Live Performance, the Interactive Computer and the *Violectra*

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This paper discusses the evolution of *schismatics* (2007, rev. 2010) for electric violin *Violectra* model and live computer processing (using Max/MSP synthesis software), the first work created in an ongoing collaboration between composer Sam Hayden and violinist Mieko Kanno. The *Violectra* (see Fig. 1), custom-built by Dave Johnson, an American luthier based in Birmingham, is an electric violin with a skeletal frame (without a sounding box) and a piezoelectric pickup. Kanno has been researching its potential as an instrument of avant-garde contemporary music performance (as distinct from its more usual associations with popular music and jazz). Hayden has been investigating the creative potential of the computer as a pre-compositional and performance tool, and *schismatics* is the point at which our research coincides. The original project had two aims 1) to produce a *Violectra*-specific piece that reflected its characteristic modes of sound production, and 2) to create a piece with fluidity to its existential form that was always different in performance yet nevertheless maintained a meaningful identity of sonic possibilities and formal coherence.

schismatics (duration ca. 15') involves a fixed notated part (see Fig. 2) for the e-violin with sonically un-fixed live digital signal processing (or DSP). All computer-generated sound originates from the live *Violectra*: there are no pre-existing sounds, synthesisers or autonomous synthesis processes. The piece consists of seven notated sections (see Fig. 3), each of which focuses on a particular combination of rhythmical subdivisions and standard violin articulation classes (col legno, pizzicato, scrape, jeté, tremolo, arco, flautando, etc.), as well as sounds which are virtually inaudible on the acoustic violin (e.g. hammer-on). The middle (fourth) movement is the quickest in tempo and shortest in duration, the other movements being progressively longer/slower, in a symmetrical structure, either side of it. The digital transformations in the original 2007 stereo version mainly involve processes of live sampling and soundfile playback, auto-triggered using Miller Puckette's *bonk~* (a Max object for detecting percussion attacks)[1]. The Max/MSP patch functioned as a complex series of delay lines, whereby controlled random processes (triggered by the detected e-violin attacks) determine which soundfiles are played, when they are played, by how much they are pitch-shifted and so on. Each of the seven sections of *schismatics* involves a different combination of DSP modules, such as filtering, ring modulation, delays, reverb, auto-panning and so on, just as each section features different combinations of e-violin articulations. The musical interest is in the *combination* of these indeterminate processes with the specific timbres of the e-violin.

[1] Puckette, M. (2009). bonk~, version 1.4 for Mac OSX, Max 5. Percussion follower for Max/MSP (MSP port by Ted Apel and Barry Threw). http://crca.ucsd.edu/~tapel/software.html.

[Sound Example 1: MK performs 2007 version of *schismatics* part 2]

The 2007 Max/MSP patch was intended to respond automatically to the live e-violin playing as a *virtual*-performer. However, these processes could also be overridden through the manual interventions of a second (human) performer if the computer response was deemed to be musically unsatisfactory (due to programming limitations). Hence, the performance of the 2007 version of *schismatics* normally required the composer on the computer to oversee the computer operation. Although the 2007 version works satisfactorily to an extent, we were unsatisfied with the 2007 version of the piece for three main reasons:

(i) There was an essentially 'reactive' behaviour in the computer, demonstrating little internal relationship between the e-violin and computer beyond an initial performer-action causing a computer-reaction: the one-to-one relationship between them was perceptually too obvious, linear and predictable.
(ii) Very different *Violectra* timbres were perceived as equivalent by the computer; the computer made little or no distinction between vastly different perceptual 'musical' differences (such as gestural differences, timbre and dynamics).
(iii) The computer-generated sonic responses were rather un-differentiated and lacking in variety, being too similar, in spite of input differences, and too close to the live e-violin timbres, without enough transformation.

In short, we felt the musical *interaction* between e-violin and computer needed further development, requiring a parallel evolution of the Max/MSP patch. In 2010 the Max/MSP patch was revised extensively, enabled by an ARHC Practice-Led research grant to investigate the creative integration of the *Violectra* and interactive computer[2]. The goal was to create an improved performance set-up that maintained an immediacy and *proximity* of performer-action to computer-reaction, as well as a sonic identity whilst avoiding the aural predictability of the *action/reaction* paradigm. The two main tasks of the revisions were:

(1) To achieve a more *interactive* performance situation between solo performer and computer through the creation of a more autonomous computer 'agent' whose interactions with the *Violectra* would need to be 'musical' enough to avoid the need for interventions by a second performer, based on human listening and decision-making.

(2) To achieve a subtler and more 'musical' relationship between live and processed sounds by using sound analysis and data-capture techniques in order to create *internal* (if not

[2] Hayden, S. (2010). AH/H018425/2: 'Live Performance, the Interactive Computer and the Violectra'. http://www.ahrc.ac.uk/FundedResearch/Pages/ResearchDetail.aspx?id=146815

obviously perceptual) relationships between aspects of my live performance and the real-time computer processing.

The term 'musical' refers in this context to a subtle yet perceivable structural relationship between sonic action and reaction: it is at once perceivable and evolving in the manner that complements the design of the piece. A 'musical' response is interpretive in the manner in which it relates to the ongoing performance and contributes creatively to the next moment. It may be difficult for the listener to identify precisely what is happening at any given point because of the less immediate way with which sonic action-reaction is mapped.

Various sound analysis Max external objects were added to the 2010 version of the *schismatics* patch, so usable analysis data could be gained from the *Violectra*'s live performance, which then would be used as control data for various processes (see Figs. 4 & 5). In the 2010 version, the mapping of analysis data to control-data for synthesis parameters enables the computer transformations of the e-violin to be *directly* related to Kanno's interpretation of the piece in performance, so the violin is no longer just a trigger for random processes. However, paradoxically, such mappings made the computer's behaviour seemingly more unpredictable from a perceptual point of view. At the same time it led to a more objective numerical-relationship between the performer's actions and the control of synthesis for the computer, relating *internally* the computer-generated sounds more closely to live performer-actions and enabling the collaborators to grasp some 'proximity' between them.

Dr Nick Collins (Sussex) was an important collaborator on the AHRC project as an expert in the fields of interactive music systems and autonomous agents for music-making. His machine listening and learning system (ll~ object) adapts to the particularities of a performance by learning, i.e. continuously updating a database with sound analysis data extracted from the input[3]. It clusters this data together into a defined number of 'states', essentially categorizing e-violin timbres numerically. It then recalls those 'states' by 'best-fit' comparison with the live e-violin signal. 7 'states' are mapped to trigger the 7 DSP module configurations available in the *schismatics* patch, formerly associated with *separate* movements. For example, if the second movement is being played, the configuration starts with DSP setting '2' on the Max/MSP patch, but *may* now switch momentarily to the configuration for the sixth movement, if the listening and learning system (ll~ object) outputs cluster state number '6'.

At the beginning of each movement, the ll~ object loads preset data files, *pre-training* the listening and learning system (ll~ object) to recognize certain timbral types associated with

[3] Collins, N. (2010). ll~, for Mac OSX, Max 5. Listening and Learning system for Max/MSP. http://www.cogs.susx.ac.uk/users/nc81/code.html#Max.

that particular movement (created in advance, using recordings of each movement). Fig. 6 details the sub-patch that deals with this machine listening and learning process. As Kanno starts to play, the number in the panel in the bottom LH corner of the sub-patch starts to change, seemingly randomly at first, but eventually settling down to a few specific numbers (or 'states') associated with specific *Violectra* timbres, which are not random, after 'learning'. These clusters are not necessarily related obviously to the perception of gestures, yet nevertheless *directly* related to the performance, statistically. This gives the computer autonomy of control (taking some away from the composer).

The computer's way of 'listening' is different to the human's: the computer response is not 'musical' in human terms. But we are embracing its autonomy as a participating agent in the music making process. It is the *mapping* of that data to synthesis parameters which is where the piece begins – in human perceptual terms. Fig. 7 provides a list of the various processes in the patch that were controlled automatically using mappings of analysis data from the various Max/MSP external objects.

One of the main structural changes to the 2010 version of *schismatics* is that rather than there being seven *fixed* configurations of DSP modules associated with the seven movements respectively (as in the 2007 version), the ll~ is used to change between the seven available module configurations *during* the performance of *each* notated movement. The effect of having non-fixed configurations changes the aesthetic framework of the piece, as the relationship between the movements is now much more fluid and interlinked. Each movement (and its associated e-violin techniques) is no longer strictly associated with particular combinations of DSP effects. The linear relationships between timbre categorization derived from ll~ clustering on the one hand and the resultant sound generation on the other hand are not obvious, often being pushed to the sonic and structural background by other control-data generation processes which are taking place simultaneously. Yet the ll~ object still has a very real, if intangible, overall causal effect on the sonic totalities (or 'Gestalts') of various processes, which is what we were after. Greater computer *agency* has made the process more *interactive*, responding (more) intelligently to the live e-violin input in a continuous feedback process between performer and computer.

In the 2010 version of the Max/MSP patch (see Fig. 8) Hayden added also new DSP modules including time-domain effects such as granulation and frequency shifting, and frequency-domain effects such as fft filtering and the convolution of live violin sound and sample playback - in order to help achieve more varied and differentiated timbres between sections. The DSP matrix~ at the heart of the patch was extensively reorganized to accommodate the increase in combinations of DSP modules. Further refinements included an improved visual

interface and 8-channel spatialization, using the method of virtual source positioning known as Vector Base Amplitude Panning (or VBAP) (Ville Pulkki, 2007)[4].

[Sound Example 2: MK plays 2010 version of *schismatics* part 1]

To conclude, having discussed the evolution of *schismatics*, I'd like to discuss briefly the latest work to come out of this collaboration, *Adaptations* (2011) for electric violin and interactive computer. The piece is to an extent conceived as an 'open-form', comprising a collection of short notated 'modules' from which the violinist freely selects during the performance. Unlike *schismatics,* the aim of *Adaptations* was to design a patch and notation that assume less in advance about the nature of a particular performance, instead adapting to each performance situation, which can now be radically different from a formal point of view, as well as the micro-structural level of detail. With *schismatics* the material configurations remained the same, so the piece was identifiable by the sound types and gestures, albeit with indeterminate surface changes in detail.

With *Adaptations*, Nick Collins' machine listening and learning techniques are now central to the architecture of the new Max patch as the *only* control process. In this case, sound types and gestures can be very different from one performance to another, due to both the 'open' notational structure and the fact that the ways in which the computer processes the live input are now *entirely* dependent on the timbral specifics of that material. The piece is hence characterised not only in the generated configurations themselves, but also the manner it which it conceives the *way* sounds are generated. In this sense, the musicality of the performer-computer interactions in *Adaptations* is *internalised* within the field of possibilities that generate sounds and gestures. The patch is intended to be useable as a general improvisation tool for multiple performance situations, as well as applicable to this new piece. More details about the project (and documentation) can be found in the project website (Fig. 9)[5].

[4] Pulkki, V. (2007). VBAP, v1.03 for Mac OSX UB. http://www.acoustics.hut.fi/software/vbap/MAX_MSP/

[5] Hayden, S. (2011). http://www.dur.ac.uk/music/intcompviolproject/