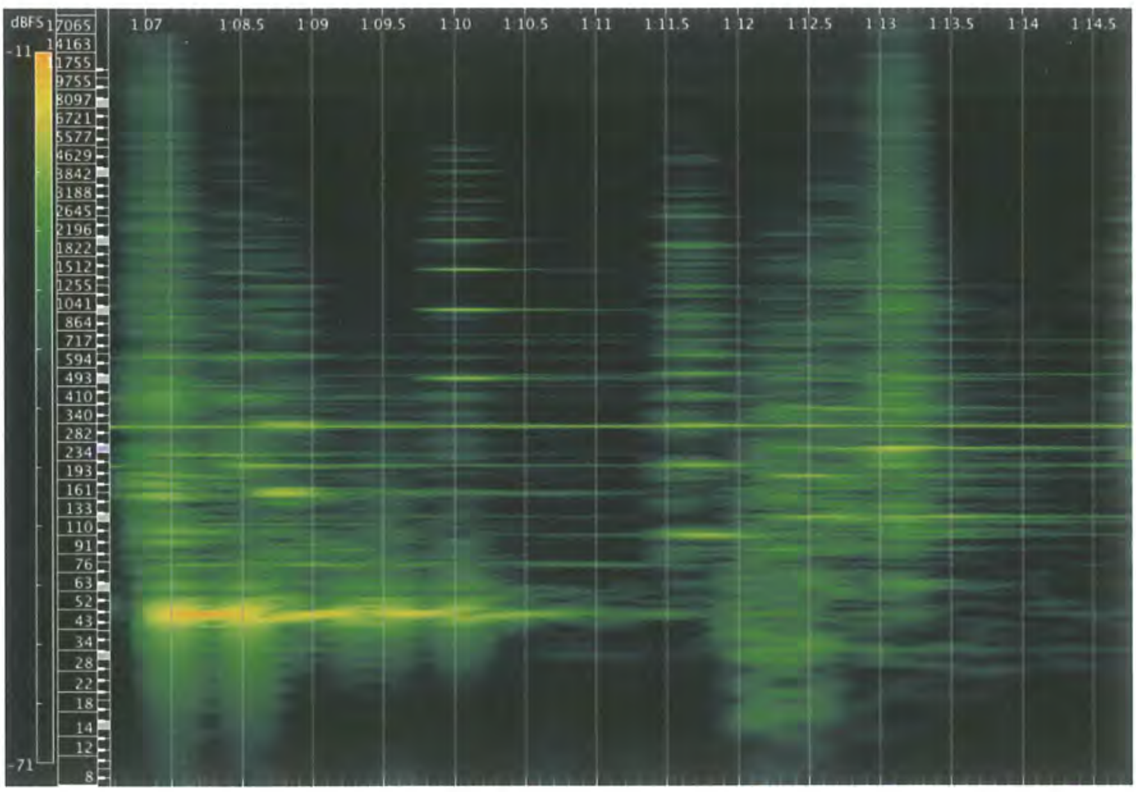


Figure 12 – Spectrogram, detail of excerpt from *attack/transition*, showing two short string pizzicato sounds followed by a clearer, bowed tone that has been augmented with reverb (just before 1:10). Duration 1:06 to 1:15.

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[50] Or snap pizzicato, "The string is plucked straight up from the fingerboard, between two fingers, so that it snaps back sharply" from Kurt Stone, *Music Notation in the Twentieth Century : A Practical Guidebook*, 1st ed. (New York: W. W. Norton, 1980), 312.

In the spectrogram, two sharp string attacks are followed by a string sound with added reverb processing, forming longer durations in the harmonic overtones and creating electronic sound derived from acoustic source.

2.3.4. Video Scoring and Synchronisation

The use of digital displays and video scoring allows the performers in *utp_* to successfully synchronise long passages of electronic sound, silence or abstract rhythm, without a regular pulse. The displays also allow the performers to respond to the intensity, shape and colour of visuals through their own playing. The use of polytexture in *utp_* provides a means of combining pre-recorded material with live instruments in a way that does not require the performers to follow exact cues or bars. Examples of this can be found in the sections *broken line 1* and *broken line 2*, where the electronics follow repetitive rhythmic patterns while the instruments are instructed to play extended notes, followed by pauses or at "[their] own tempo, differing from others". The resulting effect of this is that the instruments move in different trajectories to the electronics, contrasting precise, mechanical rhythms with more emotive, individual performance.

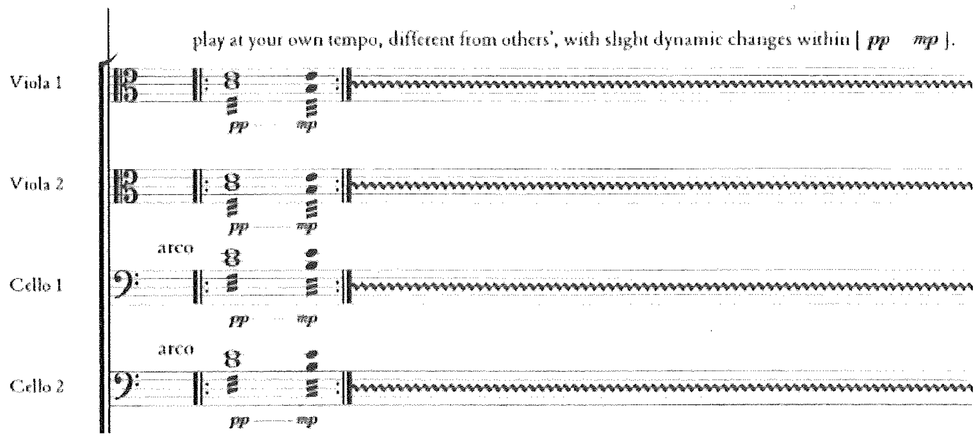

Figure 13 – Score excerpt from *broken line 2*, showing instruction to 'play at your own tempo, different from others', contrasting the electronic pulse, from *utp_* score booklet, p. 18.

Figure 14 – Score excerpt from *broken line 1*, showing indeterminate pauses after each note, contrasting the electronic pulse, from *utp_* score booklet, p. 10.

One key moment that illustrates the need for digital scoring occurs in *transition* where the players are instructed to play held notes from a given pitch set. At a particular time all instruments decrescendo to silence for 5 seconds. This acts as a bridging transition point and occurs at almost exactly halfway through the section. During this time the acoustic instruments decrescendo and stop, the electronic processing fades and silence is reached, just before moving into another foray of polyphonic, un-synchronised extended notes.

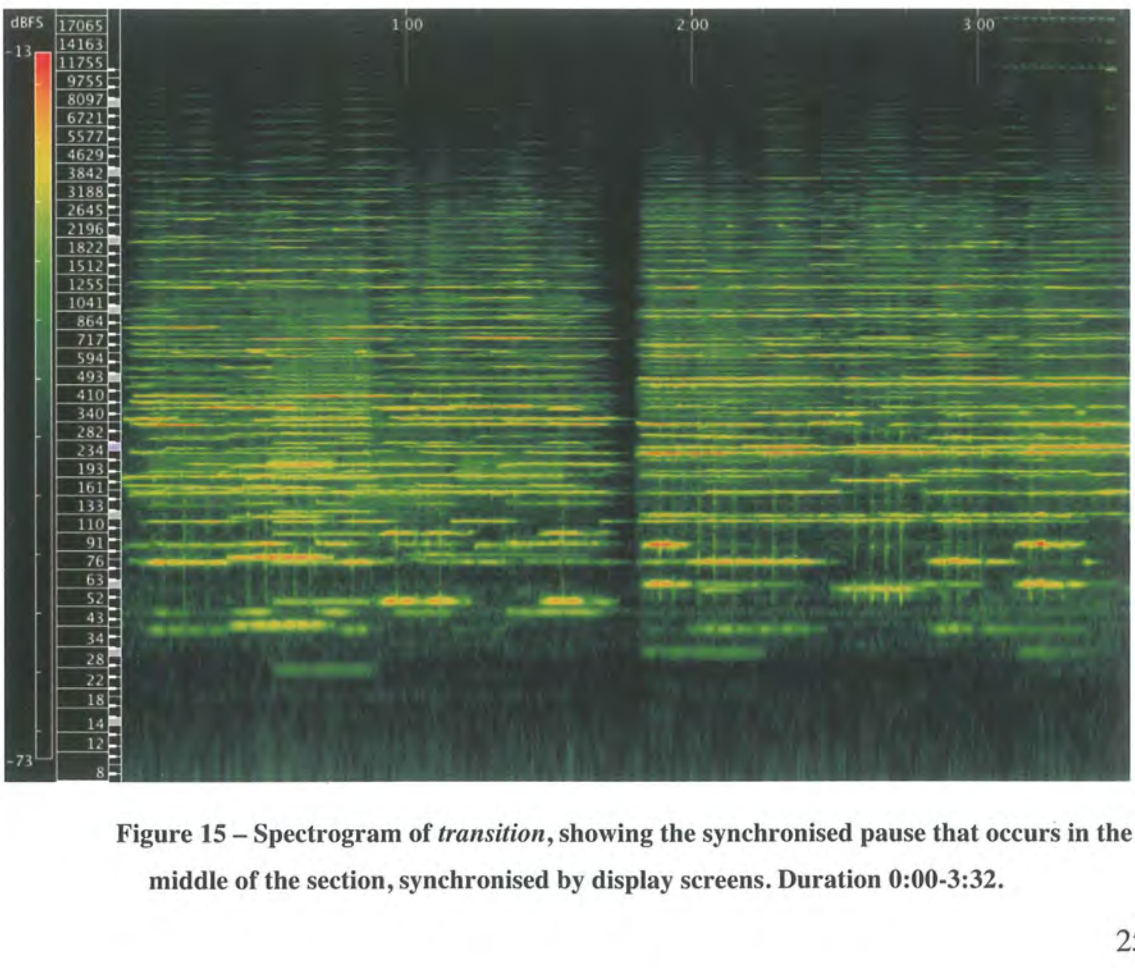

Figure 15 – Spectrogram of *transition*, showing the synchronised pause that occurs in the middle of the section, synchronised by display screens. Duration 0:00-3:32.

The use of a digital timer display here is essential because it provides exact timing of the sections (necessary for pre-recorded or synthesised parts), allowing the performers to pre-empt the silence and accounts for the electronic processing time periods.

Chapter Three

3. lucidity

3.1. Instrumentation and Format

The electronic and acoustic sound sources and techniques employed in *utp_*, are expanded upon in my own work *lucidity*, a new forty-six minute composition for electroacoustic ensemble. The score and audio recording are at Appendix A and B.

lucidity is composed for an electroacoustic ensemble consisting of clarinet, bass clarinet, cello, double bass, prepared rhodes piano/electric organ, and vibraphone/drum kit, and two computer performers controlling sound manipulation (processing) and sound generation/playback (synthesis). Each acoustic instrument's sound is captured via microphone and routed into the processing computer, which also takes sounds generated from the 'synthesis' computer. The processing computer uses custom built software that is capable of routing sounds through combinations of manipulations, granular synthesis, sampling and panning modules. There is a visual component that is projected onto, behind or above the performers, that creates slowly moving abstract colour images related to each section.

Each performer is able to see a computer monitor (display) used to show a parameter information graph, notational information, video scoring, and a timer. These computers are synchronised via a wireless network to maintain consistent timing.

Figure 16 – Screenshot of display program during *senn* showing timer, parameter information graph, video scoring and notational information.

The players are provided with printed scores that include most of the notations, directions and timing of changes, to be read from the displays. *lucidity* employs tone sets, written instructions, graphic notation and proportional notation as used in *utp_*, but uses the display screens and video in a different way by displaying graphical and randomly generated notations.

While being performed as one continuous work, *lucidity* can be divided into eight sections that each explore a specific set of techniques. While I will not be discussing the work in its entirety, I will draw attention to specific sections that directly illustrate techniques derived from *utp_*.

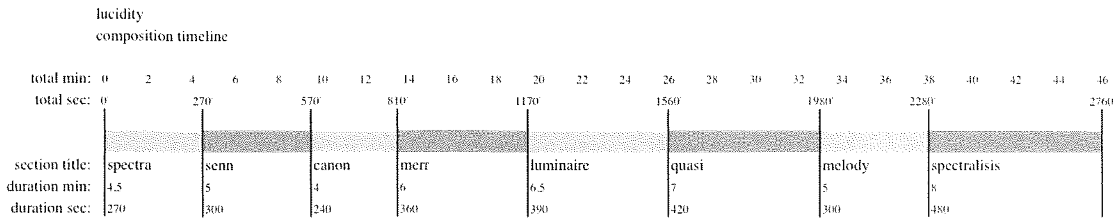

Figure 17 – Composition timeline of *lucidity* showing section lengths and order[51]

3.2. Specific Examples of Composition Techniques

3.2.1. Continuum of Sonic Properties

In *lucidity* I attempt to emphasise the sonic properties of acoustic and electronic sounds, either by combining sounds of both sources with very similar timbres, or, with extremely different timbres. *senn* illustrates this by combining electronic and acoustic sounds that both have noise-like properties. In *senn*, the ensemble follows a video score that directs the players as to the overall density. Performers are given several instructions as to the types of sound to create in this section such as slap tongue, key clicks, Bartók pizzicato, *arco détaché*, friction and scrapes, but must match their sound to the current density shown in the video. The synthesis computer provides a pulsing synthesised electronic rhythm and uses a granular synthesis engine to create a dense, textural mass by re-sampling pre-recorded percussion sounds. The sonic properties of this electronic sound are acute, wide and rich spectra, with distinct attack. The performers are asked to emulate this electronic sound, directly contrasting the sonic properties of their playing with that of the electronics.

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[51] For larger version, see Appendix A, p. iv.

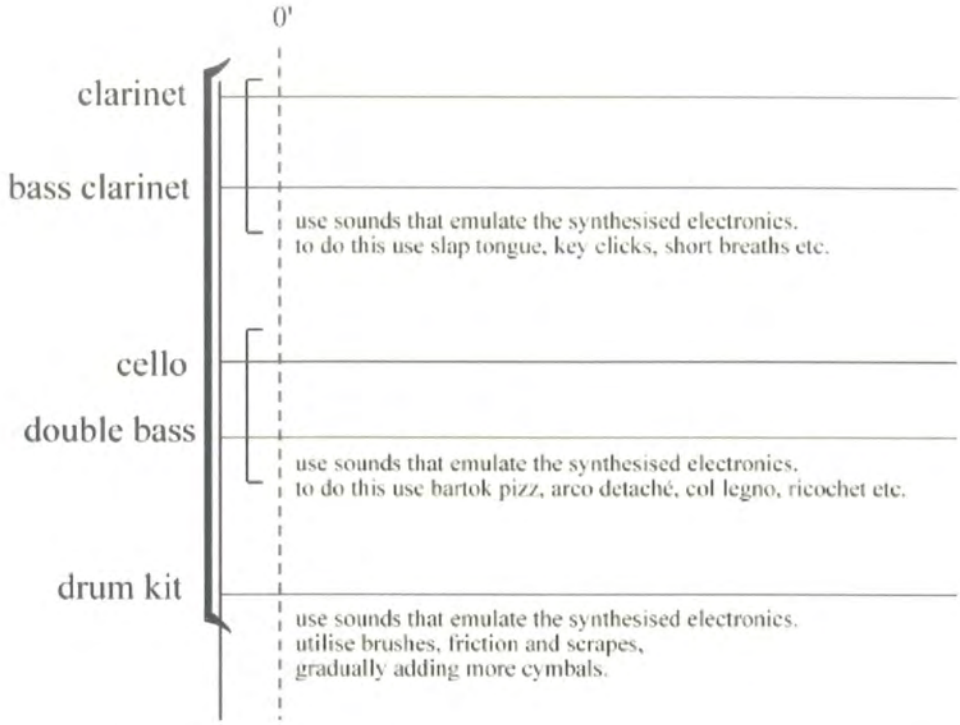

Figure 18 – Score excerpt from *senn*, showing technique suggestions for interpreting video score.[52]

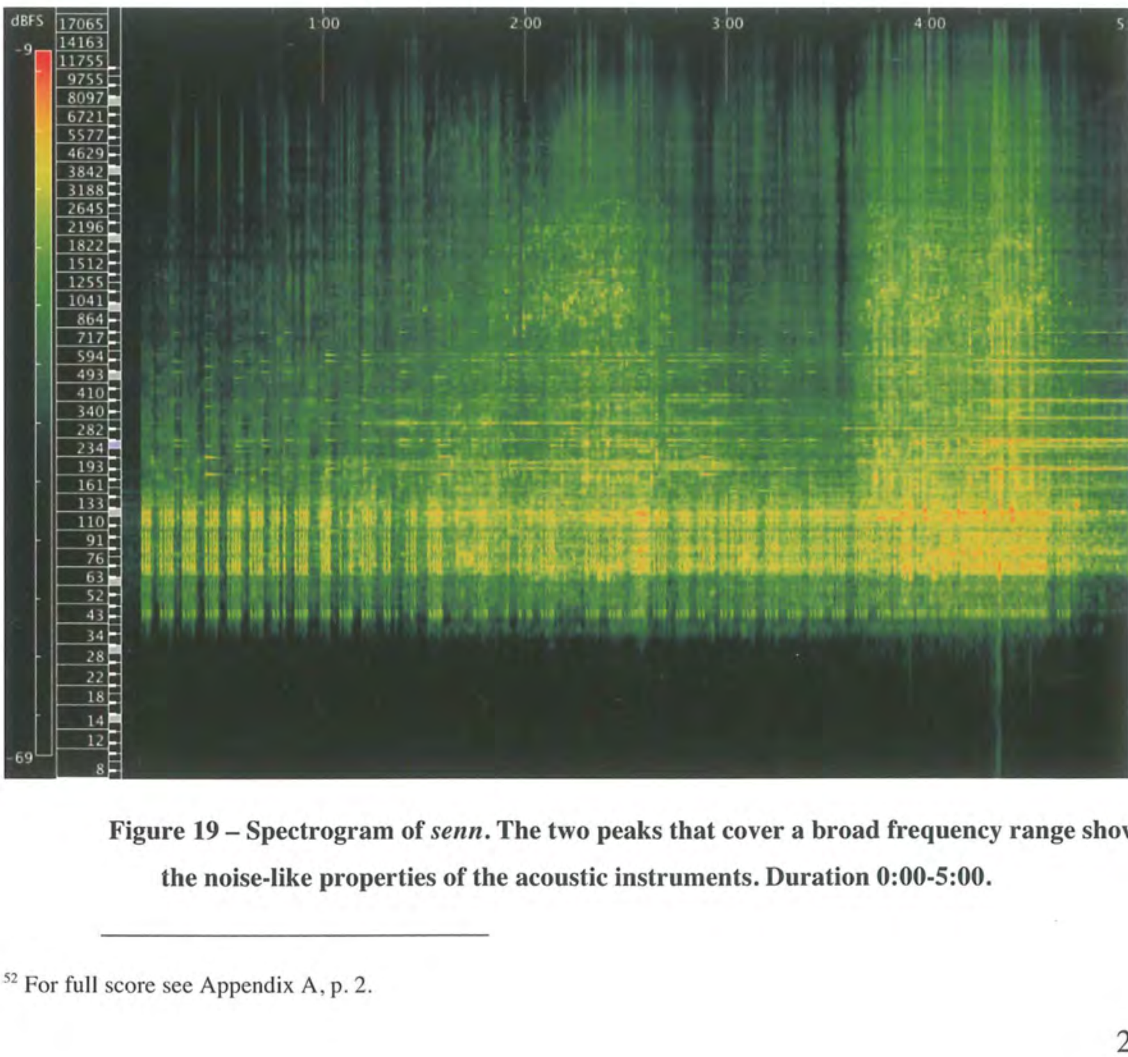

Figure 19 – Spectrogram of *senn*. The two peaks that cover a broad frequency range show the noise-like properties of the acoustic instruments. Duration 0:00-5:00.

[52] For full score see Appendix A, p. 2.

The acoustic instrument and electronic sound create noise-like spectra. The spectrogram exhibits vertical lines rather than parallel horizontal lines, demonstrating how the instrumental sound is difficult to distinguish from the electronic sound aurally. This creates timbre generated from both the acoustic instruments and electronics with predominantly noise-like sonic properties.

The extremes of different timbres between electronic and acoustic sounds are exploited in *melody*. All acoustic instruments are provided with a single pitch class at a time via the display. They are instructed to play each note within a 20 second window, beginning the note in the first 3 seconds and ending in the last 5 seconds, using a very gradual envelope and maintaining warm, clear tone. This creates chords consisting of a single pitch class played by each instrument simultaneously. Throughout *melody* the purity and alignment of the acoustic tones is contrasted with the electronic playback that produces electronic 'crackling' sounds occurring in random rhythmic patterns, and a static white noise mass, forming a textural backdrop. These are generated from manipulated recordings of bells, synthesised tones and white noise. The acoustic sounds produce narrow and sparse spectra, with no-attack. The electronic sound produces grave, wide and rich spectra with attack.

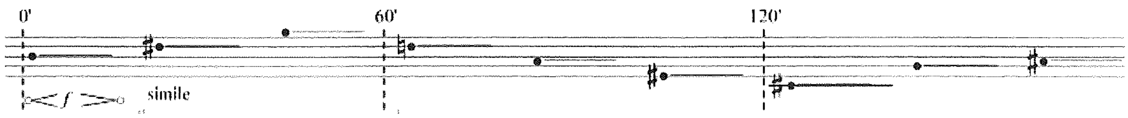

Figure 20 – Excerpt of *melody* score, 0:00-3:00. Notation showing how instruments are given single pitches to play over extended periods.[53]

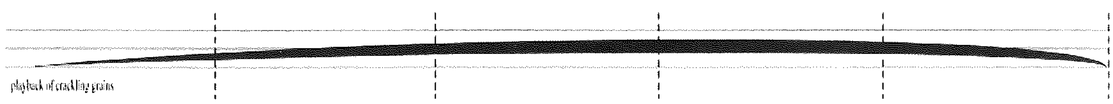

Figure 21 – Excerpt of *melody* score, synthesis part, 0:00-5:00. Notation showing volume levels of dense electronic sound added gradually over the duration.

[53] For full score see Appendix A, p. 7.

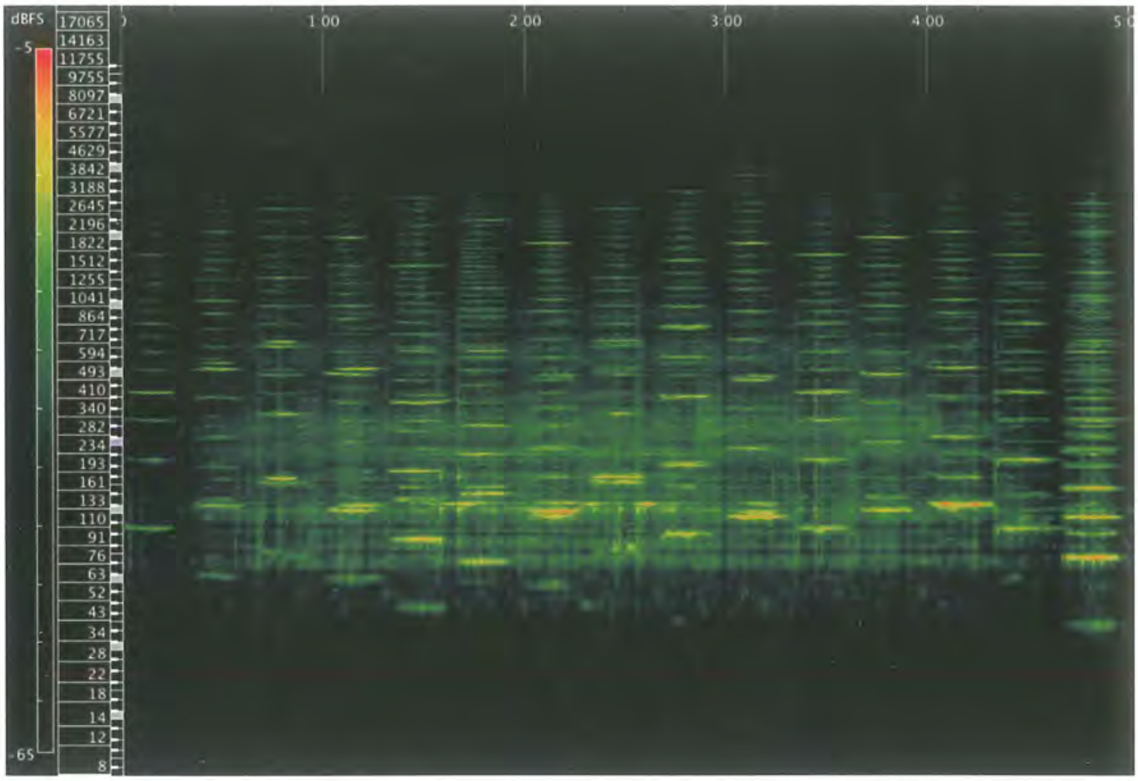

Figure 22 – Spectrogram of *melody*, showing the contrast of parallel instrument spectra and dense electronic playback. Duration 0:00-5:02.

The resulting spectrogram shows two distinct patterns: the vertical alignment of parallel horizontal frequencies created by the acoustic instruments, and the dense, textural backdrop of the electronics. The instruments retain the stable properties of held notes, while the electronic parts are scattered and noisy. The use of different timbres creates an obvious foreground and background. This creates a polytextural distancing between parts, another example of complex spectra.

3.2.2. Utilisation of the Full Range of the Frequency Spectrum

spectralisis is the most texturally complex section of *lucidity*. The acoustic instrumentalists improvise using one of seven techniques modules and one of four tone sets. The main sound source of *spectralisis* is rapid, dense granular playback from both the processing and synthesis computers generating a thick texture of moving sound. The sounds processed are captured from the live ensemble, pre-recorded and synthesised parts. The granular engine is able to play back the sounds in displaced octaves up to two octaves above or below the original sound, while maintaining the same constant playback rate. This granular engine also re-records itself as the section progresses, further processing its own output. Together with the octave displacement, frequency ranges are pushed in outwards directions throughout the section.

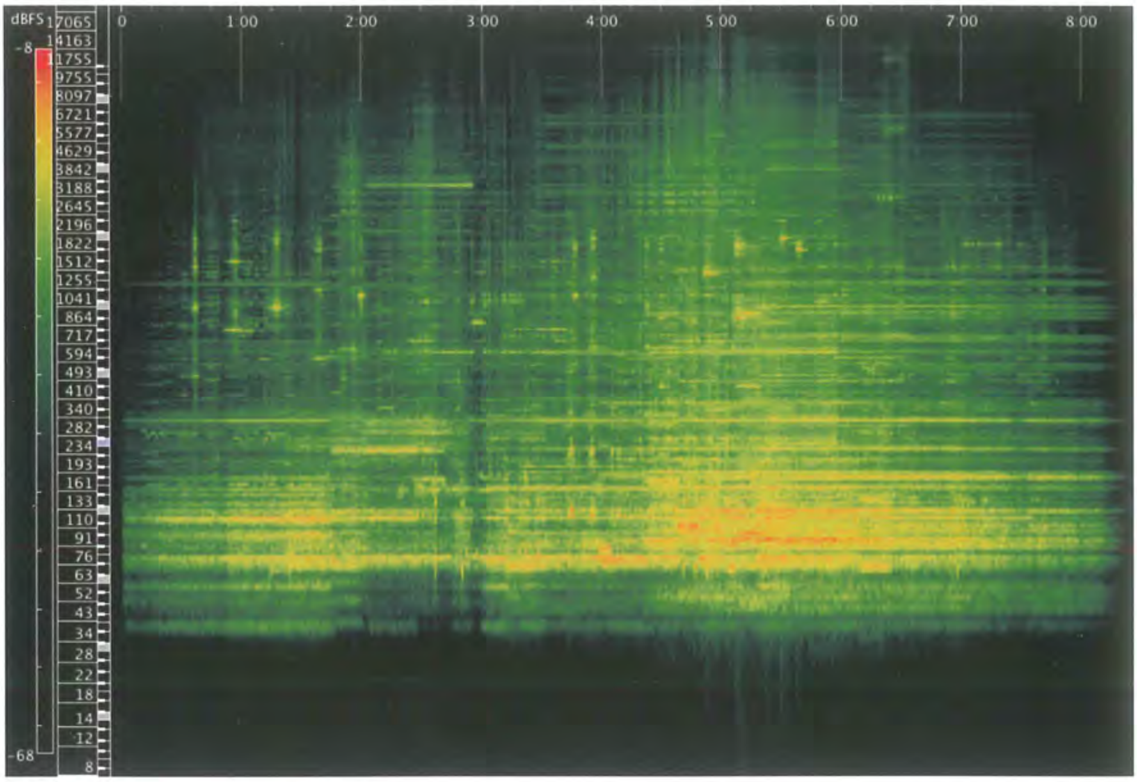

Figure 23 – Spectrogram of *spectralisis*, showing use of all frequency range at most complex point (approx. 4:30-6:30). Duration 0:00-8:26.

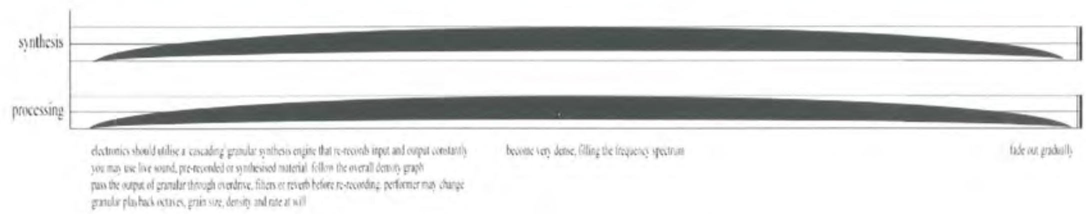

Figure 24 – Score excerpt from *spectralisis*. Synthesis and processing parts follow volume and density parameter information as well as being instructed to fill the frequency spectrum.[54]

spectralisis comprises of a conglomerate mass of sound that gradually spreads out to occupy most of the audible frequency spectrum, making particular use of low frequency sound through electronic means, with high amplitudes at low frequencies around 36-90Hz, while also reaching the frequency range above 10kHz. The instructions for the acoustic instruments are choose from one of the seven available technique modules, using pitch classes from the current tone set.

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[54] For full score see Appendix A, p. 8.

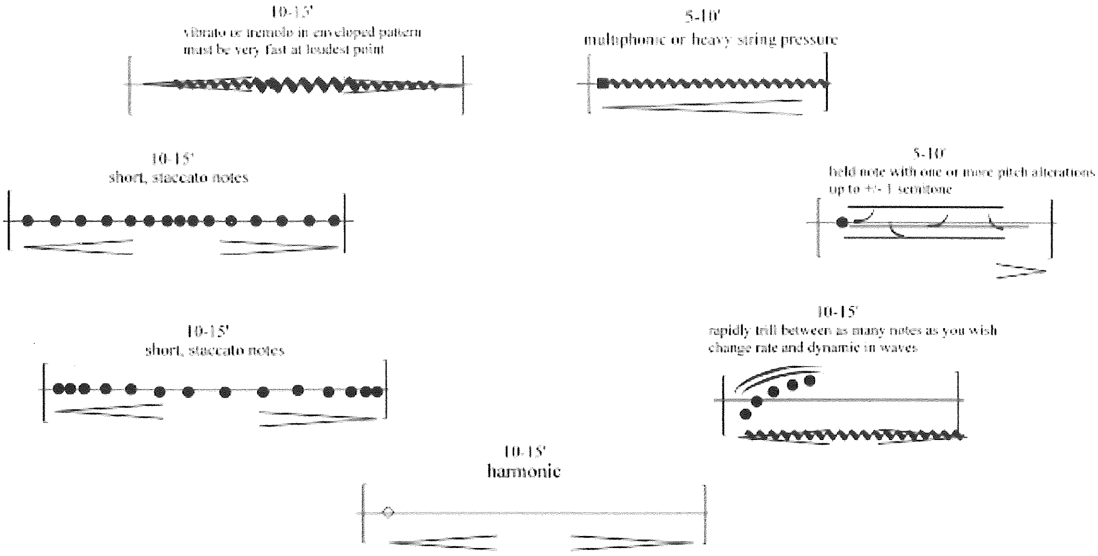

Figure 25 – Instrumental technique modules from *spectralisis*. Performers choose one technique at a time with accompanying notes from the tone sets shown in Figure 26.

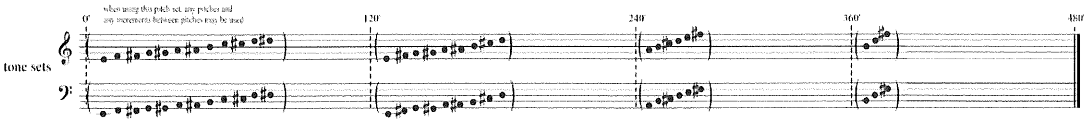

Figure 26 – Tone sets used in *spectralisis*. The number of notes reduces from all available pitch classes to three pitch classes over the duration.[55]

[55] For full score see Appendix A, p. 8.

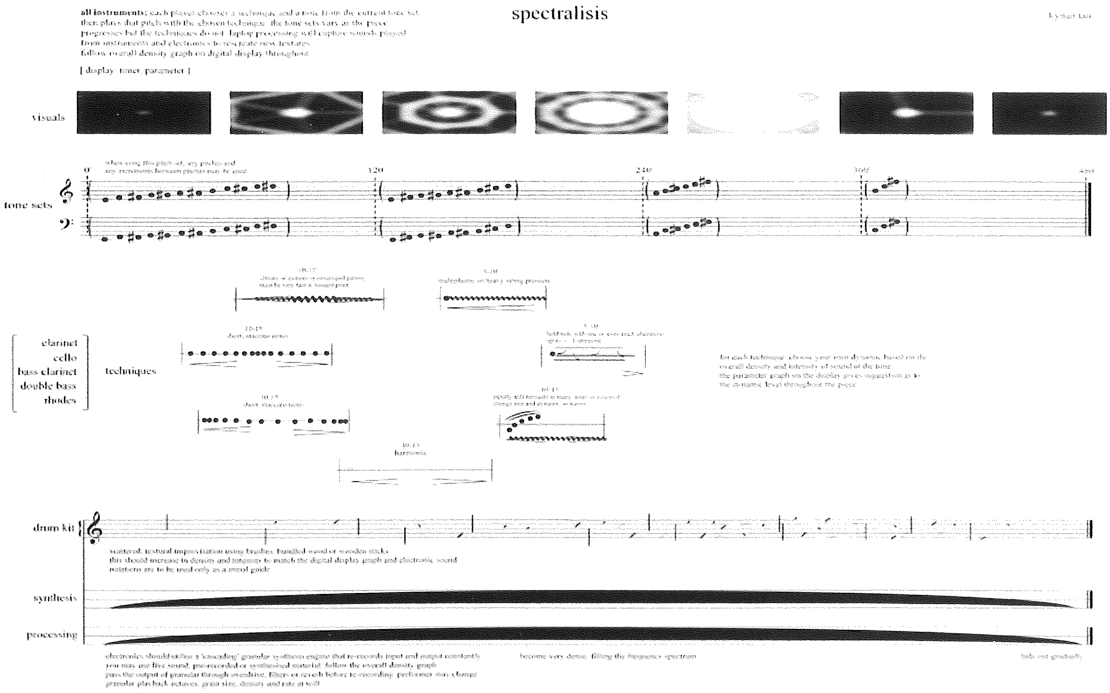

Figure 27 – Full score of *spectralisis*, showing the layout of tone sets, techniques and computer parts.[56]

As *spectralisis* progresses the tone sets become more restrictive. The first tone set contains all twelve pitch classes (plus any increments between pitches) while the final set contains only three pitch classes. This gradual narrowing of frequencies creates a refinement of spectra in the final decrescendo, creating an interesting texture due to the contrast of the electronic sound operating on such a wide frequency berth, against the instruments provide penetrating, sporadic bursts of sound. The acoustic sound is also constantly being recorded and combined with previous sounds to construct an ever-thickening sound texture. A thick, dense texture of electronic and acoustic sound using the extremes of the audible frequency spectrum is a characteristic of *spectralisis*. The way that I have utilised the frequency spectrum allows the electronics to occupy frequency ranges above and below the range of acoustic instruments. This creates textures that are extremely thick and complex, generating unusual spectra that incorporate a wide range of acoustic and electronic sounds.

[56] For larger version see, Appendix A, p. 8.

3.2.3. Augmentation of Instrumental Sounds

lucidity uses augmentation of sound spectra in real-time using combinations of audio manipulations. In *spectra*, instruments perform trills or extended tones using tone sets while the processing computer uses spectral filter, overdrive and reverb manipulations to alter the original sound of the instruments significantly before playing them back through the loudspeakers. This spectral filter consists of splitting the signal into 16 frequency bands and applying delays of varying feedback, delay times and gain to each.

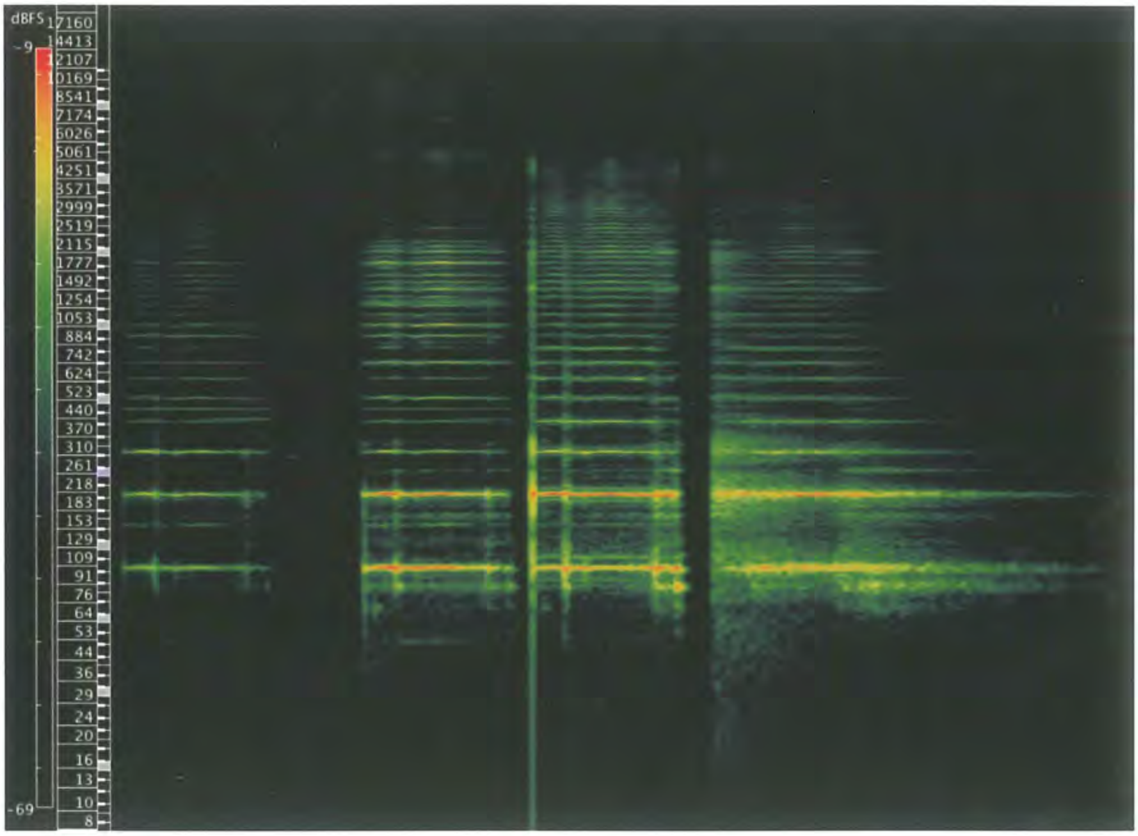

Figure 28 – Example spectrogram showing a singular cello note being passed through various augmentations, each note lasts for 4 seconds with short gaps in between. Duration 0:00-0:20.

The four discrete parts of the spectrogram show the cello note firstly with no manipulation, then with spectral filter, then with spectral filter and overdrive, and finally with spectral filter, overdrive and reverb combined. The spectrogram shows increased richness, width and density of the spectra. In the application of reverb, the sound has become smudged in the lower frequencies and has a significant reverb tail, increasing the duration of the note.

These manipulations are used extensively in *spectra* when the ensemble's individual sounds are processed. The signal path follows the same pattern as exhibited in Figure 28 and the resulting sound is passed through randomised panning to separate the sound from the ensemble. This results in an increased density of the ensemble sound that would not be possible from the acoustic ensemble alone.

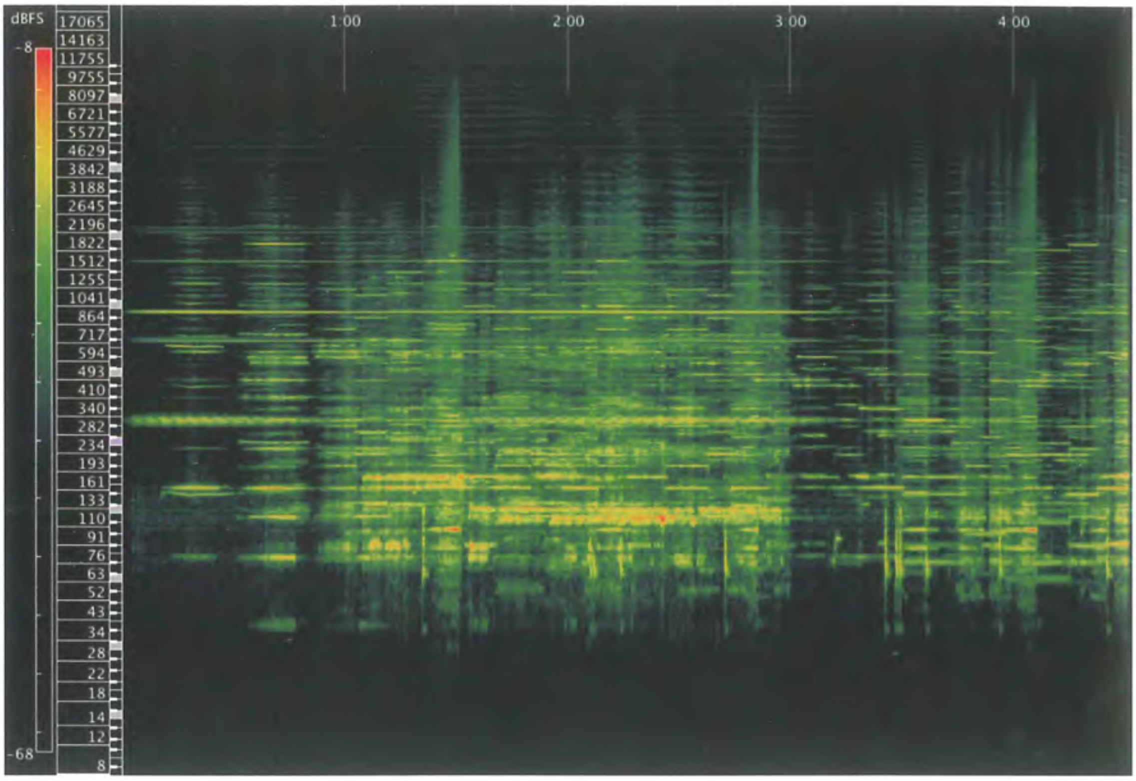

Figure 29 – Spectrogram of *spectra*, showing a high level of density and textural richness. Duration 0:00-4:32

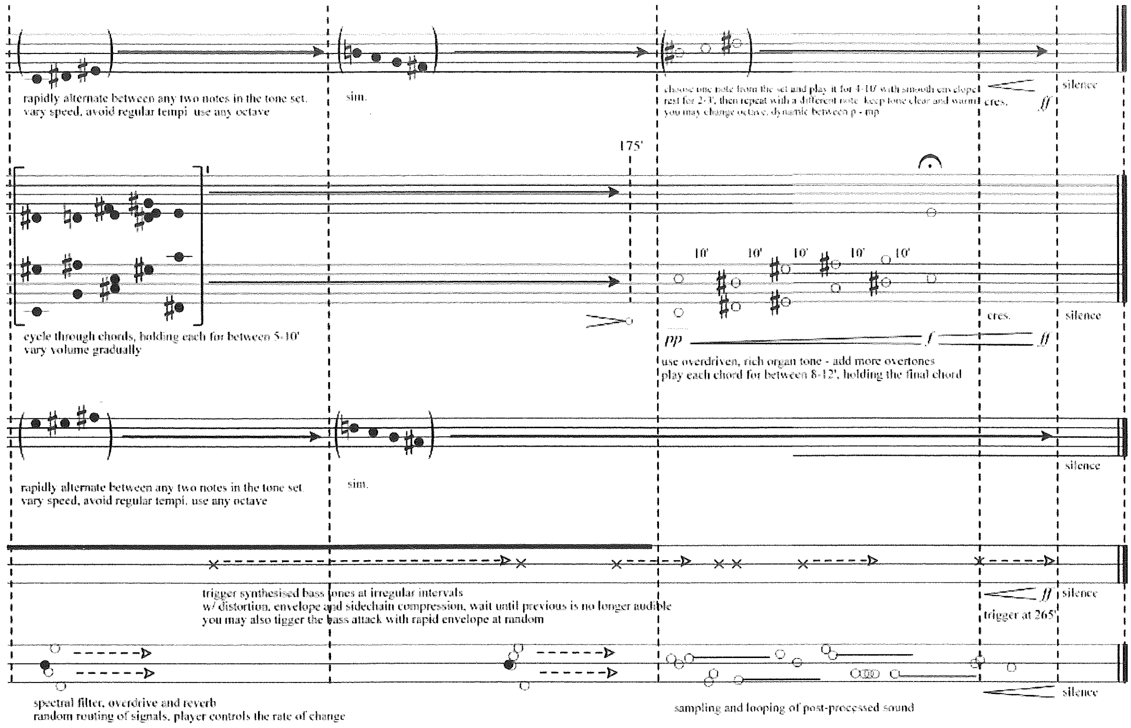

Figure 30 – Score excerpt from *spectra*, showing double bass, organ, vibraphone, synthesis and processing staves from 0:50-2:75.[57]

The notations given for the double bass, organ and vibraphone provide tone sets with instructions on how to improvise with those tone sets, each player performing asynchronously from each other. Instructions given to the processing performer are to use "spectral filter, overdrive and reverb, random panning of signals, player controls the rate of change"[58]. The processing computer layers additional augmented sound, creating a complex and rich musical texture of acoustic sound and electronic augmentations of this original sound. *spectra* uses augmented acoustic sounds to create texture derived from only the acoustic sources and manipulations of this, creating an extended ensemble. The resulting sound texture utilises the liveness of the acoustic performers but extends the sound dramatically creating a surreal and enhanced sound spectra of augmented vertical patterns.

3.2.4. Video Scoring and Synchronisation

The parameter information graph takes the form of a function graph that is scrolled across by a 'slider'. The x-axis represents time, while the y-axis represents a variable specific to that particular section. Throughout *lucidity,* this refers to the density,

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[57] As seen in Figure 30, for full score see Appendix A p. 1.
[58] *spectra* score, see Appendix A p. 1.

volume of each instrument, or overall volume. During *merr*, performers read the overall volume from the parameter graph displayed in Figure 31, while improvising around tone sets or modular passages. This allows the players to visualise the overall texture and improvise accordingly, reaching a climax after 260 seconds and then suddenly reducing to a sparse texture. The spectrogram from the resulting performance shows the direct connection and exact timing achieved with the parameter graph.

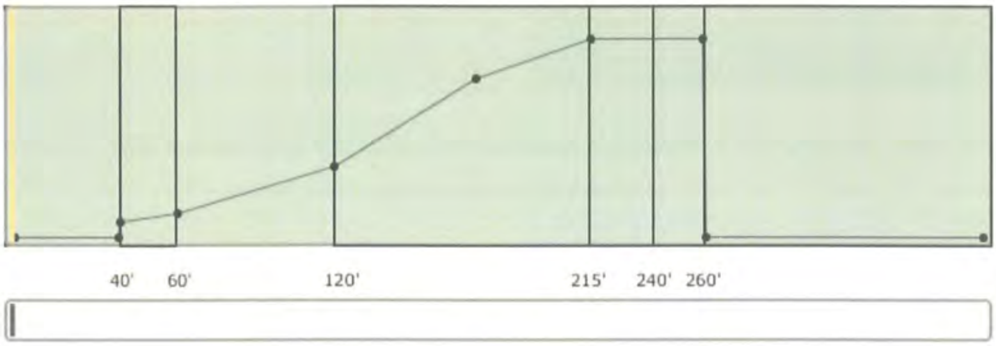

Figure 31 - Parameter graph for *merr*, showing the overall density. The yellow line scrolls across as the piece progresses, providing performers with visual representation of the density parameter, from display program.

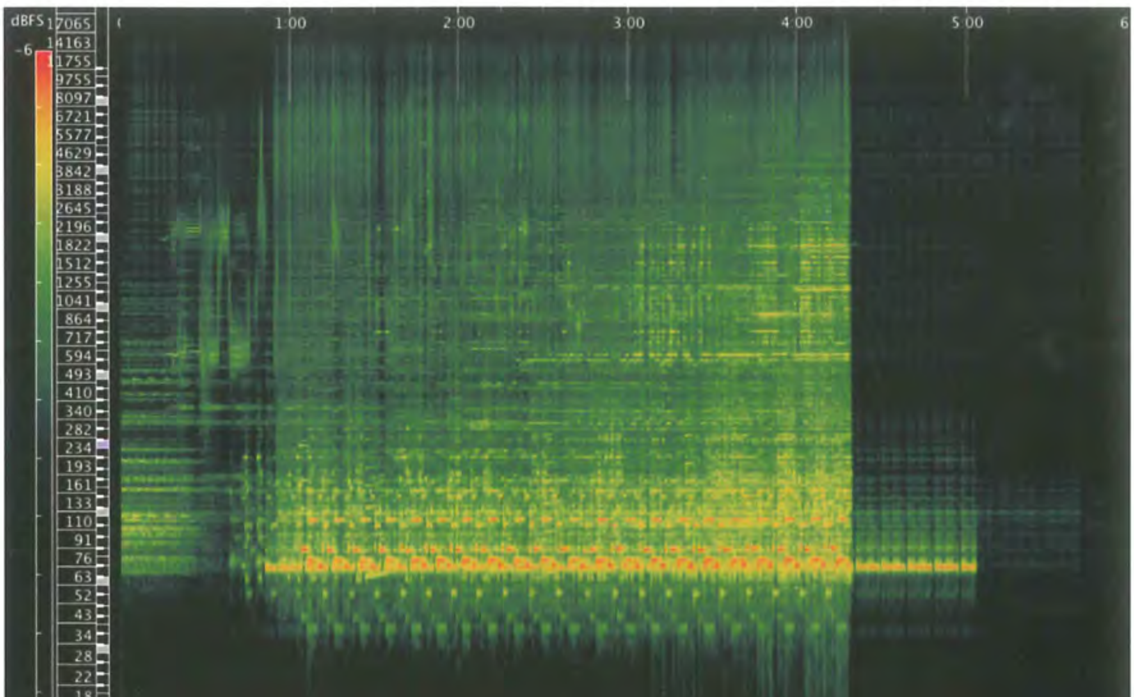

Figure 32 – Spectrogram of *merr* showing the direct correlation between the parameter graph and resulting sound. Duration 0:00-5:58

Video Scoring

The use of video scoring provides synchronised graphic notation to the performers. In *senn* the players read from a video display that shows visual noise of changing densities.

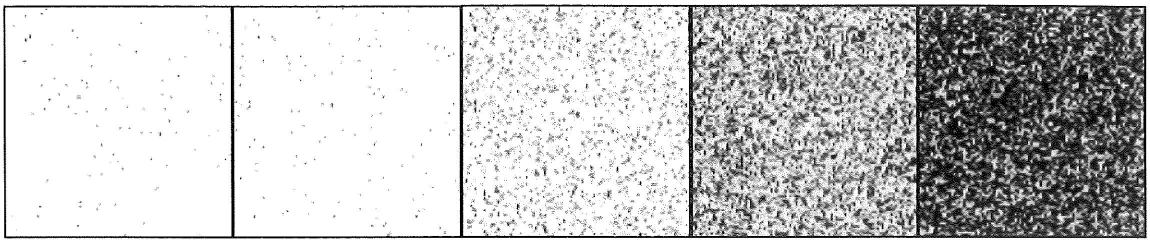

Figure 33 – Still images from the video score of *senn*, showing the changing densities in the visual noise used to direct performers.

The performers are instructed to "follow the...intensity graph and video score and use sounds that emulate the synthesised electronics...attempt to maintain the density and rate inferred by the video"[59]. Each instrument grouping is also provided with specific instructions. The electronics are not heard until well after the instruments begin to play their noise-like sounds, asking players to refer to their memory of the electronic sound.

The video gradually changes from completely white to being filled with rapidly changing black spots and lines, increasing or decreasing in density over the duration. The result of using video scoring in this controlled manner is that the ensemble is able to visualise the overall density of sound and match this with their playing at the time. The video display provides a synchronised method of controlling the ensemble and results in a tightly controlled texture that can be controlled either rapidly or gradually. It also provides a synaesthetic connection to the sounds they are to produce that proves effective in asking instruments to create noise-like sounds. The resulting sound is a tightly controlled grouping of sounds that maintained noise-like sonic properties.

Random Note Generation

During *canon* notational information is read from the display screen. The interface that the performers read is shown in Figure 35. The computer chooses the duration of each note randomly, making the parts move out of phase and overlap to

[59] see Appendix A, p. 2.

create harmony. The pitches are derived from a remapping of tones transcribed from bell spectrograms.

Figure 34 – Score excerpt from *canon*, showing the 15 note melody derived from bell spectrograms.[60]

The computer program selects the next note from the melody and assigns a random duration, within the parameters of 5-7 seconds. Through randomised probability, the percussive or struck instruments whose sounds decay rapidly are more likely to receive times closer to the minimum 5 seconds, while the string instruments which are able to sustain their sound indefinitely are more likely to receive the maximum 7 seconds. This allows the instruments with decaying sounds to play their note shortly after the previous has dissipated, enhancing the overlapping texture.

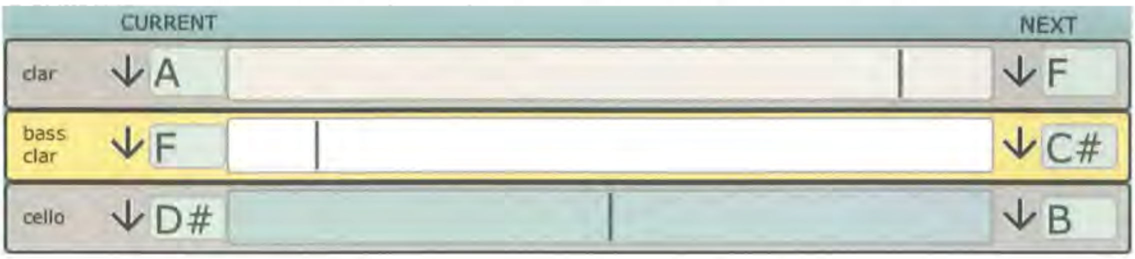

Figure 35 – Screenshot of display screen, partial example of interface for randomised notes, showing the interface for each instrument to read their current pitch class, next pitch class, direction to the next note and a graphical representation of the note length.

To begin, the notes are close together and maintain the same melodic contour with slight rhythmic delay. After some amount of notes, the notes will move out of vertical alignment and begin overlapping with each other, as demonstrated in Figure 36. This creates dissonant and dense chords as different parts play their sounds at the specified times, creating a constantly shifting and dense harmonic sound mass. Randomised note information generated by the computer allows the control of the ensemble to move from tightly synchronised to asynchronous performance between parts. This creates a gradual movement from a simple texture to a complex, overlapping harmony as the parts slowly move out of phase.

[60] For full score, see Appendix A, p. 3.

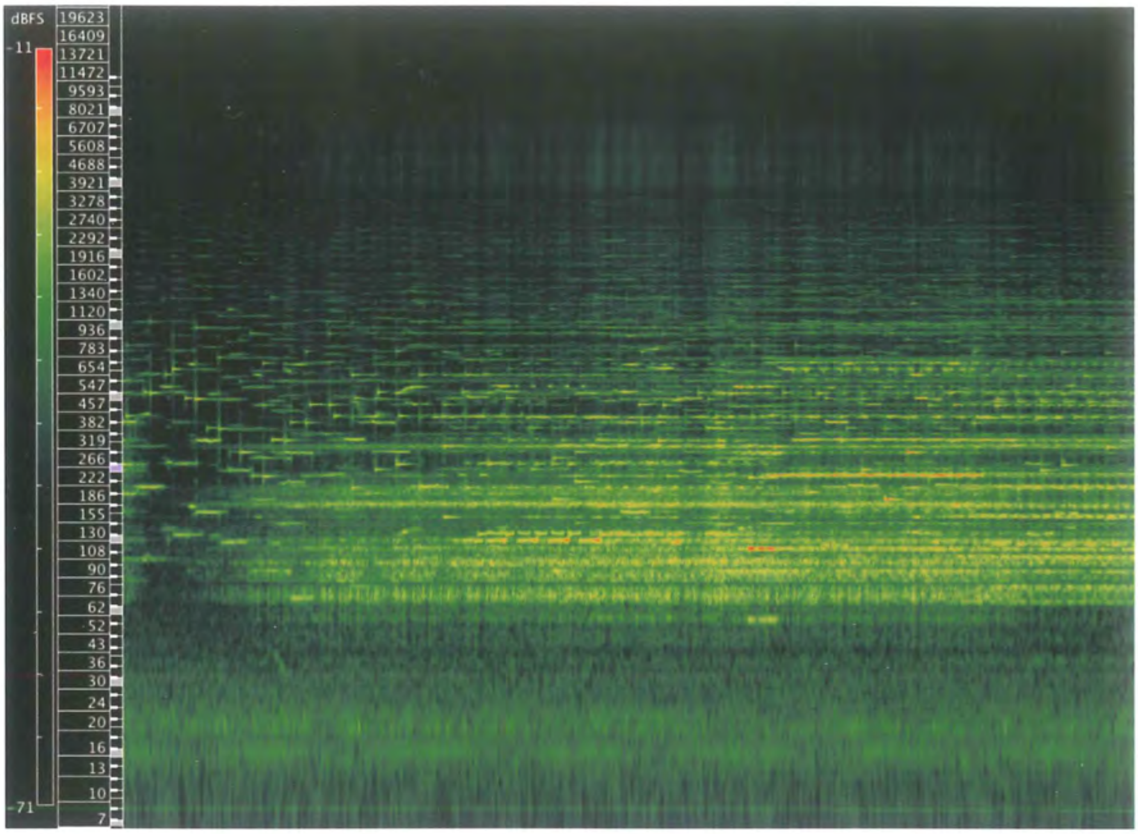

Figure 36 - Spectrogram of *canon*, showing the overlapping texture. Duration 0:00–4:00.

Conclusion and Outcomes

Through an overview of the evolution of electroacoustic music and the approaches to its composition, I have been able to create an entomology to discuss electroacoustic music in a more complete way. The analytical methods I applied in my examination of *utp_* and *lucidity* visualise and describe the sounds of these electroacoustic works, and identify a range of composition techniques that may be applied in new works. I believe my work *lucidity* integrates these techniques successfully and merges sound sources into a singular, synthetic compositional approach.

While the area of electroacoustic music has been developing alongside electronic technologies over the past seventy years, I believe a greater understanding is still needed for works to be created that completely integrate electronic and acoustic sound sources. I hope that this research can provide some insights into the compositional practice in these works and aid the development of future works for electroacoustic ensembles.

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Appendix A – *lucidity* full score

lucidity

for electroacoustic ensemble:
acoustic instruments, computer processing, sound synthesis and video projections

kynan tan
2010

performance notes

lucidity is a work for medium sized electroacoustic ensemble, comprised of acoustic instruments, electric instruments, computer sound processing, sound synthesis and visual projections. the work has been created through the study of examplar works in the field, but also through workshopping sessions spread over a period of six months during 2010. these workshopping sessions allowed testing of various notations, trying out electronic music techniques, recording the ensemble, as well as building an ensemble identity and cohesion.

synchronisation between performers, electronics and visual projections is achieved via a network of computers that are triggered by the master computer at the beginning of the performance. once all computers begin, each has a self-contained engine that will allow it to continue until the end of the performance. the synchronisation is only then checked at regular intervals to maintain timing synchronicity. the networked computers include the playback and synthesis computer, the visual projection computer and several display computers which provide players with score triggers, randomly generated material and parameter graphs.

the work was composed with specific limitations and for a particular performance venue, this was for a specific length work to be performed in an acoustically designed music auditorium. as such, the technical specifications, stage arrangements and amplification systems were specific to that venue, and may be altered for subsequent performances.

lucidity is a continuous, 46 minute work that comprises of eight sections. the time length is fixed due to the synchronisation of display screens, video and some pre-recorded sound elements. if the work is to be performed, the length of each section, the order and the number of sections performed can be altered, so long as all parts remain synchronised.

contained within the 'score' package for this work is the recording of the performance, the visuals movie file, performance scores, max/MSP patches used at the original performance and instructions on how to recreate the synthesis and playback.

the stage arrangement as well as guidance on how to interpret various notations and perform the work are provided here.

structure

spectra (4.5")
senn (5")
canon (4")
merr (6")
luminaire (6.5")
quasi (7")
melody (5")
spectralisis (8")

each section of the work is given a specific name. while the work fits together as a whole, sections may be played individually. the name of each section attempts to describe either the texture of that piece, a synaesthetic connection between the spectra of the work and a non-functional word, or, a reference to a music technique which has been recontextualised in this setting.

the score consists of one page per section, plus an appendix of the five transcriptions used in *quasi*. the transcriptions are derived from spectrograms of electronically modified bell samples. the notation is precise and requires further detail than the texture-oriented scores to the eight major sections.

player specifications

for best results, the players involved in the performance of the work should have an understanding of improvisation, electronic music, amplification and recording technique. a number of parts in the work require players to adjust their sound to contrast with electronic parts. players are also required to improvise using a specific method of playing or sound set.

score + notations

instrumentation / score order

visuals
\\
clarinet
bass clarinet
cello
double bass
prepared rhodes piano / organ
vibraphone / drum kit
ondes / synthesised electronics
processing electronics

notations

note: markings in the electronics parts of the score are to provide a symbolic representation of the sound only. they do not provide exact timing or parameter control. the combination of the written instructions plus the programming information and audio recording are necessary to reach the sonic result. generally speaking, note heads represent a pitched sound or group of sounds that are being sampled. changes between different notehead symbols represent changes in sounds. other symbols are used to suggest a particular pattern, movement or timbre of sound.

rounded brackets = any material such as notes, symbols or written instructions that are enclosed in brackets are sets of material in which the performer can choose items from to play during that alotted timespan.
square brackets = material that is repeated exactly for a specified period of time
square brackets (over instruments) = groupings of instruments that follow the same instructions.

instrument specific instructions are always written below each instrumental part.

reading off the digital display: indication of the information to be read off the display is located on the top left corner of each section's score page. This is written in the format of [display: time, notes, parameter].

specific notations

playing "in waves" = refers to following an envelope pattern for a specific technique or expression. beginning with very little, moving to rapid, loud or fast and then returning to very little. this can refer to tremolo or vibrato rate/width in combination with volume.

line and arrow = this symbol indicates the extent of the timeframe for the material that it leads from.

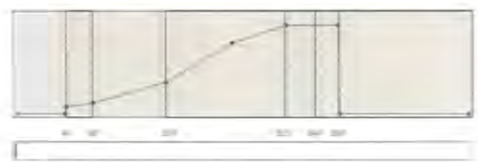
● - filled in note head = this generally refers to a pitch class given in a tone set that is to be treated with the given instructions.

○ - open note head = this refers to a note that is to be held for extended periods.

time markings = always appear in seconds (format: XXX").

tone sets = the tone sets provided allow the performers to choose from one or more of the notes and apply various instrumental techniques to these. at some points these are written in ascending order, other times notes are given in irregular orders to ask the players to make sure they are treating the set randomly.

notes bracketed within tone sets = these are to be played on a less frequent basis, or in the case of the improvisatory 'solos' in *merr*, as a leading tone / ornament.



parameter graphs = parameter graphs that are displayed on screen are scrolled through, allowing the performers to see the current density, volume, rate etc. accurately and in real-time.

canon / melody / senn - note generation = pitch classes or notations are displayed on the screen along with a slider which moves from left to right. when the slider reaches the right hand side, the note is to be played, and held until the slider moves back in that direction to the next note.

software specifications

the original performance was achieved by using two laptops for the electronic sound component. one laptop dedicated to sound synthesis, triggering samples and playback of pre-determined parts (written in score as "synthesis"), while the other was dedicated to live sound processing and received all microphone inputs as well as the synthesis outputs (written in score as "processing").

synthesis
sound synthesis: the computer generated sound in this work was created from FM synthesis, additive synthesis, granular synthesis, fine editing of samples and application of effects and equilisation. a large portion of musical material was devised in non-real-time. the real-time applications are described below.

ondes: this refers to an additive synthesizer that is controlled via tablet in a similar way to an ondes martenot. the tablet provides the instrument with frequency and amplitude information. this is tuned to just intonation (fundamental pitch A-220Hz), and allows the performer to control the intonation, volume, expression and timing of the instrument. the synthesis engine uses three sine tone oscillators with adjustable octave controls. these are fed through a bandpass filter of which the resonant frequency is controlled by the frequency input. this is passed through a reverb unit. the result is a sound that moves between blending well with the acoustic instruments and standing out as a strongly electronic tone.

performing with the actual ondes martenot instrument would also be acceptable, but was not possible for this performance.

feedback delay: this unit uses an overloaded delay line with built in filters and compression which, when pushed to the extremes, results in rapidly changing, dynamic electronic noise. the input, output, feedback, delay time and overall volume are controlled live during the performance.

for the original performance, this computer was utilizing Ableton Live software, which allowed the use of many of the max/MSP modules as plug ins as well. however, other software may be used if it provides the same functionality.

processing
the max/MSP patch used for the live processing of sounds contains many self built modules that are linked together through a matrix system which allows for any combination of signal routing. The modules that are necessary to perform this work are explained below.

compressor: parallel compressor. control-input level.

reverb: control-reverb time.

overdrive: control-gain.

pitch modulation: delay with changing time + octave shifting using fft. control-depth, rate, width, octave strength -2/+2.

ring modulation: sine tone modifier signal. control-frequency, depth, wet/dry.

spectral delay: unit that splits signal into 16 bands, applying different delay time, feedback, panning and gain to each. control-preset adjusting all above parameters.

sampler: module that records samples and plays them back in loops, the length of each is not linked. control-record time, mute on/off.

looper: looping system that consists of 5 buffers that record and then produce looped playback, locked to an original length of recording. subsequent recordings are added as layers over this. this is used to record an initial layer, and then add tiny fragments over this by only allowing recordings for a fraction of a second. control-record for each buffer.

grains: modules that record sounds and then play this back in fine grains at a rapid rate, creating a density from the original timbre. once sound is recorded, playback is controlled by random variables, moving backwards and forwards at different rates. control-record, volume, octave, grain size.

polyplay: modules in which one sound is recorded and then played back in rapid samples. adjustable presets allow the sound to move from random sampling to dense grains. control-octave, trigger rate, length of sample, beginning point of sample, panning.

panning: modules that take a mono input signal and randomly distribute to stereo. 2 available modes are: *splashing* - jumping directly from one channel to the other with a short ramp time, or *rotation* - moving in a circular motion between the stereo channels at a specified rate. control-rate, mode, on/off random jumping.

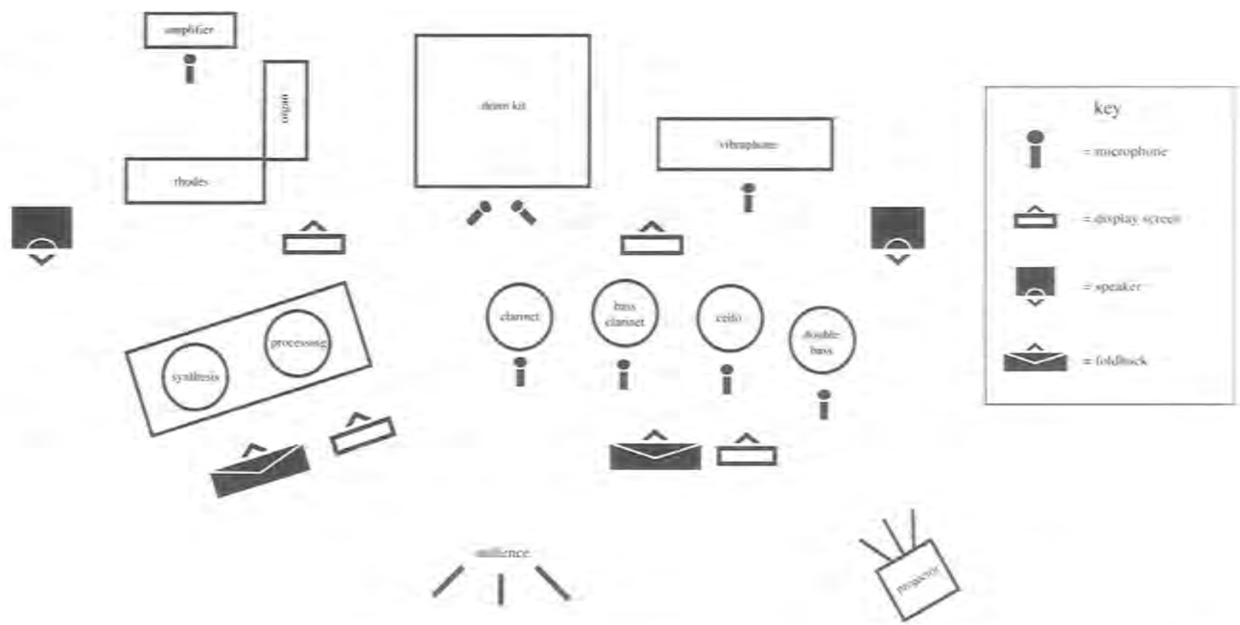
technical specifications

the original performance was achieved using the following equipment -

speakers = 2 powered PA speakers
foldback = 2 foldback monitors provided electronic elements
mixer = 8 channel mixer providing signal path into laptop, 8 channel mixer providing laptop outputs to speakers and foldback
inputs = 8 instrument microphones + 2 synthesis inputs + 2 processing inputs
outputs = 2 output channels from processing laptop, 2 from synthesis laptop
projector = this should be placed far back enough to allow the image to spill over the back wall and partially onto the performers

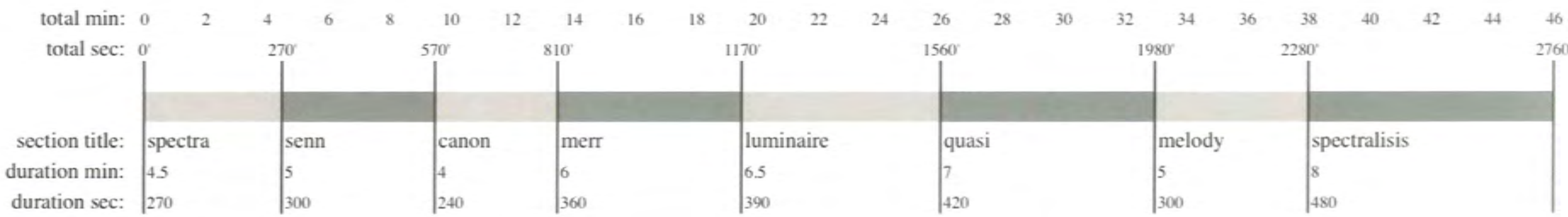
preparations to rhodes piano

prepared using gaffa tape. the middle portion of the keyboard range should be left untouched. in the lower and upper portions tape should be applied to the keyboard tines to alter the sound to become more percussive and reduce the decay time.

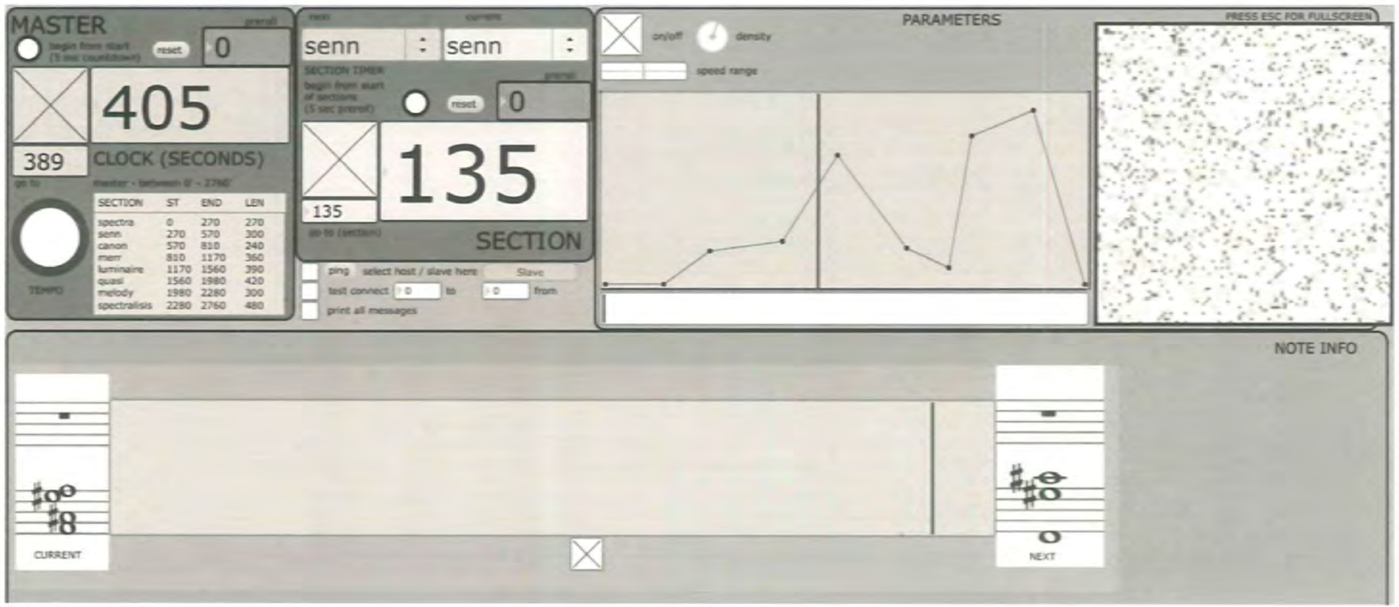


lucidity

composition timeline



composition timeline

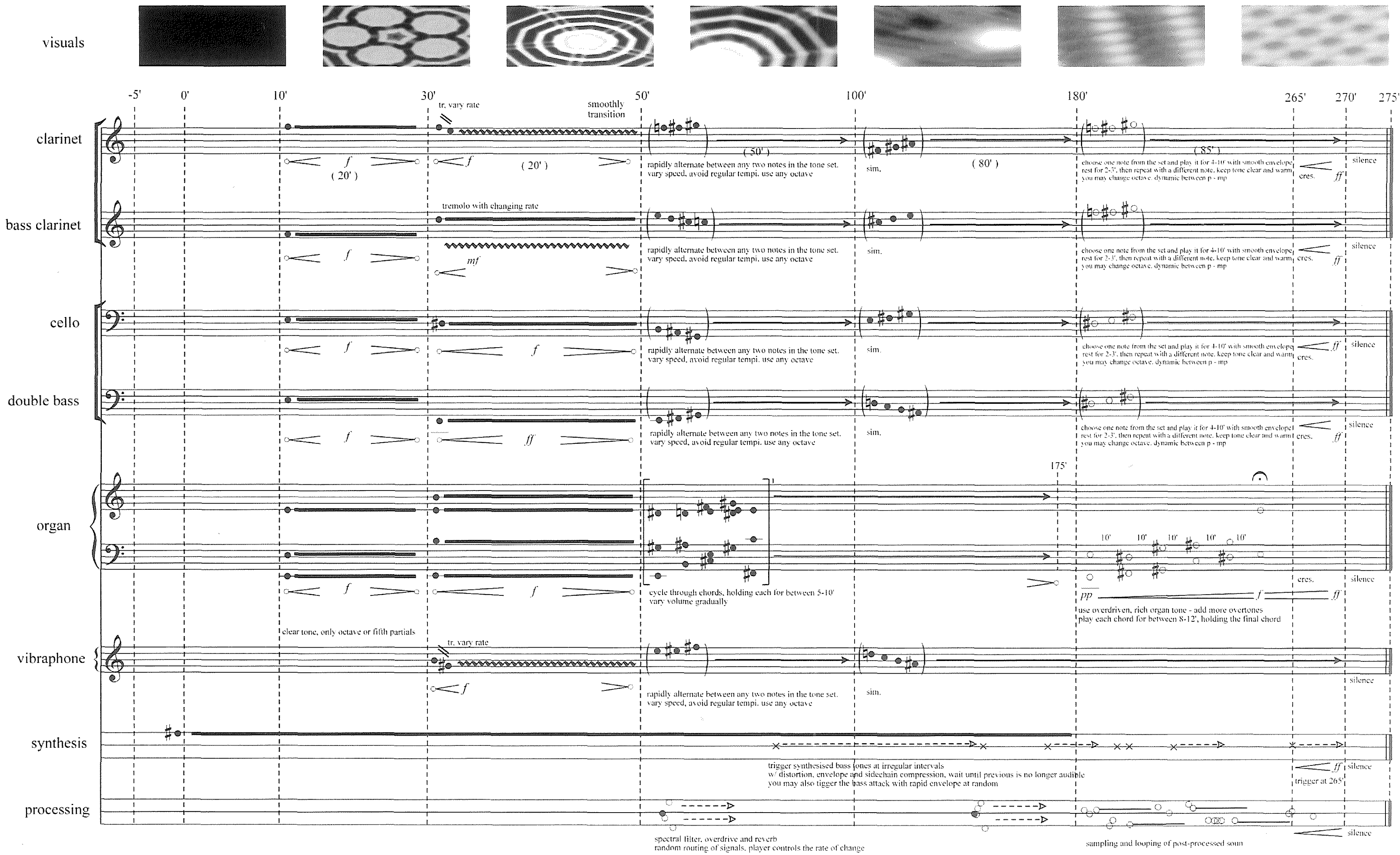


display screen example

for more information please see www.kynantan.com
or email contact@kynantan.com

spectra

kynan tan

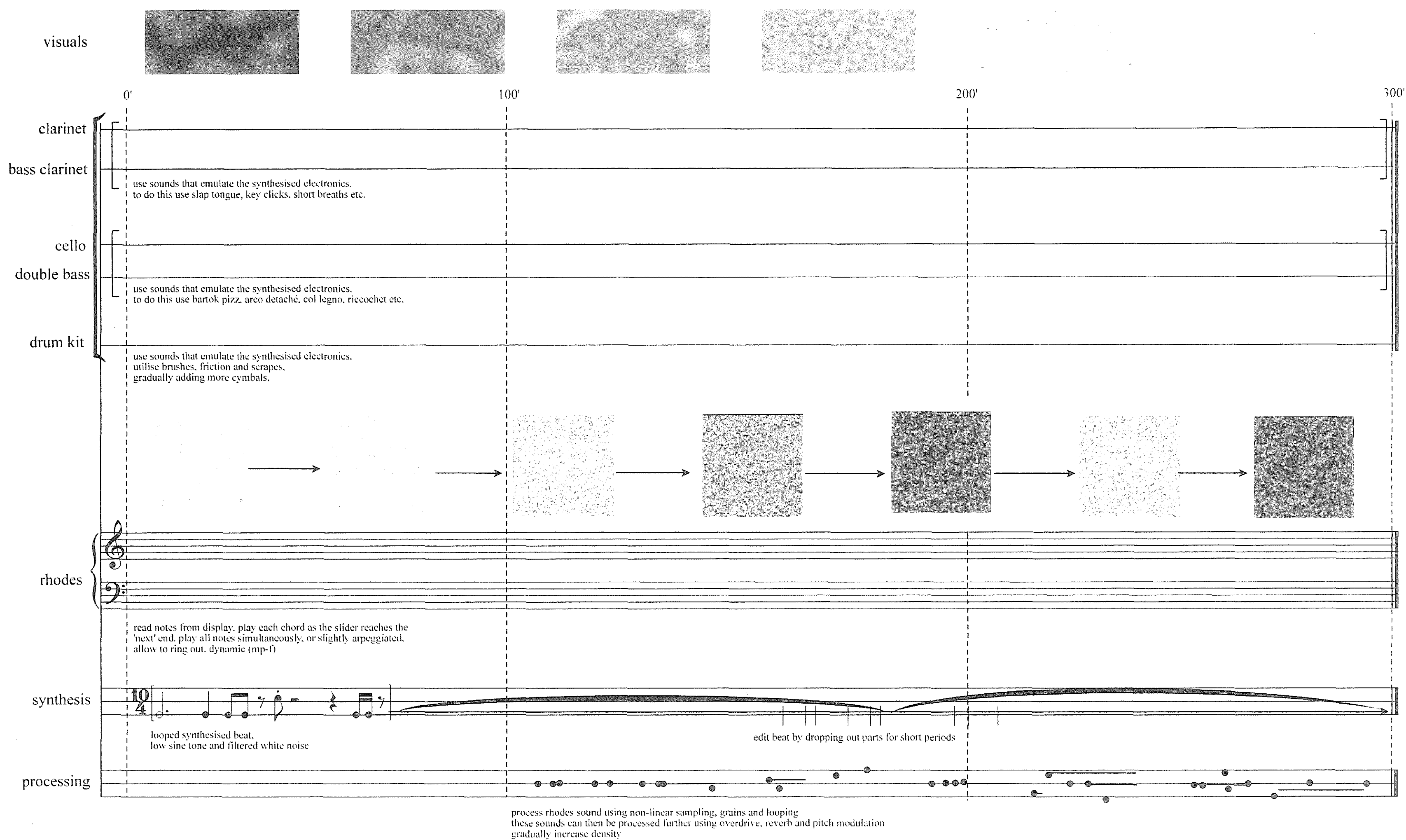


all instruments (except rhodes): follow display for intensity graph and video score. use sounds that emulate the electronic granular noise. some suggestions are provided. attempt to maintain the density and rate inferred by the video. images on the score are a guide only

[display: timer, parameter, notes]

senn

kynan tan

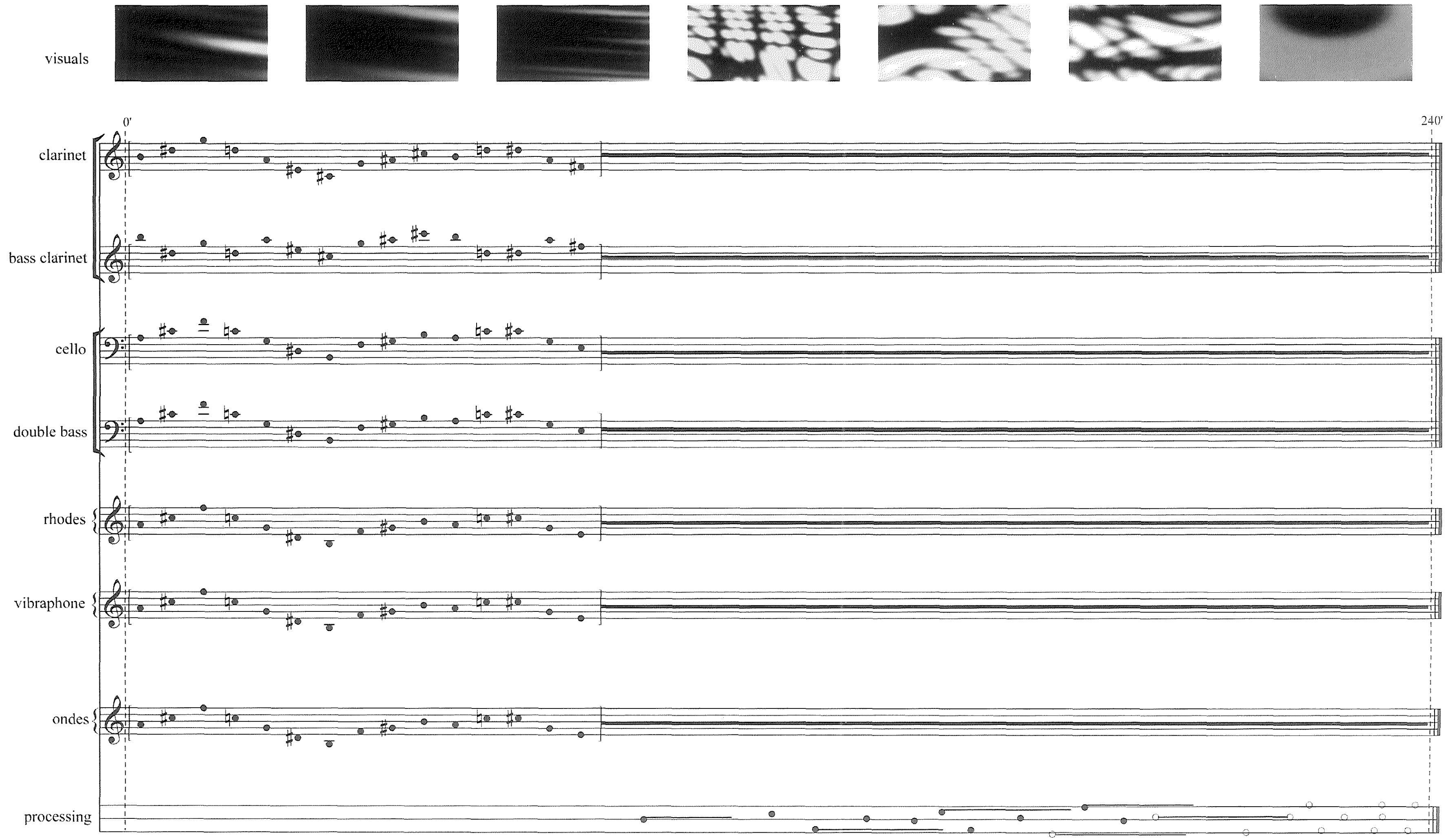


canon

kynan tan

all instruments: read notes from display. the pitch class, direction and
a grahic for note length are provided. each note lasts between 5-7 seconds.
maintain consistant volume and warm clear tone, changing register if necessary.
use normal attack. parts should move out of phase. repeat until no further note information is provided

[display: timer, parameter]



begin recording and looping ensemble sounds.
using randomly changing input paths
apply reverb and overdrive to post-looped sound

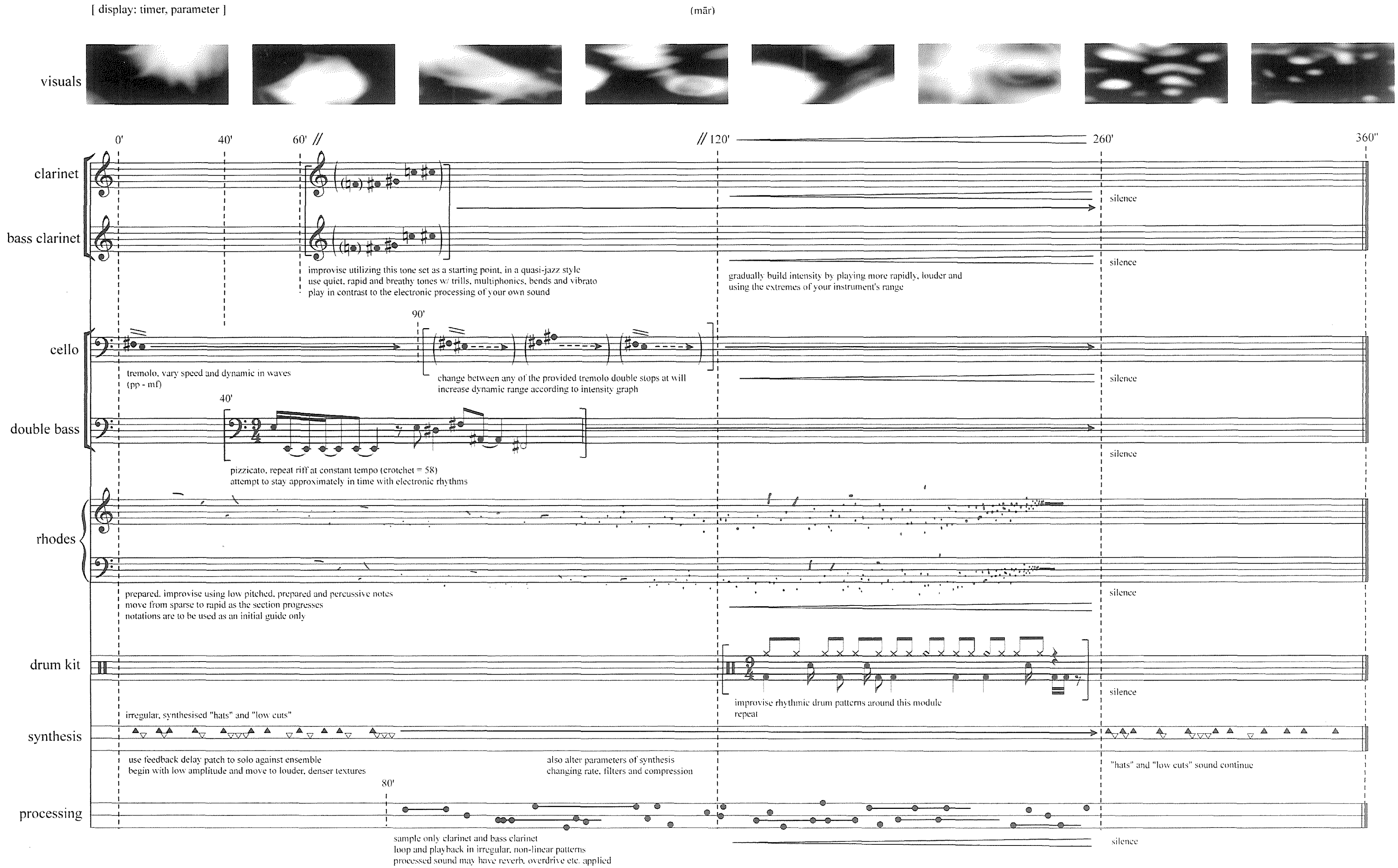
add more grains, non-linear looping and polyplay

continue loops into next section

merr

(mār)

kynan tan

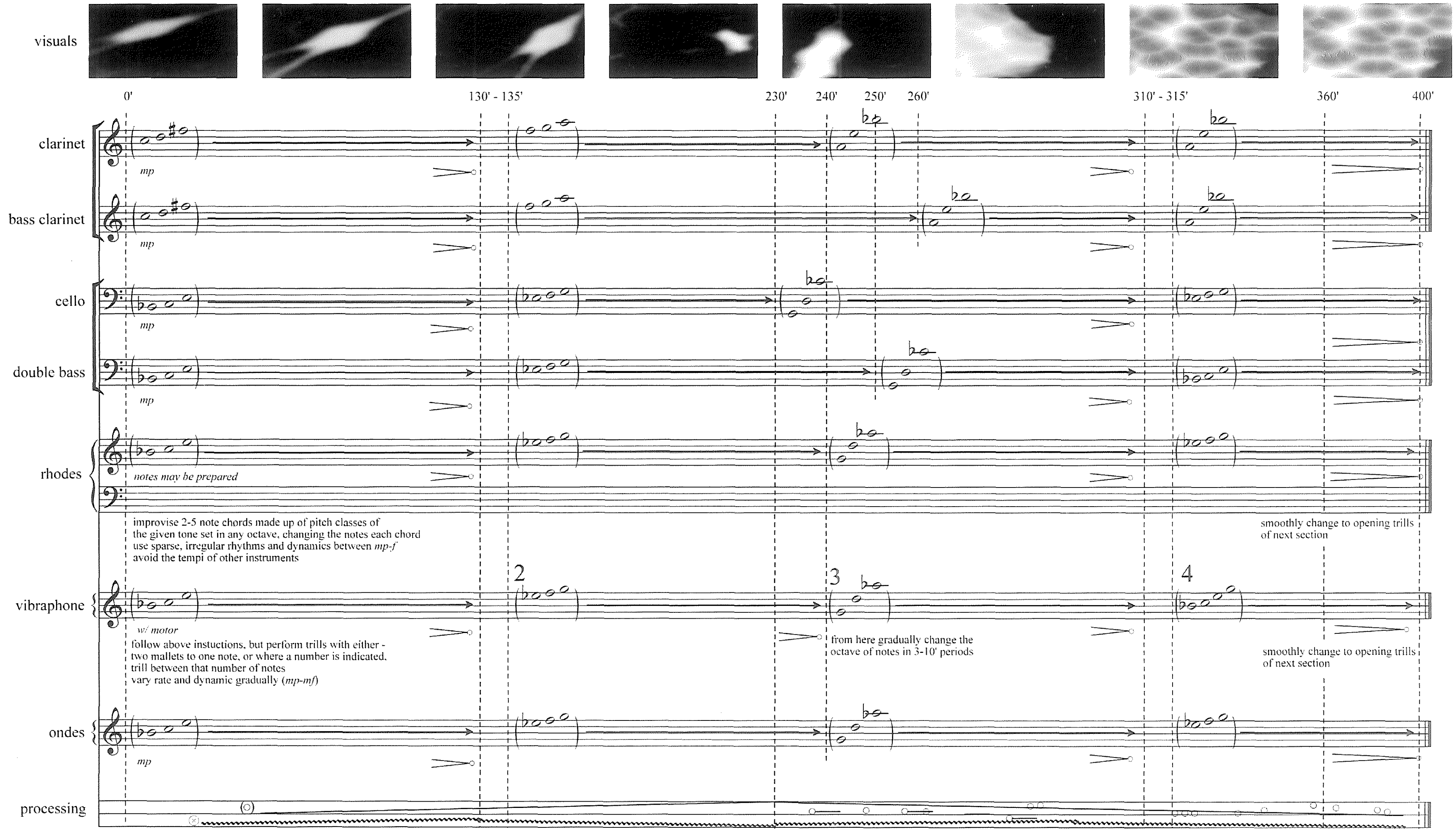


luminaire

kynan tan

all instruments: choose one note from the set and play for 4-10'
with smooth envelope. then choose a note different to the one you just played
and play after a 2-3' break between notes. keep tone as clear as possible
you may change register to keep tone warm and clear

[display: timer]



additive effects: gradually add reverb, overdrive and tremolo
to live sound. the sound should become more electronic smoothly
allow reverb tails to fade out during the instrument's periods of silence

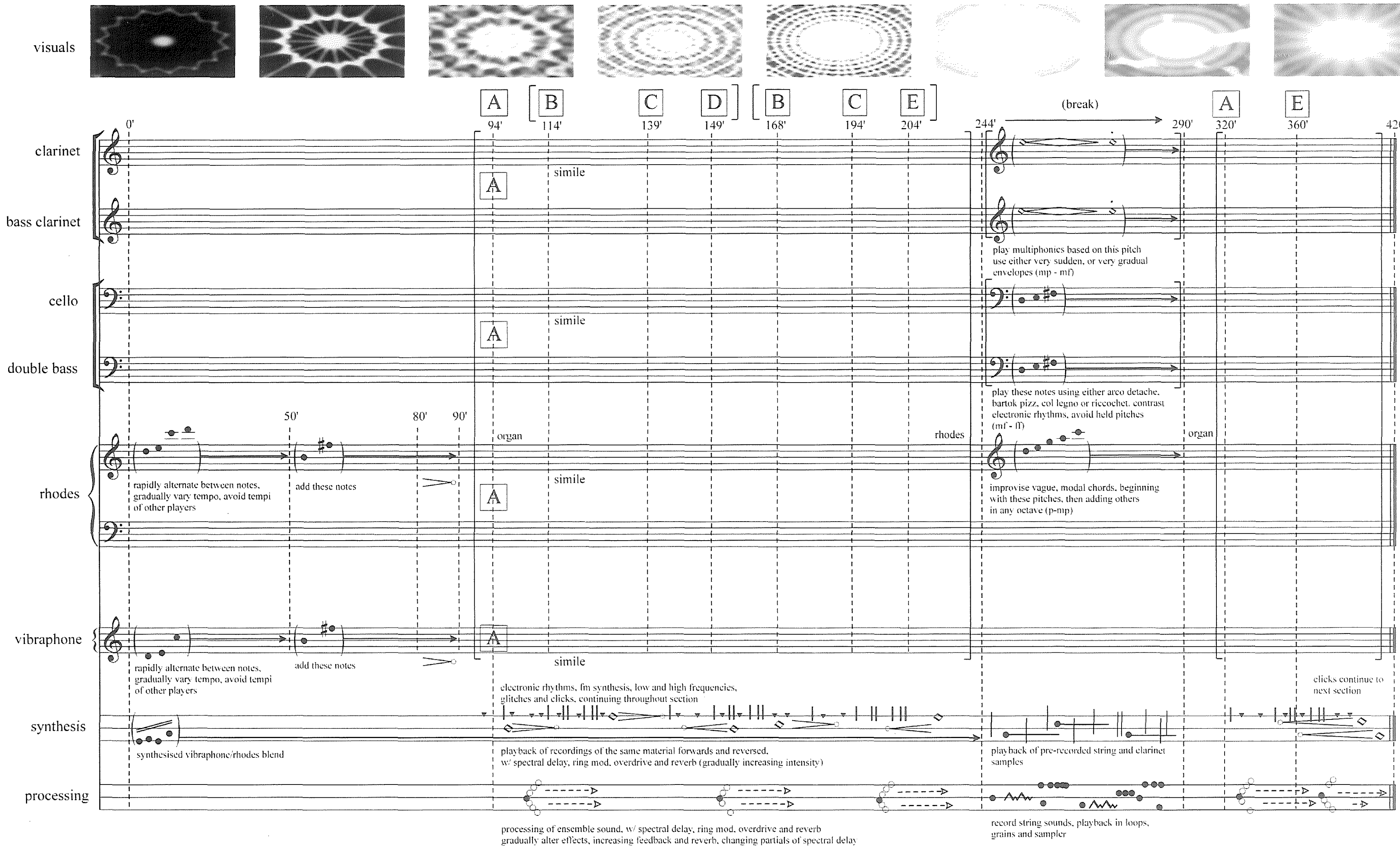
begin recording post-processed sound, and playing
back sounds in non-linear loops. overall sound should still be sparse

quasi

kynan tan

all instruments: where the markers A, B, C, D and E appear, refer to the separate scores for each module. the start time for each is marked here, however the preroll, notes and timing are shown on the digital display

[display: timer, notes]

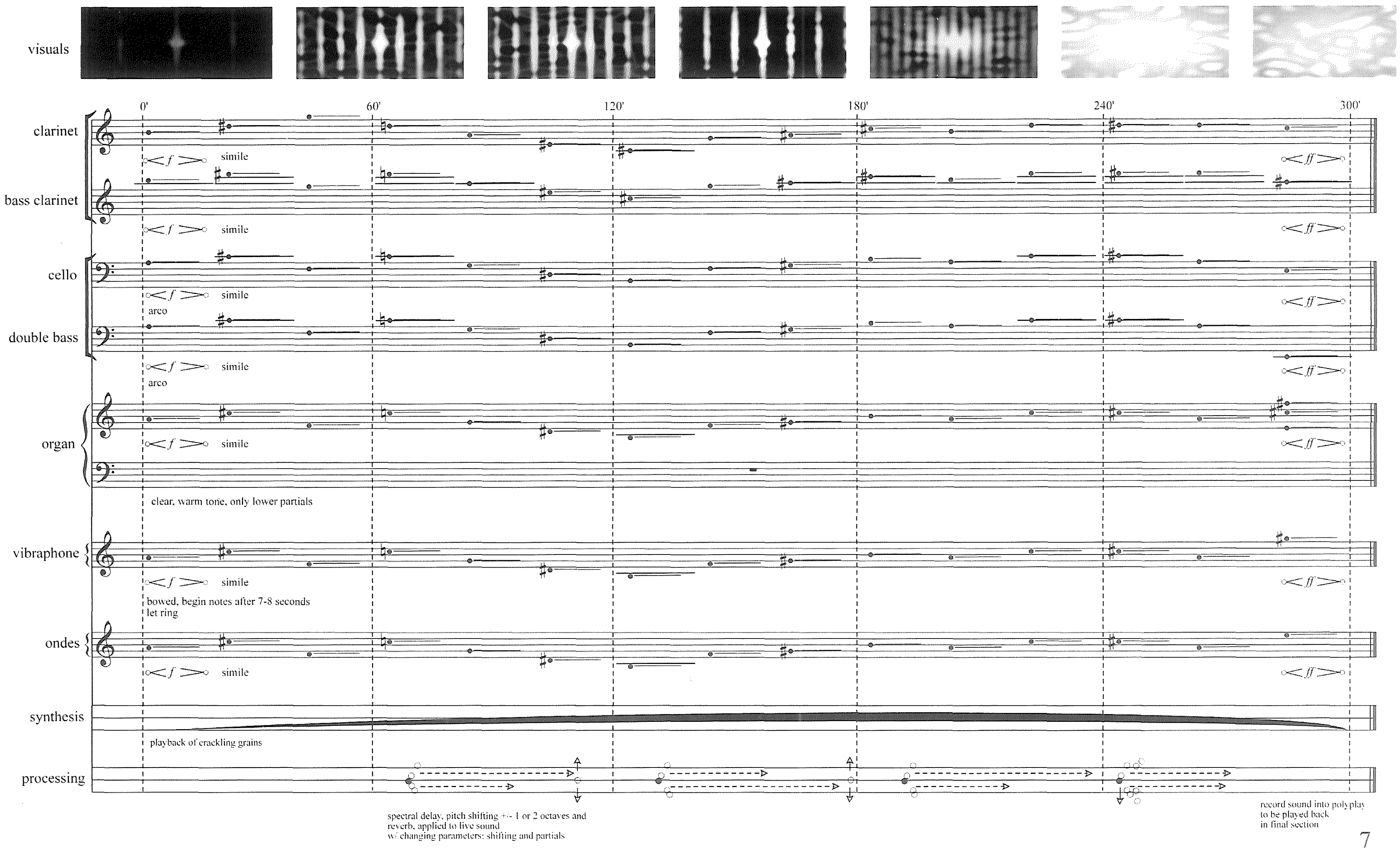


melody

kynan tan

all instruments: each note has a 20 second window. you must begin your note in the first 3 seconds,and end in the last 5 seconds.
use a very gradual envelope for each sound. maintain a warm clear tone.
changing register if necessary. notes and timing will be displayed on screen

[display: timer, notes]

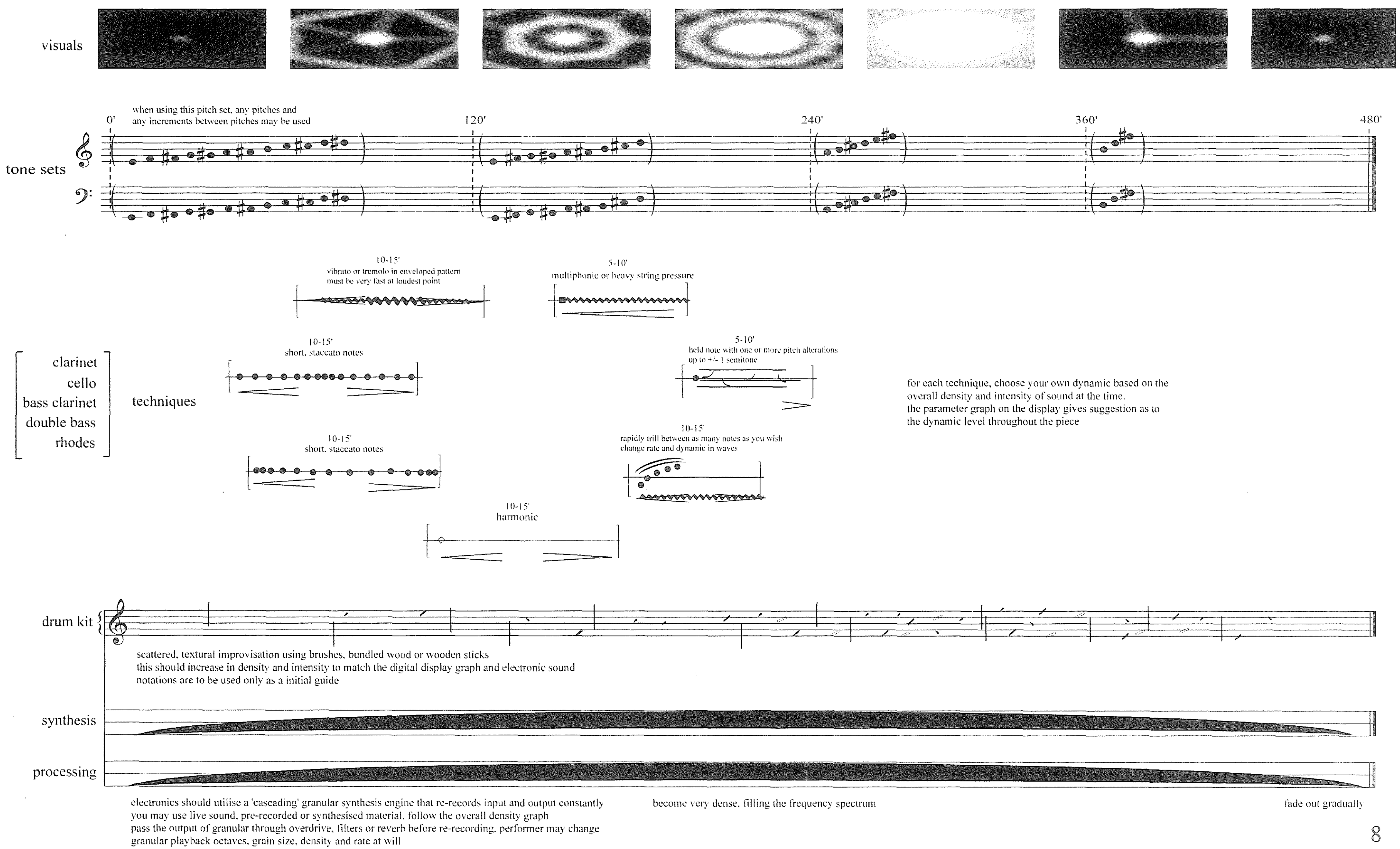


spectralisis

kynan tan

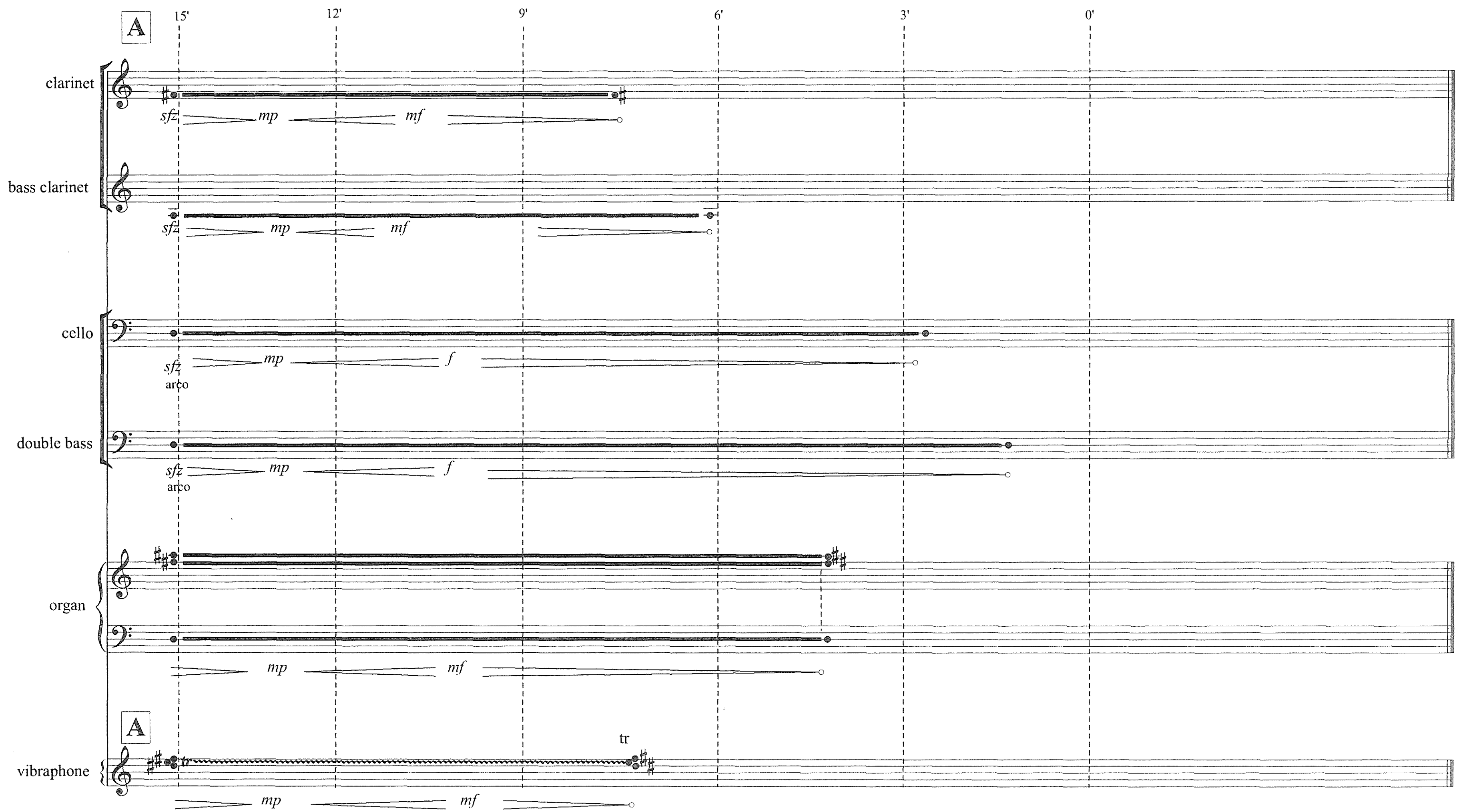
all instruments: each player chooses a technique and a note from the current tone set, then plays that pitch with the chosen technique. the tone sets vary as the piece progresses but the techniques do not. laptop processing will capture sounds played from instruments and electronics to re-create new textures.
follow overall density graph on digital display throughout

[display: timer, parameter]



note: reverse
A - first modulation, x3 timing (longer) and reverse

transcription A



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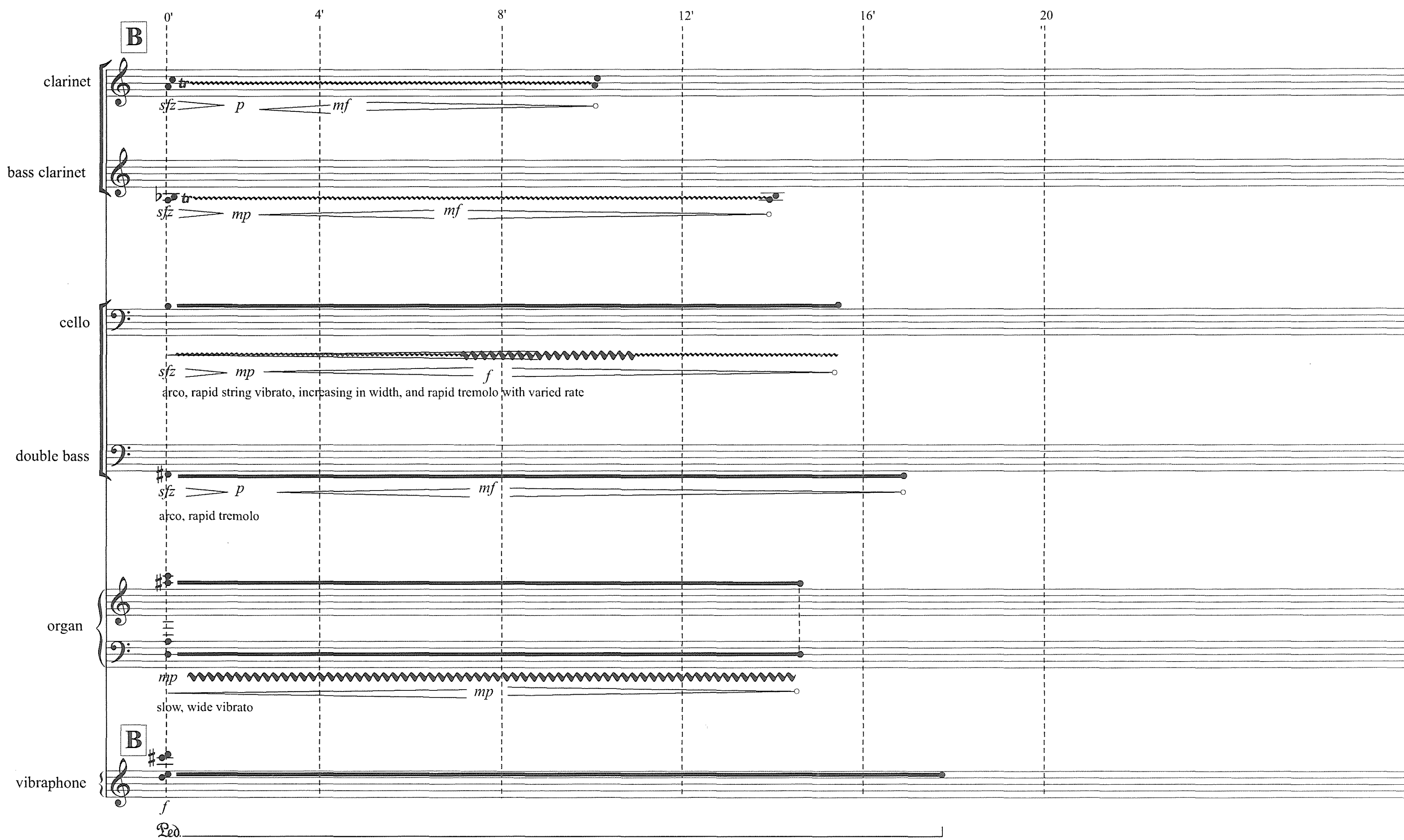

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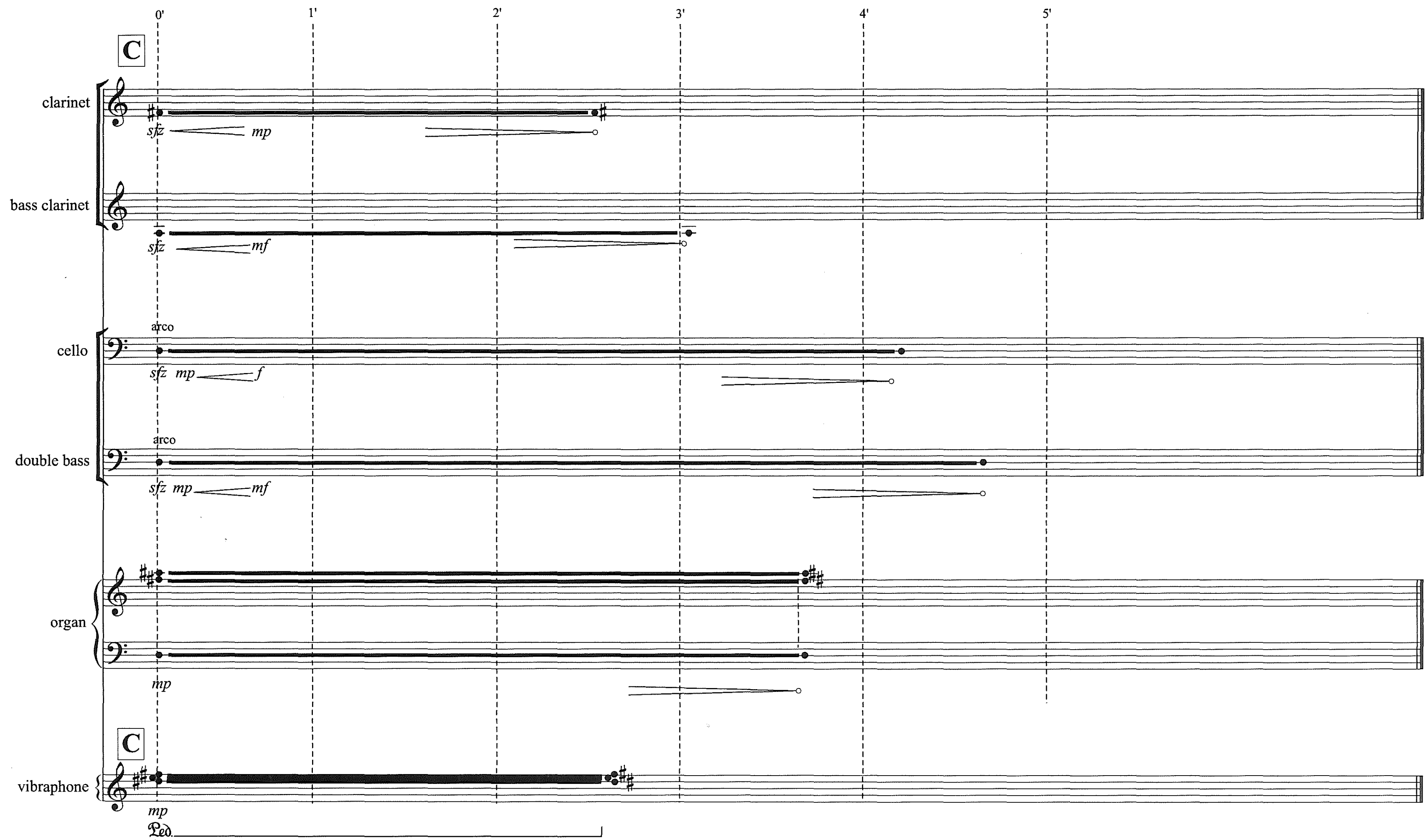
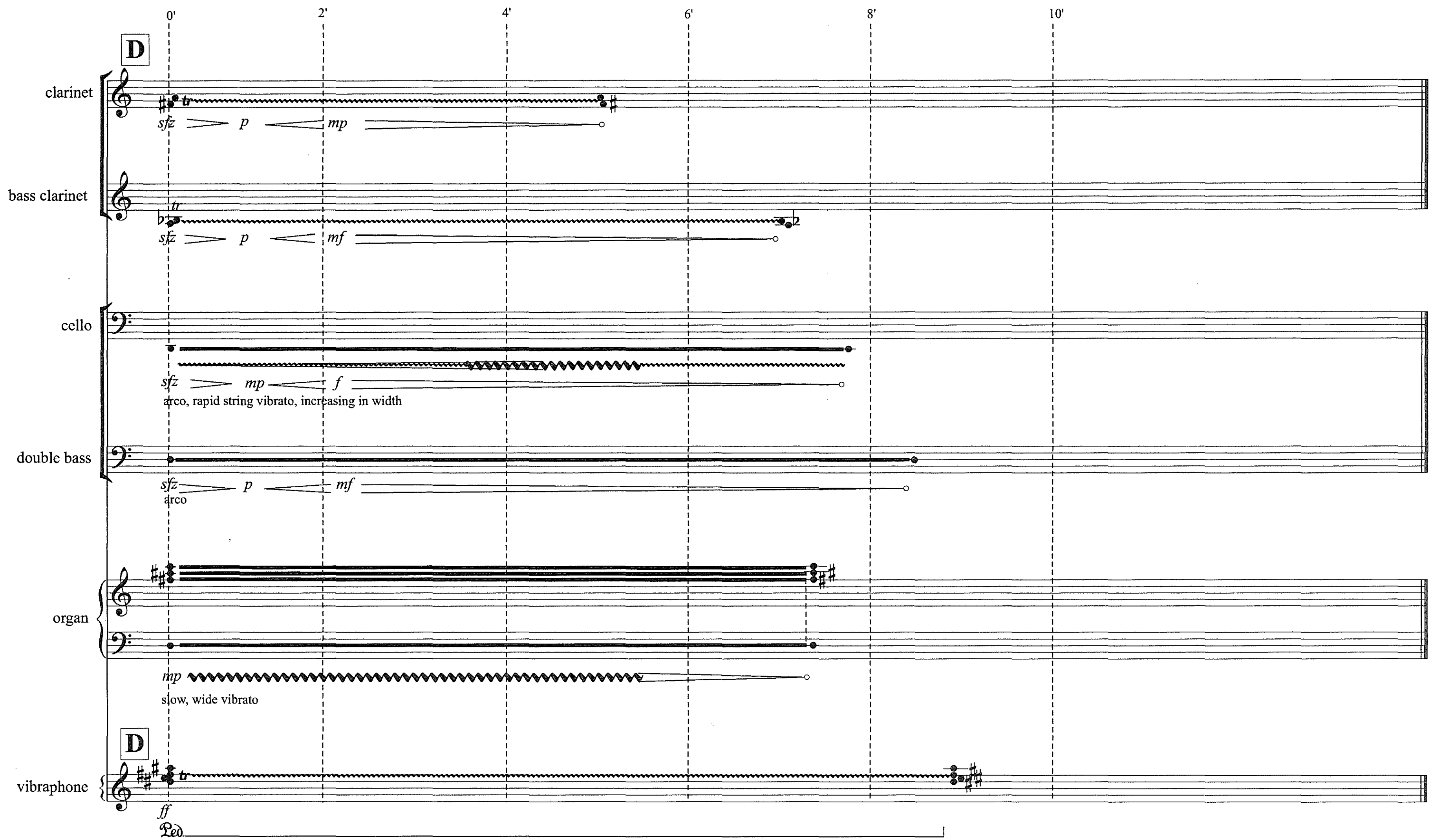
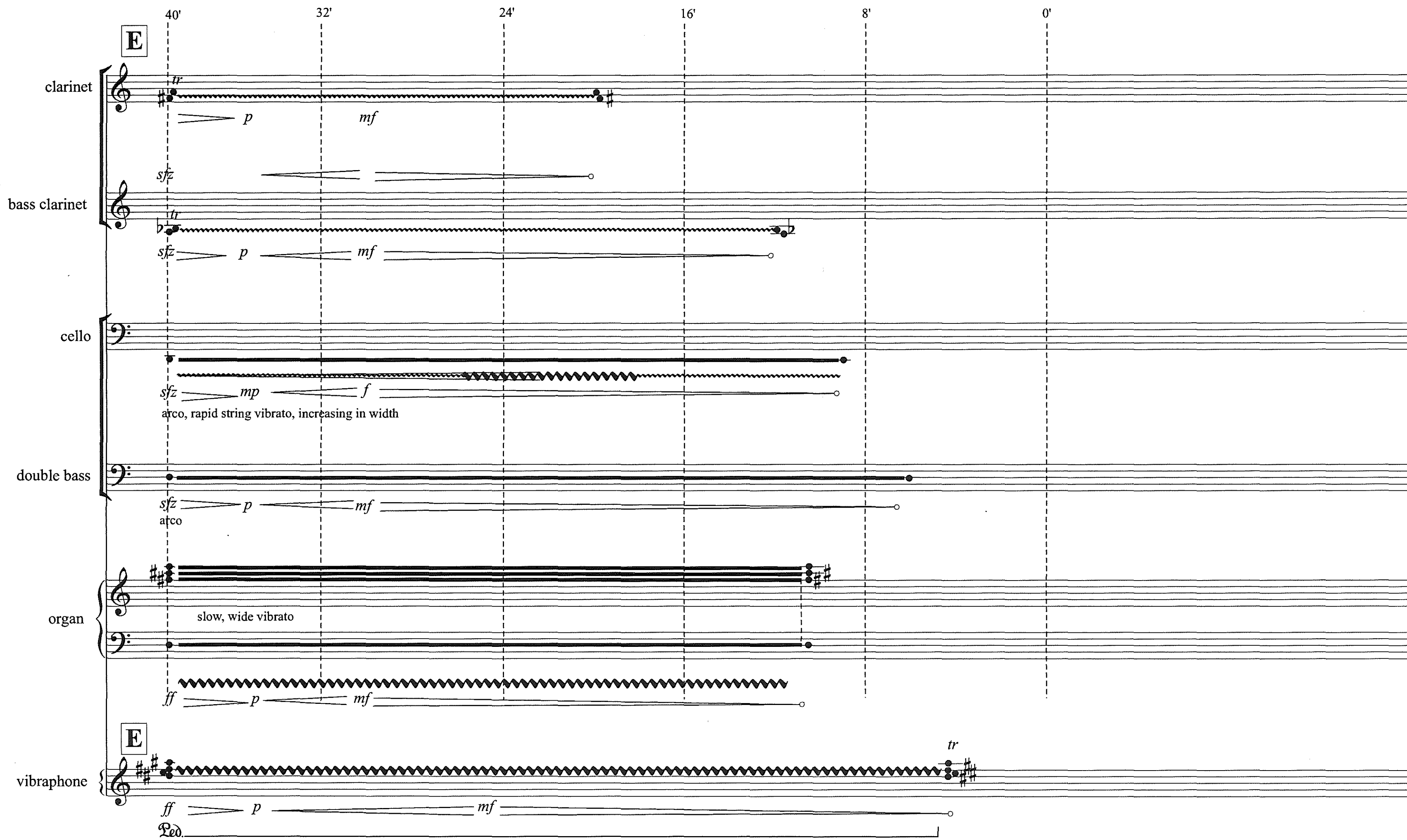


transcription D



transcription E

note: reverse
E, transcription number two, held very long and reverse
breath when necessary, clarinets to try to stagger breathing times



Appendix B – *lucidity* audio recording

Live performance recorded on the 13th October 2010
Music Auditorium, Western Australian Academy of Performing Arts

Recorded by Bob White and Charlie Daly
Mastered by Kynan Tan

8 sections // 46.5 minutes

1	spectra	4:32
2	senn	5:00
3	canon	4:00
4	merr	5:58
5	luminaire	6:32
6	quasi	7:01
7	melody	5:02
8	spectralisis	8:26

Musicians:

Ben Hamblin / Clarinet
Lindsay Vickery / Bass Clarinet
Tristen Parr / Cello
Lyndon Blue / Double Bass
Christopher de Groot / Prepared Rhodes Piano, Organ
Callum Moncreiff / Vibraphone, Drum Kit
James Paul / Synthesis Computer
Kynan Tan / Processing Computer

Appendix C – Spectrograms of *utp_* and *lucidity*

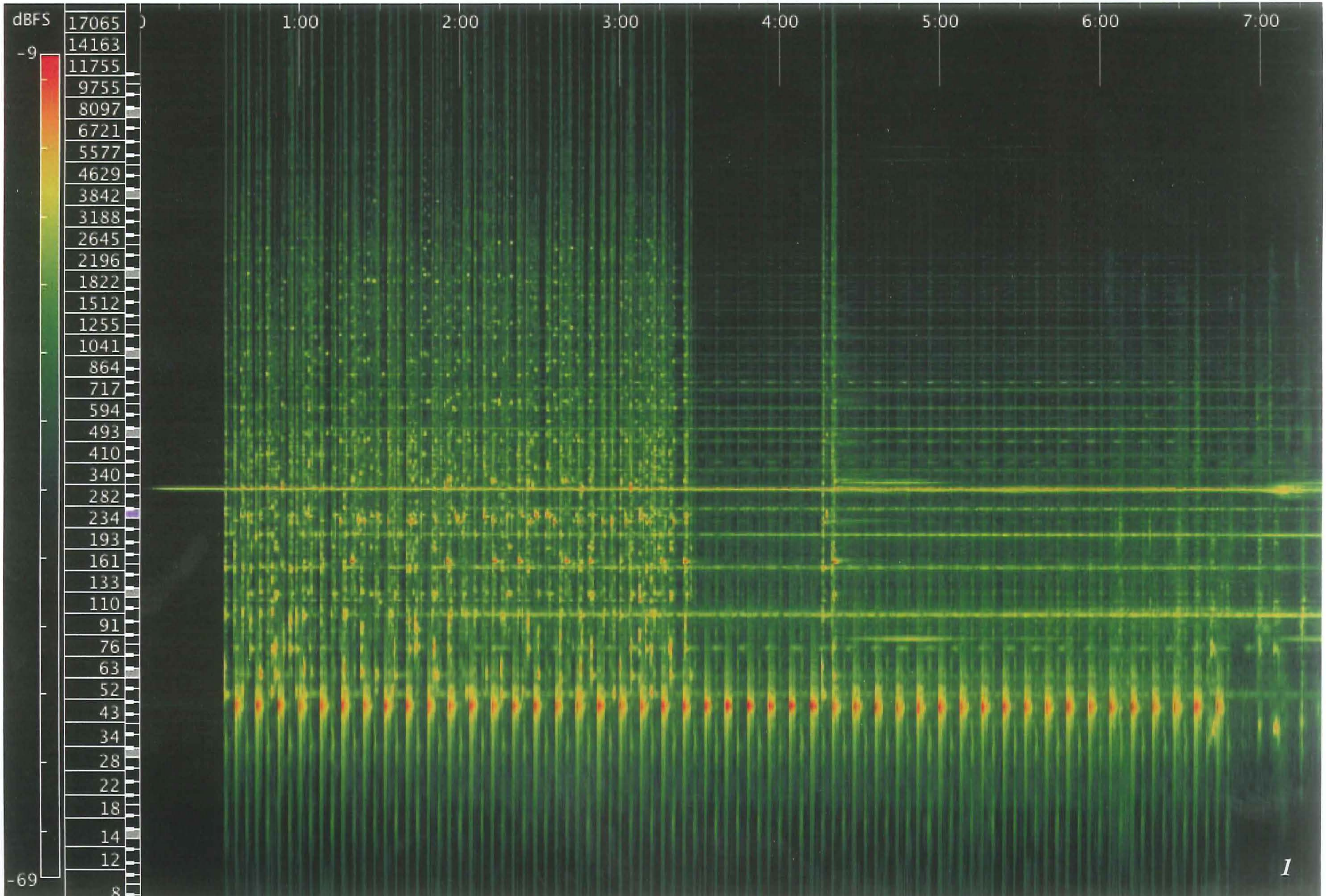
Full-page colour spectrograms created using Sonic Visualiser software.

*utp_* by Alva Noto and Ryuichi Sakamoto

1	attack / transition	7:24
2	grains	6:24
3	particle 1	6:40
4	transition	3:32
5	broken line 1	6:32
6	plateaux 1	8:07
7	silence	6:51
8	particle 2	7:00
9	broken line 2	6:29
10	plateaux 2 / end	12:59

lucidity by Kynan Tan

11	spectra	4:32
12	senn	5:00
13	canon	4:00
14	merr	5:58
15	luminaire	6:32
16	quasi	7:01
17	melody	5:02
18	spectralisis	8:26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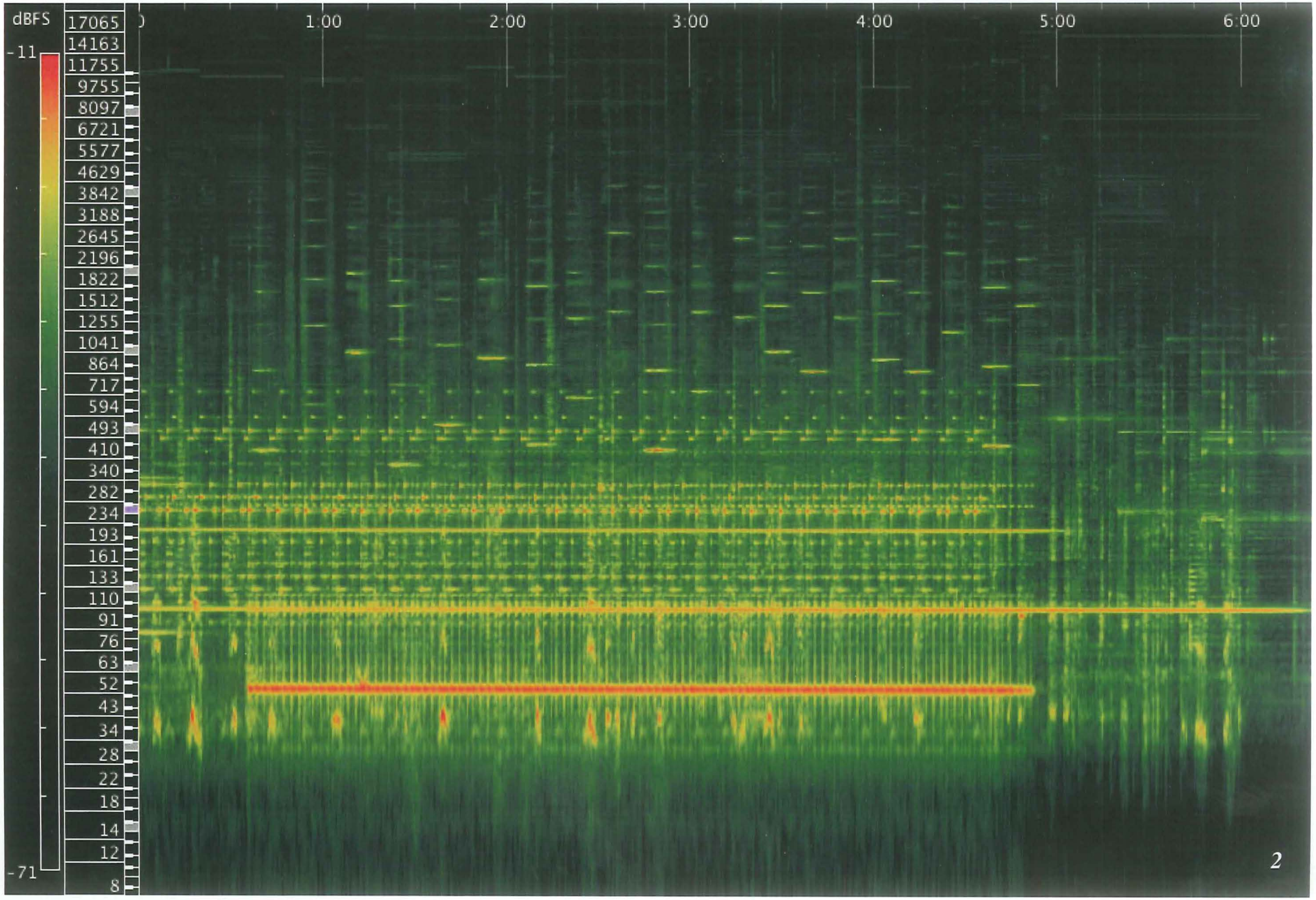
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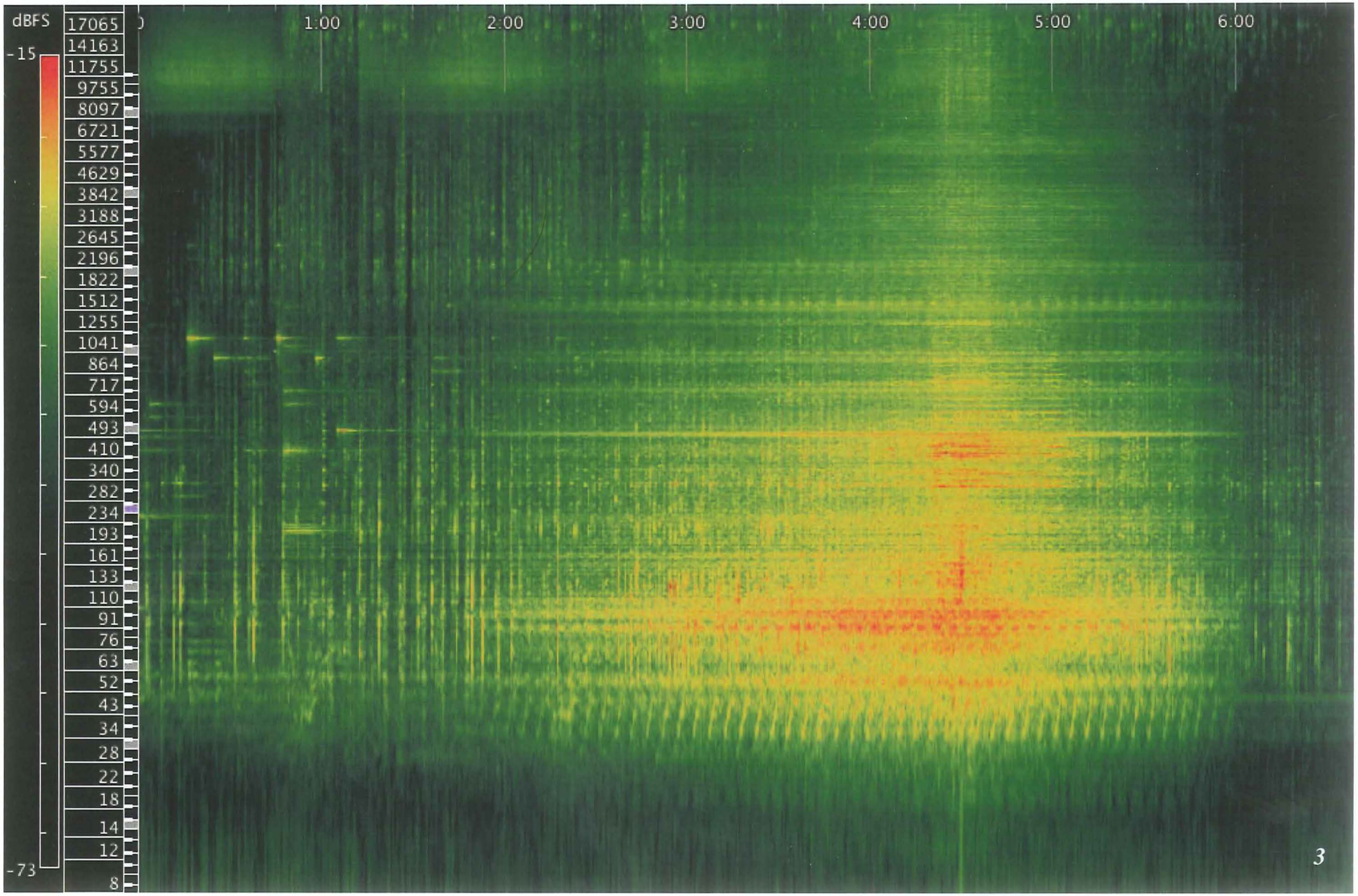
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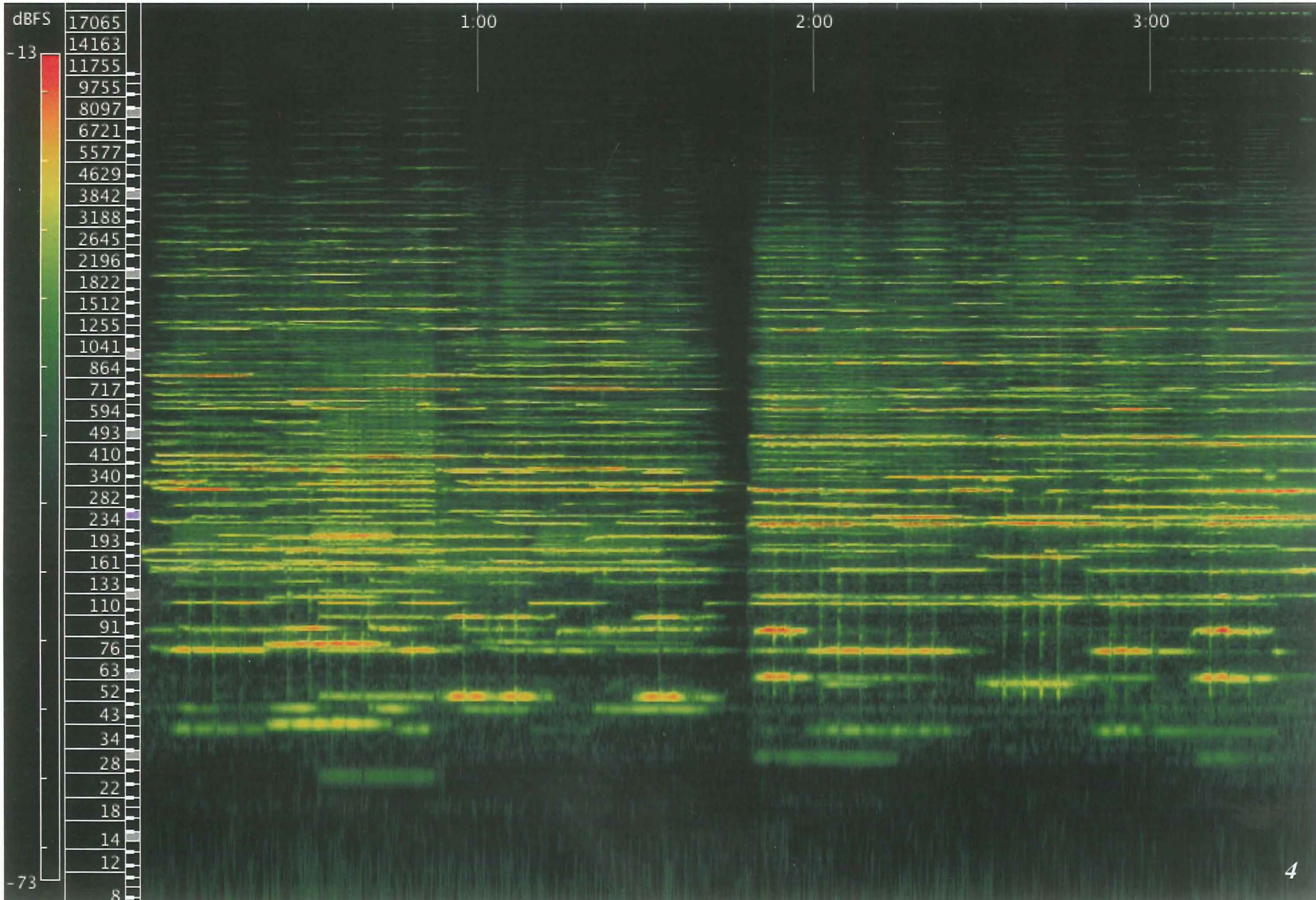
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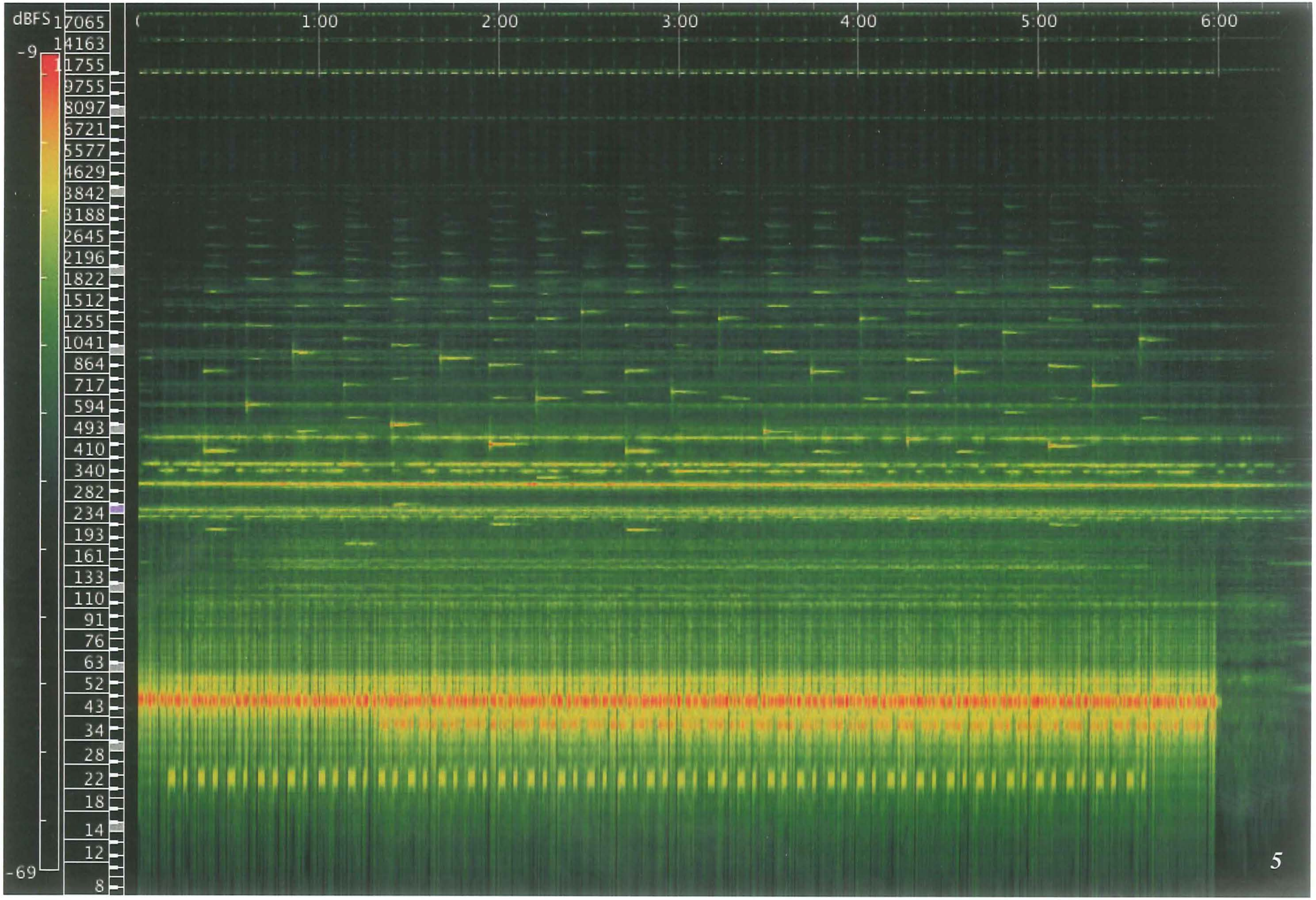
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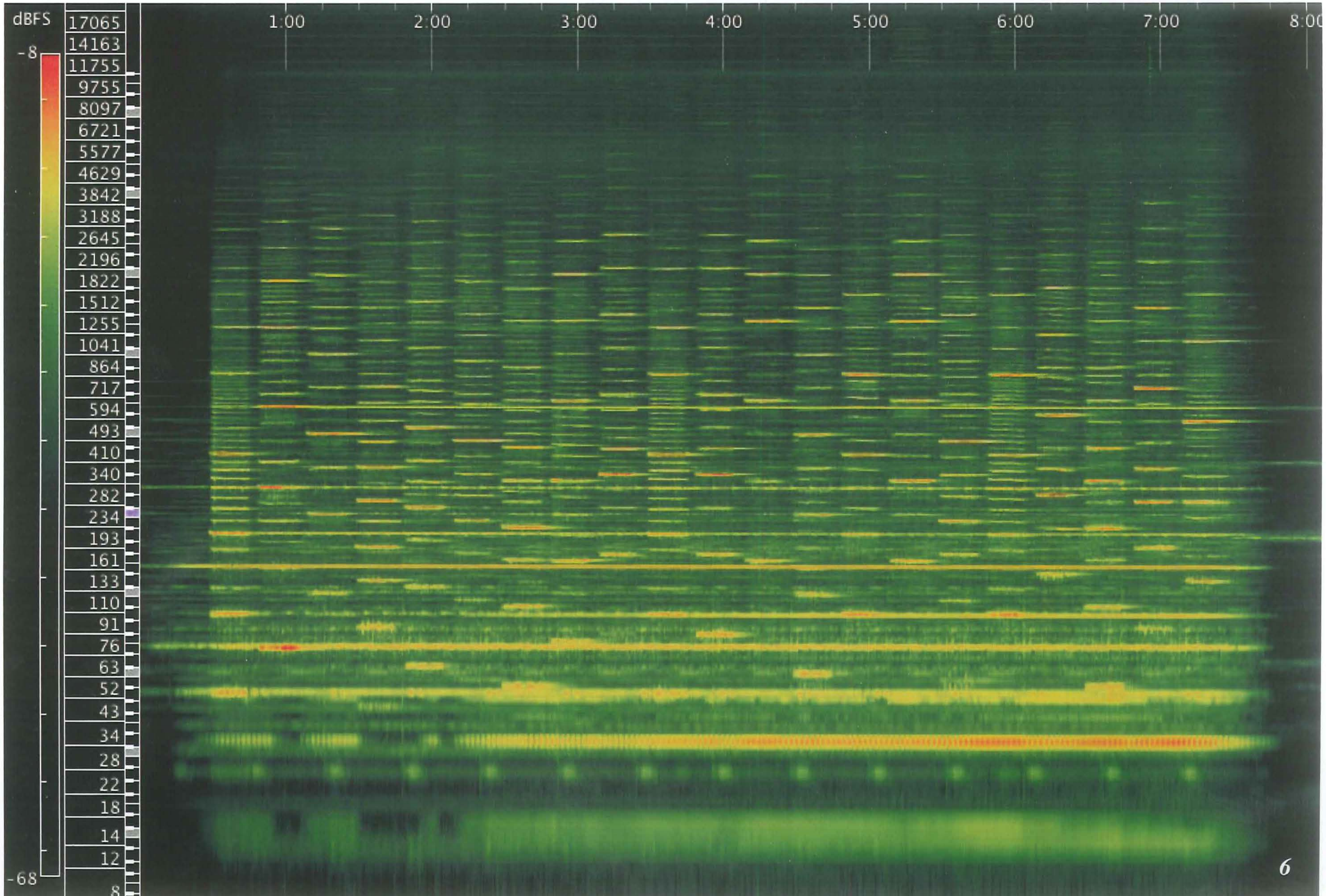
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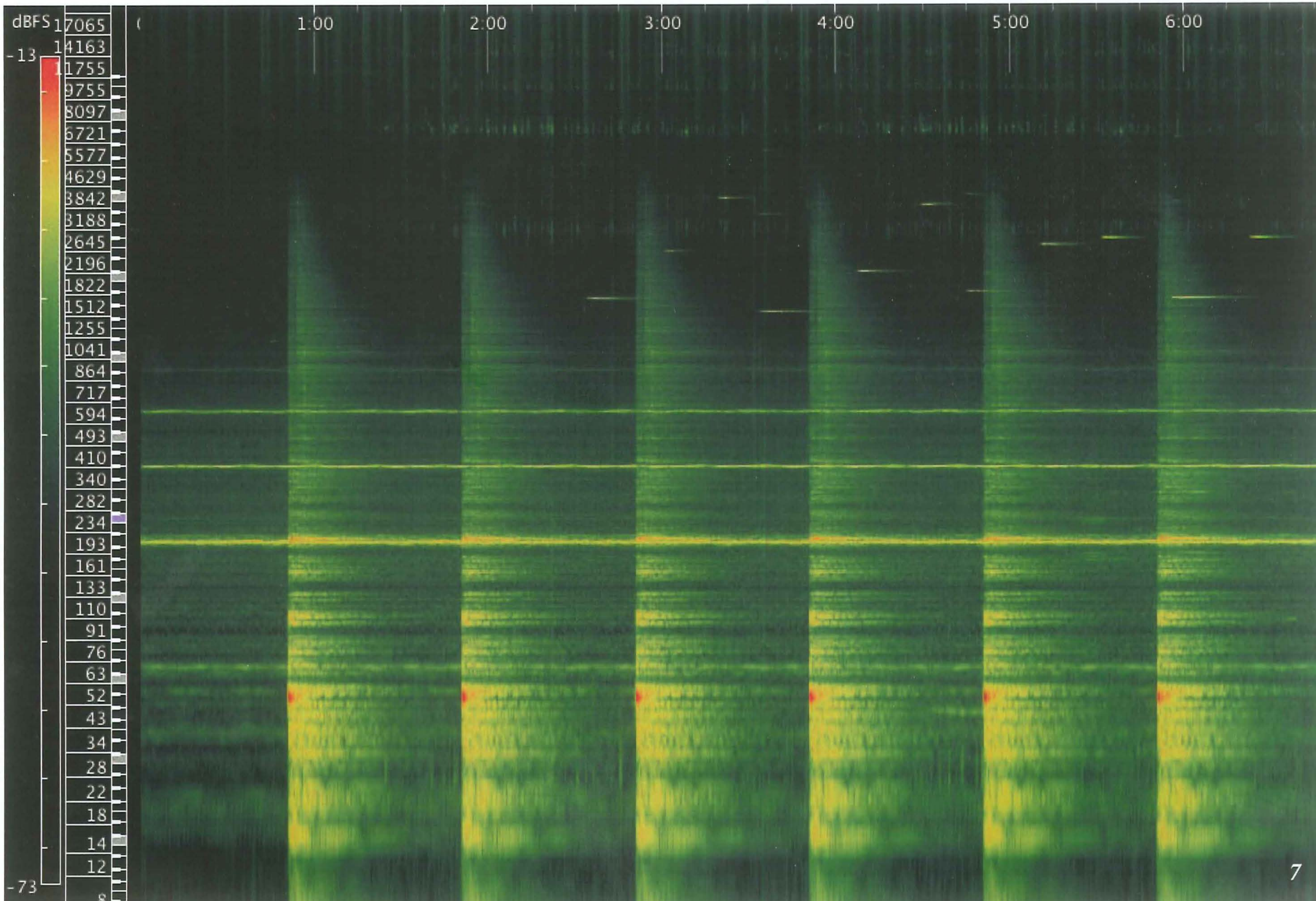
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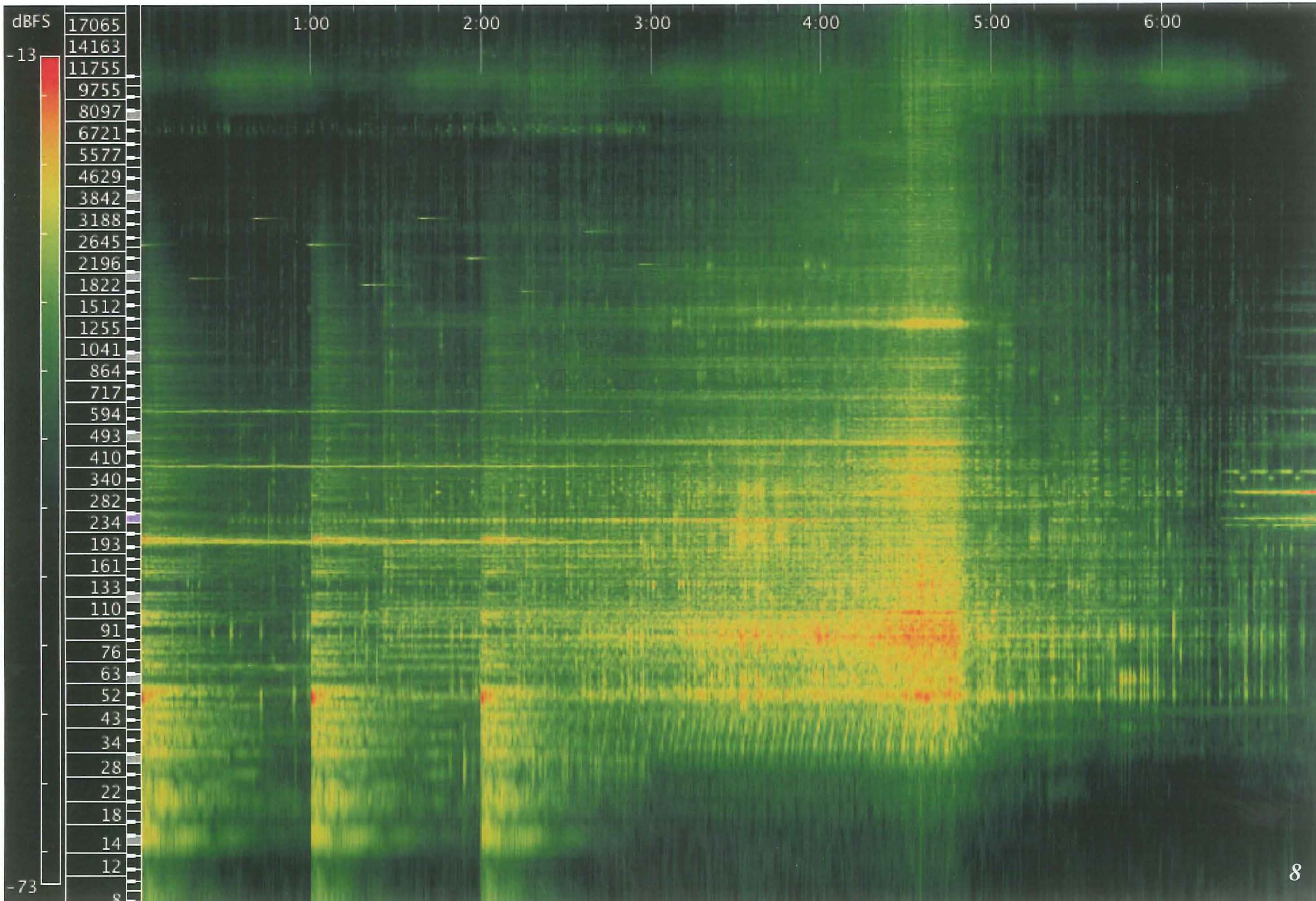
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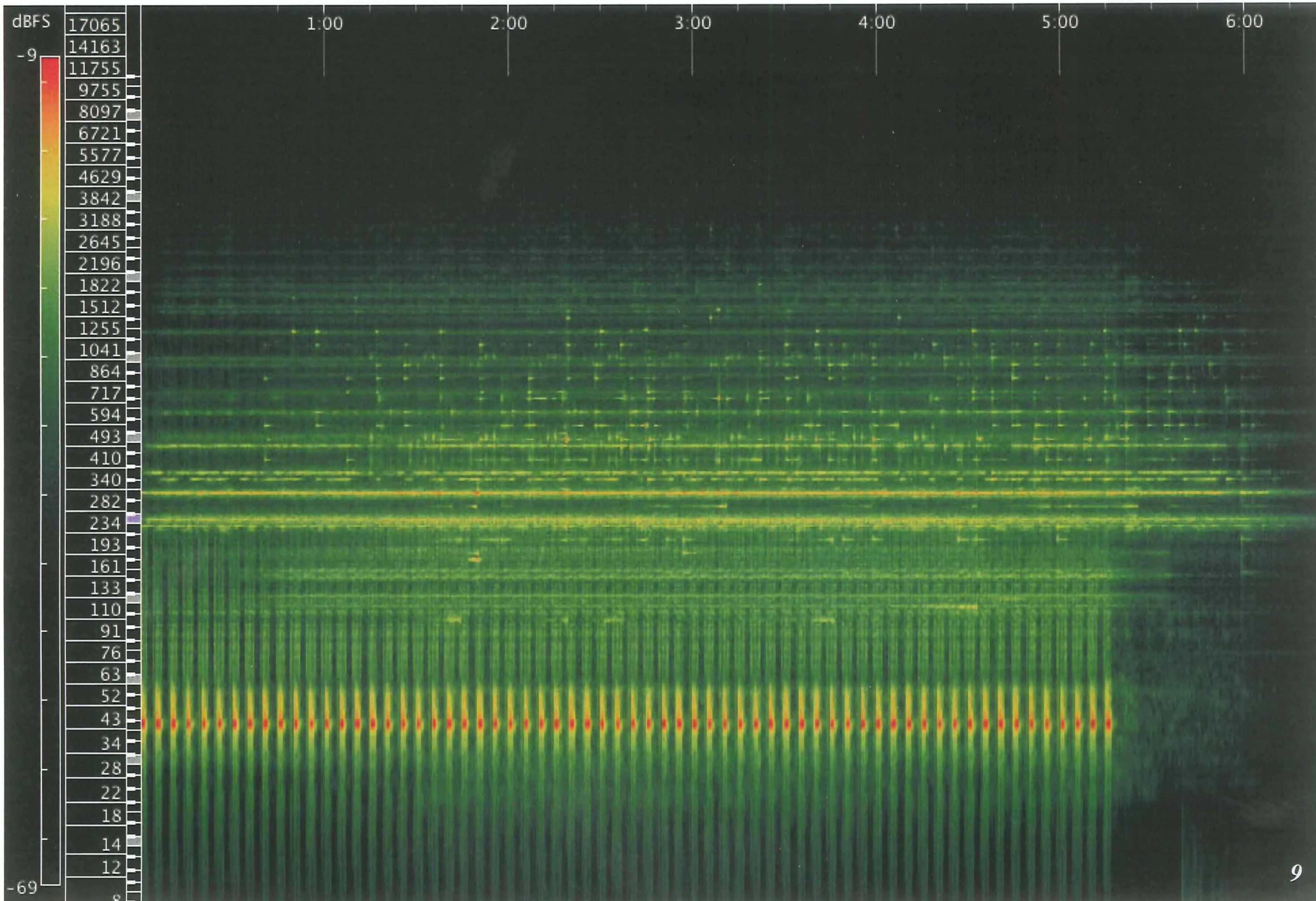
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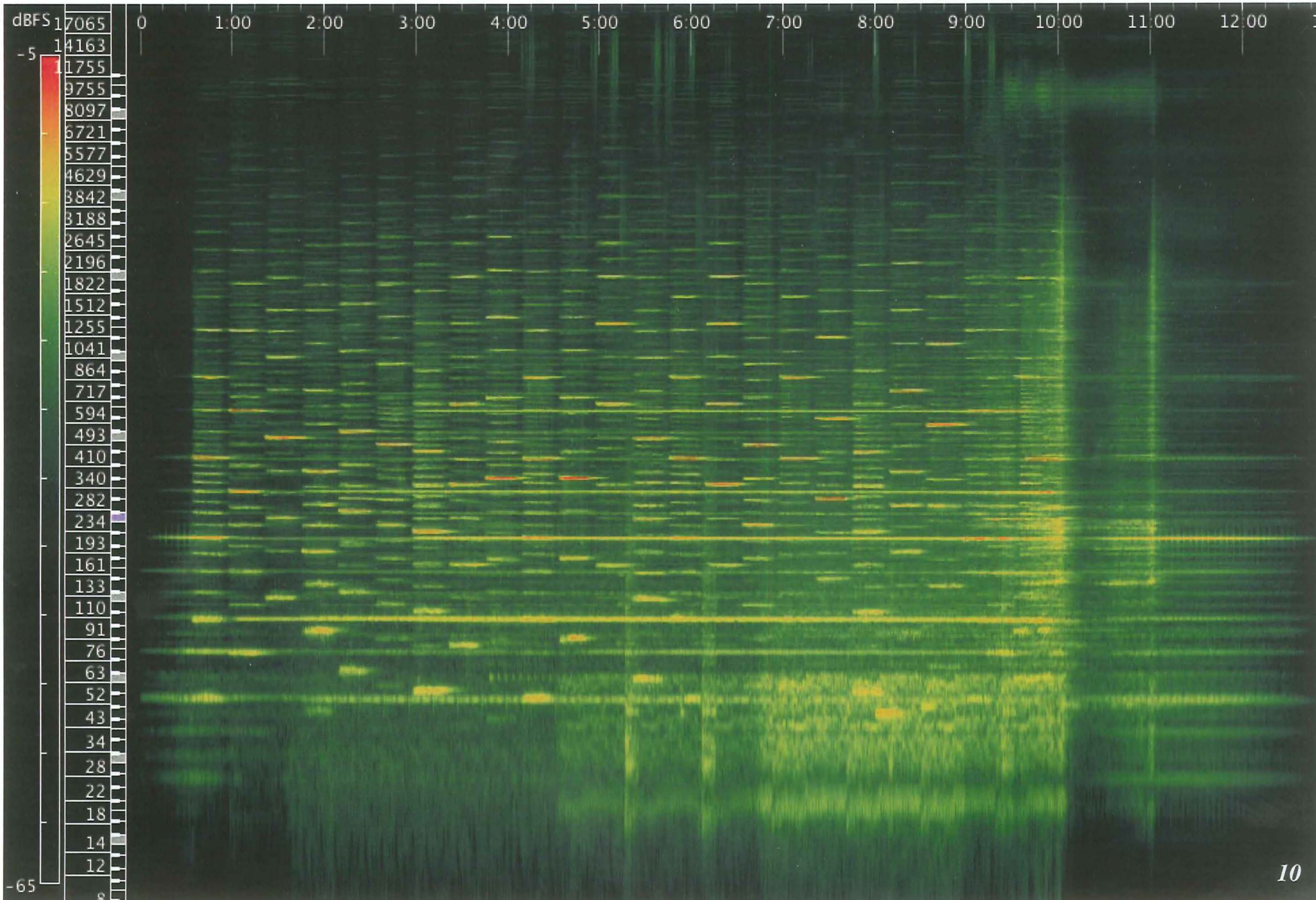
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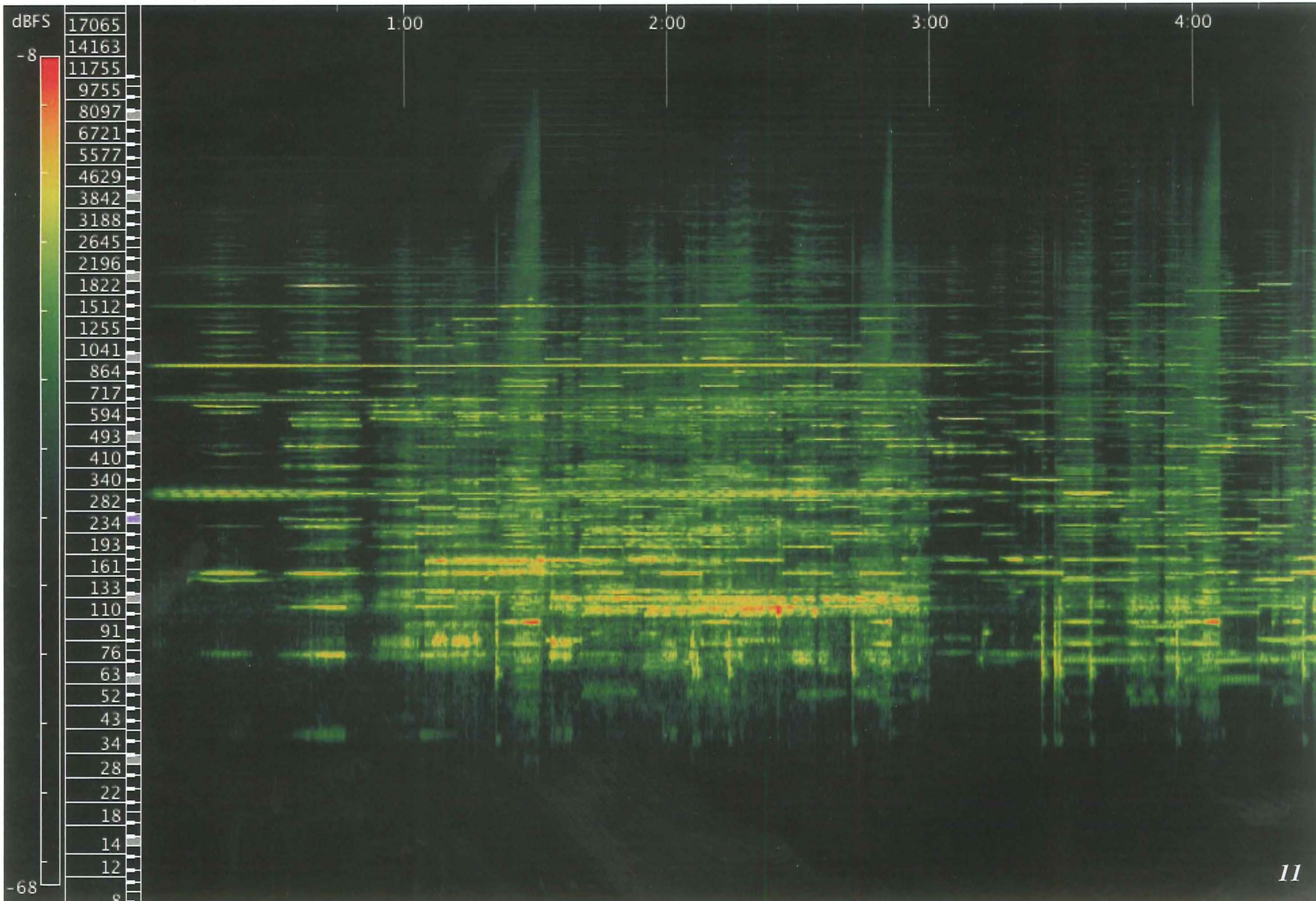
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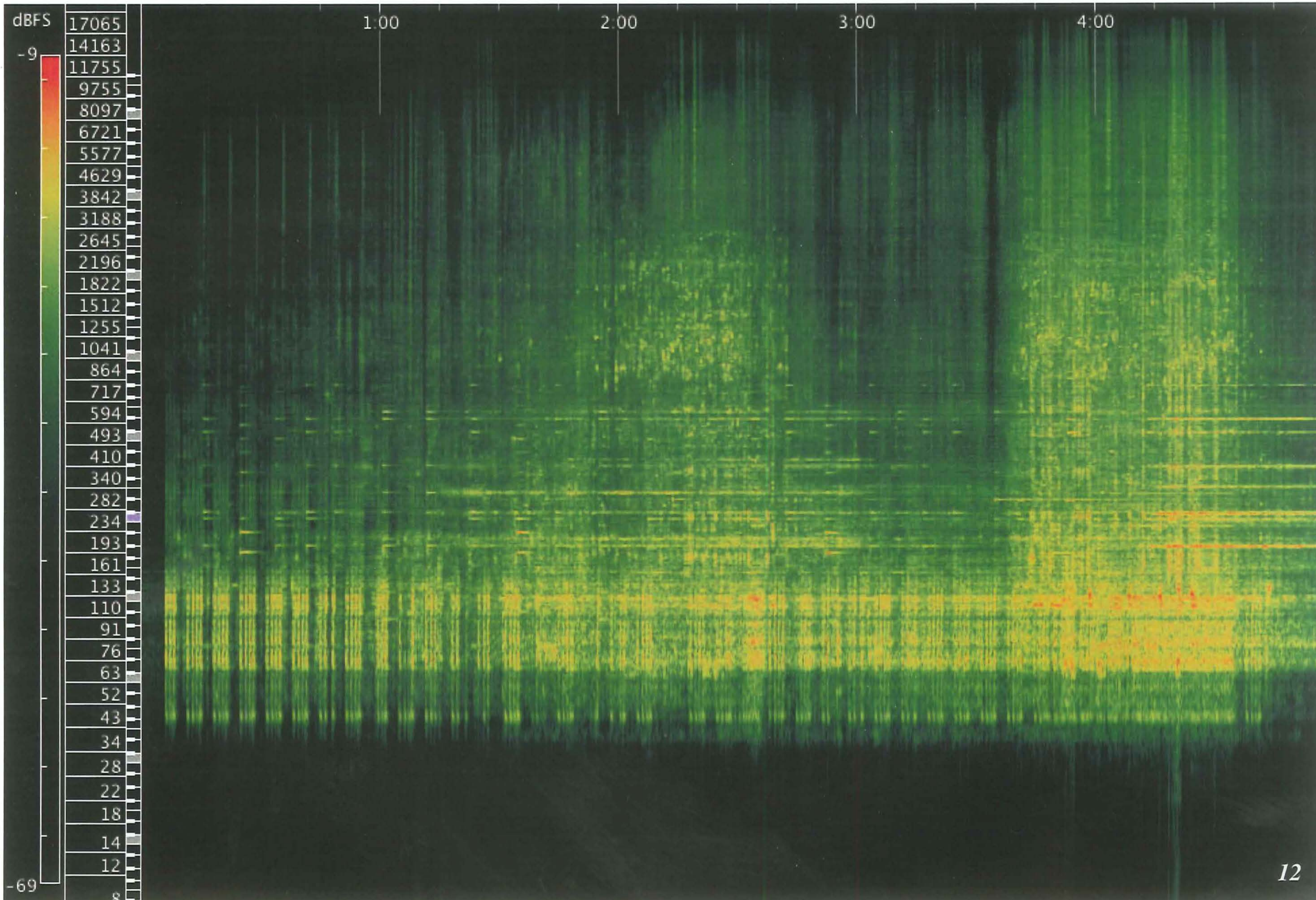
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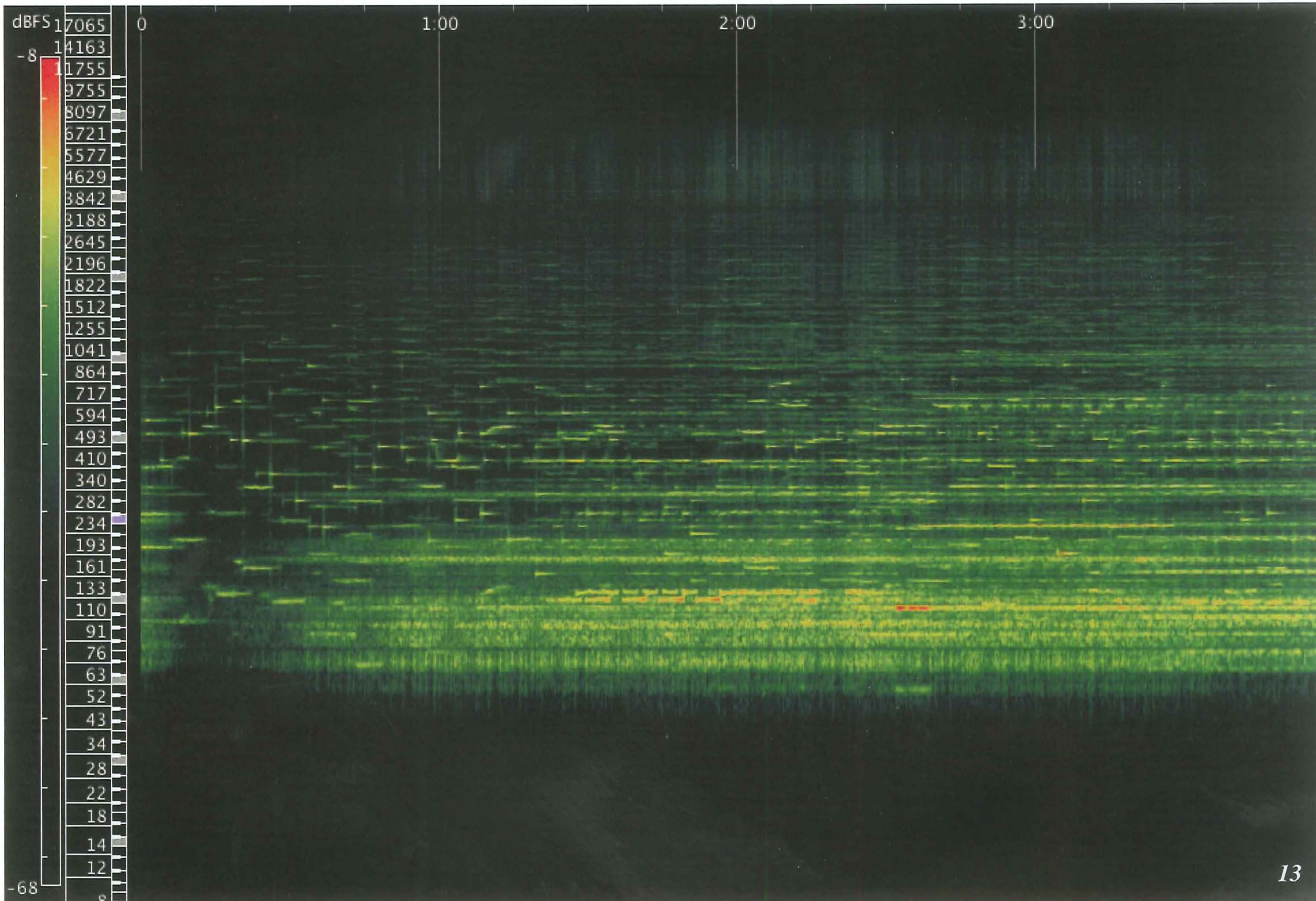
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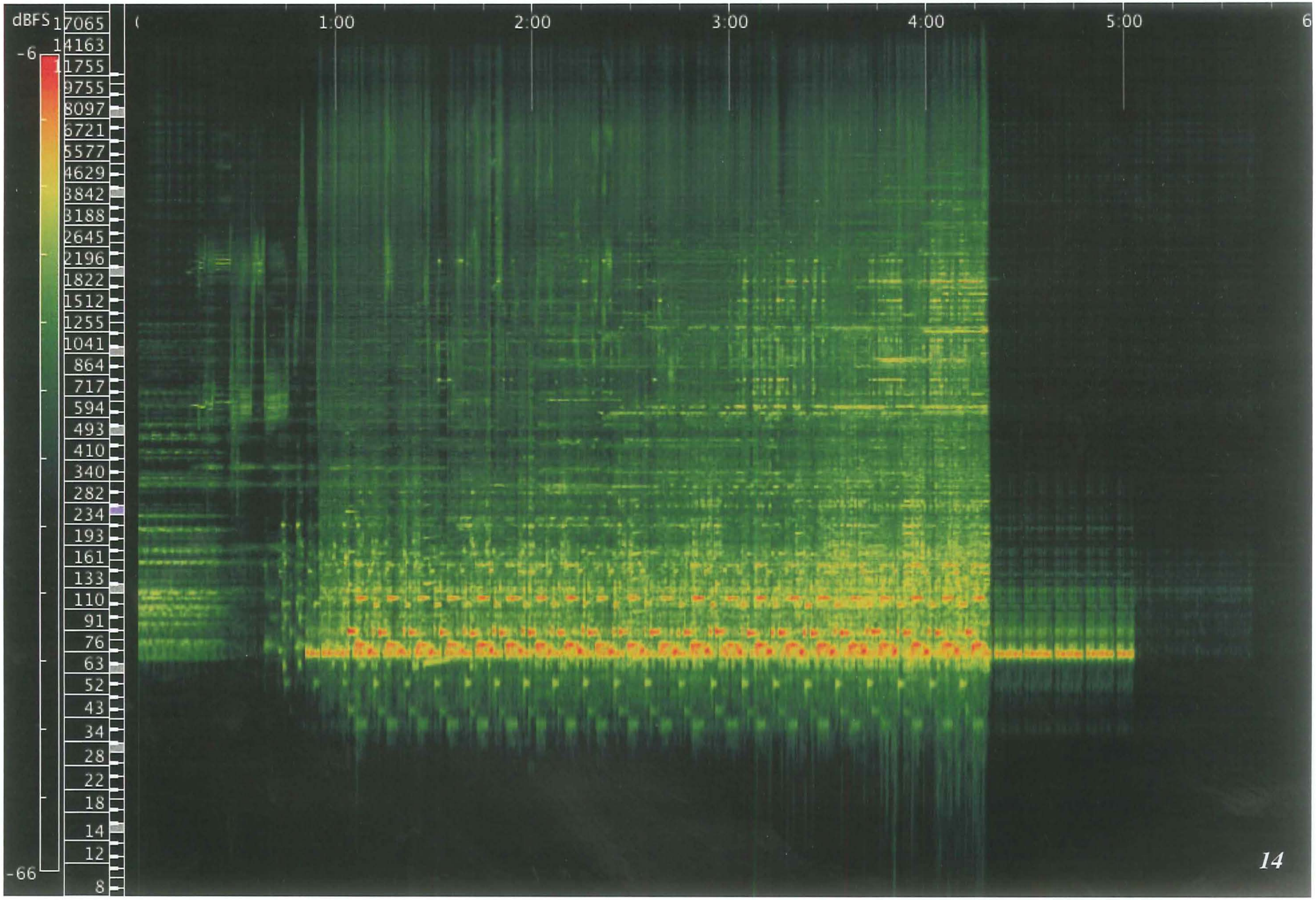
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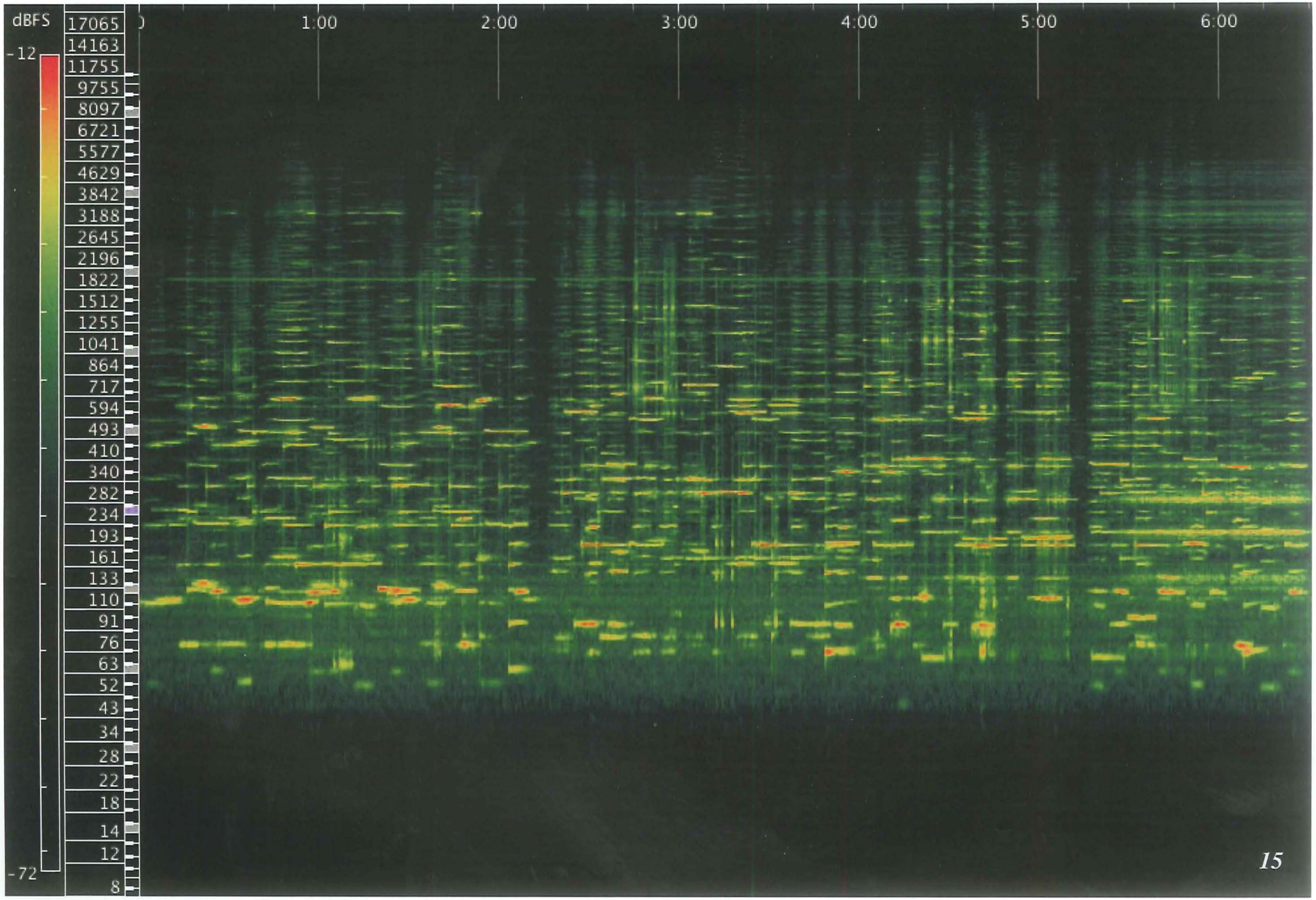
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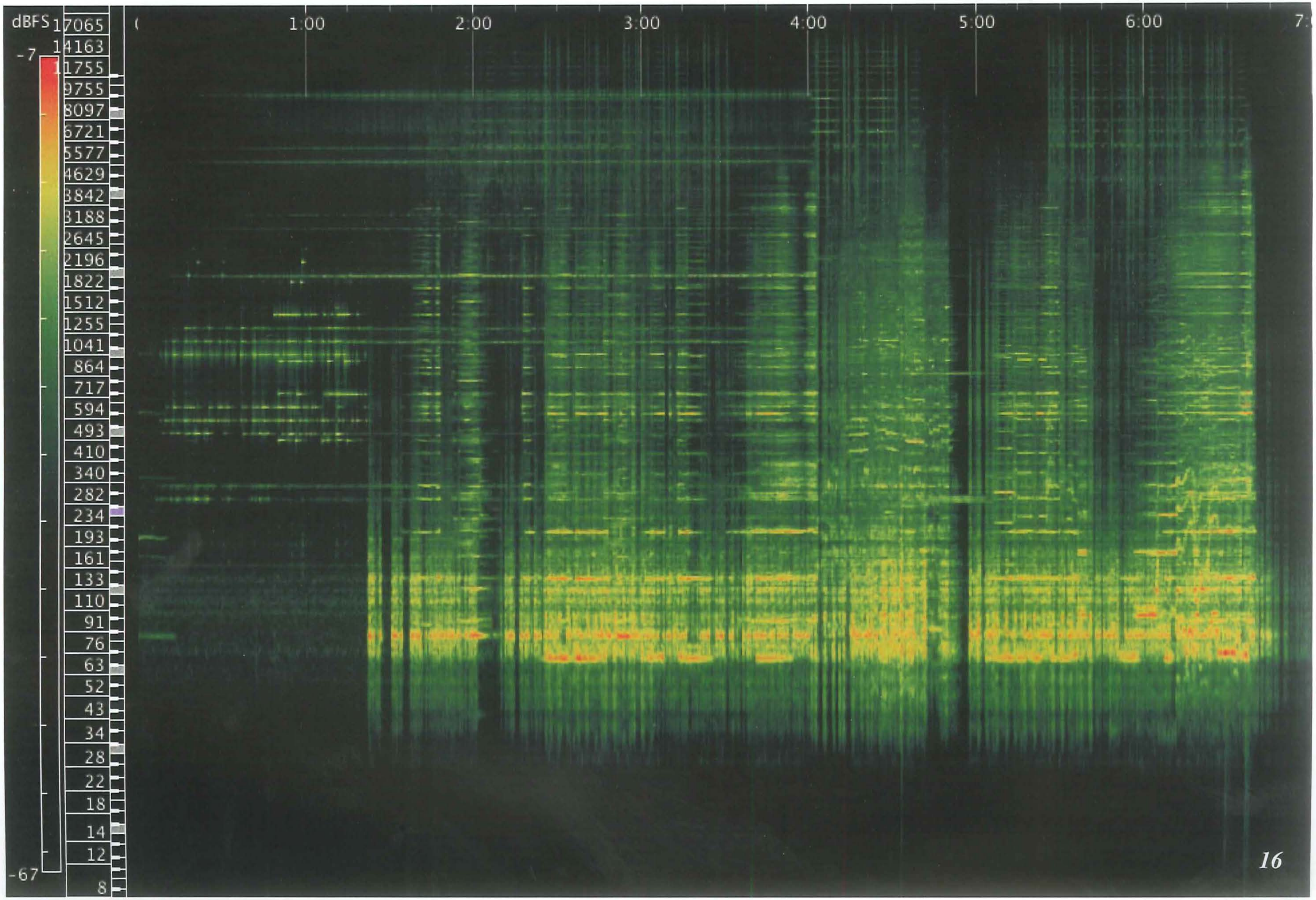
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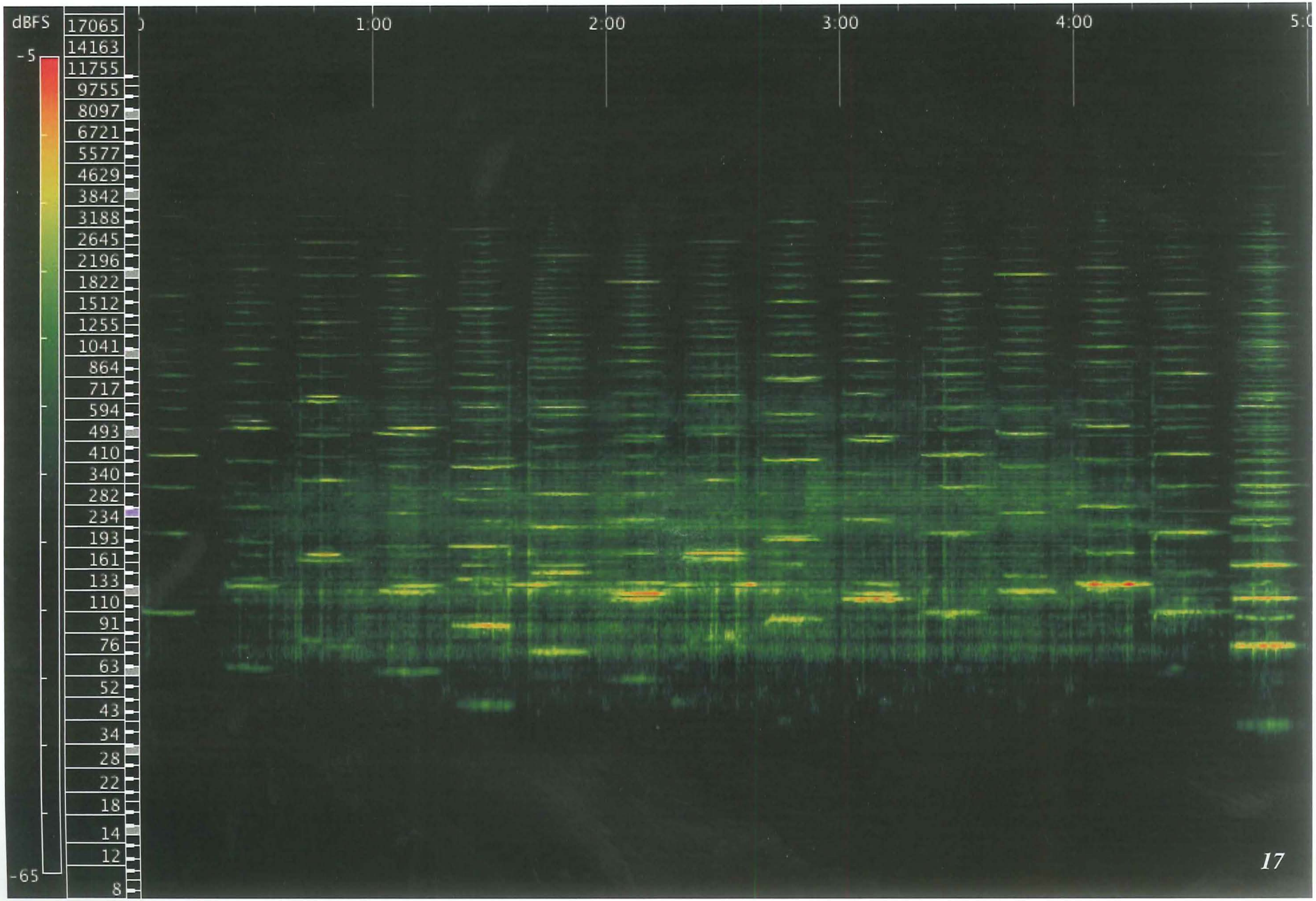
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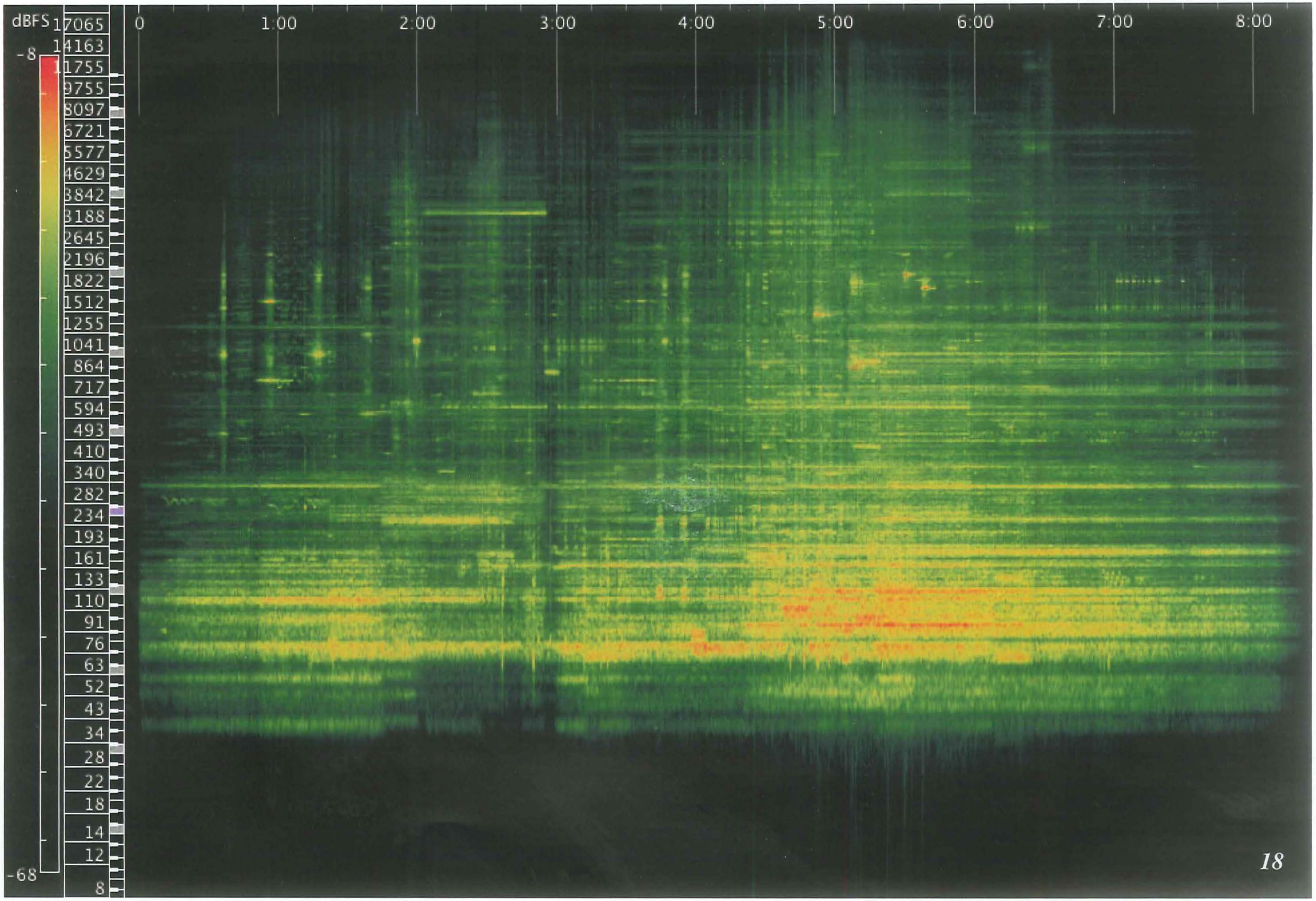
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