REAL-TIME PLUNDERPHONICS: APPROPRIATING KEYBOARD PERFORMANCES AS THEY OCCUR

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INTRODUCTION

Following a long tradition of appropriation in art ('readymades' (Duchamp), détournement (Debord) and postproduction (Bourriaud)) and music (quotation, sampling, plunderphonics (Oswald) and DJing), in this talk, I will examine the notion of appropriating music within the immediacy of its performance. I will focus on the artistic and technological considerations behind the creation of E-tudes, a work that takes live keyboard performances as building blocks for a new composition and interactive environment. In E-tudes, six pianists playing keyboards simultaneously perform various compositions from the repertoire. I plunder, process and combine the MIDI and audio signals from the keyboards in real-time through an idiosyncratic algorithmic system. E-tudes is presented as an interactive installation/performance where the performers use headphones to monitor themselves in order not to reveal the original compositions that provide material for the computer processing. The audience instead chooses between listening to different headphones distributed through the performance space playing various possible outputs generated by the computer. E-tudes therefore attempts to challenge traditional notions of performance practice, audience participation and sound representation and causality by plundering keyboard performances as they occur.

REAL-TIME PLUNDERPHONICS

As a consequence of the development of digital technologies and the increasing processing speed and power of computers, today the process of appropriation can take place in real-time. Music can be appropriated, transformed, manipulated, analysed and processed within the immediacy of performance. Not only can we derive and transform preexisting appropriated material in real-time (for example by using recordings and transforming them in a live performance), but we can also appropriate material that is produced within milliseconds of its plundered result. In other words, we can use live performances of existing music (compositions, songs, specific styles, etc., originally not written by the appropriator) as source material for new work. In addition to plundering live audio signals, we can use live Midi signals and other types of musical data in real-time. That is to say, we can combine different types of data derived from various live performances of existing music simultaneously through a process that I call real-time plunderphonics. Furthermore, if we plunder live performances from electronic instruments which produce no significant acoustic sound (the musicians can wear headphones to monitor themselves), the audience only hears the result of the process of appropriation. Consequently, a cognitive dissonance occurs between audio and visuals: given that the live performances would not be audible in their original form, and only in their re-contextualised/transformed/processed result, what the audience
would see would differ from what they would hear. In this type of performance the amount of processing of the audio signals is clearly exposed to the audience through the perception of the audio/visual relationship: the more processed the performances are, the more contrasting they will look in relationship to what is heard through the speakers. In contrast to the acousmatic tradition, this type of real-time musical appropriation makes the process of appropriation transparent to the audience through the cognitive association between audio and visuals. Even though the appropriated musical source is not recognizable through listening, it is visually exposed, disclosing visually not only the source itself, but also the amount of processing that is taking place at a particular moment (the original audible source however remains hidden from the audience). This type of real-time musical appropriation also changes the relationship with the appropriated Other: the performer becomes an accomplice in the process of appropriation (of themselves).

**E-TUDES**

_E-tudes_ is a set of electronic _études_ for six keyboards, live electronics and Disklavier.¹ These compositions were written for the ensemble _pianocircus_ for a project that became a two-year collaboration and led to two performances.² What initially attracted me to this ensemble was its very particular instrumentation consisting of six electronic keyboards. I thought this would be a suitable platform to experiment with the notion of _real-time plunderphonics_ considering that these instruments are electronic and therefore produce almost no audible acoustic sound.³ Like a book of _études_ from the repertoire, _E-tudes_ consists of a set of pieces that can be performed together at the same event or individually as separate short pieces. At present I have completed four ‘e-tudes’ as it is an ongoing project, I will continue adding new pieces to the collection. _E-tudes_ is modular in the way in which it can be presented: depending on the set of circumstances for a given event, they can be presented separately or as a whole, as a concert performance or as an installation with performative elements. In the installation version, the audience walks into, out of, and around the area surrounding the musicians and has creative control over how they want to experience the performance. By choosing between listening to the speakers in the room or to various headphones which are distributed through the performance space and which generate different outputs, each member of the audience fabricates their own version of the piece. In the installation version there are various possible outputs generated by the computer from the performance from which the audience can choose. It is also possible to have a performance where the members of the audience are wearing wireless headphones that can receive multiple channels that are transmitted in the performance space, allowing them to choose which channel and output from the performance they want to hear.⁴

I use the same configuration for all of the pieces that comprise _E-tudes_: the ensemble of six keyboards is placed in hexagonal formation and divided into two subgroups. The first subgroup, consisting of three pianists, are asked to select _études_ from the western piano repertoire at will – they can select the _études_ they prefer to perform (for example, _études_ by Chopin, Debussy or Ligeti, to mention just

1 In case a Disklavier is not available, it is possible to use a sampler with piano sounds.
3 The only acoustic sounds that can be heard are the keyclicks produced by the physical contact with the keyboards while playing. This noise is slightly audible mostly when there are no sounds playing through the speakers (or they are very quiet).
4 This was the case in the performance at Kings Place.
a few) – and are asked to play them in their chosen order during the duration of the performance. The second subgroup, consisting of the remaining three pianists, perform together from *The Sixth Book of Madrigals* by Don Carlo Gesualdo da Venosa (1566-1613). The pianists playing the madrigals send Midi information to a computer that transforms the audio signal from the *études* and schedules the computer-processing events. The audience is not able to hear in the room what the pianists are playing as the keyboards do not produce an acoustic sound. The seventh performer (performing the live electronics part) performs different tasks: at some points s/he speaks the Madrigals' text into a microphone and the spectral information from this signal is used to process the final audio output and to trigger other sound events; at other times s/he mixes the resulting sounds, controls different parameters in the computer processing and triggers sounds with a Midi controller. The live electronics part is not fixed, leaving space for improvisational elements within the human-computer interaction. Finally, through the analysis of all the inputs the computer sends Midi messages to the mechanical piano, adding yet another element to the performance. In the room the final result of the creative process of combining the simultaneous performances in diverse arrangements is diffused through the speakers. In the installation version, the headphones that are spread through the performance space portray the inner life of the performance sounding in the room and reveal the inner layers of computer processing as well as the appropriated compositions.

Computer programmes play a vital role in *E-tudes* and were written in SuperCollider – some of these programmes have been previously released (Reuben, 2010) but some were exclusively written for *E-tudes*. These programmes are used to analyse incoming Midi data to schedule events and for digital signal processing (DSP). The incoming Midi events from the pianists playing Gesualdo are analysed and divided into each voice of the original madrigals. The computer uses score following techniques to track each voice and according to its position in the score, schedules specific DSP events. The Midi note and velocity information in some occasions is used to determine certain parameters in the DSP algorithms. The DSP algorithms of the live electronics use as input two major audio sources: the input of the combined live audio of the sound generated by the three pianists playing *études* and *micro* elements derived from various recordings of existing music which I chose to appropriate. The individual live audio signals coming from each pianist playing *études* are interpolated with one another (by altering the pitch and volume of the signals). The live electronics performer can change the duration of the interpolation between *études* with the Midi controller. At the same time, the resulting signal is then pitch-shifted again through several pitch ratios (the original signal results in five different signals with varying pitch) generating multiple signals which are then mixed together. The sounding result is a very noisy signal which could be described as ‘piano noise’ (it still retains a piano-like quality). I then utilise the ‘piano noise’ as input in synthesis algorithms which filter it using several techniques. The ‘piano noise’ is very different to other types of noise generated using classic synthesis techniques in that its spectral flux is constantly changing and its rate and amount of change is fairly irregular. Additionally, the live electronics performer can change the sonic qualities of the 

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5 In the previous performances of *E-tudes*, I have performed the live electronics part myself.
6 What I mean by interpolation is a transformation of one sound to another through a process that does not necessarily fit the description of ‘morphing’.
7 Each signal is interpolated with the other by gradually pitch-shifting one signal down four octaves and fading out its volume gradually, while at the same time introducing the next signal which would be pitch-shifted four octaves down and gradually transposing it up until its original pitch, and by gradually fading it in.
the ‘piano noise’ – and therefore also change its spectral flux – by altering the interpolation time of the live audio signals coming from the pianists. Some of the ‘études’ in their final result (the output diffused through the speakers) are composed exclusively using synthesis algorithms which use the ‘piano noise’ as input. At the same time, in the installation version, the audience can listen through headphones to the different outputs at different degrees of processing – for instance, one of the headphone outputs consists entirely of material generated from the interpolation of études, while another one reveals the ‘piano noise’. In certain headphone outputs the original appropriated sources (the études and the madrigals by Gesualdo) also appear closer to their original form. The algorithms that control the overall process have generative elements – each time they are performed, they generate different results. The generative characteristics of the algorithms, the varying incoming data from the live performances (the études chosen by the pianists change for each performance of E-tudes8 and the incoming Midi data from the madrigals varies each time they are performed) as well as the improvisatory elements in the live electronics performer's part, makes E-tudes an electronic composition that changes (both in content and performance) each time that it is presented, while also maintaining certain elements that identify it as the same composition.

E-tude I

E-tude I is based on the first madrigal of Gesualdo's Sixth Book of Madrigals called “Se la mia morte brami”. In E-tude I, ‘piano noise’ is filtered in different ways using various subtractive synthesis algorithms. Several algorithms take the live electronics performer's voice reading the words of the madrigal as input to filter the ‘piano noise’ using different filtering techniques. The most prominent filtering techniques using the voice as input are vocoding (using a variation of the ‘classic’ vocoder algorithm) and a band-pass filter with variable Q that extracts the spectral contour of the signal (through FFT analysis) to determine the bandwidth and center-frequency of the filter. The microphone signal is also used for onset detection, and the live electronics performer may trigger different percussive sounds (generated by filtering bursts of ‘piano noise’ at different frequency ranges) with his/her voice. Spectral gating (an FFT technique which ignores the frequency bins which have magnitudes below a certain threshold) of a limited frequency range of the ‘piano noise’ is another technique used to isolate the strongest frequencies in a specified range – the resulting frequencies are used as pitched material that is presented either in its natural sinusoidal quality (prominently in the high frequencies) or these frequencies are mapped into Midi notes which trigger the mechanical piano (mostly using its lower range). At the same time, all pitched material (including the center frequency of some filtered sounds) is altered or defined by the Midi note information received from the pianists performing the madrigal (tuned in just intonation). The dynamics for these sounds are shaped by the Midi velocity from the performance of Gesualdo. At the same time, the different layers of sound are modified such that they have a similar phrase structure to the madrigal – the layers start and end at the same point in time as the madrigal.9 The Midi note information (mostly note-on messages, but not exclusively) at times also trigger different sounds generated through a combination of filtered ‘piano noise’ and data derived from analysis of plundered

8 This type of performance could be described as time-specific, generative and indeterminate.
9 I use this technique in many of my compositions: I plunder the phrase structure of an existing piece of music to generate the blueprint for a new composition. I also wrote a computer programme that automises this process and generates a visual representation of phrase structure using a Midi File as input.
recordings. A common technique used in E-tudes to make synthetic sounds sound more imperfect or ‘natural’ sounding is to modify the synthesised sound according to the extracted fundamental of a recorded instrumental or vocal sound – the synthetic sound becomes more irregular and therefore sounds more ‘natural’ due to the imperfection it inherits from the instrumental or vocal sound. Another technique I use to make synthesis algorithms sound more ‘instrumental’ is by deriving harmonic structures (the fundamental and partials of a sound) from FFT analysis of recordings of the instruments I want to approximate. In E-tude I, I generate sounds using these techniques to approximate sounds with similar characteristics to a celesta, several percussion instruments, to a vocal melody, high bowed string harmonics, etc. I also use FFT to combine spectra between the instrumental recordings and the ‘piano noise’. E-tude I starts with a fairly ‘abstract’ sound world – further removed from recognizable ‘traditional’ instruments or music genres and including sounds that are more noise than pitch based – gradually transforming into a more ‘referential’ sound world, made up of pitched sounds, periodic rhythms, more identifiable sounds modeled on existing instruments and pitch material that is more referential to other more recognizable musical genres. The process of transformation culminates with the emergence of a prominent melody (driven by the FFTFilter, filtering ‘piano noise’ and following the melodic contour of a plundered recording of a vocal sound) resulting in music that is reminiscent of a song (or aria) with an ostinato of very simple rhythmic patterns.

E-tude II

E-tude II uses “Beltà poi che t'assenti” (the second madrigal in the book) as the control structure of the computer processing. In this ‘e-tude’, the role of the ‘piano noise’ is reduced only to a source of noise within physical modeling synthesis algorithms, which create sounds reminiscent of instrumental sounds. These sounds include the high frequency sound based on a physical model of a bowed string which ended E-tude I, this time changing in pitch more gradually and gliding through what sounds like a variation of the main melody of the ‘song’ with which E-tude I culminates. The algorithms generate sounds reminiscent of plucked strings, percussion and wind instruments based on physical models of Korean instruments. The ‘plucked string’ sounds, for instance, are generated using a variation of the Karplus-Strong plucked-string algorithm using a burst of ‘piano noise’ as its excitation and altering it in frequency and amplitude through the extracted fundamental of a recording of a plucked Geomungo (Korean instrument) string. In addition to the sounds generated by the synthesis algorithms, the mechanical piano produces pitched material consisting of ascending arpeggios generated through the anaylisys of vowel sounds (pitch material is generated through what Clarence Barlow calls synthurmentation (Barlow, 1998)), which the live electronics performer vocalises into the microphone. The prominent melodic sound that emerges on its own at approximately the middle of E-tude II, is generated through a combination of ‘classic’ filtering techniques (band pass, high pass, dynamic bank of resonators, etc.) which filter the ‘piano noise’ to try to emulate a ‘wind instrument with vocal characteristics’. The attack and release envelopes of this sound are derived from a recording of a recorder and after the sound is released, a high-frequency noise reminiscent of human breathing follows (the frequency range of the noise was mapped approximately to the frequency range of a person's breathing-in sound). This ‘virtual instrument’ plays a melody that is plundered from a recording of Gagok – a traditional form of Korean vocal music. After a brief solo section, an ensemble of ‘virtual instruments’ joins the melodic sound and emulates music reminiscent of Gagok –
including two ‘virtual instruments’ (one of them sounds more ‘sinusoidal’ and the other sounds closer to a reed instrument) that play the melody with slight deviations in timing and tuning. These deviations are driven by a generative algorithm (meaning that each time that E-tude II is performed, the melodic deviations vary) that is designed to emulate the types of improvised melodic elaborations found in original Gagok. During the duration of E-tudes II, the rate at which sporadic events (plucked strings, percussion instruments and mechanical piano arpeggios) take place gradually becomes faster and the events themselves become more active and unpredictable (for instance the mechanical piano arpeggios become faster and with more notes and their direction starts changing randomly as they become more active), until they are squashed against each other and become cluttered at the end of the composition.

E-tude III

E-tude III is based on the third madrigal by Gesualdo called “Tu piangi, o fillimia”. This ‘e-tude’ opposes synthesised pitched sounds with a strong fundamental frequency (some of them sound almost like sine waves) at the beginning with the ‘piano noise’ that is revealed for the first time in its unfiltered and unprocessed form later in the composition. The pitched sounds consist mainly of three different types of sounds: two sustained sinusoidal pitches, ‘cellestas’ sounds and a single descending arpeggio of ‘plucked string’ sounds. The two sinusoidal pitches slowly change in frequency, first gradually detuning away from each other and later changing direction until they slowly approach each other, producing beating before merging into the same tone. The ‘cellestas’ sounds are generated in the same way as the ones that were used in E-tude I (generated from filtered ‘piano noise’) and derive their pitch material from spectral data (through synthrumentation) of the audio signal of just one of the pianists playing études. Their rhythm is triggered through onset detection of the live microphone signal (the voice of the live electronics performer reading the text of the madrigal). The descending arpeggio of ‘plucked string’ sounds – which happens only once and is reminiscent of the mechanical piano arpeggios in E-tude II – is generated through the same Karplus-Strong algorithm used in E-tude II, but instead of using a plundered recording of a Geomungo, it uses a recording of a harp. The ‘piano noise’ is first revealed as short percussive sounds (the ‘piano noise’ is filtered so that it sounds like footsteps) triggered by the live electronics performer with the Midi controller at periodic intervals. Then it is revealed as filtered noise in the high frequencies and later in the low frequencies – the filtered noise originates from a selection of FFT bins of ‘piano noise’. In E-tude III, there is a slow transition between pitched sounds and ‘piano noise’, which gradually becomes dominant as the spectrum is gradually filled with FFT bins – culminating in the complete frequency spectrum of ‘piano noise’ being diffused equally over the speakers. At the end, the ‘piano noise’ vanishes completely in a matter of seconds (through the reverse FFT process) followed by silence, and a series of sporadic and aggressive bursts of clusters played by the mechanical piano and by short phrases of sinusoidal sounds and synthrumentised piano chords revealing harmonies from the études.

E-tude IV

E-tude IV derives information from three main sources: Gesualdo’s forth madrigal called “Resta di Darmi Noia”, the études chosen by the pianists and several appropriated recordings of music by Mbuti Pygmies (Mbuti Pygmies of Ituri Rainforest, 1992). Pitched material is derived from these recordings using two
computer programmes: a vector based algorithm that reduces spectral information from SPEAR (Klingbel, 2004) to produce Midi Files (Reuben, 2010) and a real-time partial tracker (Reuben, 2010). The results from the different types of analysis are then selected and combined according to the desired musical outcome and stored as Midi-note data. The spectral data of the études is combined with the collected data from the Pygmy music recordings and the result is modified by the melodic and harmonic material from the madrigal. The Midi information resulting from this process is realised by the Disklavier, which is the only source producing sound, becoming the ‘virtual’ soloist of E-tude IV. At some points, the melodic contour from the different voices from the Gesualdo is used to modify the tempo of the different layers of the Midi note data derived from the Pygmy music – if the shape of melody goes up, the tempo progressively becomes faster and if the melody goes down, the tempo becomes slower. In addition, certain algorithmic composition strategies are used to process the final result – for example, stochastic methods are used to control note density by gradually filtering notes in and out. E-tude IV uses data of three recordings of Pygmy music, which at the same time represent three sections of the composition. The first section is based on a song for the molimo ritual, which is celebrated on special occasions such as the death of an important member of the tribe and is meant to wake up the forest from the sleep which is allowing bad things to happen to its children (Mukenge, 2002). The middle section is based on a recording of a musical bow played by a Mbuti pygmy, which morphs into the last section, derived from a recording of hunters signaling, shouting and beating.11

CONCLUSION

E-tudes is a set of compositions that explores a type of live electronics performance which attempts to establish new relationships between performer, composer and audience. It establishes at different times both interactive and interpassive (Žižek, 2003, Phaller, 2003) relationships between the performer and the technological objects as well as between the musicians and the audience. It also seeks to establish new forms of exchange between composer and performers as well as between the performers within an ensemble. E-tudes combines the use of live electronics, improvisation, real-time computation and generative music to create a result which is unfixed, responsive and which changes for each performance of the work. Additionally, E-tudes attempts to find new ways to approach the process of appropriation using real-time technologies and idiosyncratic musical strategies. First, it plunders live performances of existing music, using their audio and Midi signals as building blocks for multiple musical results, exploring the notion of real-time plunderphonics. It also appropriates micro and macro elements of notated material, recordings and live signals as well as treating the musical sources at varying degrees of processing, affecting our ability to recognise the original source. Finally, the sources from which E-tudes appropriates are, unlike classic plunderphonics, indeterminate, less familiar, obscure or exotic: music from places far removed from western culture (Korean traditional vocal music, Pygmy Music), early music (Gesualdo madrigals), pop music far from the mainstream of consumer culture and unspecified études from the repertoire.

11 Track 5, Ibid.
REFERENCES


