Models of Interaction in Works for Piano and Live Electronics

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Abstract

Live electronic sound transformation presents an array of inventive possibilities for the musician. This document is written from a performer's perspective, and focuses on three works for piano and computer-based live electronics: *Cortazar, ou quarto com caixa vazia* by Silvio Ferraz (Brazil), *Zellen-Linien* by Hans Tutschku (Germany), and *Song from the Moment* by Bryan Jacobs (USA). These pieces are placed in an historical context of the growing field of electronic music performance, particularly involving acoustic instruments and computer-based live electronics. The basic concepts of interaction in live electronic music are introduced through a review of literature and repertoire related to the field. The three pieces are then examined in terms of the electronic transformations used, synchronization methods with the computer, and performance practice issues. The author introduces "Models of Interaction" in order to illustrate comparisons with traditional performance practice. The results of this research show that performers working on live electronic repertoire must integrate new approaches in addition to building on existing skills. For composers, the creative process of writing for instruments and live electronics can entail working closely with performers in order to exploit the expressive possibilities of the instrument and successfully incorporate physical aspects of instrumental writing with technology. The final observations are aimed at both performers and composers wishing to develop an approach to integrating piano and live electronics.

Abrégé

Le traitement électronique en direct offre au musicien diverses possibilités sur le plan de la créativité. Rédigé du point de vue d'une musicienne interprète, le présent document met l'accent sur trois œuvres pour piano et sur le traitement électronique en direct à l'aide de l'informatique: *Cortazar, ou quarto com caixa vazia* de Silvio Ferraz (Brésil), *Zellen-Linien* de Hans Tutschku (Allemagne) et *Song from the Moment* de Bryan Jacobs (ÉU). Ces morceaux sont situés dans le contexte de l'évolution croissante du domaine de la musique électronique, particulièrement en ce qui concerne les instruments acoustiques et le traitement électronique en direct à l'aide de l'informatique. Les éléments fondamentaux de l'interaction de la musique électronique en direct sont présentés par l'entremise d'un examen du répertoire connexe et des écrits sur le sujet. Les trois morceaux choisis sont ensuite examinés en fonction des modes de transformation électronique utilisés, des méthodes de synchronisation informatique employées et d'autres questions relatives à l'interprétation même. L'auteure présente les "modèles d'interaction" afin d'effectuer des comparaisons avec les pratiques traditionnelles en spectacle. Les résultats de sa recherche démontrent qu'un interprète qui travaille avec le répertoire de musique électronique en direct doit assimiler de nouvelles méthodes tout en développant les compétences déjà acquises. Quant au compositeur, la démarche créative qui accompagne la composition de morceaux pour instruments et pour le traitement électronique en temps réel peut nécessiter une collaboration étroite avec l'interprète dans le but

d'exploiter toutes les possibilités d'expression de l'instrument et d'incorporer avec succès la dimension physique de la composition instrumentale à la technologie. Les observations finales de l'auteure s'adressent aussi bien aux interprètes qu'aux compositeurs qui souhaitent concevoir une façon d'intégrer le piano à la musique électronique en direct.

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Chapter 1

INTRODUCTION

The past century witnessed numerous attempts to extend acoustic properties of traditional concert instruments. The piano in particular offers great possibilities in the field of extended technique, as pioneered by Henry Cowell (1897–1965) and George Crumb (b. 1929) in works that require the performer to pluck, strum or dampen the strings of the instrument. The "prepared piano" of John Cage (1912–1992) offers another example of extending the instrument by placing objects such as screws, bolts, coins and rubber in between the strings in order to change the timbre and harmonic spectrum. Introducing electronic sound, and in particular live transformation of instrumental sound, can be viewed as the direct continuation of this tradition.

The following discussion focusses on three works for piano and live electronics:[1]

1. *Cortazar, ou quarto com caixa vazia* (1999) by Silvio Ferraz (b. 1959)
2. *Zellen-Linien* (2007) by Hans Tutschku (b. 1966)
3. *Song from the Moment* (2008) by Bryan Jacobs (b. 1979)

Each of the three pieces discussed calls for the use and extension of standard performance skills. In addition, several new skills can be developed and

[1]These pieces were studied by the author and performed in a lecture-recital at Tanna Schulich Hall, Schulich School of Music, McGill University on the 16th of May 2008. Video recordings of the performances are available on the DVD that accompanies this document.

implemented by the performer.

In this Introduction, I present the concept of performance with live electronics. Chapter 2 is devoted to a brief history of performance in electronic music and further elaboration on the performance practice issues prevalent in the field, with examples from the repertoire and literature. Chapter 3 gives particular emphasis to interaction techniques in computer-based live electronics. Chapters 4, 5 and 6 examine specific approaches to integrating instrumental piano writing with live electronics, and the performance skills required from the pianist. The results are summarized in the Conclusions in Chapter 7, and are followed by a selected repertoire list in the Appendix.

1.1 "Live" Electronics

Performers and composers wishing to make use of electronics in combination with live instruments have the options of using the instrument with a fixed (pre-recorded) soundtrack, or processing and triggering sounds live in real time.

Playing with fixed media (or "tape," which today can also mean material on a CD or computer hard drive) requires the musician to perform alongside a fixed recording of modified natural or synthesized sound. This set-up creates a specific performance situation that is very different from live electronic music. While synchronization can be either strict or flexible in works with fixed media (Ding, 2007, 6), the "tape" part remains the same in every performance. It is important to note that live electronics differ from fixed media by giving the composer and the performer an opportunity to escape the potential rigidity of strict synchronization, and to have the electronic as well as instrumental parts of the piece sound different in every performance.

Early uses of live electronics implemented amplification and live transformation of instrumental sound with analogue equipment. Today, live electronic processing is normally done digitally in a computer software patch using a program such as Max/MSP, currently the most popular computer programming software environment for pieces using live electronics. In addition to live transformations, composers also have the option to include offline transformations, or electronic transformations made in the studio. The performer is then able to synchronize, communicate and interact with the computer by triggering with an external hardware device such as a MIDI pedal, or having the computer "listen" to aspects of the instrumental sound such as dynamics, pitch, tempo, and timbre through microphones.

1.2 Repertoire

The repertoire chosen for this project was selected based on the following criteria:

1. Artistic merit and successful integration of piano and electronics
2. Technology used in terms of feasibility and portability
3. Co-ordination problems in controlling triggering and processing
4. Contact with and availability of the composer for collaboration

The first point is perhaps the most complicated philosophically, and required the repertoire to be judged from a musical standpoint. Technology has made rapid developments in recent years, and musicians are often on a quest in search of new and exciting sonorities. The works chosen for this project take the listener beyond technological innovation and "special effects," and are all musically interesting compositions.

While many pieces meet the requirements of the first point and are listed in the repertoire list in the Appendix, several were discarded due to the near-obsolete technological requirements, a major issue in performance of electronic music today. Due to the rapid ageing of technology, much of the classic and even relatively recent live electronic repertoire is virtually unplayable today. This issue is especially prevalent in works that require external hardware, whether commercial or custom-made. In many cases it is possible to reproduce external hardware and analogue or early digital effects units in a computer patch. However, porting electronic repertoire to contemporary formats is a problematic and time-consuming task, and was not implemented for this project.[2]

The third point, co-ordination problems, also proved valuable in repertoire selection. Several of the considered pieces require a complicated set-up, such as light to track the movements of the pianist, video projection, or a musical assistant to play inside the piano. These pieces had to be discarded for practical reasons, but are listed in the Appendix.

Finally, the willingness of the composers to respond to questions, whether by email communication or in person, and provide recordings or updated versions of the software patches required for performance, was another important consideration for selection. While the performer is traditionally held responsible for the final result, working on recent repertoire with live electronics can often require explanations, assistance or collaboration from the composer in addition to technical support from an experienced technician who will oversee processing and control sound projection in real time during the performance.

The discussion outline for each of the pieces is as follows:

1. General information
2. Electronic transformations used, both live and offline
3. Synchronization methods between the performer and the computer.

I borrow Shiau-uen Ding's terminology for categorizing synchronization on the continuum between flexible and strict (Ding, 2007, 6). Interaction between the performer and the computer is illustrated with "Models of Interaction," defined in chapter 3.

[2]For a discussion of the digitization process and problems of authenticity in a classic live-electronic work *Mantra* (1970) by Karlheinz Stockhausen (1928–2007), see Pestova et al. (2008).

Chapter 2

HISTORICAL OVERVIEW

2.1 The Human Presence

The importance of involving human performers in electronic music performance has been recognized by many composers, from the earliest stages of electronic music development to the present day. Concert audiences have certain traditional expectations, and a visual component can be an important part of the performance experience (Appleton and Perera 1975, 292). In his book *Electronic Music*, composer Elliott Schwartz stresses the importance of variety and spontaneity that live performance offers, and compares the combination to a "concerto in modern guise" (Schwartz, 1989, 102). Composer David Cope elaborates further in *Techniques of the Contemporary Composer*:

> Composers of electronic music often face performance problems, particularly in concert situations. Many such composers avoid performers, for example. However, performer gymnastics, potential mistakes, and particularly (it is hoped) their sensitive performances can add the intensity of live performance otherwise missing from the staleness of tape playbacks (Cope, 1997, 182-3).

The original presentation model for electroacoustic music is playback through loudspeakers in an *acousmatic* context with no visible performers. Live diffusion can be considered a performance element in these situations. This occurs when the composer or another musician projects and distributes the sound through the loudspeakers in the concert space via a mixing desk. Successful diffusion is an intricate art form that requires much skill and practice. However, certain authors do not consider it to be a performance art and claim detachment and emotional isolation of the audience as a possible result (Garnett, 2001, 32). There are other ways to incorporate live performance into the electronic music medium. The most logical is to involve human performers (dancers, musicians, or audience members) in a combination of soloistic or collaborative roles with the electronic sound, presented either in a fixed or an interactive environment. The traditional concepts of technique and virtuosity can be incorporated into these situations by introducing an instrumentalist who could be performing on an existing concert instrument, an electronically extended hyperinstrument, or a digital musical instrument, as well as a combination of the above.

2.2 The Art of Performance: a Brief History

One of the first instances of presenting live instruments and electronic sound on tape together can be found in *Musica su Due Dimensioni* for flute, percussion and pre-recorded tape by Bruno Maderna (1920–1973), composed in 1952. This piece marked an important point of departure, and was followed by other major works in this medium such as Edgard Varèse's (1883–1965) *Déserts* for orchestra and tape in 1954, Karlheinz Stockhausen's (1928–2007) *Kontakte* for piano, percussion and tape in 1958–60, and Mauricio Kagel's (1931–2008) *Transicion II* for piano, percussion, and two tape recorders.

Transicion II is an example of what came to be called "live" electronics, which means that the electronic manipulation is done in real-time as opposed to presenting an instrument alongside a tape that was recorded and edited in the studio earlier. In this piece, material is recorded and played back during performance.

In its early form, live electronic music often featured amplified sounds of instruments or objects that would not otherwise be heard in a concert hall. Early live electronic works by John Cage offer good examples of this technique in pieces such as the 1939–42 *Imaginary Landscape* series that featured amplified wire coil with frequency oscillators, or the 1960 *Cartridge Music* in which various objects are inserted into phonograph pick-ups while also using contact microphones (Chadabe, 1997, 81). The 1960s witnessed further development of this medium with the creation of many influential works requiring amplification in addition to direct real-time electronic processing of sound. Some examples are Stockhausen's *Mikrophonie I* for amplified tam-tam (1964), *Mikrophonie II* for twelve singers, Hammond organ and ring modulator (1965), and the monumental 75-minute *Mantra* for two pianos and ring modulators (1970). The latter offers an excellent example of incorporating concepts of traditional instrumental skill and virtuosity into the extended sound world of live electronic music processing while seamlessly combining the two fields.

Simultaneously, the "fixed media" combination of instruments with tape continued to expand, with contributions from leading avant-garde composers including Vladimir Ussachevsky (1911–1990), Luigi Nono (1924–1990), Luciano Berio (1925–2003) and Mario Davidovsky (b. 1934) among others. Davidovsky's *Synchronisms* series features different solo instruments with tape including *Synchronisms* No. 1 for flute and tape (1960), No. 3 for cello and tape (1965), No. 6 for piano and tape (1970), and No. 9 for violin and tape (1988). These pieces proved to be highly influential in the electronic music repertoire. Luigi Nono's *. . . sofferte onde serene. . .* for piano and tape (1976) is another important work in this genre. Written for pianist Maurizio Pollini, this piece uses pre-recorded piano sound in combination with the live instrument, and is an example of flexible synchronization between the tape and the instrument (Ding, 2007, 7).

An example of another work for piano is Jonathan Harvey's (b. 1939) *Tombeau de Messiaen* (1994). In this work, previously recorded piano sound is modified and tuned to the natural harmonic series, resulting in colourful clashes when performed simultaneously with a live piano tuned to equal temperament. This is an example of strict synchronization due to the fact that much of the piano and fixed material is in tight rhythmic unison. A similar example of strict synchronization in a piano work can be found in Michel Gonneville's (b. 1950) *Chute-Parachute* (1989). Both of these pieces create an "illusion" of live electronic processing by exact synchronization of piano sound with the playback sound, and allow the composers to escape the equal temperament of the instrument. For the pianist, achieving these colourful effects requires many hours of practice in addition to learning the notes of the instrumental part and familiarising themselves with the electronic part. It is possible to imagine such works being transferred into a live electronic environment with the computer automatically tracking the pianist's actions and responding instantaneously, thus greatly simplifying coordination and introducing more opportunities for rhythmic freedom.

With the appearance of the microprocessor during the mid-1970s, real-time modification of sound could be done with computers, offering composers more sophisticated possibilities in signal processing (Dodge and Jerse, 1997, 402). This also meant that analogue tape editing techniques developed in the 1950s could be done digitally. Many subsequent technological and artistic innovations in the field of computer music, and live processing in particular, took place during the 1980s. Tod Machover (b. 1953) took an original stance by inventing extended hyperinstruments modelled on traditional instruments at MIT in 1986, resulting in works such as *Begin Again Again* for hypercello (1991), written for Yo-Yo Ma. The composer writes:

> The hypercello allows the cellist to control an extensive array of sounds through performance nuance. Special techniques (wrist measurements, bow pressure and position sensors, left hand fin-

> gering position indicators, direct sound analysis and processing, etc.) enable the computer to measure, evaluate, and respond to as many aspects of the performance as possible. This response is used in different ways at different moments of the piece: at times the cellist's playing controls electronic transformations of his own sound; at other times the interrelationship is more indirect and mysterious. The entire sound world is conceived as an extension of the soloist – not as a dichotomy, but as a new kind of instrument (Machover, 1995).

A recent example of turning an acoustic instrument into a hyperinstrument is the *Hyperkalimba*, developed by Fernando Rocha and Joseph Malloch at McGill University in 2007-08. This instrument gives the performer the option to utilise traditional performance gestures of the kalimba thumb piano while also having access to the extended sound world of live electronic transformation. The instrument is augmented with pressure sensors, a piezoelectric contact microphone, and three accelerometers that enable communication with the computer by tracking performance gestures, sound vibrations and the position of the instrument in space (Rocha, 2008, 45).

During the 1980s, IRCAM (*Institut de Recherche et Coordination Acoustique/Musique*) became an important centre of electronic music development in Paris. The 4X computer system developed at IRCAM featured innovative real-time digital signal processing and was used to create a number of works including *Répons* (1981) by Pierre Boulez (b. 1925) for ensemble and electronics where instrumental sounds are processed and projected in the concert space in real-time, and *Jupiter* (1987) for flute and 4X by Philippe Manoury (b. 1952). *Jupiter* was also implemented in the Max/MSP software developed by Miller Puckette, and allows the flutist the flexibility of changing tempo during the piece while the computer responds (Chadabe, 1997, 183). Other developments at IRCAM led to the appearance of the ISPW (IRCAM Signal Processing Station) using the NeXT computer. This system influenced the creation of works by Kaija Saariaho (b. 1952: *NoaNoa* for ISPW and flute 1991 and *Près* for ISPW and cello 1992), Cort Lippe (*Music* *for Clarinet and ISPW* 1992), and Philippe Manoury (*En Echo* for ISPW and soprano solo 1994). Today, Max/MSP in combination with the Macintosh computer has replaced expensive systems such as ISPW and remains an important programming environment. Other software used in interactive works includes Kyma, developed by Carla Scaletti and Kurt Hebel in 1990 (Chadabe, 1997, 266).

In addition to using the computer with an existing instrument or augmenting instruments with sensors in order to turn them into hyperinstruments, performers can interact with and control computer sound synthesis gesturally by using *Digital Musical Instruments*, or DMIs (Wanderley and Depalle, 2004, 632). These instruments consist of the control interface and the sound synthesis engine on the computer, and do not necessarily resemble traditional instruments despite the fact that they can require the performer to use existing motor and musical skills. Designing a successful DMI can bring together musicians from different backgrounds, such as performers, composers and sound technicians.[1]

2.3 Performance Practice

At this stage it is important to examine various concerns of performance practice that are present in electronic music. Currently, a considerable amount of literature is available on comparisons between fixed and interactive systems, as well as the various advantages and disadvantages of each performance model.[2] It is clear from these accounts that interactive performance systems offer several advantages to the performer despite having problems of their own. They grant the musician the ability to be flexible with tempo, and reduce problems with synchronization of prominent events by providing control

[1] Examples of recent DMI research with the author's participation can be viewed on the McGill Digital Orchestra Project website: http://www.music.mcgill.ca/digitalorchestra (accessed 15 September 2008).

[2] For performer accounts, see Kimura (1995) and McNutt (2003).

over timing. Performing with fixed media has often been criticised for being inflexible as well as "insensitive and unyielding to a musician's fluctuations in tempo" (Chadabe, 1997, 68), making coordination and synchronization of events difficult. Violinist Mari Kimura writes the following regarding her experience of performing with fixed media:

> I feel quite helpless as a performer playing with tape in concert situations, especially in terms of ensemble and sound quality (Kimura, 1995, 71).

Similar concerns are voiced by flutist Elizabeth McNutt, who compares performing with tape to working with "the worst human accompanist imaginable: inconsiderate, inflexible, unresponsive and utterly deaf" (McNutt, 2003, 299). Clarinetist Gerard F. Errante laments that "there is no true interaction between the live performer and the [fixed] electronic portion" in instrument and tape works (Errante, 1985, 64). One solution for the synchronization issue is to use headphones with a click track to give the performer the tempo. However, this can cause challenges of its own, and is comparable to the experience of performing with a strict metronome (McNutt, 2003, 300) while allowing no room for the performer to adjust to the acoustics of the hall (Kimura, 1995, 71).

Despite these concerns, several musicians have voiced opinions in defense of the fixed media. Mario Davidovsky, the composer of the *Synchronisms*, claims that it is possible to compensate for the inherent inflexibility of the tape by composing a piece in such a way as to allow the performer freedom in certain passages. At the same time, the performer can rely on the steady rhythmic aspects that will be the same in every performance (Chadabe, 1997, 69). The composer Marco Stroppa develops the idea further by stating that a piece might be well suited for the fixed medium if there is a steady pulsation or proportional notation. Stroppa concludes:

> Provided that a piece does not insist too much on its very limitations, the association between a performer and a tape can be as natural and musical as any other (Stroppa, 1996, 44).

Pianist Shiau-uen Ding contributes to the debate by offering the following observations:

> Music for instrument(s) and tape has been accused of being mechanical, non-spontaneous and old-fashioned. Many people overlook the rich variety of musicality inherent in interactive works for live acoustic instruments and tape. With acoustic instruments as a 'live element', music for instrumental performance and tape may offer the same degree of interaction between players and audience, contributing to the excitement of its performance (Ding, 2006, 256).

In addition to this rift between personal preferences of composers and performers, there are further complications offered by the unique difficulties of learning and rehearsal that are not found in traditional performance practice. The delicate questions of sound balance and amplification are often addressed due to the near-impossibility to rehearse extensively with the specific sound system used in concert. The importance of taking sufficient time in dress rehearsal in order to find an appropriate playback level and the optimal speaker placement are often emphasized by performers of electronic music (Kellogg, 1975, 53). Kimura suggests having a person in the audience during the dress rehearsal to find an appropriate balance between the electronic and live elements in addition to listening to the electronic element in the concert space (Kimura, 1995, 71). Finding the right angle for the monitor speaker can also be crucial to the success of a performance (Kimura, 1995, 71).

Even the presence of microphones used for amplification creates problems by greatly altering the musician's perception and reaction to sound. "Private" noises such as breathing and finger noises become amplified and exposed, while microphones and cables can change the balance of an instrument and impede the performer's movement (McNutt, 2003, 298).

Aesthetically, it can also be difficult to merge instrumental and electronic elements in performance. Since instrumental sound usually remains psychologically "anchored" to the source, there can be complications involved in combining the two sound worlds (Emmerson, 2000, 207).

Constant listening to the electronic part by the performer during the learning process is also an important issue, in particular if any synchronization is required.[3] This is the case for pieces with live electronics as well as works with fixed media. In the case of fixed media works, rehearsal might require the performer to split the electronic material into smaller fragments or slow it down for practice (Ding, 2006, 269), as well as to memorise the pre-recorded element to feel as if the performer is "also playing the tape part" (Kimura, 1995, 71). Splitting pre-recorded material into smaller sections is one possible way to introduce an element of interaction into a fixed media piece. In case of a work with silences between sections with attacks that are coordinated with instruments and the electronics (as opposed to continuous resonance in the electronic part), the attack sections can be "triggered" by the performer with the use of an external device such as a MIDI pedal, simplifying coordination.[4]

Even without rigid synchronization, the performer should be very familiar with the sound world of the electronic part in which the instrument is to be immersed. This is important for issues of phrasing, timing, dynamic balance, articulation and projection, which can change drastically when the instrumentalist is introduced to their electronic partner (McNutt, 2003, 300). Problems can arise if the performer is unable to hear the electronics until very

[3]See Basingthwaighte (2002, 81) and Mead (2005, 356).

[4]This technique was used by the author to create an interactive version of *a perspex case displays a forgotten moment* (2007) by Caroline M. Breece (b. 1977) for piano, harpsichord, vibraphone and tape with *The Contemporary Keyboard Society* in March 2007.

late in the learning process, as is unfortunately often the case due to technical difficulties or the composer's inability to complete the programming on time.

The above literature review makes it clear that both live and fixed electronic music performance media have certain advantages and disadvantages for the performer and the composer, often depending on personal preferences. In both cases, however, the performer should view electronic sound as being equal in importance to instrumental sound, and approach learning the electronic part in the same way as learning the orchestral part of a concerto or the parts of his or her chamber music partners.

Chapter 3

INTERACTION

3.1 Models of Interaction

In traditional performance, musicians interact with each other, their instruments, the audience and the acoustic properties of the hall. In order to illustrate this concept, Figure 3.1 shows a simple diagram of a solo performer interacting with the instrument in a traditional performance Model of Interaction. The sound of the instrument reaches the audience and comes back from the hall to the performer. (This diagram can easily be expanded to include the chamber music performance model, the concerto performance model, etc.)

Figure 3.1 can be contrasted with the fixed media performance models discussed in the previous chapter, as illustrated in Figure 3.2. The performer still interacts with the instrument. However, instead of only reaching the audience directly, the sound of the instrument is now also amplified and is heard by the listener through the speaker array along with the electronic sound (while this is not always necessary, it is customarily the norm in larger concert halls in order to have the two sound worlds blend better). The electronic sound also reaches the performer through a monitor speaker placed on stage.

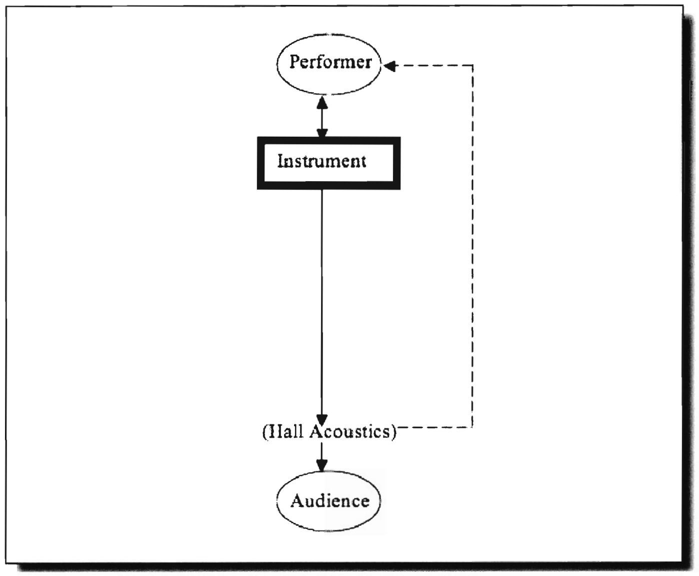

Figure 3.1: Traditional Performance Model of Interaction.

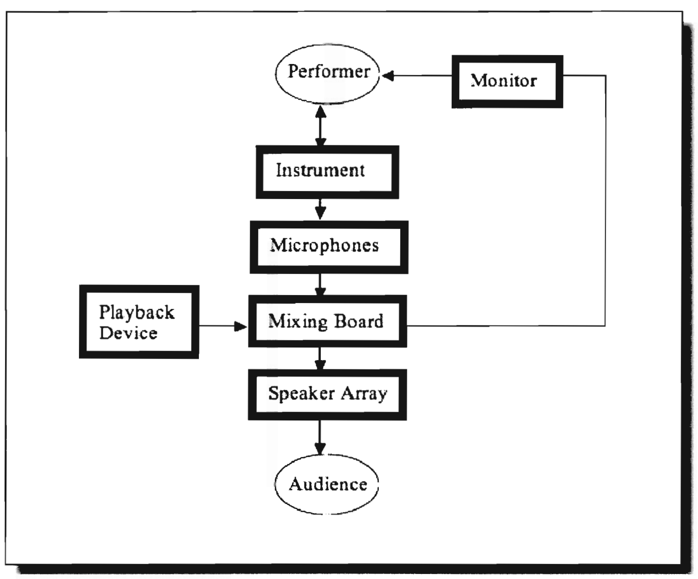

Figure 3.2: "Fixed Media" Model of Interaction. While the hall acoustics are still present, they are omitted from this diagram for the sake of simplicity.

Similarly, we can use this approach to illustrate interaction between the performer and the computer. In order to accommodate the idea of interaction in computer-based live electronics, a more accurate description would be "interactive music systems," a term introduced by Robert Rowe and defined as computer music systems "whose behaviour changes in response to musical input" (Rowe, 1993, 1). For the purposes of this paper, the more general term of "live electronics" is used in the sense of being computer-based "interactive music systems" that can include offline transformation in addition to live transformation of sound.

Regarding interaction in computer music, the composer Guy Garnett writes:

> Interaction has two aspects: either the performer's actions affect the computer's output, or the computer's actions affect the performer's output... (Garnett, 2001, 30).

This can be compared to communication between performers in the traditional chamber music model where duo partners perform notated or improvised music (Winkler, 1989, 25).

In more complex interactive relationships,

> ... a composer can assign a variety of roles to a computer in an interactive music environment. The computer can be given the role of instrument, performer, conductor, and/or composer. These roles can exist simultaneously and/or change continually... (Lippe, 2002, 2).

In the chapters that follow, several such roles assigned to the computer and the instrumentalist will be examined, resulting in different models of interaction and synchronization between the computer and the performer.

3.2 Techniques of Interaction

The following is a brief examination of common interaction and synchronization techniques between the performer and the computer in works with live electronics, as well as problems and possible solutions from the literature.

3.2.1 Score Following

The concept of *score following*, introduced simultaneously but independently by Barry Vercoe and Roger Dannenburg in 1984, involves entering a score into the computer and comparing it to the musician's playing of the same score on a note-by-note basis (Puckette and Lippe, 1992, 1). The computer can "listen" to the live input through microphones and track the musician's tempo, frequency (pitch tracking) or dynamics (amplitude following) in order to determine the location in the score. This technique allows events or processing to be triggered automatically at precise moments, greatly simplifying synchronization problems that are prevalent in works for instruments and fixed media (Kimura, 1995). Tempo estimation can be achieved by comparison of time offsets between live events and those stored in the computer, allowing the computer to adjust the rate at which it schedules events. Barry Vercoe's score-following program uses tempo estimation and "remembers" the performer's interpretation from rehearsal, decreasing the chances of error in performance even if the performer deviates from the score (Rowe, 1993, 52-3).

Pitch tracking can be used in works with variable tempi that would not lend themselves easily to tempo estimation (Puckette and Lippe, 1992). An example of a composition based on a pitch-tracking score follower is *Pluton* (1989) for piano and computer by Philippe Manoury. The computer transforms the sound of the piano by harmonizing, frequency shifting, time stretching, spatializing, adding reverberation, and performing analysis/resynthesis[1](Puckette and Lippe, 1992, 2). However, considering that musicians can make mistakes in concert, pitch tracking is not always accurate. As Miller Puckette and Cort Lippe explain,

> Even if the score follower always works in rehearsals, a musician is not infallible. It is essential that someone be on hand to follow both the musician's playing and the computer's following during a performance, ready to intervene if and when the performer and computer fall out of synchronization (Puckette and Lippe, 1992, 3).

Charles Dodge and Thomas A. Jerse describe frequency analysis as the most difficult and least reliable score following option, especially in passages with trills or vibrato (Dodge and Jerse, 1997, 415). Puckette and Lippe acknowledge this problem in their pitch-tracking algorithm with tremolos and notes that are rich in harmonics (Puckette and Lippe, 1992, 3). The authors provide one solution to pitch tracker unreliability regarding Pierre Boulez's *Explosant-Fixe* (1972). In this piece, grace notes were used between unpredictable and unreliable flute tremolos, forcing the score follower to wait for these control notes before advancing the sound processing (Ibid.).

Mari Kimura also mentions the unreliability of pitch trackers in following violin sounds that are rich in harmonics, as well as their inability to track double stops. Kimura builds "safeguards" into her own pieces to avoid triggering the electronic part by accidentally touching or even coughing onto the string (Kimura, 1995, 73–74). Elizabeth McNutt discusses similar problems with pitch trackers, accusing them of being unable to decipher complex flute timbres that contain many high partials. McNutt likens the situation of a pitch tracker failing to trigger an event to an accompanist who stops playing because of a wrong note (McNutt, 2003, 300). The same author

[1]During the analysis stage, the computer extracts parameters of the sound, which are then used to resynthesise the sound again. The advantage of analysis/resynthesis methods for composers lies in the fact that instead of recreating the sound exactly, modifications to the analysis data can create interesting new sounds (Miranda, 2002, 29-68).

cites Philippe Manoury's *Jupiter* (1987) for flute and computer as an example of pitch-based score following. In this piece, sections of live material are recorded and played back at a later stage, creating uncertainty regarding missed recording cues that can result in drastic consequences (McNutt, 2003, 301). Similar score following issues are present in *Music for Flute and Computer* (1994) by Cort Lippe, and were solved by having a human assistant advance the computer through the sections of the piece instead of relying on a score follower (Ibid.). This case raises questions regarding the "interactivity" of the computer system.

3.2.2 Score Orientation

Score orientation is another category used to classify interactive processes in computer music (Rowe, 1993, 58). Instead of comparing events to a stored score, the computer listens to more general characteristics that can include the performer's register, dynamic level, or density of texture. Alternatively, the computer can respond to selected events in the performance such as a high note at a given pitch in order to advance to the next section in the piece. Because this technique requires only selective "listening," it provides less immediate interaction than score following and can be less problematic. The computer can also respond to a trigger from the performer through contact with a sensor or controller, communicating via MIDI (Musical Instrument Digital Interface) or OSC (Open Sound Control). Theoretically, the sensor or controller can take on any conceivable shape including a camera tracking eye movement, a headband that sends information based on its position in space, or a small finger trigger; however, it is more commonly found in the form of a MIDI keyboard or pedal.

Using a footswitch pedal to trigger events is a widespread alternative to using score following algorithms in performance, but can also be problematic. McNutt describes this technique as particularly awkward for standing performers (McNutt, 2003, 299), changing body position and resultant sound, while Kimura is concerned with the visual distraction for the audience and undesirable "process give-aways" (Kimura, 2003, 289). Foot pedals can create problems for sitting musicians as well, changing the weight and body balance for string and wind players as well as creating co-ordination challenges. One solution to using pedals, offered by Mari Kimura, involves "flexible timewindows" that were designed using Max/MSP software for Macintosh. These "windows" create flexible overlapping sections within a piece. The software advances automatically between the sections after a certain amount of time has elapsed. This procedure is used in the case of a trigger (such as a note or a rest) failing to activate the transfer (Kimura, 2003, 290).

3.2.3 The (Live) Electronic Pianist

Both score following and score orientation techniques have been implemented in works for piano and live electronics. Score following methods seem particularly well suited for the piano due to its stability of pitch, clarity of attack and dynamic control. Some examples of the use of these methods can be found in *Music for Piano and Computer* by Cort Lippe written in 1996. This piece calls for a pitch tracker, an amplitude follower (which includes attack, threshold, and rest detection), and a spectral analyzer (Lippe, 1997, 1). Pitch and amplitude analysis are also employed in *Three Meditations for Prepared Piano and Computer* (2002) by Thomas Ciufo to control aspects of sound transformation. However, the inharmonic pitch content of the prepared piano notes can provide some problems in this context (Ciufo, 2002, 11).

Approaches to the score orientation method by triggering events with external equipment are also often implemented in music for piano and live electronics. A classic example of using external hardware is Karlheinz Stockhausen's *Mantra* for two pianists and ring modulators. In the original version, each pianist would control a dial in order to change the sine wave used to modulate the piano sound in an analogue ring modulator unit. While to-

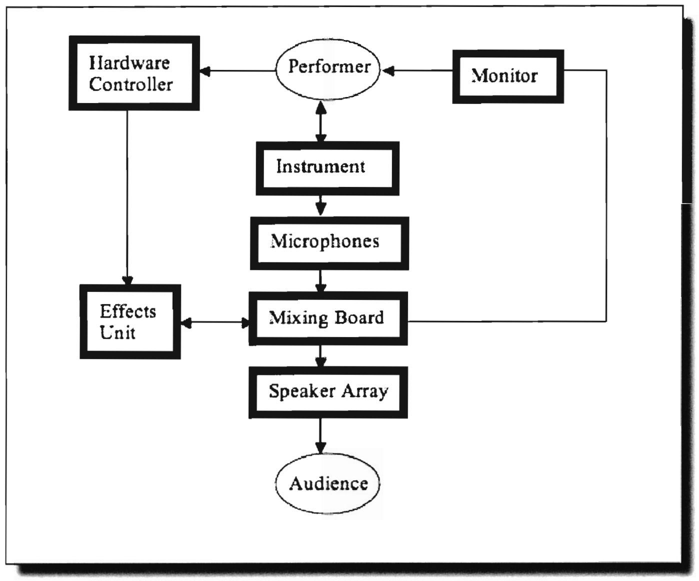

Figure 3.3: "External Hardware" Model of Interaction.

day the analogue equipment can be replaced with a software patch, greatly simplifying touring and solving problems of technological obsolescence, the pianists are still required to use external hardware controllers in order to communicate with the computer (Pestova et al., 2008). Figure 3.3 shows the interaction in the original version of *Mantra*. In addition to interacting with the instrument, the musician communicates information to the effects unit through an external controller interface in order to modify live instrumental sound in real time.

Another hardware solution involves a MIDI pedal or even a MIDI keyboard to trigger pre-recorded sound files in order to avoid the hazards and unreliability of real-time score following systems. This technique is very common, and is demonstrated in *Related Rocks* (1997) for two pianos, percussion and live electronics by Magnus Lindberg (b. 1958). While it might seem like a natural option for a pianist to use a second keyboard and an extra pedal, this is not always the case. Despite being modelled on a traditional grand piano action, MIDI keyboards are nonetheless different instruments, offering far less control and sensitivity than their acoustic ancestors. Navigating between two keyboards at the same time offers an additional challenge to the performer and may not appear as natural from the audience's perspective. It must be noted that the unfamiliarity of the equipment can complicate the learning process, making it even more important to allow for extra rehearsal time before the performance to get used to new instruments.

Another option is to use an acoustic MIDI piano (a concert instrument capable of sending MIDI messages),[2] or the Yamaha disklavier, which is an acoustic piano with the capacity to send and receive MIDI messages. This instrument can be described as a digital counterpart to the player piano favoured as a composition and performance tool by Conlon Nancarrow (1912–1997). *Duet for One Pianist* (1989) by Jean-Claude Risset (b. 1938) is one of many works to use the Yamaha disklavier, and is the first instance of real-time computer interaction involving acoustic as opposed to electronic sound (Risset and Duyne, 1996). In this piece, the computer interacts with and responds to the pianist through the same instrument by using triggers that detect pitch, dynamics and tempo. The composer designated the soft pedal of the disklavier to act as an "invaluable emergency precaution" in case of problems during performance (Risset and Duyne, 1996, 67), and claims that this work is "demanding and rewarding from an expressive standpoint - the pianist is in charge"(Risset and Duyne, 1996, 73). The disklavier also continues to be employed in an improvisatory setting by the composer George Lewis (b. 1952). In this context, a computer algorithm "listens" to human collaborators on other instruments, and controls the piano. The danger in this type of interaction lies in the computer's potential failure to "listen" due to technical difficulties such as malfunctioning microphones, as well as

[2]Any standard acoustic piano can be converted into a MIDI instrument by fitting a *Moog Piano Bar Acoustic MIDI Converter* over the keys (http://www.soundonsound.com/sos/mar05/articles/moogpianobar.htm, accessed 13 August 2008).

its inability to measure up to a human pianist in tone colour and dynamic control.

Alternatively, the pianist can perform with a duo partner who controls the interaction and synchronizes with the computer. This option is used in *Duel* (2007) for piano and sound projection by Rob Godman (b. 1964). The sound projectionist follows the performance from the score and initiates transformations and spatialization of the electronic part by using an Akai MPD24 USB/MIDI Pad Control Unit and a Saitek P880 gamespad as performance interfaces that communicate with the computer (Godman, 2007). The goal of this work is to address the issues of theatre and communication between the audience and the performers in electroacoustic music.[3] An additional Akai MPD16 USB/MIDI Pad Control Unit is used by the pianist in the second movement of the piece to trigger samples and control transformation parameters (Godman, 2007). Further co-ordination between the pianist and the sound projectionist is achieved through conventional chamber music cues and a timer displayed on the screens of two networked laptops, one used by each performer. While normally this work is performed with the sound projectionist in the middle of the concert space, it can also feature the second performer on stage with the pianist due to the highly theatrical and collaborative nature of the sound projectionist's part. A similar approach to the computer performer controlling parameters of electronic transformation is discussed in Chapter 4 below.

[3] Rob Godman, interview by author, email communication, 6 September 2009.

Chapter 4

THE EMPTY BOX: *Cortazar, ou quarto com caixa vazia*

From an early age he heard people talk about the piano. In his town, the closest thing to a piano was a portable pianola owned by the inhabitants of the house by the bridge. But it was really the sound of the piano: a sound that could make him leave that place and dream of other places and other sounds... That is how he came to write the piano piece: forgetting for a while the brass band that usually accompanied him, and making the sound that he didn't know directly but dreamt about in every detail. The piece was conceived and written practically in one night, among the sounds of the wind whistling in the small streets and the lost howling of the maned wolves... or were they dogs, frightened by the moonrise? Everything came to him at once. The introduction, the first chords, the timbre of the instrument, more real than the band that will imprint its colors on him again as soon as the sun rises... That is how he told me about his piece for solo piano, while I admired intensely the arabesques of the score. Everything begins with three chords. A different timbre deconstructs the identity of the instrument that the Western world had bound and enslaved to the temperament of scales and arpeggios. Sometimes one, sometimes another, the notes of the chords are left to ring *alone, drawing curves in the sound. The certainty of listening to a gamelan when in contact with the score is intense...*

–Silvio Ferraz, translated from the Portuguese by Fernando Rocha

4.1 General Information

Translated as *Cortazar, or room with an empty box*, the title of this work is an homage to the Argentinian novelist Julio Cortázar (1914–1984), who is greatly admired by the composer Silvio Ferraz.[1] The "empty box" refers to the software patch written for the piece in Max/MSP. The patch is used as a "digital resonance box" that requires an input from a live instrument in order to produce sound.[2] The pianist is metaphorically locked in a room throughout the piece, and manages to "break the windows" during a virtuosic cadenza and release the sound of the instrument.[3] Written in 1999 and reworked in 2008, this piece lasts approximately five minutes in performance, and requires a musical partner to perform on the computer alongside the pianist.

Cortazar, ou quarto com caixa vazia also exists in a version without any electronic transformation, and can be performed with just the acoustic instrument. The instrumental score remains the same for both versions. This approach is typical for the composer, who always assumes two performance possibilities for his works with live electronics. Other pieces in the series include *Poucas Linhas de Ana Cristina* (1999) for clarinet and live electronics, *Green-Eyed Bay* (2000) for piano and live electronics, *Mesmo se tudo voltasse ao mesmo tempo* (2002) for violin and live electronics, *Ladainha* (2008) for guitar and live electronics, and a new work to be written for vibraphone and live electronics for percussionist Fernando Rocha. In these pieces, the electronic sounds are used as an added "resonance" that enhances the acoustic

[1] Silvio Ferraz, interview by author, email communication, 26 April 2008.

[2] Ibid.

[3] Silvio Ferraz, email correspondence with Fernando Rocha, 5 May 2008.

properties of the instruments. According to the composer, the option to leave out the electronic transformation provides more flexibility for the performers, and allows for more performances to take place when technical support and hardware are not available.[4]

The piece opens with a softly reiterated E-flat, marked *sempre un poco staccato*. Accents, chords and filigree are gradually introduced into the part, which grows in rhythmic complexity. While most of the writing alternates between rhythmic harmonic progressions and rapid pianistic passages, these are interrupted by a slow monodic line with widening ornamentation and pedalled resonances in bars 45-51, allowing the performer and the audience time to breathe:

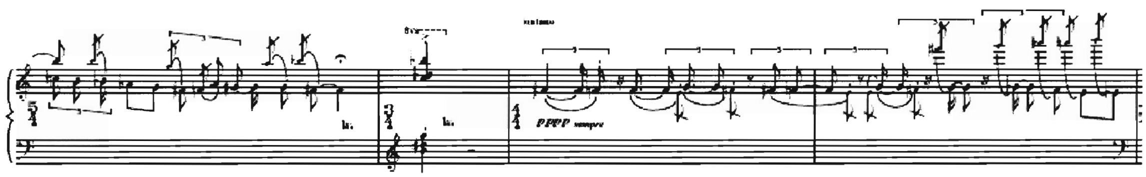

Figure 4.1: *Cortazar, ou quarto com caixa vazia*, bars 48-51.

An explosive cadenza section follows in bar 53. The piece extinguishes itself in a softly repeated B-flat, interrupted by a sudden *ff* B-natural one octave higher just before the end.

4.2 Electronic Transformations

All of the transformations in this piece are performed live; no pre-recorded material is triggered. The composer asks for four speakers, two placed at the front of the hall, and two at the back. Figure 4.2 shows a visual representation of the speaker arrangement in the hall. Untreated piano sound is projected through the two front speakers. Automated spatialization of

[4]Silvio Ferraz, interview by author, email correspondence, 25 June 2008.

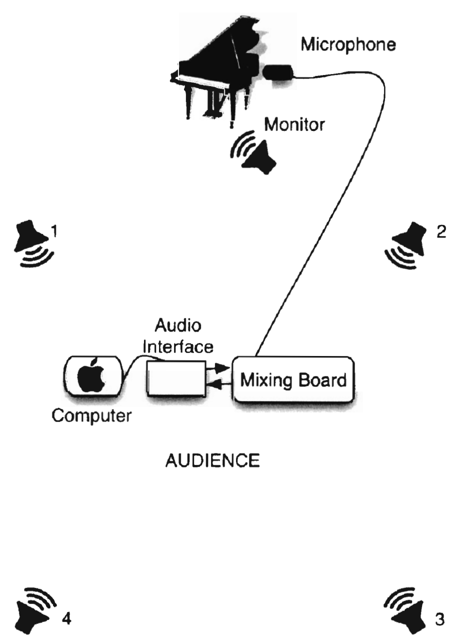

Figure 4.2: *Cortazar, ou quarto com caixa vazia*, surround sound representation. The diagram shows four speakers placed around the audience, with a monitor speaker facing towards the pianist. The composer indicates the use of one directional condenser microphone placed close to the crossing point of the bass and treble strings.

the transformed piano sound is an important parameter, and is initiated depending on presets chosen prior to performance by the computer performer. These can also be modified during the performance. The spatialization patch was developed with the assistance of the composer Sérgio Freire (b. 1962), who is a frequent collaborator of Silvio Ferraz. Figure 4.3 shows the spatialization window of the patch with different presets instantiated. Two sound sources are being panned independently, represented visually by dots moving through the concert space. The four vertical sliders represent the levels of the four speakers placed around the audience.

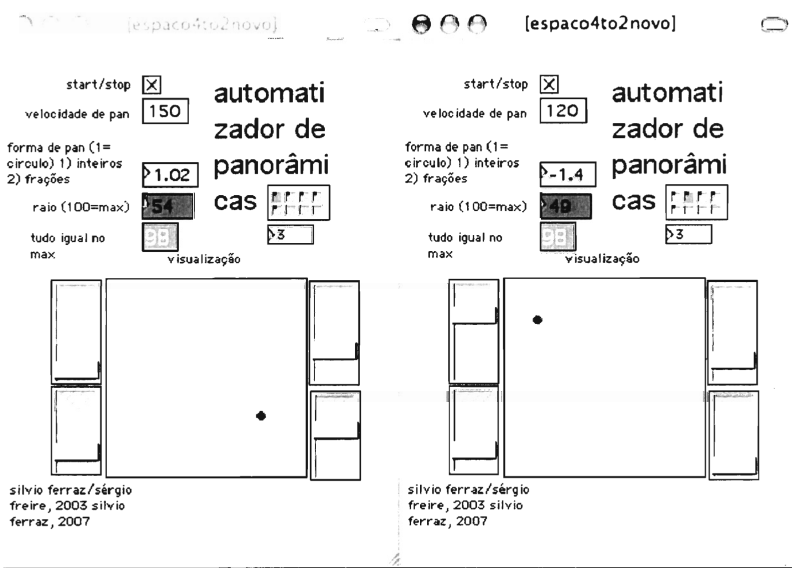

Figure 4.3: *Cortazar, ou quarto com caixa vazia*, spatialization module.

Amplitude modulation[5] is another process used in *Cortazar, ou quarto com caixa vazia*, and can be selected freely from several different configurations, each providing a characteristic sound. The piano sound is picked up by a microphone, and acts as a modulator to a set of eight partials. The dis-

[5]The term modulation is used to describe an audio signal (carrier) varying according to another signal (modulator). Amplitude modulation occurs when a modulator influences the amplitude of a carrier (Miranda, 2002, 20).

tribution of the partials can be varied according to a pre-set partials chart, represented visually and shown by a circle in Figure 4.4. Amplitude modu-

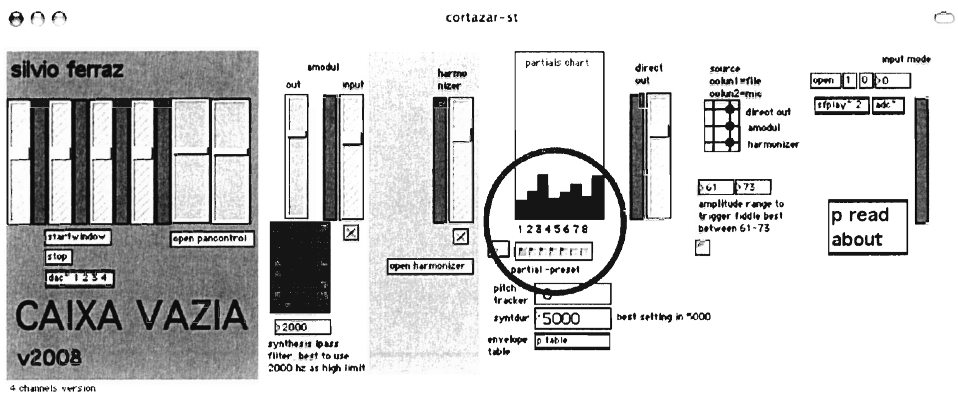

Figure 4.4: *Cortazar, ou quarto com caixa vazia*, main interface. The partials chart is circled.

lation enriches the harmonic spectrum of the instrument and adds a slight distortion. This effect is heard at the opening of the piece, where it is used in a very subtle way. Initially, the audience hears only the direct piano sound, with the processing becoming gradually more apparent with the addition of louder accents and chords in the piano part, which activate the amplitude modulation (Figure 4.5). This is also the case at the end of the piece: the amplitude modulation is activated again with the *ff* B-natural.

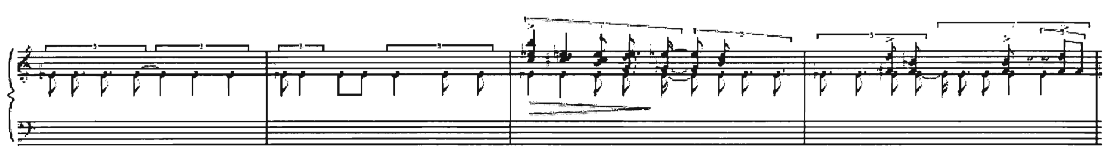

Figure 4.5: *Cortazar, ou quarto com caixa vazia*, bars 7-9. The accents activate amplitude modulation.

Harmonization is another effect used to treat live piano sound, transposing and adding pitches to those played by the instrument. An automatic glissando is included in the transposition parameters to create quarter-tone oscillations in parts of the composition, resulting in gamelan-like sonorities (Ferraz, 2008). This effect is used during the piano cadenza section, which is the most active part for the instrumentalist, and is represented partially in Figure 4.6.

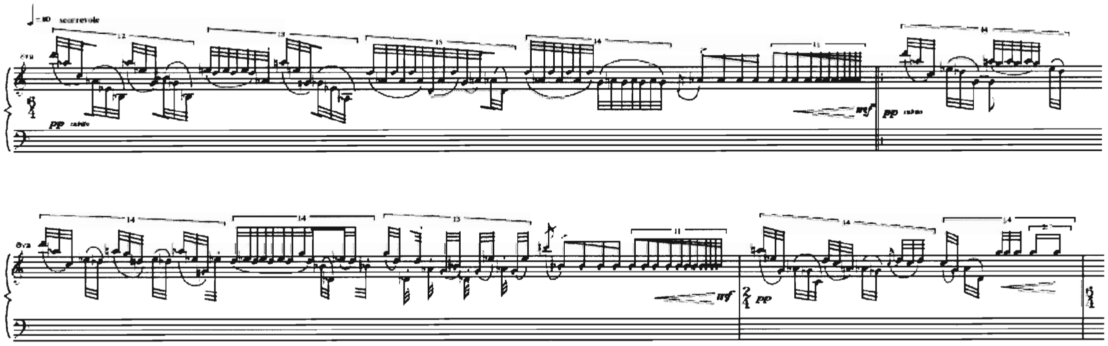

Figure 4.6: *Cortazar, ou quarto com caixa vazia*, Cadenza, bars 53-56.

4.3 Synchronization

In this piece, all of the synchronization with the computer is carried out by the assistant, who follows the pianist and changes transformation parameters at specific bar numbers. This computer performer can be present on stage with the pianist, or play from a position in the middle of the hall. The composer usually performs the electronic part himself. Regarding this, he writes:

> I always play "computer" in my own music, so I have the habit to improvise the "computer" part.[6]

[6] Silvio Ferraz, interview by author, email communication, 25 June 2008.

The fact that the transformations are usually improvised by the composer assumes an intimate knowledge of the score and the computer patch. In order to have performances without the composer being present, these elements were notated in a set of written instructions. The instructions must be practiced by the computer performer, who is required to study and follow the score and make interpretative musical decisions in real-time. This is comparable to the role of a collaborative duo partner or accompanist in traditional chamber music, and necessitates rehearsal time with the pianist.[7]

In order to simplify performance, the patch was modified by Fernando Rocha and Bryan Jacobs. In the version used for this project, several parameters are automated. Instead of moving sliders and interfacing with the patch directly, some of the changes are initiated with triggers from the computer performer at specific bar numbers. These start pre-programmed events, such as gradually raising or lowering delay levels, activating the harmonizer and increasing or decreasing amplitude modulation over time. This version still leaves scope for improvisation and direct manipulation of parameters (Figure 4.7). The fact that the changes are automated means that the patch

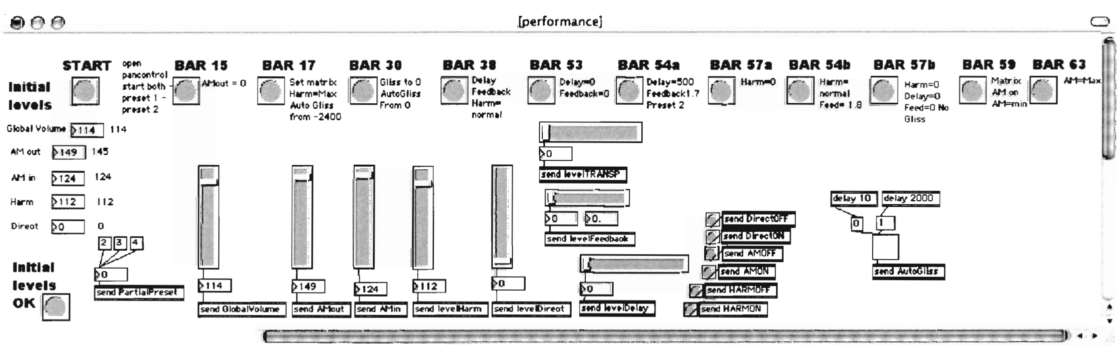

Figure 4.7: *Cortazar, ou quarto com caixa vazia*, automated interface.

can also be controlled by the pianist directly through an external trigger such

[7] In addition to often having a second performer at the computer, electronic repertoire normally requires an experienced sound projectionist to follow the scores and control the levels at the mixing desk during rehearsal and performance.

as a MIDI foot pedal, approximating the score orientation methods discussed in Chapter 3. This option could be beneficial when the pianist does not have an opportunity to rehearse with an assistant prior to the concert. However, it would rule out any possibility of improvisation with the electronic transformation parameters, and might be less interesting musically, since the electronic transformations will sound almost exactly the same in every performance. While the pianist is dependent on a partner in order to perform this piece, the possible benefits include the ability to change transformation parameters depending on the acoustic of the space and the instrument used. The computer performer can also vary parameters depending on the performance. Even though the pianist has no direct interaction with the computer performer through traditional methods of cueing or visual contact, events in the piano part can be influenced by listening to the electronic transformation. For example, articulation, dynamics, pedalling and timing can vary based on reverberation or length of a glissando in the electronic part. The pianist can and should listen and take time before proceeding. An example of such a pause can be found in bars 48 and 49: it is natural to allow the electronic resonance to sound before continuing (see Figure 4.1). When played with a duo partner, this piece can sound fresh in every rendition, and can be an interesting collaborative experience.

Figure 4.8 shows the model of interaction for *Cortazar, ou quarto com caixa vazia*, which includes a computer and an audio interface, used to communicate with the computer. The assistant follows the performer and interacts with the computer, while the sound comes back to the performer from a monitor speaker, influencing decisions of timing, tempo and articulation based on the transformation parameters employed.

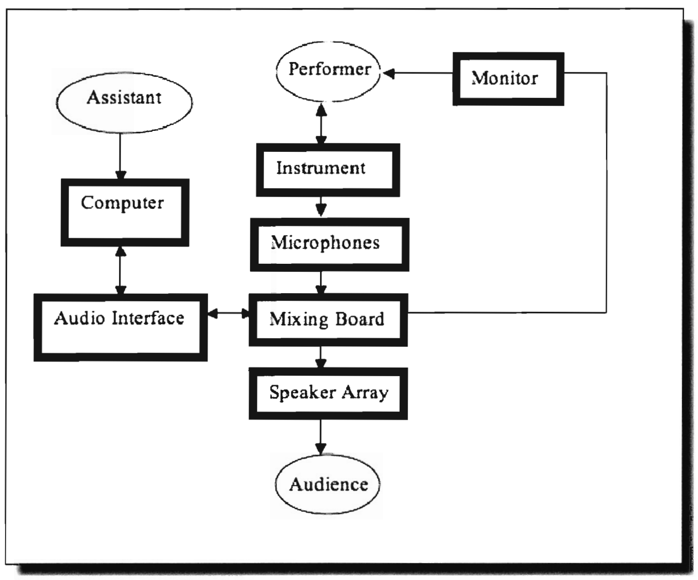

Figure 4.8: *Cortazar, ou quarto com caixa vazia*, Model of Interaction.

Chapter 5

CELLS AND LINES: *Zellen-Linien*

> *"Zellen-Linien" uses all my research on prepared piano and live-electronics I undertook over the past years. I wanted to create an "electronically prepared" piano. There is no physical preparation on the instrument at all. Since 1999 I experimented with the real-time analysis of the instrumental gesture of the pianist and with possibilities to control the live-electronics through the gesture of the player. A first result was the composition "Das Bleierne Klavier." Since then, many performances of that piece enriched my experience and led finally to this new work.*
>
> –Hans Tutschku

5.1 General Information

Zellen-Linien by Hans Tutschku grew out of of the structured improvisation *Das Bleierne Klavier* (The Leaden Piano, 1999/2001), which is performed by the composer himself at the piano. *Das Bleierne Klavier* is organized into 32 sections with written instructions regarding aspects of the performance that require the pianist to be closely familiar with the interaction and electronic transformation in the work. The piece experiments with "mapping the performer's gestures to live treatment controls," and uses similar processing techniques to *SprachSchlag* (2000) for percussion and live electronics (Tutschku, 2003, 33).[1] *Zellen-Linien* lasts approximately 20 minutes in performance, and was composed following requests from several pianists to play *Das Bleierne Klavier*.[2] In both pieces, the pianist "plays" the computer directly as an extension of the acoustic instrument (Tutschku, 2003, 33). The composer writes:

> ...because I came to electroacoustic composition through playing, I'm not a composer but rather a performer/composer. I want to "play" the studio, to have it respond to what I'm doing as if it were an instrument. *Das Bleierne Klavier* was at first research into the notion that there is not one instrumentalist who plays the traditional instrument and then another person who controls the electronics. I wanted to try to have everything handled by one single musician. The piano gestures control all of the electroacoustic part... (Nez, 2003, 17)

As implied in the title, *Zellen-Linien* (cells-lines) explores the idea of musical cells and lines. The musical material can be distributed between these two categories. The cells provide the harmonic framework for the piece, and first appear in bars 13 and 16 (Figure 5.1). The lines are represented by repeated notes, threaded throughout the piece in gestures that either accelerate and slow down smoothly or in intentionally staggered and unnatural ways. The freely speeding up and slowing down sections are presented proportionally (see Figure 5.2), while the more complex *accelerando* and *ritar-*

[1]In contrast to *Das Bleierne Klavier*, *SprachSchlag* requires an "accompanist" to advance the computer through events by pressing the space bar while following the score, as opposed to the soloist controlling the processing changes from the stage (program note available at http://www.tutschku.com, accessed 15 June 2008).

[2]Hans Tutschku, interview by author, Montreal, 18 April 2008.

dando passages are notated precisely in order to sound "slightly strange."[3] The composer opts for very small rhythmic denominations in these passages (Figure 5.3).

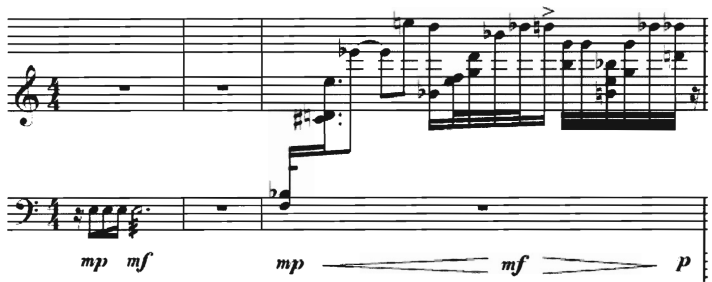

Figure 5.1: *Zellen-Linien*, bars 14-16: the "cell" gesture is in bar 16.

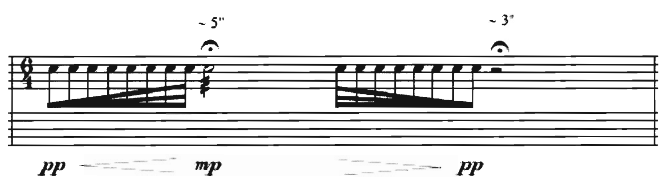

Figure 5.2: *Zellen-Linien*, bar 4: smooth *accelerando* and *ritardando*.

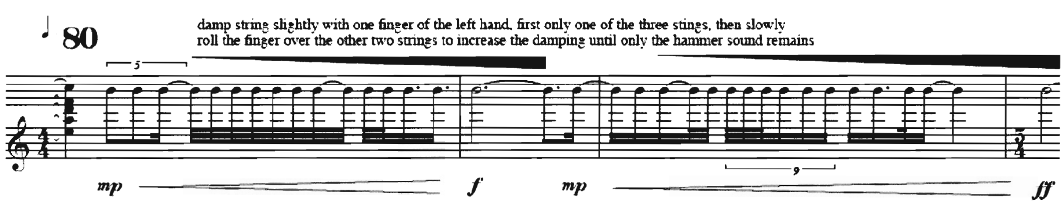

Figure 5.3: *Zellen-Linien*, bars 40-43: uneven *accelerando* and *ritardando*.

The piece opens and ends with untreated piano sound. The electronic sound appears to grow out of the harmonics of the opening chords and melt

[3]Hans Tutschku, interview by author, email correspondence, 1 April 2008.

into the resonance of the last chord, which is held until silence. In the "piano cadenza" section in bars 81-111, the instrument is also presented solo. Musically, this offers an interesting point of release and comparison for the audience. Here, as well as in many other sections of the piece, the pianist makes use of extended instrumental technique. Progressively increasing or decreasing muting of the strings while repeating a B-natural in accelerating or decelerating motion is an effect used several times in the piece. This is notated graphically with a widening or narrowing wedge above the music staff (see Figure 5.3). The composer indicates this muting technique to be done with the left hand, assuming a standing position of the performer and placement of the music stand on an angle. However, this can also be performed while sitting down if the muting is done with the right hand. In either case, a way has to be found to avoid the music stand in order to play inside the instrument.

Despite being fully written out, *Zellen-Linien* retains some freedom in timing and an improvisatory feel. The durations of the initial chords are written approximately as seconds, while in bar 8 the performer chooses freely from different repetitions of the E-natural, each with its own character (Figure 5.4).[4] In this section, the piano acts as a "shadow" of the electronics. The instrument "echoes" a chord first heard in the electronics. The piano itself only reaches the same harmonic progression in bar 148, and again in bar 296. This technique of foreshadowing is employed in order to avoid the overused model of hearing the instrument followed by a reaction from the electronics, and to develop more complex temporal relationships between the two sound worlds.[5] Similarly, some of the elements are introduced by the piano, and only later recalled in the electronics. These passages are not recorded live in concert due to the difficulty of obtaining untreated piano sound without leakage from the speakers, but were pre-recorded earlier. Examples of this

[4]Hans Tutschku, interview by author, Montreal, 18 April 2008.
[5]Ibid.

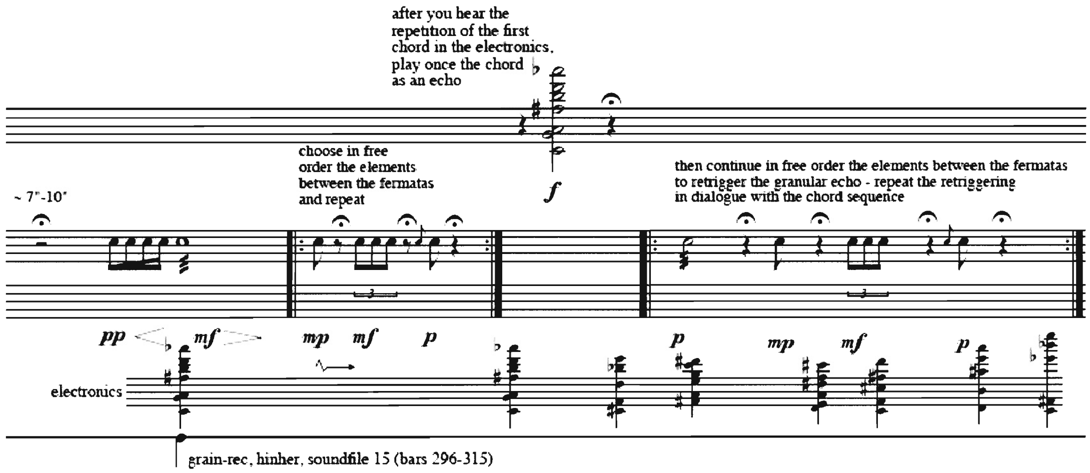

Figure 5.4: *Zellen-Linien*, bar 8: quasi improvised elements.

technique include the repeated note with muting played in the piano part in bars 40-44 and recalled in the electronics in bars 56-58 while the piano echoes a similar rhythm in a lower register, as well as the slow passage played by the pianist in bars 70-79 and recalled partly in the electronics during the extended section inside the piano starting in bar 196.

The idea of musical characters is often present in Hans Tutschku's work. Theatre is an important inspiration for the composer, based on the experience of studying acting:

> In my childhood, I followed two parallel paths: music and theater. I started to study theater in Berlin, which at a certain point I abandoned for music, but I never regret that I studied acting... Even if I don't go on stage any more as an actor, my musical thinking is very much influenced by gesture and movement. You can see this in analyses of my instrumental and electroacoustic pieces: sound structures, melodies, and instruments, for example, play the roles of characters (Nez, 2003, 16).

This is also the case in *Zellen-Linien*:

> In many compositions I'm thinking [of] musical structures and elements as "figures" or "characters" in a play. They encounter each other, carry out a certain "role" and sometimes change their character. They come into [the] foreground, leave the stage for two acts, only to re-appear later on... The functioning of drama is definitely something in the back of my head when I think about musical structure... Many of these musical lines and figures in *Zellen-Linien* came out of a "mental picture," they have certain qualities. Sometimes I'm telling the player these characters, sometimes not – it depends. But the general picture for this piece is that you tame a wild animal. It's all a question [of] when to "feed" it, when to hold the tension, etc.[6]

Many dramatic and surprising character changes take place during the course of the piece. The fragmented energy of the opening cells gives way to the more fragile and subtle details of the cadenza, which morph into an aggressive cluster section in bars 112-147. The colourful passages performed inside the piano that follow in bars 164-207 are interrupted by virtuosic filigrees presented with contrasting insertions in bars 216-272. The role of the pianist as a conjurer or tamer of a wild animal in relation to the instrument and the electronics is also a strong mental image in the work. According to the composer, the piano is "hypnotized" and made to "float" in the final section of the piece (bars 296-325)[7]. Here, the pianist slowly plays through a progression of chords that were presented in the electronic part near the opening, which are taken over by the electronic sound. While the durations are notated, there is freedom in timing for the performer depending on the reaction of the electronics. This coda sounds different in every rendition of the piece, making the performance a highly interactive experience, and introducing elements of what the composer terms "guided randomness" or "liveliness" as compositional parameters (Nez, 2003, 23).

[6]Hans Tutschku, interview by author, email correspondence, 25 April 2008.

[7]Hans Tutschku, interview by author, Montreal, 18 April 2008.

5.2 Electronic Transformations

5.2.1 Offline Transformations

In addition to using untreated sections of the score, various treatments are applied to pre-recorded piano sounds that are played back at different points during the performance. The composer's goal for *Zellen-Linien* was to create an "electronically prepared" piano,[8] and prepared piano sounds are often featured. An extended section on page 9 of the score creates a strong aural illusion of a prepared piano that constantly changes its own preparation. This is achieved by triggering prepared piano sound files with each instrumental gesture, and balancing the two sound sources in the hall.

Another technique used in the piece adds modified piano-like resonances to the sound of the live instrument. This is achieved with an extended application of "resonant models" (Tutschku, 2003, 34). The composer distinguishes between his use of the concept and "a real resonant model," which "describes a sound with one single energy impact, followed by an exponential decay of resonance." (Ibid.) Instead, melodic piano fragments with continuous energy input were analysed in *Diphone*, a sound-morphing software developed at IRCAM.[9] The achieved model was then synthesised in a single excitation, or "hit." As a result, all of the frequencies that change over time in the original sounds occur simultaneously in the synthesised sound. Spatial movement and glissandi were also added to the resulting sounds in order to extend the piano resonance and "tease the ear" (Tutschku, 2003, 36). Some examples of this transformation technique can be heard in the resonances added to the low fortissimo chords that open the piece.

[8]Program note available at http://www.tutschku.com, accessed 21 June 2008.

[9]For a general introduction to *Diphone*, see Miranda (2002, 213-215).

5.2.2 Live Transformations

Real-time recording and playback of the live performance is used in different ways in *Zellen-Linien*. Piano material is recorded and played back with delay or in a zigzag motion. This zigzag "scrubbing" technique is achieved by taking two random points in the sound file and playing between them forwards or backwards. The direction is then reversed, and a new point of arrival chosen. This process is then repeated.[10]

Granular synthesis is another transformation technique used in the piece. The computer analyses live sound and regenerates it in short bursts, or "grains."[11] In addition to simply looping a single grain to create a continuous sound, grains can also be extracted from different parts of the sound file for more complex textures (Roads, 1996, 183). In *Zellen-Linien*, the use of granular synthesis demonstrates further elements of "controlled" or "guided" randomness. Instead of remaining static, the speed, transposition, duration and starting point of each grain changes in order to give movement and "direction" to the sound.[12] An interesting percussive effect is achieved when the grain happens to be taken from the initial attack sound of the piano (the "knocking" sound of the hammer rather than the resonance of the strings), which is then looped. This effect was the direct inspiration for the irregular muted repetitions of the B-natural discussed earlier, and is an example of acoustic imitation of electronic processing.

Other transformations include catching and prolonging piano chords at the same dynamic level by recording and "freezing" their spectral resonances. Each chord sounds beyond its natural duration until the pianist interrupts with a new chord, starting the process again with a different harmony. This technique is used for bars 148-163, and in the final section in bars 296-325. Both sections are different in every performance, with three layers

[10]Hans Tutschku, interview by author, Montreal, 18 April 2008.

[11]For comprehensive examinations of granular synthesis, see Roads (1996, 168-185) and Roads (2001, 85-118).

[12]Hans Tutschku, interview by author, Montreal, 18 April 2008.

of electronic sound happening simultaneously: the spectral freezing of the chord, playback of fragments heard earlier, and granular "looping" to create directional sounds that either accelerate or decelerate.

Spatialization is another important element in this piece, and is integral to the composer's output in general, much of which focuses on surround sound electroacoustic works. The unprocessed piano sound is amplified through the front two speakers, placed on either side of the instrument. Both offline and live processed elements are spatialized in predetermined trajectories in a circle around the audience, moving on the periphery (as opposed to crossing the sound field) in changing speeds. The spatial movements tend to either accelerate or decelerate in "natural gestures" that can be compared to movements of a conductor.[13] Instead of allocating specific speakers for events, the composer defines spatial movement by degrees of distribution. This means that the piece can be realized in versions with four, six or eight speakers. While a stereo version is available for rehearsal purposes, this effect is not comparable to the complex and virtuosic dimension added to the performance by using the full eight-speaker array. The inherently unrepeatable live concert experience is made even more unique by this fact, meaning that this work cannot be perceived by the listener in the same way or fully appreciated through a stereo recording. Figure 5.5 shows a visual representation of the placement of the eight speakers in the hall, along with the MIDI pedal.

5.3 Synchronization

Zellen-Linien employs flexible synchronization with the computer, and uses both score following and score orientation methods, as introduced and defined in Chapter 3. The performer uses a MIDI pedal to cue the computer to start events or to advance the computer through the score in preparation for a change. The extra pedal is placed on the floor close to the other piano pedals.

[13]Hans Tutschku, interview by author, Montreal, 18 April 2008.

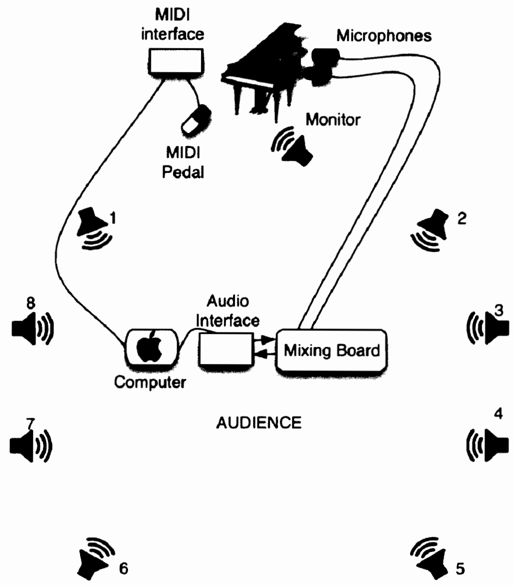

Figure 5.5: *Zellen-Linien*, surround sound representation.

While all the interaction is controlled by the pianist from the keyboard, there is an additional safety net built into the piece. The performer has the option to have a technician follow the score and advance any missed cues by pressing the space bar of the computer. The technician can also reverse an event if the pianist presses the pedal too many times. However, potential MIDI pedal synchronization difficulties are minimized due to the fact that the cues are spaced sufficiently far apart and are usually written within a phrase, making it easier to think of the gesture as part of the music. The right pedal is also notated precisely and does not change often, which greatly simplifies co-ordination for the pianist.

The difficulty of using the MIDI pedal in *Zellen-Linien* is introduced when the performer has to stand up in order to mute, strum and pluck the strings inside the instrument for an extended period of time while still using the MIDI pedal and the right pedal simultaneously (bars 164-207, shown partially in Figure 5.6). This requirement makes it necessary to place the MIDI pedal

Figure 5.6: *Zellen-Linien*, bars 179-186. The MIDI pedal is notated on a separate line. The dotted lines indicate damping with one hand.

on an angle and at some distance further back from the other piano pedals in order to be able to balance on the two pedals while standing. The MIDI pedal also has to be taped to the floor in order to prevent unintentional movement during performance. The music stand with the score must be lowered so that the performer can reach inside the instrument, introducing further difficulties in transitions to and from this section (one solution would be to memorize the piece and remove the stand altogether). In combination with other co-ordination challenges of extended technique, such as finding correct strings for pizzicato passages, this section is quite demanding.

Using the MIDI pedal is more natural for a seated pianist. The composer suggests keeping the left foot on the MIDI pedal as much as possible to avoid accidental triggering or having to look for the pedal in preparation for a trigger.[14] While this technique works well for most of the piece, it does affect the general balance in active virtuosic passages, which can be more comfortable with the foot placed in a different position in order to be anchored during lateral movement on the keyboard. In addition, it is prudent for the performer to remove the foot from the MIDI pedal during the cadenza

[14]Hans Tutschku, interview by author, Montreal, 18 April 2008.

in order to minimise the chances of accidental triggering of the section that follows and have greater physical freedom. The left foot is then used for the middle pedal in bars 101-106, while the *una corda* pedal can add colour in the *ppp* progression of bar 100.

Further changes are initiated by the computer listening method of attack detection.[15] The computer combines the input signals of the two microphones used and traces the resulting amplitude of the instrument with an envelope follower in the patch (see Figure 5.9). As soon as the amplitude of the instrument exceeds the set threshold, the computer begins playback of pre-determined sound files.[16] This method of synchronization works particularly well with the piano. One effective example is found in the previously mentioned "electronically prepared" piano section in bars 228-245, which uses attack detection to activate the sound files.

Attack detection allows very precise coordination and freedom in timing for the performer. However, it is crucial to find optimal microphone placement during the dress rehearsal for this technique to work correctly. While precise instructions are given in the score (Tutschku, 2007, 2), the microphone positions can change depending on the piano used. One microphone is placed in the middle of the low register, while the second microphone is placed directly above the high F that is used to trigger prepared piano resonances in bars 228-245. The threshold for triggering is set to *mezzo piano*, and has to be tested during the dress rehearsal. This passage is used as a sound check: the *pp* B-natural in bar 234 should not trigger a resonance if the levels are set correctly, allowing for selective triggering of sound files

[15]The term "attack detection," also referred to as "amplitude thresholding" (Roads, 1996, 523), is used here to describe computer detection of an attack signal of the piano (notes or chords played by the pianist) by measuring its amplitude (dynamic range). The attack is defined as "the time interval during which the amplitude envelope increases" (Bello et al., 2005, 1035). For distinctions between this and the related, but not interchangeable concepts of "transient" and "onset" detection, see Bello et al. (2005).

[16]In addition to triggering sound files, a second lower (softer) threshold is used to start granular synthesis. The same technique of setting two different amplitude thresholds for triggering and granular synthesis is used in *SprachSchlag* (Tutschku, 2003, 28).

(Tutschku, 2003, 38-39) and creating a game for the pianist (see Figure 5.7). This law of selective triggering above *mp* is set up and then broken down by introducing a secondary rule. As soon as the amplitude falls below a certain threshold, a counter starts. The resulting "time windows" determine that attack detection will not retrigger even if the target amplitude is reached until the specified amount of time has passed. The signal must remain below a certain amplitude for this amount of time in order for the next attack to trigger.[17] As a result, bar 239 does not trigger a resonance because it is too close to the *forte* minor ninth in the left hand, and insufficient time has elapsed (see Figure 5.8). A similar section based on the high F that triggers prepared piano resonances appears in *Winternacht* for percussion and piano, starting in bar 108 of that piece (Tutschku, 2006, 11).

Figure 5.7: *Zellen-Linien*, bars 228-236. The circled *pp* does not trigger.

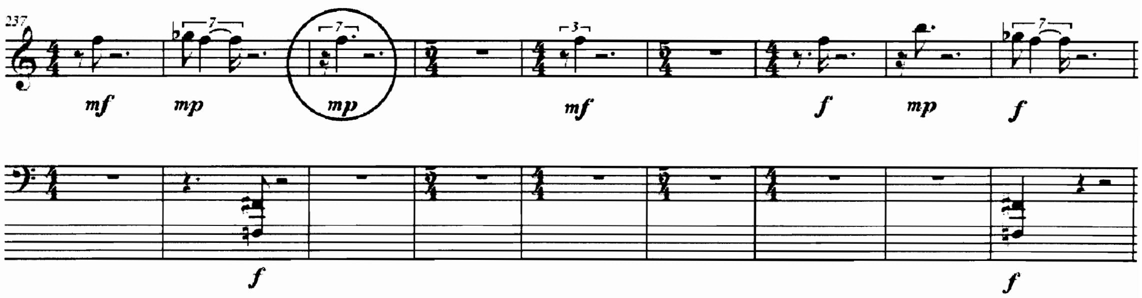

Figure 5.8: *Zellen-Linien*, bars 237-245. The circled F-natural in bar 239 does not trigger despite being *mp*.

[17]Hans Tutschku, interview by author, Montreal, 18 April 2008.

In order to activate attack detection, the performer also has to be prepared to occasionally adapt their dynamic range. Several modifications were made to the dynamics indicated in the original score. Examples of this can be found in bars 70, 246 and 272, where a *forte* or *fortissimo* was required instead of the indicated *mezzo piano* in order to activate the transitions. These changes were included in the updated version of the score along with several other modifications based on rehearsals and performances.

Another important issue when playing with electronic sound is the fact that the performer is physically outside the speaker field and does not have an accurate representation of the sound balance in the hall while on stage. This issue was already introduced in Chapter 2. In works with highly intricate spatialization such as *Zellen-Linien*, it is particularly unfortunate if the performer is unable to get the full effect of spatial movement, which is such an important element in the piece.[18] Therefore, it is most important not to have the stage monitor level too high in order to allow the performer to experience some spatial depth and movement. The level has to be set during the dress rehearsal, and also lowered during the performance by the sound technician in high volume passages in bars 110-147 in order to avoid discomfort. At the same time, it is important not to put the level so low that the energy is lost for the performer. The monitor can then be raised back to the original level for the rest of the piece. In order to experience the effect of spatialization in this piece it is helpful to ask a friend to sight-read a section of the score, and listen from the middle of the hall. Although this issue is not present in traditional performance practice, it is still comparable to the question of sound balance in instrumental performance. Musicians are trained to project their sound to the audience and compensate for the fact that the impression on stage is never an accurate representation of the sound in the hall. This skill is very important when playing with electronic sound.

[18]While in some situations it might be possible to place the front speakers behind the piano and include the performer more in the sound field, this was not experienced by the author in concert.

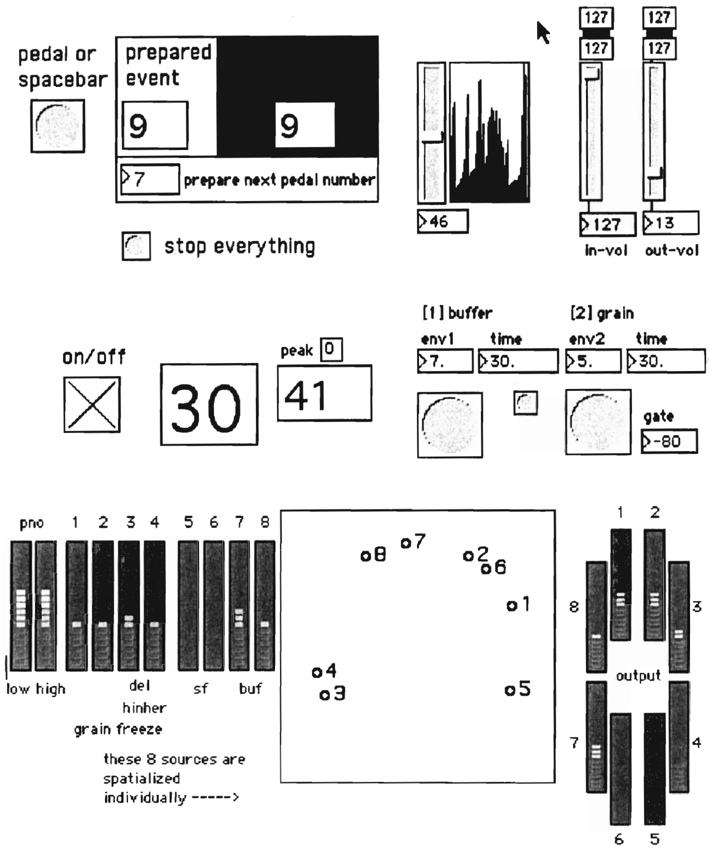

Figure 5.9: *Zellen-Linien*, the software interface (part). Prepared and actual event numbers (32 in total) are displayed at the top of the screen. The envelope follower window in the top right corner shows the incoming amplitude signal. Spatialization of eight different elements is represented visually in a circle. A "stop everything" button was added by the composer for rehearsal in order to stop processing, clear the recorded sound and "rewind" the patch to the beginning. Event numbers can also be typed in manually in order to start the piece at any point. This application does not require any external software to run, and can be downloaded from http://www.tutschku.com (accessed 21 June 2008).

Despite some challenges, the combination of MIDI pedal cues and computer listening in this piece is extremely successful and satisfying for the performer. The integration of the pedal cues into the writing and the freedom in timing afforded by attack detection can be compared to conducting an orchestra from the keyboard while performing a concerto. While the instrumentalist engages in a high level of interaction with the electronic sound and is required to listen and adapt their playing based on the response received, he or she is never in a rhythmically subordinate relationship. The fact that the electronic sound is slightly different in each performance makes *Zellen-Linien* surprising and exciting for the pianist, always leaving space for new interpretation. At the same time, the musician can feel in control of the interaction and is able to concentrate fully on the changing moods, playfulness and energy of the piece.

The model of interaction for *Zellen-Linien* is presented in Figure 5.10, below. The performer communicates decisions to the computer through the MIDI trigger and interface, as well as audio information that is picked up from the instrument by two microphones. The sound comes back to the performer through a monitor speaker, influencing further creative decisions.

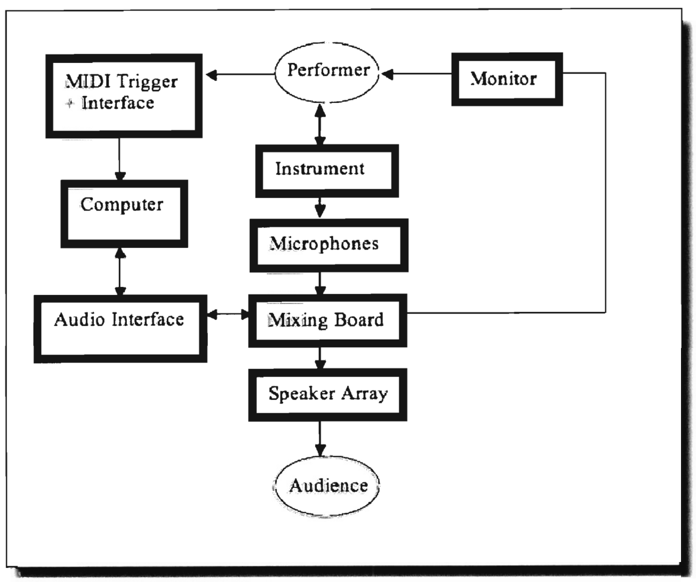

Figure 5.10: *Zellen-Linien*, Model of Interaction.

Chapter 6

SHADOWS AND VOICES: *Song from the Moment*

> *Song from the Moment is a spontaneous song, expelled from the body of the piano without restraint, and without concern for peering eyes. It represents both frantic moments of frenzy and private moments of exhaustion and embarrassment. The language of the piano flirts with old tonalities and attempts to discover new ones. The piano is joined by a chorus of voices, all singing the same song.*
>
> –Bryan Jacobs

6.1 General Information

Song from the Moment by Bryan Jacobs was written especially for this project. The creative process of the composition of this piece involved a direct collaboration between the composer and the performer regarding technical aspects of piano playing and expression of ideas through notation. *Song from the Moment* contrasts mechanical and relentless elements with fragile and subtle sections, and is comparable to the rest of the composer's output, which often explores non-verbal vocal utterances and extremes of register. This piece is part of a series of instrumental and electroacoustic works by Bryan Jacobs that employ short vocal samples, which include partial utterances, gasps and screams. Other pieces in the series are *To Capture the Break* (2006) for 12 musicians, *Within Scenes of Hurt* (2006, electroacoustic), *Into Callous Hands* (2006-07, electroacoustic), *Coloring Regret* (2007) for 21 musicians and live electronics and *A Gentle Ruin* (2007) for oboe and live electronics.

Lasting approximately fourteen minutes in performance, *Song from the Moment* merges traditional piano sound with folk music-inspired vocal gestures. This is achieved through an almost constant use of ornamentation in the piano part. Examples of the ornamentation can be seen in the high-energy onslaught of the opening tremolo gestures, developed through the piece. The tremolos are juxtaposed with rhythmic sections structured on quintuplets (Figure 6.1). These gestures are interrupted with chromatically rising *subito pp* passages, ornamented with short grace notes and played two octaves apart (Figure 6.2) These passages gradually develop into a rhyth-

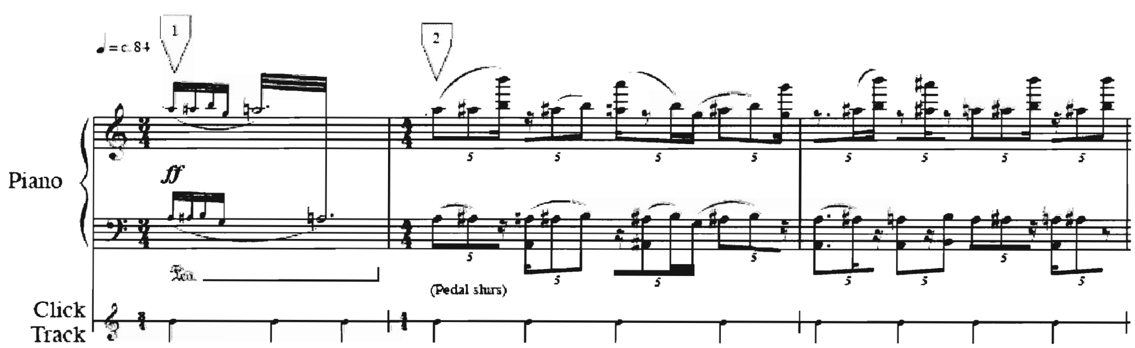

Figure 6.1: *Song from the Moment*, bars 1-3.

mic climax on page 5. The texture rarifies into a slow section, ornamented with grace notes and quasi-arpeggiated chords. An *accelerando* launches the second climax, which is a march-like passage in the registral extremes of the

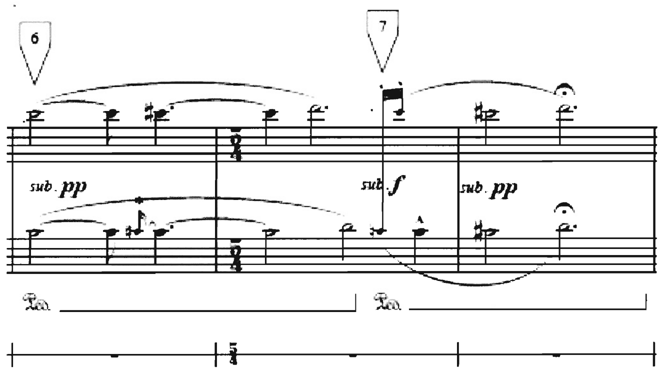

Figure 6.2: *Song from the Moment*, bars 17-19.

instrument, shown in part in Figure 6.3.

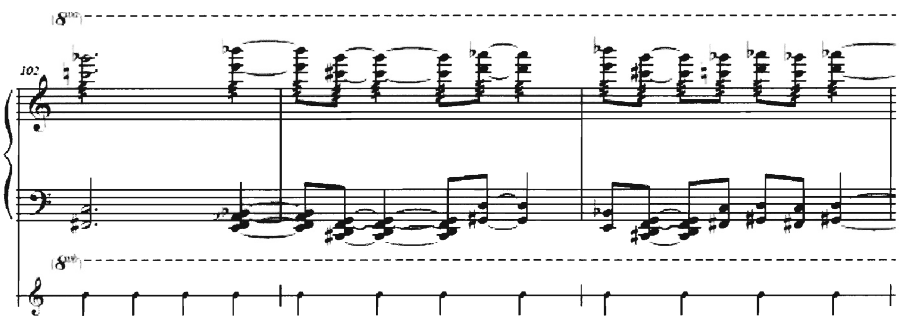

Figure 6.3: *Song from the Moment*, bars 102-104.

Another example of the use of ornamentation is demonstrated in the extensive trill sections that follow in bars 109-123 and 181-204. The second of these sections combines the previously presented ornamented tremolos with the trills (Figure 6.4). This section in particular requires a lot of stamina from the pianist. It can be challenging to sustain the *fortissimo* due to the fact that this section is followed directly by an intense recapitulation of the driving rhythmic material heard at the opening of the work (Figure 6.5).

The rhythmic sections are meant to create a mechanical effect. The mech-

Figure 6.4: *Song from the Moment*, bars 181-182.

Figure 6.5: *Song from the Moment*, bars 226-227, recapitulation of rhythmic material with incorporated tremolos.

anism that is set up eventually breaks down at the end of the piece, where the previously ceaseless and energetic material is rendered with increasingly irregular repetitive interruptions (Figure 6.6).[1]

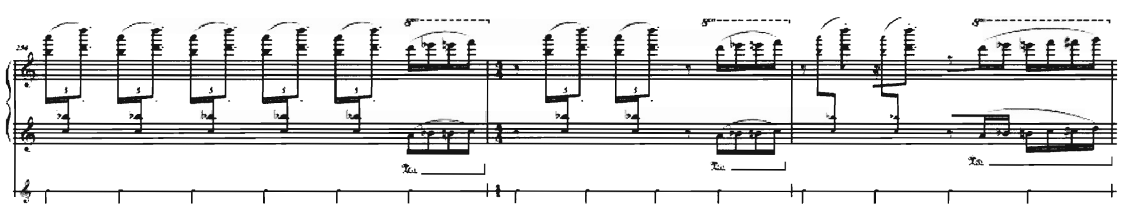

Figure 6.6: *Song from the Moment*, bars 234-236, interruptions.

The mechanism finally collapses in a still coda marked "Drunkenly." Interlaced motifs descend to the bottom of the keyboard, with all resonance

[1]Bryan Jacobs, interview by author, Montreal, 20 April 2008.

stopping abruptly at the end. The composer compares this effect to a tape that is cut.[2]

Collaborative improvisation and experimentation by the performer and the composer influenced the compositional process of *Song from the Moment* during the workshop and rehearsal period in April and May 2008. This resulted in modifications of tempi and dynamics throughout the piece, as well as the development of quasi-improvised elements, demonstrated in bars 141-146. The rhythm of the repeated notes and the duration of the rest in this section are relatively free, with approximate timings indicated in seconds (Figure 6.7).

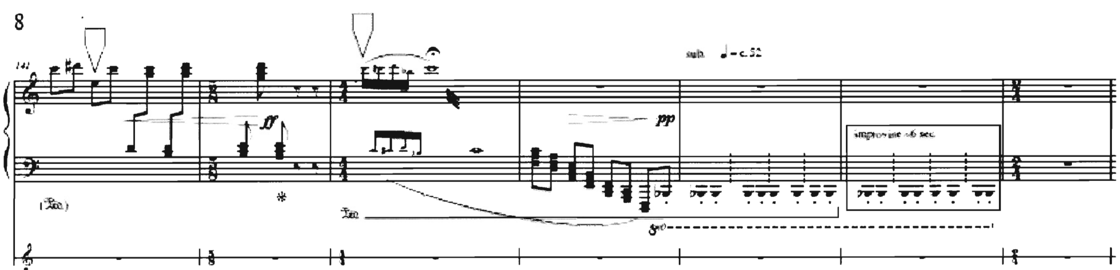

Figure 6.7: *Song from the Moment*, bars 141-147.

Further changes made to the score involved a general thinning of the texture to simplify registral jumps and clarify the lines. Examples of this include removing double notes and octaves from fast configurations and rearrangement of material between the hands, as can be seen in an earlier and final versions of the same bar, represented in Figures 6.8 and 6.9 respectively.

More specific changes shifted some of the focus of the work from the piano part to the electronic part. An example of this can be seen in the trill sections, where the pianist plays the treble part of what used to be two lines, while the bass line is taken over by the electronics. This solution was employed instead of having both hands play two simultaneous lines of

[2]Ibid.

Figure 6.8: *Song from the Moment*, bar 233, early version.

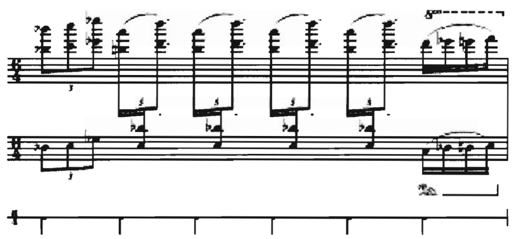

Figure 6.9: *Song from the Moment*, bar 233, final version.

trills for extended periods of time. Some of the other material that had successfully migrated into the electronic part includes accelerating sections that create extremely rapid shimmering textures in bars 124-130, 134-142, and 155-180. The composer's intention was to have these passages sound as fast as possible, originally played by the pianist. A more effective solution was to have the pianist begin the sections, and have them taken over by the electronic sound at super-human speeds.

6.2 Electronic Transformations

6.2.1 Offline Transformations

Offline transformations in *Song from the Moment* consist of several previously modified sounds. These include samples of detuned piano sounds, which are heard either fixed or with added glissandi. In addition, the composer uses synthesized plucked and bell-like sounds done with *Sculpture* in Apple's *Logic Pro* software, as well as various vocal samples.

6.2.2 Live Transformations

Spatialization of both offline and live processing is done using seven-channel surround sound, as shown visually in Figure 6.10. While untreated piano

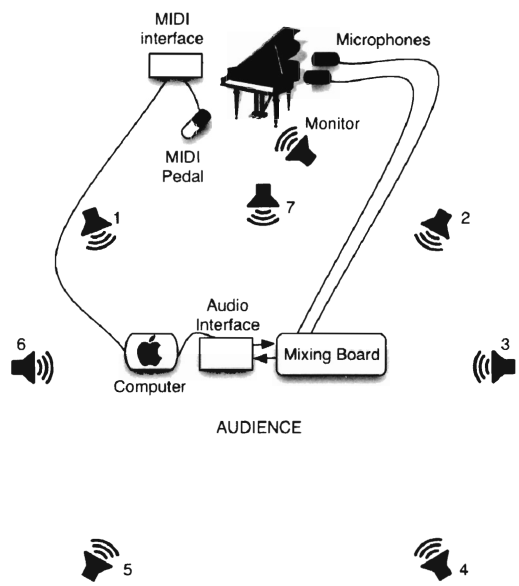

Figure 6.10: *Song from the Moment*, surround sound representation.

sound is heard from the two speakers on either side of the instrument, Bryan Jacobs also uses an extra speaker placed in the middle of the stage for this piece. Most of the piano-like samples and piano sounds originate from the front three speakers in order to blend them with the sound of the instrument itself. The composer refers to the resulting ambiguity between live and electronic sound as a desirable aspect to the composition.[3] Instead of

[3]Bryan Jacobs, interview by author, email communication, 8 July 2008.

panning sounds between the speakers, each speaker has a different mixture of sounds. Plucked sounds often originate from the back speakers, while the middle speakers are reserved for the bell sounds, although this set-up does vary throughout the piece.[4] The seven speakers are represented visually by level meters in the bottom right corner of the patch, as shown in Figure 6.11.

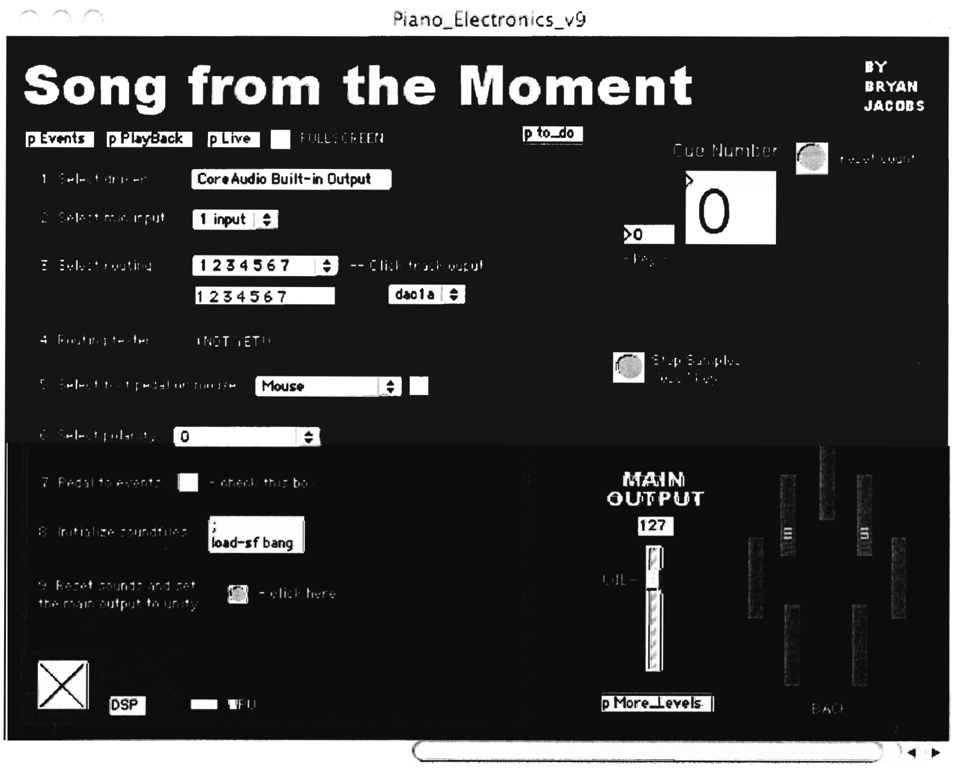

Figure 6.11: *Song from the Moment*, main interface.

In *Song from the Moment*, the computer processes live piano sound by mixing it with vocal samples. These sounds are never heard directly, but are used to provide "a hint of vocal flavour."[5] This is achieved by real-time

[4]Bryan Jacobs, interview by author, email communication, 30 June 2008.
[5]Bryan Jacobs, interview by author, Montreal, 20 April 2008.

analysis of piano sound parameters, which are then used to control the vocal samples. The dynamic range of the instrument is tracked with an amplitude follower, which controls the parts of the vocal sound file that are played based on the amplitude of the signal. The pitch of the piano controls the pitch of the vocal sample. However, the composer avoids direct correlation of pitch between the piano and the resulting vocal sounds. Finally, the timbre of the instrument is also analysed, and compared to the timbre of the vocal samples. The computer then takes qualities of both sounds, and performs cross-synthesis, which means that the two sounds are morphed together into one hybrid in real-time. This technique uses IRCAM's SOGS~ object in Max/MSP (Smooth Overlap Granular Synthesis), which overlaps grains at varying intervals, and can result in manipulation of the vocal elements to the extent of being unrecognizable. The resulting sounds are never heard separately from the sound of the piano: they exist only as a shadow of the instrumental sound. These vocal shadows are played through the speakers simultaneously with the live piano sound. Figure 6.12 displays the cross-synthesis engine window in the patch. The waveform in the upper part of the window represents the vocal sample.

6.3 Synchronization

Song from the Moment fluctuates between strict and flexible synchronization methods with the computer, and uses both score following and score orientation. In the strict sections, the performer has to synchronize with a click track. The click track is played through a headphone worn by the pianist, and is notated in the score on a staff added to the bottom of the system to make sure that the performer adheres precisely to the tempo specified by the composer (Figure 6.13). The click track level has to be set precisely in rehearsal, since it cannot be modified once the performance begins. In this piece, the level is programmed to go up automatically in dense and loud

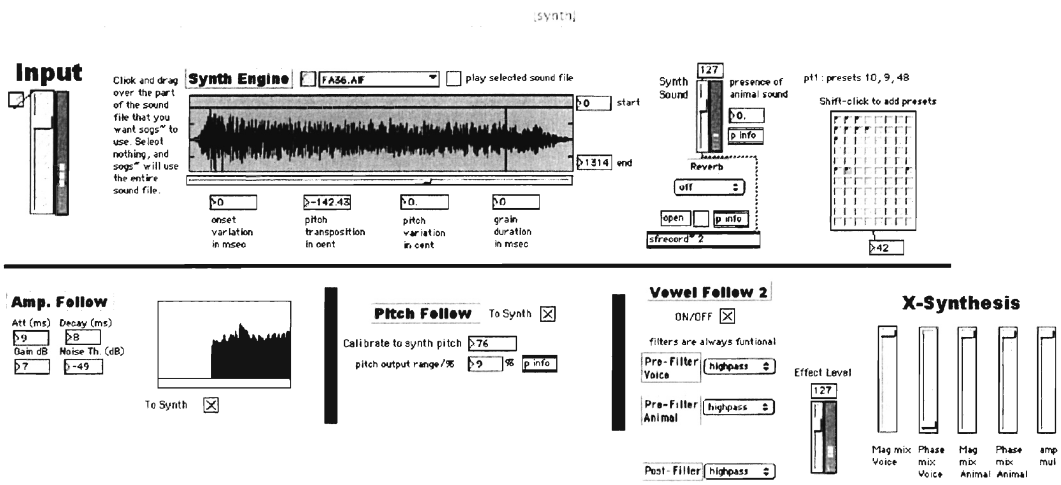

Figure 6.12: *Song from the Moment*, vocal cross-synthesis.

passages where the piano part is more active. The click track is used to synchronize the performer with the computer in sections where samples are played back in the same rhythm as the piano part. This type of performance approximates the fixed media performance model, discussed in Chapter 2. While the performer can still vary the dynamic range, pedalling and articulation based on potentially more or less resonant acoustics of the hall and the properties of the instrument, he or she is unable to modify the tempo, which remains identical in every performance. This means that the performer has to be rhythmically strict in register jumps in the piano part that coincide with attacks in the fixed electronic part. While it might be more intuitive for a pianist to take time before landing on the downbeat in these sections, this is not always possible due to the strict synchronization (Figure 6.13). This way of playing can be compared to a more standard model of following a conductor in a non-solo ensemble role. In some passages, having the click track can provide psychological comfort for the performer, since the tempo will always remain stable. The exception is that the computer "conductor"

Figure 6.13: *Song from the Moment*, click track notation. Circles show challenging register jumps, co-ordinated with the click track.

is not able to adjust to the situation in case of any problems, and it is up to the pianist to remain in synch with the computer. An additional difficulty is the unfamiliar physical sensations related to having an earpiece in one ear. This changes the perception of live sound and adds the weight and movement of the headphone cable, regardless of how it is attached.

In the freer sections, the performer presses the MIDI pedal to trigger sound files or processing. This method of synchronization allows the performer more scope for rhythmic interpretation than playing with the click track. However, due to the complex nature of the score, the extra pedal can create co-ordination challenges despite that fact that the action of using a pedal is quite natural for a pianist. It must be remembered that the nature of the MIDI pedal is very different from the piano pedals. The MIDI pedal is an on/off mechanism with no gradations in between, and missing a cue or playing one too many can result in unpleasant consequences such as skipping a section of the piece or starting a section early.[6] While this might not be an issue in works with less frequent MIDI pedal changes, in *Song from the Moment* the MIDI pedal effectively becomes a second instrument. There are 108 MIDI pedal cues over the course of the fourteen minutes of this work (an average of seven per minute), which demands constant attention from the pi-

[6]Because of these issues, this piece requires an assistant to follow the performer at the computer and correct the cues if necessary, since the computer itself is not able to adjust to mistakes like a human chamber music partner.

anist. In addition to this challenge, the performer must play the MIDI pedal simultaneously with many right pedal changes. These are often co-ordinated, but can also happen independently from each other, as can be seen in Figure 6.14 below.

The MIDI pedal is placed in line with the other piano pedals to the left of the *una corda* pedal, and is notated with triangular wedge shapes above the music staff (Figure 6.14). Due to the highly rhythmical and frequent nature of the pedal cues, it would be more useful for the performer to have this information presented in rhythmic notation on a separate staff below the system. However, this space is already taken by click track notation, and it might be too complicated for the performer to have two extra lines of rhythmic notation to read in addition to the piano score.

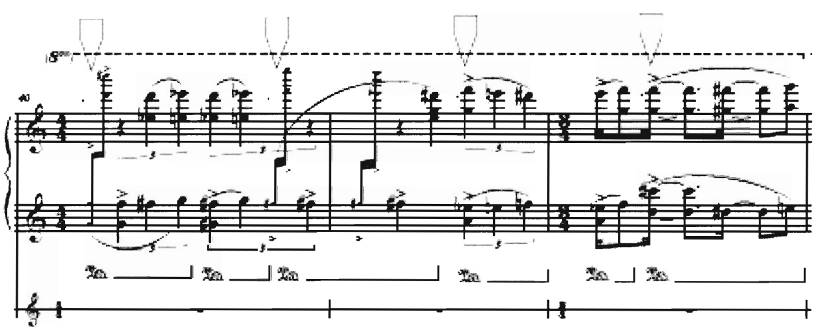

Figure 6.14: *Song from the Moment*, bars 40-42, MIDI pedal notation. Note also the right pedal changes.

There are several other challenges related to the MIDI pedal use in *Song from the Moment*. At times, the MIDI pedal is used simultaneously with the click track. It can be challenging for the pianist to get used to working with two types of unfamiliar synchronization at the same time. Another difficulty involves precise synchronization of attacks in soft passages with many MIDI pedal cues, as can be seen in bars 148-149 (Figure 6.15). Staggered piano-like attacks were originally to be triggered with an amplitude follower. Although this method of synchronization is successful in louder sections, the piano signal is very low at this point (*pp*), and was not sufficient to activate the amplitude follower. The sound files are triggered with the pedal instead. Due to the fact that it is extremely difficult to time the placement of a note with reaching the bottom of the MIDI pedal (the trigger occurs only at a specific point), the sounds seldom start exactly together in performance.

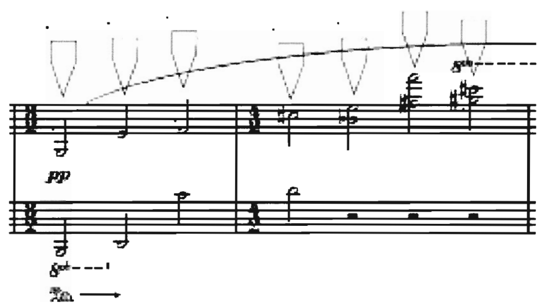

Figure 6.15: *Song from the Moment*, bars 148-149.

An additional challenge is due to the fact that when the pianist presses the pedal, there can be a tendency to make a slight accent in the piano part. It can be counterintuitive and difficult to avoid this when the MIDI cue coincides with a soft beginning of a crescendo passage, as can be seen in bars 86 and 88 (Figure 6.16). A way to avoid this problem could be to place MIDI pedal points during downbeats or rests preceding phrases in the piano part, as demonstrated by the examples in Chapter 5.

Another issue in *Song from the Moment* is that because of frequent trigger points, the performer is required to keep the left foot constantly on the MIDI pedal. This means that the colouristic possibilities of the *una corda* pedal cannot be used until the very end. There are several passages that might be enhanced by this timbre change, such as in example 6.15 above. Composers need to consider these issues of co-ordination and physicality when writing for instruments with live electronics.

The interaction between the performer and the computer in *Song from*

Figure 6.16: *Song from the Moment*, bars 86-88. Note the crescendi.

the Moment fluctuates between flexible and strict synchronization. While the model of interaction for this piece resembles the model from Chapter 5 (Figure 6.17), the added click track shifts the focus from the performer to the computer, which assumes a more dominant role in this work.

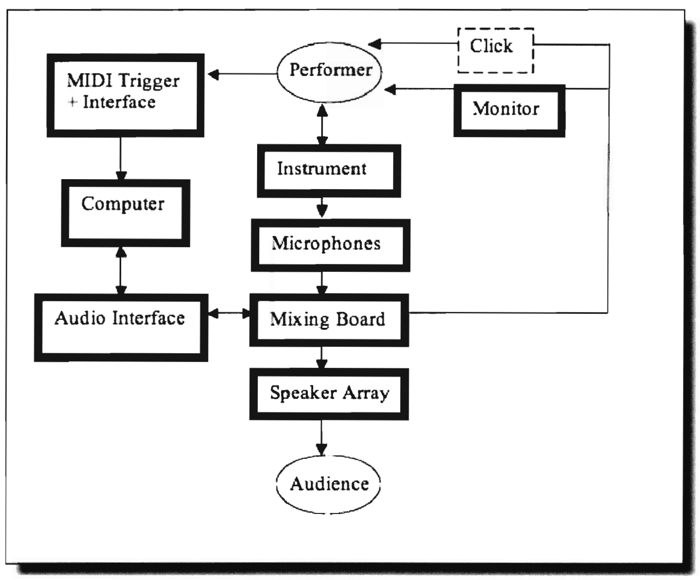

Figure 6.17: *Song from the Moment*, Model of Interaction.

Chapter 7

CONCLUSIONS

This paper introduced live electronic music performance in an historical context, and discussed three approaches to extending the piano by integrating the instrument with computer-based live electronics. Each of the three pieces discussed uses a different approach to composition, sound transformation and synchronization between the performer and the computer. In addition, each of the three pieces has a different Model of Interaction. These models can be compared to traditional performance practice, and require the performer to utilise several existing skills. New skills also have to be learned.

Interacting with the computer or an accompanying musician performing at the computer is similar to performing with chamber music partners, as demonstrated in *Cortazar, ou quarto com caixa vazia* by Silvio Ferraz. Triggering sound files or processing with a MIDI pedal or computer listening methods approaches conducting an orchestra from the keyboard while performing a concerto, as shown in *Zellen-Linien* by Hans Tutschku. Playing with a click track in strict synchronization can be compared to following a conductor, as illustrated in *Song from the Moment* by Bryan Jacobs. Finally, playing with a monitor speaker while the audience hears the full speaker array is necessary in all three pieces, and is comparable to issues of sound balance and projection in traditional performance practice. These issues show that performance with live electronics has similar challenges and affords the musician the same combination of freedom and discipline as standard repertoire.

In addition to using the above skills, which are cultivated by every musician as part of standard performance practice, basic awareness of technology and processing is required for successful interpretation of works with live electronics, as well as for practical reasons. Listening to electronic transformation can affect performance decisions of timing, articulation, dynamics, and pedalling, as exemplified in *Cortazar, our quarto com caixa vazia.* Establishing the correct dynamic level in order to activate attack detection in specific sections can be crucial in order to correctly trigger events at the right moment, as is the case in *Zellen-Linien.* Physical co-ordination with new sensors and devices such as MIDI pedals is also an important aspect, unique to live electronic repertoire. This is the challenge in *Song from the Moment*, which introduces the MIDI pedal as a second instrument, used in combination with a click track. As a general observation, touring and rehearsal of this repertoire can be simplified if the performer is willing and able to at least partially participate in the setting up of the required equipment. Working with new technology always adds an extra layer of stress for the performer, and awareness of this is essential when embarking on projects that require extra time to set up and get used to the equipment and the processing. Therefore, collaboration with a professional sound projectionist and a positive and experienced technical support team can be vital to the success of a performance.

Strengthening collaboration between composers and performers is also important in the growing field of works for instruments and live electronics. In order to be able to successfully exploit the expressive properties of instruments, composers need to be aware of the physical challenges in music making, in particular in combination with technology. When writing for piano and live electronics, examples of this include the inherent difficulties and fragility of MIDI pedal co-ordination in combination with extended technique, right pedal changes, the use of *una corda*, and exact synchronization by triggering in soft passages. Further challenges for the performer can be created by combining physical jumps and register changes with strict synchronization with the click track. These issues can be avoided by opting to employ more reliable synchronization methods between the performer and the computer such as attack detection methods in louder passages and the judicious use of the MIDI pedal. While a satisfying interactive performance naturally includes a certain amount of give and take and changing relationships with the electronic sound, the musician has to feel in charge of their performance. This can be achieved regardless of whether the musician is in an accompanying or soloistic role, and is not different from any chamber music interaction. The ability to be creative with phrasing, articulation and stylistically acceptable breathing or flexibility are just some of the elements that make for an expressive performance and create a satisfying experience for both the performer and the audience. Compositions that allow for these components to be structurally integrated tend to be the most satisfying to play.

We must continue to find new ways to reach compositional goals in ways that are natural for our instruments. This can only be achieved by direct experimentation or working closely with an experienced performer. It is most important that composers trust performers on what is successful for the instrument, and allow their artistic vision to be guided by these parameters. Simultaneously, the performers of today must take a much more active interest in music creation, and reach out to their composer colleagues in order to contribute to our future musical legacy. Combining instruments with live electronics can be an exciting and enriching experience for composers, performers, music technologists and our audiences, providing a unique opportunity to develop new expressive possibilities, influence an evolving art form, be part of a changing musical tradition, and learn an enhanced sensitivity and openness to sound. These skills can in turn be applied in any musical practice.

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Appendix: Works for Piano and Live Electronics

The following pages include information on pieces for piano (solo or duo) and live electronics. This reference collection aims to provide a starting point for research for pianists, composers and musicologists wishing to investigate the medium further. Strictly fixed works are excluded unless the fixed sounds are triggered by the performer and/or used in combination with live treatment. This database was assembled with the assistance of several colleagues and members of the Canadian Electroacoustic Community discussion mailing list. Please refer to www.xeniapestova.com/electronicrepertoire.html for a full list of contributors and updated information on the database.

Peter Adriaansz b. 1966
Waves: four pieces for E-bow piano, sines and live-delay (2007)

Pedro Amaral (b. 1972)
Transmutations (1999) for piano and live electronics

Chengbi An (b. 1967)
Gediao (2006) version for piano and live electronics

Kevin Austin (b. 1948)
Onde (1980) for piano, tape and live electronics

Larry Austin (b. 1930)
Accidents (1967) for piano and live electronics
Accidents Two (1992): Sound Projections for Piano with Computer Music
Quadrants: Event/Complex No. 4 (1972/1994) for Disclavier and tape/electronics

Jacopo Baboni Schilingi (b. 1971)
Deuxième réflexion (1996) for piano and computer

Richard Barrett (b. 1959)
Adrift (2004-07) for piano and live electronics

Daniel Becker (b. 1960)
Revolution (2004) for disklavier and live electronics

Burton Beerman (b. 1943)
Conversations (2004) for piano and KYMA

Marcus Bittencourt (b. 1974)
Malédiction (2001) for piano and unmanned ensemble (automated live electronics controlled by the pianist)
Mifune (2004) for piano and unmanned ensemble (automated live electronics controlled by the pianist)

Per Bloland (b. 1969)
Elsewhere is a Negative Mirror, Part I (2005) for piano with electromagnetically controlled resonance

Jerke van den Braak (b. 1984)
Composition for 2 wiimotes and disklavier (2007)

Chris Brown (b. 1953)
Retrospectacles (2003) for piano and interactive computer processing
Shuffle (2004) for piano and interactive computer music system

Ludger Bruemmer (b. 1958)
Le temps du miroir (2004) versions for piano and live electronics and for piano, computer and video
Move (2006) for piano and live electronics

Jamie Bullock (b. 1977)
Variations (2007) for piano and live electronics

Alex Burton
structures défuntisées (2005) for disklavier and live electronics

John Cage (1912–1992)
Electronic Music for Piano (1964, software version available by Christopher Burns)

Edmund Campion (b. 1957)
Natural Selection for MIDI grand piano and live electronics (2002)

Pierre Charvet (b. 1968)
Neuf Etudes aux deux mondes for piano and computer (2000)

Thomas Ciufo (b. 1965)
Three Meditations (2001) for prepared piano and computer

Michael Clarke (b. 1956)
Enmeshed II (2007) for piano and computer

Ricardo Climent (b. 1965)
DejaVu88~(2001) for piano and live electronics

Denis Cohen (b. 1952)
Jeux (1983/89) for MIDI piano and computer

Elliot Cole (b. 1984)
The Parable of the Sower (2006) for piano, microphones and delay

James Correa (b. 1968)
Ekdysis b (2003) for piano and live electronics

Cindy Cox (b. 1961)
Darsana I (1993) for disklavier

David Cronkite (b. 1964)
Alchemical Cuisine (2005) for disklavier and live electronics

Jocy de Oliveira (b. 1936)
Encontrodesencontro (1985) version for piano and live electronics
Wave Song (1985) version for piano and live electronics (with Ron Pellegrino)

Inouk Demers (b. 1970)
Chambre, vue (2006) for piano, live electronics and film (with Anna Geyer)

Sascha Janko Dragicevic (b. 1969)
Quarks No. 3 from *Strom fliehender Zeitraume* (2000-01) for piano and live electronics

Louis Dufort (b. 1970)
Particules (2006) for disklavier, live electronics and video
Hyper Lucidity (2005) for disklavier and live electronics

Michael Edwards (b. 1968)
segmentation fault beta 1.1 (1996) for prepared piano and custom-designed real-time sound mixing software (Artimix, with Marco Trevisani)
I believe the highest human achievement can be accomplished with a raging heart (2006-07) for piano and computer
for Madga Cordell, if she'll have it (2007) for piano and computer
Marios Joannou Elia (b. 1978)
Eco I (2001) for piano and live electronics ad libitum

Karlheinz Essl (b. 1960)
Con una certa espressione parlante (1985) for amplified piano and electronics, with assistant and live recording
Lexikon-Sonate (1992) for computer-controlled piano

Richard Bunger Evans (b.1942)
Mirrors (1978) for pianist and two tape recorders

Brent Fariss (b. 1972)
Piano Sonata No. 1 (1998) for amplified piano and live electronics
The Lamb and The Snow...or...47 ways to listen to an out-of-tune piano (2006-2008) for piano, cued recordings, speakers, and live electronics

Silvio Ferraz (b. 1959)
Green-Eyed Bay (2000) version for piano and live electronics
Cortazar, ou quarto com caixa vazia (1999) version for piano and live electronics

Carlo Forlivesi (b. 1971)
The Fairy's book covered in dew (1997-98) for piano and live electronics

Patrick N. Frank (b. 1975)
RZ-gamma-III (2002) for piano and Gamma-Synthesizer

Bradford Garton (b. 1957)
look-ma-no-hands (2006) for computer-controlled disklavier

Rolf Gehlhaar (b. 1943)
Klavierstueck 1-2 - constellations (1973) for amplified piano and live electronics

Roberto Girolin (b. 1975)
Quieti momenti d'inquietudine (2001) for piano, tape and live electronics
Galassien II (2006) for piano, tape and live electronics

Bob Gluck (b. 1955)
In the Bushes (2004) for computer assisted piano and electronics
Questions, Questions (2005) for computer-assisted piano and computer interface
Eighteen Hands (2006) software-based performance interface for computer-assisted piano

Rob Godman (b. 1964)
Halo (2005) for piano and responsive electronics
Duel (2007) for piano and sound projection with optional video

Michail Goleminov
Prelude and Fugue for piano and live electronics

Ali Gorji (b. 1978)
Urrealis (2005) for piano and live electronics

Annie Gosfield (b. 1960)
Lightning Slingers and Dead Ringers (2008) for piano and sampler

Larry Goves (b. 1980)
My name is Peter Stillman. That is not my real name. (2007) for piano, keyboard and distortion

Jonathan Green (b. 1983)
Into Movement (2007) for piano and motion sensors

Georg Friedrich Haas (b. 1953)
Ein Schattenspiel (2004) for piano and live electronics

Stanley Haynes (b. 1950)
Pyramid Prisms (1977) for piano, tape and live electronics

Sorrel (Doris) Hays (b. 1941)
90s, A Calendar Bracelet (1990) for MIDI grand piano and tone generator

Fredrik Hedelin (1965)
Den envetna lyssnaren (1997) for piano and live electronics

Jeff Herriott (b. 1972)
Velvet Sink (2001) for prepared piano and live electronics

Jean-Luc Hervé (b. 1954)
Déja piano (2000) for disklavier and live electronics

Elizabeth Hinkle-Turner (b. 1964)
What Would Ruth Do (1993) for piano and live electronics

Ralf Hoyer (b. 1950)
Sonata (1985) for piano, tape and live electronics
Jam Power (1995) for piano and live electronics

Shintaro Imai (b. 1974)
Figure in Movement II (2006) for piano and real-time audio/visual processing technique
Filtering (2002) for piano and live electronics

Bryan Jacobs (b. 1979)
Song from the Moment (2008) for piano and live electronics

David Jaeger (b. 1947)
Quivi Sospiri (1983) for piano and synthesizers

Victoria Jordanova (b. 1952)
Piano Sonata (1996) for amplified aged piano and interactive electronics

Thomas Kessler (b. 1937)
Piano Control (1974) for piano and live electronics (with synthesizer)

John King
23 Rubai'yat (2006) for piano and live electronics

Juraj Kojs (b. 1976)
Three Movements for unprepared piano and electronics (2004)
All Forgotten (2006) for piano and live electronics

Johannes Kreidler (b. 1980)
Piano Piece 3 (2004) for piano and live electronics

Yannis Kyriakides (b. 1969)
hYDAtorizon (1998) version for piano and live electronics
legerdemain (2005) for piano with optional electronics

alcides lanza (b. 1929)
plectros III (1971) for piano and synthesized sounds

Christien Ledroit (1975)
Shards (2001) for piano and live electronics

Lukas Ligeti (b. 1969)
Delta Space (2002) for disklavier and live electronics

Cort Lippe (b. 1953)
Music for Piano and computer (1996)

Alvin Lucier (b. 1931)
Nothing is Real (1990) for piano, teapot and miniature speaker
Music for Piano with Slow Sweep Pure Wave Oscillators (1992)

Mauro Lupone (b. 1965)
Himmel-Feuer (2000) for prepared piano, bird whistles and live electronics

Eric Lyon (b. 1962)
Psychic Driving (1999) for piano and computer
Private Lesson (2007) for piano and computer

Giorgio Magnanensi (b. 1960)
Extensio modi (1993) for amplified prepared piano, tape and live electronics

Philippe Manoury (b. 1952)
Pluton (1989) for MIDI piano and live electronics

Maximilian Marcoll (b. 1981)
hundert Rahmen, hochkant (2005) for piano and live electronics
samstag morgen - berlin neuklln. studie. und selbstportrait. mit hirsch. (2007) for piano and live electronics

Alexandros Markeas (b. 1965)
Penser - classer (1997) for piano and live electronics

Gustavo Matamoros (b. 1957)
Piano, ma non tango (1996) for piano, tape and live electronics

Silvia Matheus (b. 1955)
Hands for piano, live electronics and video (2002)

Paula Matthusen (b. 1978)
...of one sinuous spreading... (2003) for piano and computer

Philip Mead (b. 1947)
Lux Perpetua (2005) for piano and live electronics
Matrix (2006) for piano and live electronics
Three Evocations (2006) for extended piano and electronic sounds

Flo Menezes (b. 1962)
Mahler in Transgress (2002-03) for two pianos and live electronics

Eduardo Reck Miranda (b. 1963)
Grain-Streams (1999) for piano, tape and live electronics

Stephen Montague (b. 1943)
Haiku (1987) for piano, tape and live electronics
Tongues of Fire (1983/93) for piano (and stones), tape and live electronics

Stephan Moore (b. 1973)
Moving Target (2008) for piano and live electronics

Gordon Mumma (b. 1935)
Onslaught (1961) from *Gestures II* (1958-62) for two pianos with live electronics and tape cycling
Medium Size Mograph (1963) for piano 4-hands with live electronics and magnetic tape
Presessions (1974) for piano with live electronics and tape cycling
From the *Rendition Series* (2006) for piano, two performers with internal live electronics
Gambreled Tapestry (2007) for piano with internal live electronics

Dafna Naphtali (b. 1960)
Landmine (2000) for disklavier and live electronics

Vassos Nicolaou (b. 1971)
Orbit (2005) for MIDI piano and live electronics

Ichiro Nodaira (b. 1953)
Neuf Ecarts vers le défi (1991) for MIDI piano and computer

Katharine Norman (b. 1960)
Trying to Translate (1991) version for piano and live electronics

Charlemagne Palestine (b. 1945)
Celiassedo for piano and live electronics

John Palmer (b. 1959)
Renge-Kyo (1993) for piano, tape and live electronics (with Lexicon PCM-80 effects processor)

Juan Pampin (b. 1967)
OID (2004) for piano, live electronics and digital video

Brice Pauset (1965)
Perspectivae Sintagma I (1997) for MIDI piano and live electronics

Bruce Pennycook (b. 1949)
Praescio VII [Piano and then some] (1994) for piano and computer sounds

Andrea Pensado (b. 1965)
Desencuentros (1993) for piano and live electronics

Russell Pinkston (b. 1949)
TaleSpin (2000) for disklavier and electronic sounds

Robert Pritchard (b. 1956)
Postcards From Our Futures (1989/1996) for piano, sound files and optional video

Philip Reeder (b. 1982)
By Response (2008) for upright piano and live electronics

John Richards (b. 1966)
Suite for Piano and Electronics (with video projection, 2002)

Joan Riera Robuste (b. 1968)
Deformacions (2008) for piano and live electronics

Jean-Claude Risset (b. 1938)
Duet for one Pianist (1989) for disklavier

John Ritz (b. 1978)
thought-forms (2007) for piano and live electronics

Roque Rivas (b. 1975)
El eco de las sombras (2004) for MIDI piano and live electronics

Bruno Ruviaro (b. 1976)
Thirteen Small Parts of Something (2003) for piano and live electronics (with Masaki Kubo)
Instantanea (2005) for prepared piano and live electronics

Somei Satoh (b. 1947)
Hymn for the Sun (1973) for two pianos with digital delay
Kagami (Mirrors, 1975) for two or three pianos with digital delay
Cosmic Womb (1975) version for two pianos with digital delay
Incarnation 2 (1977) for piano with digital delay

James Saunders (b. 1972)
The unassigned series (2000-) versions for piano with dictaphones, CD and E-bow (for Sebastian Berweck) and piano and live electronics (for Philip Thomas)

Giacinto Scelsi (1905-1982)
Aitsi pour piano amplifée (1974) arranged for piano and computer by Kerry Young

Asbjorn Schaathun (b. 1961)
Physics (2003) for piano and live electronics

Dieter Schnebel (b. 1930)
2 Studien (1988) for piano and live electronics

Matthias Schneider-Hollek (b. 1963)
les jours calmes à Clichy-sous-Bois (2005) for piano and live electronics

Oliver Schneller (b. 1966)
Five Imaginary Spaces (2000-01) for piano and live electronics
And Tomorrow (2004) for piano and live electronics

Martin Schuttler (b. 1974)
venus 5 (2002) for piano and live electronics

Roger Smalley (b. 1943)
Monody (1972) for piano with live electronic modulation

Rand Steiger (b. 1957)
awhirl (2008) for piano and live electronics

Karlheinz Stockhausen (1928–2007)
Mantra (1970) for two pianists and live electronics

Morton Subotnick (b. 1933)
Liquid Strata (1977) for piano and live electronics
the other piano (2007) for piano and surround sound processing

Kotoka Suzuki (b. 1971)
Piano con moto (2007) for piano, live electronics and video (with Claudia Rohrmoser)

Jorrit Tamminga (b. 1973)
Subito Piano (2006) for piano and live electronics

Stefan Tiedje (b. 1956)
Enlightened Clavier (1999) for piano and live electronics

Hans Tutschku (b. 1966)
Das Bleierne Klavier (2000) for piano and live electronics
Zellen-Linien (2007) for piano and live electronics

Joseph Martin Waters (Jozefius Vaatierz Rattus, b. 1952)
Drum Ride (1991) version for piano and three live synthesizers
Drum Ride (1999) version for piano and live electronics

Thomas Wenk (b. 1959)
Recordame (1997) for piano and live electronics

Paul Wilson (b. 1974)
Osin's Fall (2005) for Piano and Live Electronics

Michael Young (b. 1968)
piano_prosthesis (2007) for piano and *NN Music*

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