TOWARDS MUSICAL INTERACTION: SAM HAYDEN'S *SCHISMATICS* FOR E-VIOLIN AND COMPUTER (2007, REV. 2010)

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ABSTRACT

This paper discusses the evolution of the Max/MSP patch used in *schismatics* (2007, rev. 2010) for electric violin (Violectra) and computer, by composer Sam Hayden in collaboration with violinist Mieko Kanno. *schismatics* involves a standard performance paradigm of a fixed notated part for the e-violin with sonically un-fixed live computer processing. Hayden was unsatisfied with the early version of the piece: the use of attack detection on the live e-violin playing to trigger stochastic processes led to an essentially reactive behaviour in the computer, resulting in a somewhat predictable one-to-one sonic relationship between them. It demonstrated little internal relationship between the two beyond an initial e-violin 'action' causing a computer 'event'. The revisions in 2010, enabled by an AHRC Practice-Led research award, aimed to achieve 1) a more interactive performance situation and 2) a subtler and more 'musical' relationship between live and processed sounds. This was realised through the introduction of sound analysis objects, in particular machine listening and learning techniques developed by Nick Collins. One aspect of the programming was the mapping of analysis data to synthesis parameters, enabling the computer transformations of the e-violin to be directly related to Kanno's interpretation of the piece in performance.

Sam Hayden's *schismatics* (2007, rev. 2010), written for the Violectra electric violin and live computer processing (duration approximately fifteen minutes) is the result of an extensive and ongoing collaboration between composer Sam Hayden and violinist Mieko Kanno. Kanno has been researching into the potential of the electric violin as an instrument of avant-garde contemporary music performance (as distinct from its more usual associations with popular music and jazz). Hayden has been following his investigations into the potential of the computer as a tool to extend his compositional technique, both in the contexts of (a) live digital signal processing in performance (using Max/MSP) and (b) computer-assisted composition for the generation of notated musical materials (using IRCAM's OpenMusic). This paper will discuss *schismatics* as an example of the former tendency, and the point at which the research of Kanno and Hayden coincide.

Figure 1. Violectra

The Violectra, custom-built by Dave Johnson, an American luthier based in Birmingham, is an electric violin with a skeletal frame (without a sounding/amplification box). It has a piezoelectric pickup but no MIDI pickups. *schismatics* utilises a Max/MSP patch to 'perform' the real-time computer processing of the live input from the Violectra, the only source from which all the computer's sounds are generated (there are no preloaded samples, software synthesizers or other autonomous synthesis processes). The processed sounds are distributed together with the amplified sound of the Violectra, resulting in the overall sound of the piece having a seamless sonority where there is no qualitative difference between the sound of the Violectra and the sounds of the computer's output.

The collaborative goals of the project in 2007 were to create 1) a Violectra-specific piece that reflected its characteristic modes of sound production, and 2) a piece with fluidity to its existential form that was always different in performance yet nevertheless maintained a meaningful identity of sonic possibilities. The performance of the 2007 version of *schismatics* normally required the composer on the computer to oversee the

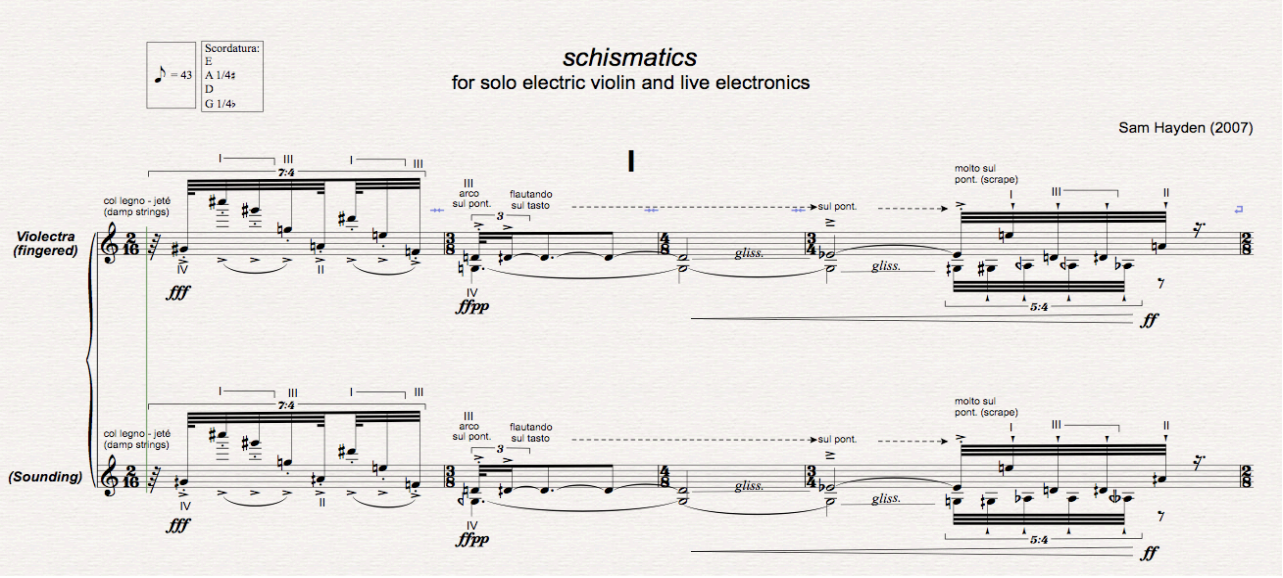

Figure 2. Extract from *schismatics* (opening)

computer operation and overall sound (though it may be and has been done without him), as a second (human) performer, with a view to *intervening* in the automated computer processes during performance. In 2010 the Max/MSP patch was revised extensively as part of an ARHC Practice-Led research project entitled 'Live Performance, the Interactive Computer and the Violectra'[1]. One of the goals of the 2010 revisions was to make the presence of the second performer unnecessary by creating a performance set-up, which involved a seamless interaction between computer and performer with no third-party interventions. To achieve this end, the autonomous computer interactions with the Violectra would need to be 'musical' enough as not to require external 'interference' based on human listening and decision-making. Substantial work was also involved in upgrading the patch from Max 4.6 to Max 5.

The live Violectra plays its own fixed notated material as direct output while at the same time providing sonic materials for the live computer processing. Yet this fixed notated material creates an *unfixed* sonic result, given the built-in unpredictabilities of the Max/MSP patch. The computer is *reactive* in the sense that it is inactive in the absence of input from the violin. However, since the live performer makes real-time, on-the-spot decisions from listening to the computer-generated sounds, there is an interesting ongoing interaction of feedback between the performer and the virtual computer 'agent'. The relationship of the two is complex: since there is no clear aural boundary between the live Violectra sound and the computer-processed sounds (due to their identical source) the blurred distinction between them creates an interesting ambiguity at the heart of the performance, adding a new dimension and meaning to the visual-gestural aspects of live performance.

schismatics continues and extends Hayden's established interest in applying the controlled random permutation of micro-musical materials to *real-time* performance. He had previously utilized such processes for the generation of materials for fixed notated scores. The mapping of random permutations of prime numbers to pitch fields and rhythmical materials was a compositional method for the generation of the notated music for *schismatics*. He also used the same numerical mappings in the patch as control data for live DSP. Hence, there is an internal relationship between what Xenakis (1992, p. 264) might have called the 'out-of-time' and 'in-time' structural aspects of the composition [1].

The piece consists of seven sections, each of which focuses on a particular combination of prime number subdivisions of the quaver beat (e.g. 3:2 16th notes, 5:4 and 7:4 32nd notes, 11:8 and 13:8 64th notes, etc.) and violin articulation classes (col legno, pizzicato, scrape, jeté, tremolo, arco, flautando, etc.). The opening of the piece is characterized by rapid gestures, featuring 5:4 and 7:4 rhythmical subdivisions, juxtaposed with double-stopped microtonal sustained textures (Figure 2).

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. Scordatura is used for the creation of particular microtonal scales and non-tempered intervals (which are exaggerated through frequency shifting and non-linear sample playback). There is also a focus on very quiet sounds that become audible through amplification and compression, such as 'hammer-on' (tapping of a left-hand finger on a specified note). The real-time digital transformations involve the now fairly standard processes of live sampling and playback (auto-triggered by attack detection), time domain effects such as delay, granulation, filtering, ring-modulation, frequency shifting and panning, and frequency domain effects such as fft filtering and the

[1] See: http://www.dur.ac.uk/music/intcompviolproject/.

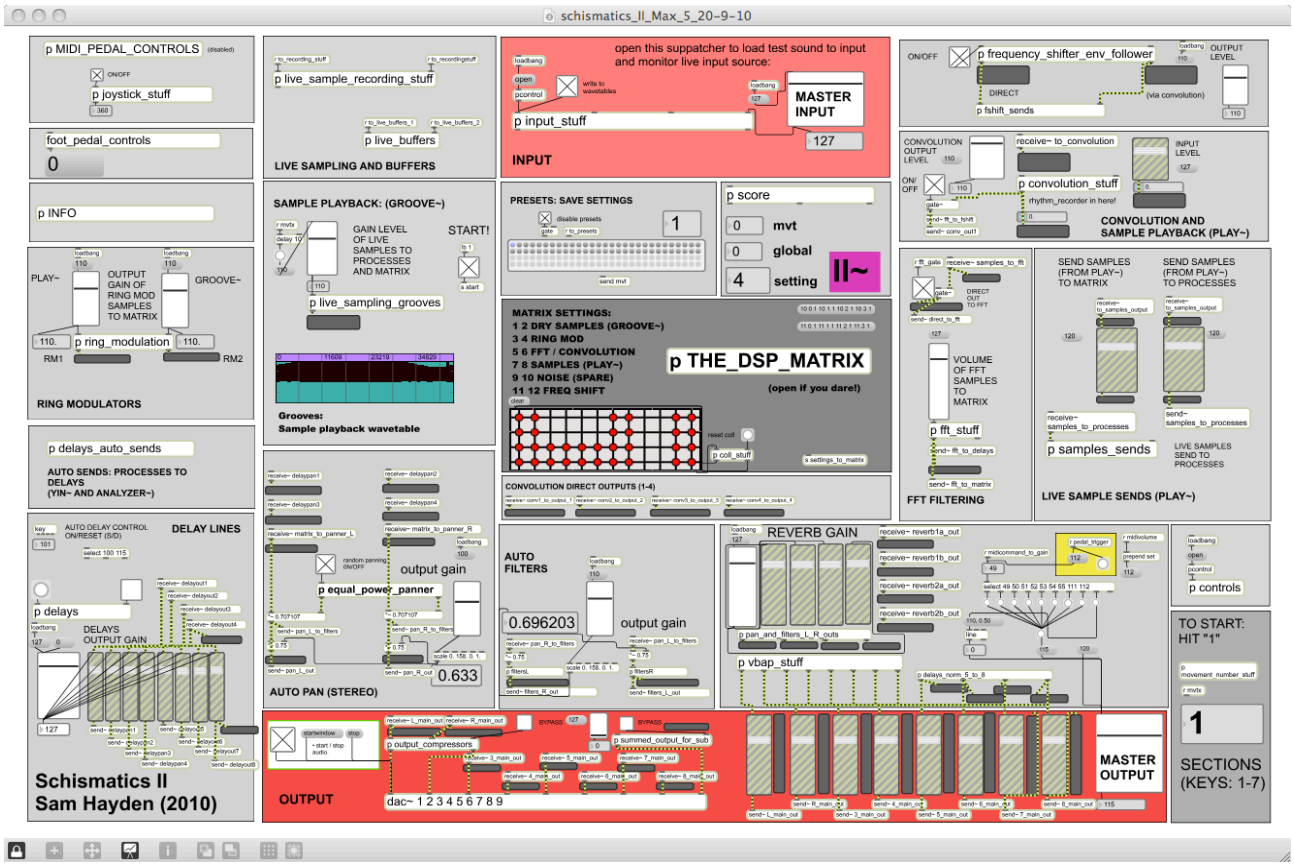

Figure 3. Max/MSP patch for *schismatics*

real-time convolution of live violin sound and sample playback. The interest is in the *interaction* of these processes with the specific timbres of the e-violin. Each of the seven sections of the piece involves a different combination of these DSP modules, just as each section features different combinations of e-violin articulations and sonorities.

It's worth going back to the original version of *schismatics* to discuss the development of the patch. The early prototype versions exclusively used the attack detection object, 'bonk~' by Miller Puckette (2009) [2], a musically useful object developed originally for detecting percussion onsets (transients) beyond certain amplitude thresholds, in order to trigger sampling and playback processes. However, Hayden felt this was limited in the present context for two reasons: (a) very different Violectra timbres were perceived as equivalent attacks by the object; the computer made little or no distinction between vastly different perceptual and 'musical' differences (gestural, timbral, dynamics, etc.), and (b) the one-to-one relationship between performer-*action* and computer-*reaction* was perceptually too obvious and linear, so more musical subtlety was needed in the programming.

The question for the collaborators became how to solve these two issues in order to achieve an intuitively more 'musical' response from both the performer's and listener's points of view. 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. The original 2007 patch for *schismatics* was a prototype, requiring significant development to become a professional concert-patch. In order to make the computer's listening, reactions and interactions more 'musical' the patch required improvements: (i) more subtle methods of sonic analysis and data-capture beyond simple triggers based on attacks (onset detection), (ii) more differentiation between timbres for the computer, and (iii) more internal information about such timbres, in order to achieve a more varied and subtle response to their timbral differences. In general, the computer needed to generate more analysis data regarding the Violectra's live sonic materials. However, as Thomas Ciufo (2003, pp. 3-4) notes, the question of what *kinds* of real-time sound analysis can be done, and what, then, should be *done* with all this analysis data '…is a difficult question that can have many interesting answers depending on the design and context of the system' [3].

In the 2007 version of *schismatics*, most control data in the patch was mapped to effects parameters and other sound processing techniques (triggered initially by attack detection) and generated via quasi-stochastic processes of varying complexity, often using the excellent Real Time Composition Library (RTC-lib) for algorithmic composition by Karlheinz Essl (2010) [4]. But the original computer processing for *schismatics* (2007) was

essentially *reactive,* albeit unpredictably, more or less functioning as a complex delay-line. In order to facilitate a more 'intelligent' musical responsiveness in the patches, synthesis parameters in the revised 2010 version are now controlled by data generated from a *combination* of automated processes including (a) envelope following (amplitudes), (b) data capture (i.e. the writing and recalling of temporal data from performed 'events', derived from time difference between attack points (or onsets), into a 'coll' data array), (c) stochastic processes, using Essl's RTC-lib, (d) feature detection, using the analyzer~ object by Tristan Jehan (2008) [5], which outputs multiple sound analysis perceptual features, and most importantly, (e) customized machine listening and learning techniques, in particular the ll~ Max 5 external object developed by Nick Collins (2010) of the University of Sussex [6]. He is an additional and key co-collaborator on the AHRC project as an expert in the fields of interactive music systems and autonomous agents for music-making (Collins, 2007, pp. 171–84) [7]. The ll~ object enables the real-time automatic clustering of timbres, based on the K-means clustering algorithm for unsupervised learning (Collins, 2011) [8]. These real-time analysis techniques were added in order to relate *internally* the computer-generated sounds more closely to live performer-actions. The mapping (and manipulation) of sound-analysis data, acquired through such techniques, to control-data for synthesis parameters at once made the computer's behaviour seemingly more unpredictable. 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, enabling the collaborators to grasp some 'proximity' between them.

Hence, greater computer *agency* has made the process more *interactive*, responding intelligently to the live e-violin input in a continuous feedback process between performer and computer. The development of the ll~ external object enables the real-time automatic clustering of textures and gestures in a stand-alone module which categorizes timbres numerically, whilst learning and adapting to the particularities of a performance in real-time, according to data derived from the analysis of the live Violectra signal. 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 movement. At the beginning of each of the seven movements, the ll~ object loads preset data files, *pre-training* the ll~ to recognize seven different timbral/textural types (or 'states') associated with that particular movement (created using recordings of each movement). These seven states are then mapped to trigger the seven DSP module configurations formerly associated with *separate* movements. For example, if the second movement is being played, the configuration starts with setting '2' on the Max/MSP patch, but *may* now switch momentarily to the configuration for the sixth movement, if the ll~ object outputs cluster state number 6. For each movement, the computer is nevertheless biased towards using a particular combination of DSP modules (because of global pre-training) but *may* sometimes choose module combinations used in other movements. The effect of having non-fixed configurations changes the aesthetic framework of the piece. The introduction of this mobility of the configurations has a significant overall effect on the concept of the work, as the relationship between the movements is now much more fluid and interlinked. Hence, the movements (and their associated e-violin articulation classes) are no longer strictly associated with particular combinations of DSP effects. Because multiple control-data generation processes are taking place simultaneously the linear relationship between timbre categorization, derived from clustering, and the resultant sound generation is not obvious, often being pushed to the sonic and structural background. Yet it still has a very real, if intangible, overall causal effect on the generated sounds, which is what Hayden was after.

Other improvements to the patch included more efficient enveloping/windowing associated with randomized sample playback and granulation. More subtle and differentiated spectral processing was implemented in order to help achieve more varied and specific timbres between sections, in particular through the real-time convolution of live and sampled materials. The DSP matrix~ at the heart of the patch was also extensively reorganized to increase the available combinations of DSP modules and hence the overall timbral flexibility of the patch. Further refinements included an improved visual interface, and the added options of physical interfaces such as pedals (MIDI or USB Mouse Pedal) for the performer to control parameters and settings. In the original 2007 version both the Violectra's live sound and computer's processed sounds were only distributed in stereo. The 2010 patch incorporates 8-channel spatialization using a Max/MSP implementation of the method of virtual source positioning known as Vector Base Amplitude Panning (or VBAP) by Ville Pulkki (2007) [9]. VBAP is a method for positioning virtual sources to arbitrary directions using a setup of multiple loudspeakers. In VBAP the number of loudspeakers can be arbitrary, and they can be positioned in arbitrary 2-D or 3-D setups (Pulkki, 2000, pp. 304-307) [10]. In the 2010 version of *schismatics*, the direct Violectra sound itself remains in stereo but the computer generated sounds are now distributed across 8-channels, using the VBAP technique.

From the outset, the 2007 patch was intended to respond automatically to the live e-violin playing, but these automated computerized processes could also be overridden through the occasional manual interventions of a performer (usually the composer) if the computer response was deemed unsatisfactory – due to deficiencies in the original programming. In the 2010 version, the computer functions more successfully as an

autonomous *virtual*-improviser, so there is less necessity for a second (human) performer to intervene to keep things musically interesting. While it cannot be claimed that the capabilities of the live musical 'agent' at work here are equivalent to human music making - what Robert Rowe (2001) calls a 'holy grail' of computer music [11] - it is an improvement to the 2007 version. The precise nature of the computer processing of (and sonic response to) the live Violectra sound will be slightly different in each performance, owing to subtle differences in the live performances themselves, as well as significant stochastic elements built into the Max/MSP programming, which now run alongside the new real-time analysis elements rather than being replaced by them. Yet the use of such analysis techniques (e.g. ll~, analyzer~, envelope following, data capture of temporal information, etc.) means that the computer now maintains a more meaningful internal relationship with the live performed material and doesn't simply act as a trigger for random processes. The result of the 2010 revisions is that the computer responses to the Violectra are more *interactive*, being necessarily different in each performance, whilst maintaining sonic consistency and the identity of the piece.

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