Title: Playing with Audio: The Relationship Between Music and Games

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Playing with Audio: The Relationship Between Music and Games

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Playing with Audio:

The Relationship Between Music and Games

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Abstract

Real time audio signal analysis opens up possibilities for interactive musical compositions where game strategy is controlled using audio signal input produced by a musician. It also introduces the possibility of using a musician's sense of game play to shape a musical performance.

The author argues that new musical compositions based on games require further development before musicality can be expressed through the framework of a game. In such compositions, games

Game design theory provides the backdrop for an examination of musical compositions based on games. In these compositions, games are referenced either by engaging the idea of game play or focusing on game structure. The same is true of electronic games that in some way relate to music. These games typically allow little individual musical expression; an 'ideal' musical performance is determined by the game's developers.

The author argues that new musical compositions can be developed in tandem with new games technology in which musicality can be expressed through the framework of a game.

Statement of Originality

This thesis describes a number of compositions and musical applications.

The concept of *Metris* was developed in collaboration with Terumi Narushima. Metris is a version of Tetris, (Alexey Pazhitnov, June 1985). The first version of *Metris* is an extension of a Java version of Tetris by Per Cederberg, 2003 (http://www.percederberg.net/home/java/tetris/tetris.html). The GUI and game engine are by Per Cederberg.

The bell synthesis model is by Terumi Narushima. Its implementation in original Java code is my own. All code managing audio output, including wave-table and additive synthesis, is my own work and uses no third party Java audio tools. The second version of *Metris* also uses Narushima's bell model. All the code for Metris, including Bell Editor, is entirely my own work.

The concept of *Battle Metris* was developed in collaboration with Terumi Narushima. *Battle Metris* is a version of 'Battle Tetris', which has at its origins Alexey Pazhitnov's 'Tetris'. I am unable to verify the origins of 'Battle Tetris'. All network code in *Battle Metris* is my own work. All musical material played in *Battle Metris* is mine, with the exception of material derived from Narushima's bells.

Mark's Egregious Game of Life is based on other Cellular Automata applications, especially 'Mirek's Cellebration', developed by Mirek Wójtowicz, 2001, (http://www.mirekw.com/). It implements the '.lif' file format used in 'Mirek's Cellebration'. All code in *Mark's Egregious Game of Life* is my own original work. Other composers have used CA for audio synthesis. However, the concept of using object-oriented cell relationships for synthesising audio using CA is, to the best of my knowledge, my own.

Medium Racing uses Pure Data, developed by Miller Puckette. Audio analysis in *Medium Racing* is performed using the *fiddle~* object, developed by Miller Puckette. All other Pd code used in *Medium Racing* is my own. The concept of the MIDI2Xbox is my own. I designed the circuitry based on the AVR microcontroller using technical information found on the Atmel Website[1]. I programmed the microcontroller using assembly language in Atmel's AVR Studio 4. Without the existence of circuit schematics for the Xbox controller, I designed and built an interface between an Xbox controller and the microcontroller. I designed and built the enclosure for the MIDI2Xbox.

The concept of interactive musical composition for mobile phones was proposed by A.Prof. Greg Schiemer in the ARC Discovery Project "Pocket Gamelan: tuning musical applications for wireless internet". All the code for *pd2j2me*, developed for this project, is my own original work.

I'm Wrong, You're Right was presented in this thesis is a reworked version of a work presented for assessment on the 3rd of November, 2003. It was reworked by appropriating game design theory presented in this paper. Otherwise, this thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge, the thesis contains no material previously published or written by any other person, except where due reference is made in the text.

Mark Havryliv

16th December 2005

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[1] AVR 8-Bit RISC from Atmel, 2005 <http://www.atmel.com/products/avr/>

Prologue

In this thesis I investigate the musical possibilities of using real time audio signals as controlling agents in an electronic gaming console where game strategy is controlled using audio input produced by a musician using conventional musical instruments. This opens the way for a new kind of games interaction based on musically expressive signals rather than emotionally neutral mechanical controllers. Here composing music fuses with designing a game in which audio signals control the game's trajectory and where a musician's sense of game play shapes its performance. My folio of creative work includes interactive compositions that take initial steps in this direction.

At the point where this coalescence takes place, 'playing' a game and 'playing' music becomes one and the same thing. It is necessary therefore to address a potential source of confusion for the reader, namely, the similarities between concepts that apply in both music and games as well as overlaps in the terminology used to describe them. This happens in Chapter 1 Games and Game Controllers which clarifies the frames of reference necessary to assess the effectiveness of a controller for an electronic game.

Chapter 2 A Survey of Music and Games, is the first of a 2-part review in which I survey musical compositions inspired by or based on games. It looks at ways in which various composers have made connections between music and games.

The second part of the review, Chapter 3 Music as a Motivator in Electronic Games, covers electronic games in which music is a significant part of the game design. Game design theory provides a backdrop for the discussion in both parts of the review.

Chapter 4 From *Metris* to *Battle Metris*, presents my work, *Battle Metris*, an electronic game which allows a new type of musical experience for observers and participants which is a mixture of the individual participant's musicality and sense of game play. The work includes original code developed in Java.

The Epilogue summarises further steps required to achieve the goal of this thesis. These steps include development of original tools. These include *Mark's Egregious Game of Life*, an audio synthesis framework based on artificial life (unpublished) and *pd2j2me*, which exports musical applications created in an object-oriented graphical music composition language such as Pure Data into the Java 2 Micro Edition where they can be used with mobile hand-held devices.

The thesis contains an Appendix on CD ROM which includes four refereed papers, scores and code for four musical applications. Two of the papers are directly related to this thesis; the first, entitled "Metris: A Game Environment for Music Performance", describes the development of *Metris* and *Battle Metris*; it was presented at CNNR, Pisa, on 26th September 2005; the second entitled "Pocket Gamelan: a Pure Data interface for mobile phones", describes the development of *pd2j2me*; it was presented at NIME'05, University of Victoria, Canada, on 28th May 2005. Papers are provided as PDF files as is a score comprising parts for six performers. Code presented in the appendix includes *Metris*, performed at Pisa, 26th July 2005, *Battle Metris*, performed at 1/4_inch, Faculty of Creative Arts, University of Wollongong, 20th October, 2005 and *Medium Racing*, performed at Sonic Connections, University of Wollongong, 12th September, 2004. The code for *Metris*, *Battle Metris* and *Mark's Egregious Game of Life* exist in versions that have been tested running under Windows XP.

1 Games and Game Controllers

In the current generation of gaming consoles, an input device typically allows control through human movement. It is designed to articulate the intentions of a player in the virtual world of a game by triggering, or continuously controlling game actions.

An effective relationship between a game and a controller contributes to what Salen and Zimmerman, in "Rules of Play", describe as *meaningful play*.

> Meaningful play concerns the relationship between decision and outcome, and complexity concerns the way that parts relate to each other in a system. In games where meaningful play does exist, some aspect of the game system will be complex.[2]

For a controller to be effective, it must match the range of input required by a game. It must also add authenticity to a game experience that immerses the player in the virtual world of the game. Both conditions can also be explained using Salen's and Zimmerman's *primary schemas* for understanding game design: *rules*, *play* and *culture*.[3] These three schemas will later be used to provide the backdrop for the discussion of musical and game examples in Chapters 2 and 3.

Musically expressive audio signals are an extremely complex data source; in order to match the extent of possible variation in audio control, a game's response must be at least equally complex. Traditionally, game controllers are mapped to visual responses in a game world; however, audio signals must affect game actions by interacting with the game world's sonic representation, instead of being mapped to visual responses.

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[2] K. Salen and E. Zimmerman, *Rules of Play* (Cambridge, Massachusetts: MIT Press, 2004), p.157.
[3] ibid. p.5

1.1 Effective Controllers

As described by Salen and Zimmerman, meaningful play requires at least some part of a game system to be complex.[4] A game controller is a significant part of a game system; it defines the physical constraints placed on a game player's interaction with the rest of a game system. Therefore, a game's response to a controller must match the complexity of the physical actions possible with the controller. In turn, a controller must facilitate physical actions which are suitably matched to the *game actions* required by a game.

Game actions will be used throughout this thesis to mean events controlled by a player to determine the progression of a game, e.g. in a car racing game, the continuous control of steering and accelerating. These events are usually performed on the screen by a game character, or *avatar*, which represents a player in the virtual world of a game, e.g. in a car racing game, the car under the control of a player. Two such games, 'Project Gotham Racing 2'[5] and 'Midtown Madness 3'[6] are described in the next section.

A game controller is the interface between the real world context of a player's environment and the virtual world of a game. The term *authentic* will be used throughout this thesis to mean the extent to which a game controller matches the player's environment and the virtual world. The extent to which a game experience is meaningful is determined by the authenticity of the controller in the context of a game's virtual world. In their quest for authenticity, many controllers attempt to replicate the real life action associated with a game. An example relevant to this

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[4] ibid p.157

[5] *Project Gotham Racing 2* <http://www.xbox.com/en-US/games/p/projectgotham2/> Date viewed: July, 2006

[6] *Midtown Madness 3* <http://www.xbox.com/en-US/games/m/midtownmadness3/default.htm> Date viewed: July, 2006

thesis is discussed in Section 1.1.5; ‘Karaoke Revolution 3’[7] is an audio controlled game in which a microphone is the physical input device. However, games like ‘Project Gotham Racing 2’ and ‘Midtown Madness’, demonstrate that simply replicating the real life action of a game does not guarantee meaningful play; a controller must match the virtual world of a game in order to be effective. A ‘Tetris’[8] controller, described in Section 1.1.4, is an example of a controller which is authentic even though it does not replicate real life actions; it replicates game actions which exist only in the virtual world of ‘Tetris’.

1.1.1 ‘Project Gotham Racing 2’ & ‘Midtown Madness 3’

‘Project Gotham Racing 2’ (Microsoft Game Studios, 2003), or ‘Project Gotham’, and ‘Midtown Madness 3’ (Microsoft Game Studios, 2003) are games which simulate real world racing situations using motor vehicles. Figures 1a and 1b show their respective packaging.

Please see print copy for Figure 1

Figure 1: ‘Project Gotham Racing 2’ and ‘Midtown Madness’ game box illustrations. The difference in imagery demonstrates how meaningful play is derived in different ways in ostensibly similar games.

[7] *Karaoke Revolution Volume 3 for PS2* <http://www.gamespot.com/ps2/puzzle/karaokerevolution3/> Date viewed: December, 2005

[8] *Tetris* Alexey Pajitnov, Dmitry Pavlovsky & Vadim Gerasimov 1985

‘Project Gotham’ simulates physical aspects of professional motor sports as accurately as possible. A ‘Project Gotham’ game experience is meaningful because a player is rewarded for winning a race in the same manner in which a race-car driver wins a race in the real world, i.e. taking good lines through corners, braking well, avoiding damage and handling the behaviour of individual cars in an effective way.

‘Midtown Madness’ also rewards competent driving but a meaningful game experience is principally derived from the fun of driving recklessly through dense traffic – there is no traffic in ‘Project Gotham’ other than cars competing in the same race. The real challenge in ‘Midtown Madness’ is to avoid serious collision. A spectacular collision, or one narrowly avoided, is a highlight of this game, especially in multi-player mode.

1.1.2 Complexity Between Physical Input and Game Actions

Powerful computing hardware resources currently allow modern game developers to use complex models when developing the response of the car to input from the player. Some parameters which define a car’s response include engine size, turbo type, tyre selection, torque tuning, spoiler type, gear ratios, car length and weight distribution. A player’s action directing a car to turn left or right will be assessed by the game within the context of its velocity, its current direction, its mechanical characteristics and the surface of a track at that point in a race. A car will react differently to the same physical input depending on the current state of these variables. Clearly, a binary (on/off) input for turning left or right is too inaccurate, there is no way for a player to articulate an intention to make a gentle turn; unless it is scaled by the game to the current state of a car. A binary turn at high speed will cause a tail-spin; a binary input is insufficient to monitor the current state of a moving vehicle.

The accuracy required to perform a game action in a meaningful way is matched to the physical accuracy of the controller in a racing game. A steering wheel interface concentrates on two significant game actions: both hands are used for steering (the action which requires the most sensitivity) and both feet are used for controlling velocity.

Although both games are more effectively controlled using a steering wheel than using a standard console controller, by virtue of their game contexts means a player is far more likely to use a steering wheel in 'Project Gotham' than in 'Midtown Madness'. The next sub-section describes how the use of a steering wheel in 'Project Gotham' enhances the game experience, while it detracts from the authenticity of the game experience in 'Midtown Madness'.

1.1.3 Authenticity and a Meaningful Game Experience

An effective game controller will augment the authenticity of a game experience. It matches the game's attempt to create an immersive, consistent environment. Often, a controller augments the authenticity of a game by the extent to which it replicates real life actions associated with a game. In a racing game, a steering wheel controller can be considered authentic because the player controls a car in the game, just as a racing car driver in the real world uses a steering wheel and foot pedals.

However, a steering wheel can detract from a game experience if meaningful game play is not derived from a simulation of several conditions as well as the invocation of a context a player associates with the use of a car in the real world.

The extent to which a physical controller simulates real life actions is not an indicator of an authentic game experience.

In 'Project Gotham' meaningful play can be defined as the successful execution of real life driving techniques; a steering wheel enhances this game's experience and tends to immerse a player in its virtual world. However, unlike 'Project Gotham', 'Midtown Madness' defines meaningful play on a driving context that is unrealistic to the point of absurdity. A steering wheel is incongruous with the virtual world created by this game and does not enhance the game experience. Even though the controller is entirely consistent with the control of a real world car, it shares little of its symbolism with the way in which meaning is derived in this game. 'Midtown Madness' does not demand the implied devotion of time and mental energy required to sit behind a dedicated, desk-based controller. The use of a steering wheel in 'Midtown Madness' feels superfluous compared with its use in 'Project Gotham'.

The level of authenticity a controller can add is not dependant on whether a game attempts to replicate something in the real world; authenticity in a game world is determined by the game itself. As the 2004 version of 'Tetris'[9] shows, a controller must be an authentic part of this game world.

1.1.4 Tetris

Tetris is played by organising a sequence of blocks, shown on a rectangular 10 by 20 screen with the aim of completing a row, at which point that row is removed. It uses only six digital actions and no force-feedback. The falling blocks are arranged into seven shapes whose trajectory can be affected by a small set of game

[9] 'Tetris' Radica Games, 2004

actions: a shape can be rotated clockwise or anti-clockwise, moved horizontally across the screen and accelerated down the screen.

Please see print copy for Figure 2

Figure 2: The seven shaped blocks in 'Tetris'.

Figure 3 shows the controller for the Radica TV version of 'Tetris'. This controller offers limited functionality compared to standard controllers, but its design is subtly skewed to reflect the game actions in Tetris. The main button is a large square similar to the square piece in the game; the edges of the controller feature the rest of the shapes from the game. This makes the controller slightly non ergonomic; one of the player's hands does nothing but hold the interface. However, its design is entirely consistent with the game, e.g. rotating the square on the controller rotates a shape on the screen; pushing the square on the controller to the right moves a shape on the screen to the right.

Please see print copy for Figure 3

Figure 3: The game of 'Tetris', normally played on a computer keyboard, can also be played using a purpose-built controller designed to augment the game experience.

1.1.5 'Karaoke Revolution 3'

One example of an effective relationship between a game and its controller is an audio controlled game called 'Karaoke Revolution 3' (Namco, 2004). The game world in 'Karaoke Revolution 3' is a simulated Karaoke venue with a virtual crowd which responds positively or negatively to the player's performance. Lyrics and coloured bars scrolling along the bottom of the screen indicate the words, pitch and duration to be sung. Audio input is analysed to extract pitch and rhythm whilst visual feedback indicates the accuracy of the performance on which points are won and lost. It is an instance of game design tailored to an existing controller, in this case a voice singing into a microphone. Here, the physical character of the game controller (voice) is perfectly matched to the input requirements (pitched sound) of the game. The controller undeniably enhances the game experience. Given that a microphone is usually associated with singing, it is consistent to design a singing game. Easier levels available in digitised karaoke accommodate non-expert singers by not requiring performers to have perfect pitch and harder levels allow a singer to seriously challenge their own abilities. Music performance is an intrinsic part of the game rules.

1.2 Towards Audio Controlled Games

An audio controlled game is defined by the relationship between the sound created by a game system and a player's sense of musicality. At the most primary level, a music audio signal is a complex controller, capable of expressing many different parameters at one time; these can be measured using standard audio analysis techniques like pitch analysis, spectral analysis, envelope following etc. Information gathered by these techniques must retain a sufficiently complex relationship with progression through the game, on both the micro and macro level, to make meaningful play: ideally, any measurement of a musical audio signal must be considered partly as a musical product of what music has come before. However, this information does not sufficiently describe a player's sense of musicality. This thesis argues that approaching audio controlled games as a 'mapping' problem, no matter how complex, is fatally flawed.

An audio controlled game will require bi-directional interaction between sound defined and created by its game rules and audio signals performed by a player. As musicians do not typically associate sound with the control of an avatar, authenticity can only be achieved by creating a game context consistent with real world musical performance. Musicians are comfortable interacting with computer generated sound; sound must now become intrinsic to the rules of a game.

Using models of game design theory proposed by Salen and Zimmerman as a framework, the next chapter describes musical compositions which are in some way inspired by or based on games. Also using this model of game design theory, Chapter 3 describes electronic games in which music is a significant part of the game design, as well as discussing the author's previous attempt at an audio controlled game. *Metris* is then presented as an electronic game which creates music based on an individual's style of game play by establishing a dichotomy between a player's sense of musicality and sense of competitiveness. This approach is motivated by the ubiquity of the electronic game as a highly-defined, voluntarily-entered arena for the expression of competitiveness. Musical works have used games-related concepts in many instances; this thesis, however, focuses on the potential of maintaining a scope of enquiry limited to electronic games, and a deep appraisal of the opportunities in combining the principles behind their design and those involved in music composition.

2 A Survey of Music and Games

A musical composition is like a game in that the rules and parameters to control the structure of an aesthetic experience are devised prior to its realisation in performance. In a musical work, the composer specifies how these rules and parameters should be realised by a performer over time and an ideal performance is a manifestation of the composer's artistic intentions. In a game, however, it is the player who determines its trajectory. Both composers and game designers have created works which attempt to link game play and music.

Composers including Wolfgang Mozart, Iannis Xenakis, John Cage, Mauricio Kagel, John Zorn and John White have incorporated game design theory in their works. However, while game design theory recognises "…a game is a set of parts that interrelate to form a whole",[10] musical works inspired by games typically don't engage with an entire game system; game features are appropriated selectively to suit a composer's style. Alternately, in many electronic games music is used as part of the motivation, reward system or cultural attraction. Games like 'Amplitude',[11] 'Frequency'[12] and 'Taiko: Drum Master'[13] attempt to enhance the degree of player immersion by engaging the player musically. The author's audio controlled game, *Medium Racing*, attempts to control live musical performance based on the progression of a car racing game. However, these games are not designed to create music based on a genuine appreciation of musicality and its relationship to playing a game. An audio controlled game must build music into the game rules. By analysing

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[10] Salen and Zimmerman, *ibid*., p.152.
[11] *Amplitude* <http://www.us.playstation.com/content/ogs/scus-97258/site/> Date viewed: July, 2006
[12] *Frequency* <http://www.us.playstation.com/PS2/Games/SCUS-97125> Date viewed: July, 2006
[13] *Taiko Drum Master* <http://www.namco.com/games/taiko/> Date viewed: July, 2006

previous work in both fields using game design theory, it is possible to see how games might readily incorporate music as an intrinsic motivator.

2.1 Three Schemas for Analysing Music Based on Games

Salen and Zimmerman identify three primary *schemas* for understanding game design, each containing a cluster of related schemas. Each schema is "a way of framing and organising knowledge."[14] The three primary schemas are *rules*, *play* and *culture*:

- **Rules**

  This contains formal game design schemas that provide the essential logical and mathematical structure of a game. It is the organisation of the designed system.

- **Play**

  This contains experiential, social, and representational game design schemas that define a context for a player to engage with the game and with other players. It constitutes the human experience for participants in a game system.

- **Culture**

  This contains contextual game design schemas that investigate the larger cultural contexts within which games are designed and played. It provides the larger contexts engaged with and inhabited by the system.[15]

These three schemas not only provide a framework for understanding game design as outlined in Salen and Zimmerman, they can also be used to facilitate an analysis and a general categorisation of musical compositions that are either based on or inspired by games.

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[14] Salen and Zimmerman *ibid.*, p. 5.
[15] i*bid.*, p. 6.

Like schemas applied as a framework for understanding game design the categories can also be applied to composition:

- **Rules**

  Compositions may include those in which music is determined by progression through a game; this can either be real-time or pre-processed.

- **Play**

  Compositions may include those in which the relationships between performers will in some way be coloured by extra-musical competition; the player's experience of the musical piece/game system is defined by both musicality and playfulness.

- **Culture**

  Compositions may include those in which the effectiveness of the performance requires the complicity of the audience; in such performances, an audience has the potential to become engaged by virtue of the fact that the musicians are performers and at the same time contestants in a game. The reaction of the audience may also affect how performers will perform the work. These compositions typically have titles which draw attention to their use of games, e.g. *Duel* and *Stratégie* (Xenakis); *match* (Kagel).

Rules, the first of these schemas, refers to the formal structure of a game, while play and culture refer to a game's symbolism and its cultural context. Symbolism allows players to interact with a game's formal structure. The game's cultural context imbues a game experience with extra meaning. These two schemas frame closely related themes and are referred to hereafter as a game's *representational universe*, as distinct from a game's formal structure.[16]

Salen and Zimmerman demonstrate how varying the cultural context and symbolism of the representational universe of Poker alters the game experience:

> Perhaps Spades becomes Death, Hearts becomes Love, Clubs becomes War and Diamonds becomes Sex. The change might entail a graphical alteration to the suits as they appear on the cards or the name by which players refer to the cards. (*"I've got an eight of War."*) This seems like a radical change to make to a deck of cards. But on a formal level, nothing has changed at all: the game remains the same. It goes without saying that the *experience* of playing Poker with such a deck would be different than the experience a player would have with a standard deck. But the formal system of a game, the game considered as a set of rules, is *not* the experience of the game. It would be possible to play a game of "Poker" that would not resemble Poker on the surface, and might not be recognised as Poker by observers, but would still possess the formal structure of Poker.[17]

This quote demonstrates how games rely on symbolism as well as rules. The same is true of musical compositions based on games.

The next section, 'Play and Culture', will examine two musical examples, Mauricio Kagel's *match* (1964) and the John Cage and Marcel Duchamp chess game, *Reunion*[18] (1968), which are based on the representation rather than the formal structure of a game. The following section, 'Rules', will discuss the different types of rule systems which may constitute the formal structure of a game, and demonstrate their use in two musical examples, Iannis Xenakis's *Duel* (1959) and John Zorn's *Cobra* (1984).

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[16] *ibid.,* p. 120
[17] *ibid.,* pp. 120-121.
[18] Lowell Cross, "Reunion: John Cage, Marcel Duchamp, Electronic Music and Chess", *Leonardo Music Journal* 9 (1999), pp. 35-42.

These two compositions are based on existing formal structures but create unique representational universes rather than appropriating an existing realisation of a game.

All four compositions engage the audience by virtue of the fact that the musicians are not only performers but contestants in a game; the play and culture schemas establish the framework for analysing the nature of this engagement.

2.2 Play and Culture

The play and culture schemas frame an understanding of the extent to which a musical performance is based on the actual rules of a game or on the symbolism used to flesh out the formal structure of a game. These two schemas also illuminate how the performers' relationships and audience's perception of a performance are influenced by the fact that a composition is based on a game.

2.2.1 Mauricio Kagel *match* (1964)

Mauricio Kagel's *match* for three players (1964) is a piece which strongly invokes the play and cultural aspects of a game; musical development in the piece is not based on the formal structure of a game. Kagel intends performers and audience to approach this work understanding that it relates to a tennis match. This understanding frames the performance of the piece. Kagel manipulates the cultural context of the audience's appreciation by associating musical performance with game play. He does this by establishing an extra-musical motivation for the performers; this intention is reflected in the nature of the performance set-up, instructions marked on the musical score, particularly in the opening bars of the piece where he specifies the kinds of physical actions required of the performers. Two cellists sit facing each other at opposite ends of the stage with their side profiles visible to the audience. A percussionist is positioned in the centre towards the back of the stage, the position an umpire takes in a tennis match. The piece begins with the cellists playing alternating Bartok pizzicatos, evoking the rhythm and the sound of a bouncing ball in a tennis match. This is shown in Figure 4. The rally ends, and the second cello 'serves', only to have the percussionist interject, requiring the cellist to serve again suggesting that the player has violated a foot-fault rule. Kagel has manipulated the context such that this is a natural question.

Please see print copy for Figure 4

Figure 4: The first two and a half bars of *match*, demonstrating the tennis-like exchange between the two cellos. (*match*, Mauricio Kagel (1964) Universal Edition, 1967, permission granted to reproduce excerpt, 2005)

Björn Heile notes in his forthcoming book on Kagel[19] that only the first page contains the concrete sonic allusion to a ball game. Thereafter both cellists continue to 'compete' with each other, oblivious to the inept assertions of the 'umpire' percussionist, as they seek to upstage one another with increasingly difficult acoustic manoeuvres. Heile suggests that the interaction between performers is entirely consistent with standard chamber music practice; the superimposition of identities – i.e. performer as performer and performer as competitor – makes for an effective performance.

[19] Björn Heile, *The Music of Mauricio Kagel* (Aldershot: Ashgate, forthcoming)

In one of his performance notes, Kagel states:

> MATCH should ideally be performed twice in the same concert. Experience has shown that the listening audience will react the first time more to as spectators [sic].[20]

This suggests that he intends an audience to understand its performance in equivocal terms: on the one hand, performance is represented as a game in which they are spectators, while on the other hand, performance is represented as a realisation of a musical score in which musical relationships may vary according to the performers' musical interpretation.

2.2.2 John Cage *Reunion* (1968)

Another work which principally engages an audience through the cultural association of gaming and music is *Reunion* (1968), the sonification of a number of chess games played between John Cage, Marcel Duchamp and Teeny Duchamp. Lowell Cross describes the event:

> [Cage] and Duchamp would play chess at centre stage, and the moves of the game would result in the selection of sound sources and their spatial distribution around the audience. Duchamp would sit in a comfortable easy chair (Cage would be content with an ordinary kitchen chair); Teeny would sit close by and watch; my 'oscilloscopic' TV sets, on stage, should be in operation; and the chess aficionados at centre stage would drink wine and smoke (Duchamp, cigars; Teeny and Cage, cigarettes). All the while, Cage's composer-collaborators [David] Behrman, [Gordon] Mumma, [David] Tudor and I [Lowell Cross] would provide electronic

[20] Mauricio Kagel, *match für drei spieler* (Universal Edition, 1964), p. 6.

> and electroacoustical sounds of the concert experience. Clearly, *Reunion* was to be a public celebration of Cage's delight in living everyday life as an art form.[21]

Cross believes Cage's quest for "purposeful purposelessness or a purposeless play"[22] was:

> elegantly defined in *Reunion*, but as a musical performance, the work's ultimate realisation was indeed inconclusive.[23]

> Finally, the circumstances attending *Reunion* permitted no correlation between Cage's elegantly proscribed application of his system of indeterminacy and his underlying hope that elegant games of chess could bring forth elegant musical structures. The games clearly were not elegant, and I, for one, held no expectation that they could have brought forth elegant, or even interesting, musical structures. After this inconclusive event, what remained of *Reunion*? High theatre, Cage's appeal to intellectualism, and everyday life.[24]

The event was not well received by newspaper critics; epithets included "mighty boring", "infinitely boring…an example of total non-communication, all around".[25] One critic concluded that the "fusty, dusty, illustrious visitors are just about sufficiently fossilised for reverent immurement in a university".[26]

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[21] Cross, *ibid*., p. 37.
[22] "Experimental Music" in John Cage, *Silence* (Middletown, CT: Wesleyan University Press, 1961), p. 12.
[23] Cross, *ibid*., p. 41.
[24] *ibid*.
[25] Quoted in *ibid*.
[26] Quoted in *ibid.*

Please see print copy for Figure 5

Figure 5: The set-up for *Reunion*. Marcel Duchamp is playing John Cage, with Duchamp's wife, Teeny, looking on. David Behrman and Gordon Mumma are creating music in the background.[27]

Cross's dissatisfaction with the musical result and the lack of elegant structure brought forth by the chess game is easily explained with an analysis of the influence of game play in this work. The event was clearly geared towards theatricality more so than musical expression. The status of the players, the novelty of a chess game controlling sound and the theatricality of the set (wine, cigars, oscilloscopes, a lounge chair, a kitchen table; see Figure 5) superimposed on a concert hall set up with electronic and audio components contribute to theatricality. It is a composition whose efficacy is based on the engagement of an audience by the playing of a game of chess which creates music. Ironically, it is for precisely this reason that the composition could not bring forth elegant music based on the formal structure of chess. Theatricality demands the game of chess be brought into the concert hall intact; the symbolism and physical representation must be retained. However, the physical realisation, the board game, is only a

[27] *ibid.*

representation of the formal structure of chess, and in this way is no truer a representation of a chess game than, for example, a written record used to document a match. *Reunion* attempts to tease out the underlying structures of chess using only the physical movement of chess pieces. A sonification of the text of a written record would be as effective a method; it may indeed be more effective, as the text codes used to represent pieces and moves contain more information than whether a board position is occupied or not. But theatricality demands the physical representation and symbolism of the board game; in *Reunion*, the musical progression is determined by the physical representation of chess, decoupled from the elegance of its formal structure. For example, there is no sound which indicates Cage may not be able to move a knight which is under attack; the possible manoeuvres he considers are never sonified, nor is the intricacy of Duchamp's strategy represented musically. The game rules determine which move Cage may make next, but the sonic outcome is a bi-product of the game rules, not a progression through them.

The relative level of indeterminacy in the music produced by the movement of chess pieces may have satisfied Cage's aesthetic, but the musical bi-product is less likely to match the elegance of chess.

2.3 Rules

Unlike *match* and *Reunion*, other compositions based on games use the formal structure of a game to determine musical progression. In most compositions based on games, the play and culture elements are expressed similarly: they exploit the incongruity between a game in a musical performance to engage the audience and create extra-musical motivation for performers. However, compositions engage game rules in many different ways, principally because different games use different rule systems. As the rule system for a game controls the formal structure and progression of a game, it also affects the musical progression of a composition based on a game. Although in *Reunion*, for example, the musical progression is not a representation of the game's formal structure, it *is* a representation of the physical representation of the game's formal structure, and as such, the rule system still determines musical progression, albeit in a significantly abstract way. The rules schema allows the formal and representational aspects of a game to be separated, and helps define how the formal structure of a game affects musical progression.

Salen and Zimmerman identify seven ways to understand the rule systems which may constitute the formal structure of a game. Music compositions based on games typically use four of the seven rules, and will be discussed in this chapter. They are:

- **Game Theory Systems**

  Games which require a player to deploy a consistent mathematical strategy; game theory is not a theory of game design, but of tactical decision making.[28] Game theory can be used to analyse the decisions a player makes in *Battle Metris* when weighting their musicality against their sense of competitiveness, similar to the competitive instincts and conductor-managed distribution of performance rights in Zorn's *Cobra*. However, Section 2.3.1 discusses game theory with reference to two musical compositions based on game theory systems: *Duel* (1959) and *Stratégie* (1962), by Iannis Xenakis.

- **Systems of Conflict**

  Conflict is intrinsic to all games; the struggle between players to achieve victory in a game drives its system of conflict.

[28] J. Von Neumann and O. Morgenstern *Theory of Games and Economic Behavior* (Princeton: Princeton University Press, 2004)

- **Systems of Information**

  Games which manipulate how information is distributed in a game, i.e. how much information is known to all players, to individual players, to the game system only or randomly generated. Improvised music has much in common with both Systems of Conflict and Systems of Information. An example of improvised musical composition based on these systems is *Cobra* (1984) by John Zorn, discussed in 2.3.2.

- **Emergent Systems**

  Games which use emergent systems in some way generate unpredictable patterns of complexity from a limited set of rules. A number of compositions and music production systems are based on Cellular Automata. An example which uses neural networks is *MIDI-Connect4* (2005) by Eduardo Miranda, discussed in 2.3.3.

The remaining three rules have also been used in music compositions, albeit in compositions which do not explicitly deal with games:

- **Systems of Uncertainty**

  Uncertainty is a central feature of every game; it can relate to the uncertainty of an overall game outcome or to "…specific operations of chance within the designed system"[29]. *Gestures II* (1958-62) by Gordon Mumma, shown in Figure 6, is a piece which uses the term 'game' to describe the nature of play between performers. It is an example of a system of uncertainty determining both the overall outcome of the piece (especially duration) and specific operations within it.

[29] Salen and Zimmerman, *ibid*. p. 174.

…this single-page of musical score for two pianists is an encoding of a possibly very long composition, though it is sometimes performed as short as 6 seconds…[30]

The single score page includes parts for both pianists, in a ‘game form’ of distinct musical phrases. Each pianist may start at any phrase. The phrases follow the horizontal (or slightly diagonal) ‘ligature’ lines, either to the arrow at the end of each line, or switch from one staff to another where the vertical lines intersect. When each pianist ends a phrase at an arrow, a pause is required.[31]

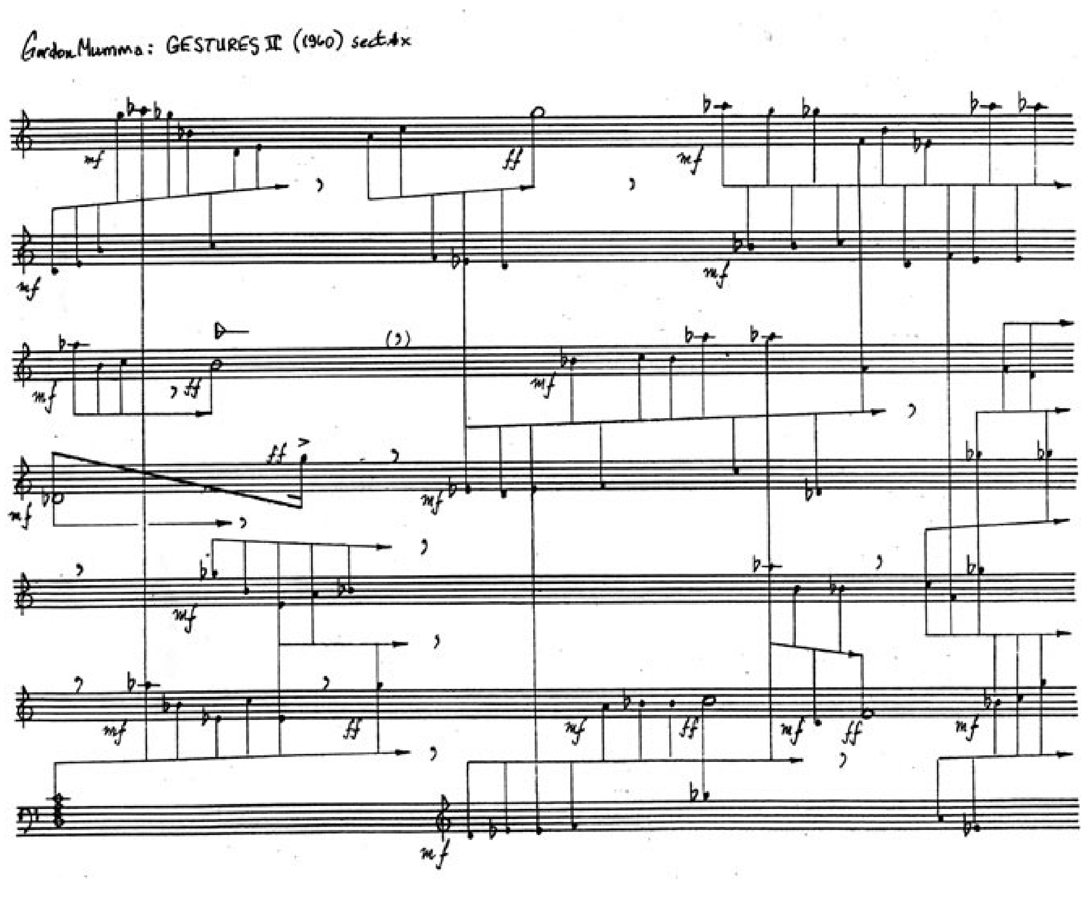

Figure 6: Gordon Mumma, *Gestures II* (1958-62)[32]

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[30] G. Mumma, “Graphical Scores” 2002 <http://brainwashed.com/mumma/score.html> Date viewed: December, 2006

[31] *ibid.*

[32] *ibid.*

- **Information Theory Systems**

  Information theory is the study of the movement of information in a system, how information is sent and received, and the noise which may impair this transmission.[33] Charades is a game in which players fight against the noise inherent in its structure; "…the pantomime gestures of Charades introduce noise into the system through their inherent ambiguity."[34] A musical example of this is *Monophonic Variations* (1986) and *Polyphonic Variations* (1987-88) by Greg Schiemer and Graeme Leak. Here, a "…simple linear feed-back shift-register [generates a sequence] similar to cyclic codes used for error-correction in digital communication".[35] Player input is recognised as "data that has been generated erroneously. The algorithm generates new rhythmic information as it tries to correct the 'deviant' data – which the percussionist had deliberately chosen to make it behave that way."[36]

- **Cybernetic Systems**

  Cybernetic systems consist of 'negative feedback' and 'positive feedback' systems which self-regulate the behaviour of a larger system. An example of this is a music theatre work by David Tudor and Gordon Mumma entitled *Mesa, for Cybersonic Bandoneon* (1966) in which elaborate electronic circuitry attached to the Bandoneon semi-automatically regulates possible sonic events.[37]

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[33] C. E. Shannon and W. Weaver, *Mathematical Theory of Communication* (Champaign: University of Illinois Press, 1963) p. 8-9
[34] Salen and Zimmerman *ibid*., p. 197.
[35] From CD liner notes, *watt ever*, (Tall Poppies TP074 CD2, 1996)
[36] *ibid*.
[37] R. Teitelbaum, "Music of Our Time: A Second Wind for Organ" c.1968 <http://www.emf.org/tudor/Articles/second_wind.html> Date viewed: December, 2006

The following examples engage audiences and performers with the idea of game play but attempt to base musical progression on the formal structure of a game rather than the existing physical and symbolic representation of a game. In these compositions, music is incorporated into the representational universe which interacts with its formal rule system.

2.3.1 *Duel* (1959) & *Stratégie* (1962) – Game Theory Systems

Game theory was introduced into music by Xenakis in his works *Duel* (1959) and *Stratégie* (1962). These works are not based on any existing games; game theory is the branch of economics traced back to *Theory of Games and Economic Behaviour* by Oscar Morgenstern and John Von Neumann (1944). Game theory is a powerful tool for managing possible outcomes and conflicts which result from decision making when both parties operate on the basis of each party's self-interest.

Game theory is used in Xenakis's work to create and manage external conflict, or *heteronomy*, between two conductors, each in charge of an orchestra, who direct tactical deployments of musical material in contest with each other. Xenakis briefly mentions the role of the individual conductors sense of musicality:

> [Conductor] X's second choice is a function of both his taste and Y's choice. In his turn, conductor Y, acting on X's choice and his own taste, either chooses a new tactic or keeps on with the old one…[38]

However, 'playing to win' is at the core of Xenakis's appropriation of game theory.

[38] Iannis Xenakis, *Formalized Music* (New York: Pendragaon Press, 1992), p. 123.

…at the end of the combat one might *a.* proclaim a victor, or *b.* award a prize, bouquet of flowers, cup, or medal, whatever the concert impresario might care to donate.[39]

…the successive partial scores can be announced automatically on lighted panels in the hall, the way the score is displayed at football games. If the conductors just use their fingers, then a referee can count the points and put up the partial scores manually so they are visible in the hall.[40]

Given that point allocation is determined in a progression of tactical deployments by conductors, it may be more appropriate to view *Duel* and *Stratégie* as works which in some way mimic a game show. One conductor poses a question to the other, who must provide the best scoring answer; in this way points are accumulated until an end-point (determined either by a points limit or time limit) is reached and the conductor with the most points is declared winner.

Please see print copy for Figure 7

Figure 7: The payoff matrix, with probability ratios, for *Duel*.[41]

[39] *ibid.*, p. 127.
[40] *ibid.*, p. 122.
[41] *ibid.*, p. 117.

However, it is not a simple question and answer scenario. Game theory games by definition require a player to create and maintain a strategy to win. The conductors already know the proportions in which different tactics must be played for an optimal result; these are shown in Figure 7, the payoff matrix showing probability ratios for each conductor. Xenakis determined these whilst constructing the rules so conflict is created between the urge to score highly in a single exchange but possibly leaving oneself vulnerable in the next. In this way, Xenakis manages a sophisticated determination of musical progression. His management of probabilities determines which musical passages are more likely to be played than others and his management of game theory determines which combinations are likely to be played together at any time. At the same time, he ensures that the balance between playing question-answer and adhering to strategy is determined by the conductors at the time of performance. It is an elegant game, and an elegant arrangement of musical material. Xenakis has successfully managed a cultural context for the performance with the pageantry of winning and the competitive playfulness between conductors. However, this is quite different from a musical game in which musical progression is determined by the resolution of a conflict between a performer's sense of musicality and the competitiveness generated by a game environment.

Continuing the chess metaphor, the musical passages a conductor can choose to perform in *Duel* and *Stratégie* can be likened to chess pieces; they form the representational universe of the respective musical games. The conductors must deploy the musical passages depending on their relative strengths, similarly to how a chess player judges the strength of a chess piece when determining their next move. However, this scenario does not fully acknowledge that the musical meaning behind each passage is very subjective; Xenakis, as composer, is responsible for determining the strengths of each passage despite each conductor having their own views on which passages are more musically favourable. Whilst there is nothing wrong with the creator of a game being responsible for the meanings given to the game pieces, when the game pieces have an inherent value outside of the magic circle of the game, their external meanings should also be incorporated into the game. For example, the symbolism chosen for chess does not encourage a player to favour moving one piece more than another, each piece is moved on a purely tactical basis. Imagine, though, a young girl who loves horses; every time she has to move a chess piece she would much rather move the horse than any other piece. She must resolve her love of horses with the move which is most strategic. A musical game must require the player to resolve these urges; it must not ignore the fact that any symbolism within the magic circle of a game has meaning outside of it as well. Unlike a standard chess player, a musician will have musical preferences – preferences towards certain musical products which result from game moves. A musical game must recognise and build these preferences into its rules.

2.3.2 *Cobra* – Systems of Conflict and Systems of Information

John Zorn's *Cobra* is one in a series of his compositions which draw on games or sport for inspiration, usually as a system of conflict and information management. This is especially true in *Cobra*, where strongly defined rules determine when an improviser is allowed to play; these rules are known to performers but are adjudicated by the conductor, who may allow a player to 'interrupt' another player or refuse their entry. The conductor directs the players using colour-coded cards placed on a table, and the players make requests using hand signals. In this way, Zorn creates a theatrical, improvisatory environment where the sound is determined by performers but a conductor controls the structure and manages conflict and information. The players have information which tells them when they can play, it is up to them to know when they can play and request the conductor to allow them to do so. In this way, a player who retains and manages this information effectively will make more successful requests to play than a player who doesn't. In the more complicated game piece, *Xu Feng,* Zorn appropriates battle metaphors and requires even more complicated management of information.

> The colour-coded cards signify three major conditions. Condition 1 deals with downbeats and qualifiers (pool; runner; substitute; etc. and rhythm: arhythmic; loud; quiet; etc.) Condition 2 sets up 'trio battle positions' (war) such as spy or renegade soloist or challenge duo. Condition 3 (concerto) involves soloists, duos and 'base'. Hats and headbands are used in the guerrilla systems, and hand gestures between players and prompters also control the flow of the improvisation.[42]

There is no method for determining a winner. The immediate satisfaction or disappointment for a performer creates a system of conflict where the musical and competitive urges of a player are in conflict with their need to follow the directions properly. Now, the conductor is the master of information, and by virtue of this becomes an active participant in the conflict.

Like Xenakis, Zorn has created a magic circle in which players compete with each other; an audience is engaged by the incongruity of performers playing like competitors.

[42] S. Maykrantz, *The John Zorn Web Site, Biography and Discography – footnotes* 2004 <http://www.omnology.com/zorn-notes1.html> Date viewed: December, 2006

> It's a blast to watch. It's a lot more interesting live than it is on record. I mean, it really is a theatrical event. It's a sporting event! Cause you never know what's gonna happen.[43]

Both Xenakis and Zorn create an explicit game environment for their performances, and engage their performers (players) with a sense of playfulness. However, the different rule systems they have employed demonstrate the different ways games can be appropriated, and interestingly, how they are culturally sympathetic with their composer's respective styles and typical audiences. Where Xenakis has created an elegant, almost traditional game of strategy, Zorn has created a playful, schoolyard type game, recalling a 'cops-and-robbers' game of information and conflict management. One performance engenders a careful observation and appreciation of long term tactical and musical development whilst the other provokes amusement and a genuine sense of play. These examples of cultural sympathy are important references as we move toward digital games and music performance.

2.3.3 Electronic Game Environments – Emergent Systems

> Emergence is above all a product of coupled, context-dependant interactions. Technically these interactions, and the resulting system, are *nonlinear:* The behaviour of the overall system *cannot* be obtained by *summing* the behaviours of its constituent parts.[44]

Most of the well known examples of emergence come from the study of Cellular Automata (CA). CA are "grid-based systems [in which] a set of rules dictates how

[43] John Zorn in H. Mandel, "Composing Game Pieces", *Future Jazz* (1999), pp.171-173.
[44] J. Holland, *Emergence: From Chaos to Order* (Reading, PA: Helix Books, 1998), pp. 121-122.

the cells behave and how their states change over time."[45] Perhaps the most well known set of CA rules is John Conway's Game of Life, published as a puzzle in *Scientific American* in 1970.[46] The most striking characteristic of the Game of Life is the complex behaviours and patterns which emerge from a very simple, but refined, set of rules:

> Life occurs on a virtual checkerboard. The squares are called cells. They are in one of two states: alive or dead. Each cell has eight possible neighbours, the cells which touch its sides or its corners.
>
> If a cell on the checkerboard is alive, it will survive in the next time step (or generation) if there are either two or three neighbours also alive. It will die of overcrowding if there are more than three live neighbours, and it will die of exposure if there are fewer than two.
>
> If a cell on the checkerboard is dead, it will remain dead in the next generation unless exactly three of its eight neighbours are alive. In that case, the cell will be 'born' in the next generation.[47]

Figure 8 exhibits the complexity which can emerge from the simple rules of Life. In this example, the dark squares are alive and the lighter squares are grid positions which at one time had been occupied.

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[45] Salen and Zimmerman, *ibid.*, p. 161.
[46] M. Gardner, *The fantastic combinations of John Conway's new solitaire game "life".* (Scientific American 223, October 1970) pp. 120-123.
[47] C. Langton, *Artificial Life: An Overview* (Cambridge: MIT Press, 1995), p. 112.

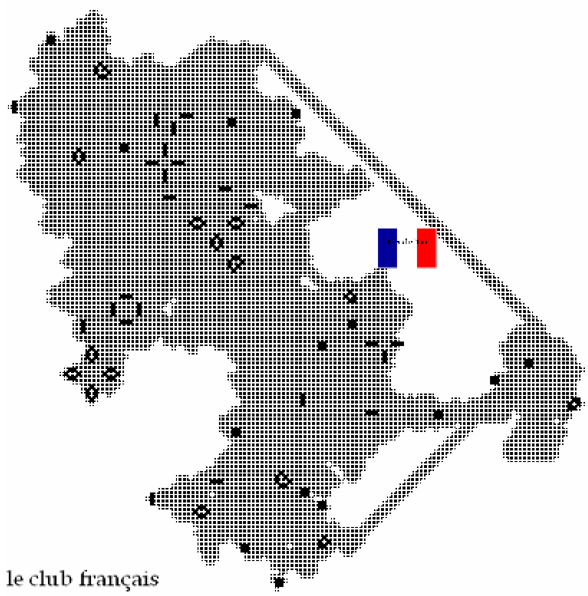

Figure 8: An artwork created by the author with his CA application (see appendix – 'Mark's Egregious Game of Life').

Shapes which emerge regularly and the jagged, yet consistent, edges of this image created as the cells ripple outwards over time, are a product of the emergent properties of the Life rules. Common CA shapes which can be seen in this figure include:

- **The oscillator**

  This shape appears as a three cell line which oscillates between a vertical or horizontal orientation.

- **The glider**

  This shape looks slightly like half an arrow and will move in a constant direction. A glider is responsible for the long diagonal line in the top right hand corner and the bottom right hand corner.

- **The square**

  Four cells which form a square shape will not die unless another shape comes into contact with them. They are dotted around the example.

A number of composers have used CA to control sound, both to select pitch and durations as well as controlling larger scale musical progression. The timbral and harmonic characteristics of the resultant music, however, are often limited by realisations in MIDI and an arbitrary mapping of algorithmic data to a twelve-tone equal temperament. Pitch and duration values are typically selected by mapping the Cartesian coordinates of live and dead cells.[48] [49] [50] Dave Burraston et al[51] provide a comprehensive history of CA music software, including more sophisticated engines such as Eduardo Miranda's CAMUS[52] and Dale Millen's Cellular Automata Music Application.[53] Inspired by Cage's *Reunion*, discussed earlier in this chapter, Miranda has also recently developed MIDI-Connect4, a system which creates music based on the progression through the traditional game, Connect 4.[54]

[48] P. Reiners, *Cellular automata and music: Using the Java language for algorithmic music composition*, 2004 <http://www-106.ibm.com/developerworks/java/library/j-camusic/>
[49] P. Reiners, *Automatous Monk: The Cellular Automata Music Composition Program* 2004, <http://www.automatous-monk.com>
[50] J. Elliot, *Transmusic: cellular automaton music,* 2001 <http://jmge.net/camusic.htm>
[51] D. Burraston and E. Edmonds "Cellular Automata in Generative Electronic Music and Sonic Art : A Historical and Technical Review" *Digital Creativity 16(3)* pp. 165-185 (2005)
[52] E. Miranda, *CAMUS: A Cellular Automata Music Generator,* 2002 <http://website.lineone.net/~edandalex/camus.htm>
[53] D. Millen, "An Interactive Cellular Automata Music Application in Cocoa", *Proceedings of the International Computer Music Conference 2004* (Miami University, 2004).
[54] E. Miranda and Q. Zhang, "Composition as Game Strategy: Making Music by Playing Board Games Against Evolved Artificial Neural Networks", *Proceedings of the International Computer Music Conference 2005* (Barcelona, 2005), p. 471-474.

Please see print copy for Figure 9

Figure 9: The 6x7 Connect 4 board. It is the light coloured player's move, but they are in an un-winnable position. The dark coloured player can form a vertical line in the first from left column or a horizontal line in the second from bottom row.

The physical representation of Connect 4 is a six-row by seven-column horizontal array, as shown in Figure 9 and Figure 10; game pieces are dropped into the columns and obey gravity, dropping to the lowest possible position in that column. A game is won when one player positions four of their game pieces in a succession in any direction – horizontally, vertically or diagonally.

Please see print copy for Figure 10

Figure 10: The dark coloured player wins by connecting four game pieces in a horizontal line in the second from bottom row.

Miranda uses an artificial neural network to create an automated game system against which another computer player or human player can compete. The neural network also drives the music production system called the 'musicator'[55]. It does so by mapping Cartesian coordinates of each game move to musical forms.

In Connect 4, its physical representation is a more significant part of the formal structure than in many other games. The constraints of the game are permanently altered as a position is occupied. This feature allows Miranda's musicator to generate music based on the game's formal structure by assessing the physical moves each player makes. This distinguishes it from other systems for generating music from existing games or CA. While Miranda has engaged the representational universe of Connect 4, musical progression is nevertheless determined by the formal structure of the game. However, this does not mean music is built into the game rules. Music in *MIDI-Connect 4* may be a sophisticated bi-product of the formal structure but it is not an inherent motivation.

Cellular Automata music need not be confined to accompaniment for predominantly visual game systems where neighbouring cells are mapped to a Cartesian plane of X/Y coordinates. Generative algorithms can also be used as a method for audio synthesis.[56] [57] [58] [59] Early stages of the author's work in this field is briefly discussed in a later chapter.

Except for *MIDI-Connect 4*, the musical works surveyed in this chapter have adapted either reasonably complex games or similarly complex theories; this thesis, on the other hand, presents musical adaptations of two relatively simple games: Tetris (*Battle*

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[55] *ibid.*
[56] P. Bowcott "Cellular Automata as a means of high level control of granular synthesis" *Proceedings of the 1989 International Computer Music* (San Francisco, USA, 1989) pp.55-57
[57] A. Hunt, R. Kirk and R. Orton "Musical Applications of a Cellular Automata Workstation" *Proceedings of the 1991 International Computer Music Conference*(Montreal, Canada, 1991) pp.165-168
[58] J. Chareyron "Digital synthesis of self-modifying waveforms by means of linear automata" *Computer Music Journal 14(4)* pp.25-41 (1990)
[59] NYR <www.nyrsound.com> (2005) Date viewed: July, 2006

Metris) and a car-racing game ('Medium Racing'). These two games, Tetris especially, require only a limited number of game actions and present a fairly restricted game world, limiting the composer to a small range of non-trivial musical decisions: this allows a more comprehensive consideration of the individual relationships between game actions and music production, and the relationship between a player's sense of musicality vs. game play.

The next chapter will examine electronic games which use music and/or musical performance as a motivator.

3 Music as a Motivator in Electronic Games

A number of electronic games feature some aspect of music as part of their formal structure, reward system or cultural attraction; however, they are not designed to create music based on an individual's sense of game play. Their goal is musical engagement rather than musical expression. As with music compositions based on games, the relationship between these electronic games and music can be understood within the same framework of rules, play and culture presented in the previous chapter:

- **Rules**

  Games in which part of the formal structure is defined by musical progression; e.g. 'Taiko: Drum Master' (2004), a player must hit a drum controller in time with music played by the game in order to score points; the music being played determines the timing of the drum hits.

- **Play**

  Games in which a player's experience of a game is heightened by using music as part of the reward system; music is an explicit motivator in an otherwise typical game. 'Amplitude' (2003) is a racing-type game in which musical rewards feature as *power-ups* – "objects which add extra abilities to the game character".[60]

- **Culture**

  Games in which a player's experience is enhanced by the demonstration of technical/musical competence in a social context. In 'Karaoke Revolution Party' (2005) the participation of a real or virtual audience motivates a player,

[60] *Power-Up* in Wikipedia, 2005 <http://en.wikipedia.org/wiki/Powerup>

along with a sense of personal achievement. This category also describes the process by which a game might engage a player by featuring music that invokes a specific cultural association. In 'Amplitude', for example, a player remixes existing pop songs.

In turn, the three frameworks can be generalised into two categories:

- **Rules**

  Games in which the player must play music to win the game; "…the motivation for perfecting timing and rhythmic response is to win a game as the reward"[61].

- **Play and Culture**

  Games in which the relationship between a game world and a player is strengthened by the capacity given to a player to play with musical consequences and the cultural significance of the music being manipulated. "…gameplay [sic] allows you to mix and remix hit songs from major recording artists like Garbage, David Bowie, P.O.D., BT, Weezer, Pink, Dieselboy, blink 182, Run DMC, and more - within more than 20 immersive levels."[62]

The following subsections discuss an example from each category: 'Taiko: Drum Master', a game in which the formal structure is largely based on music, and 'Amplitude', a game in which music acts as a motivator.

3.1.1 'Taiko: Drum Master'

'Taiko: Drum Master' (2004), or 'Taiko', is a game in which music performance determines part of its formal structure. Music also forms part of its

[61] T. Blaine, "The Convergence of Alternate Controllers and Musical Interfaces in Interactive Entertainment", *Proceedings of the 2005 International Conference on New Interfaces for Musical Expression* (Vancouver, BC, Canada, 2005), p. 28.
[62] *Playstation.com – Games – Amplitude,* 2003 <http://www.us.playstation.com/games.aspx?id=SCUS-97258>

representational universe. It is played with a small replica of a Japanese taiko drum; a player plays along with music as directed by visual prompts which scroll across the screen from the right. In this game, the game actions consist of three kinds of drum strokes, prompted visually: hitting the centre of the drum, hitting the rim and performing a drum roll. A player accumulates points by performing the prompted drum stroke on cue. Figure 11 is an example of two-player mode, in which two players perform either the same pattern or a complementary pattern to the same music. In this figure, Player 2 has been awarded bonus points for consecutive correct hits, or an especially accurate hit. Along with the visual imagery of this game, music and musical performance form a large part of its representational universe. However, music is also part of its formal structure.

Please see print copy for Figure 11

Figure 11: ‘Taiko’. This screen shot demonstrates ‘two-player’ mode; visual prompts indicate the type of drum hit required and when to execute it. Points are accumulated by performing the correct hits; consecutive correct hits a rewarded with bonus points, as seen in Player 2’s screen.

This game is a variation of a common game format; it is essentially a game which tests a player’s physical reflexes and concentration. In this way, it is no different to a duck shooting game at a carnival. However, unlike other games of this type which use a random or non-random algorithm to generate the timing of game events, the timing of this game's events is driven by the rhythm. This allows musical interaction between the game and a player. By engaging with the rhythm, a player anticipates the timing of the strokes; the player 'feels' the music and its rhythm, and uses this intuition to advantage over the game. In this way, part of a player's interaction with the formal structure of 'Taiko' is defined by music.

Although 'Taiko' allows interaction between a player and its formal structure, the interaction does not need to be defined by its representational universe. Because part of the game's formal structure is determined by music, a player can interact directly with this through musical responses.

3.1.2 'Amplitude'

In the game 'Amplitude' (2003), music does not form a significant part of the game's formal structure as it does in 'Taiko'. In 'Amplitude', a conventional game controller is used to "…activate sequences of notes placed on tracks in futuristic tunnel-shaped settings."[63] As a player progresses through the game, more musical tracks are unlocked; game manoeuvres can be performed in response to these tracks (e.g. extra drum parts may be added, a bass line may be sped up etc.).

There is a relationship between a player's proficiency with a conventional controller and the musicality the player is able to express. In 'Amplitude', this relationship is implemented almost punitively:

> As you blast the notes it keeps the song going. If you don't hit any notes on the vocal track there will be no singing, don't hit any notes on the drums area, and you

[63] Blaine, *ibid.*, p. 31.

have no percussion in the song. The object is to keep each track playing by hitting each of the notes on the tracks.[64]

While the process of remixing music is at the core of the formal structure of 'Amplitude', music does not significantly determine how a player plays the game. The victory condition in 'Amplitude' is the realisation of an 'ideal' performance which has been predetermined by the game's developers. In determining the obstacles to victory in the game, the developers have decided what constitutes a worthwhile musical result.

3.2 Creating Music Based on Game Play

Although both 'Taiko' and 'Amplitude' engage a player musically they do not encourage musical expression; they link a concept of musical success to success in a game. This is in part because their intention is to create a game system in which "[e]ach level dances around the outer limits of the player's abilities, seeking at every point to be hard enough just to be doable."[65] This approach attempts to keep game play and musical interaction rewarding at all levels of play. However, it also makes is necessary for game developers to decide what constitutes musical success; by definition, this limits the capacity a player has to express personal musicality. Making music in this way has more in common with traditional musical instrument learning techniques which prescribe the level of technical attainment necessary to perform certain music. This can be likened to a pianist who, in order to express themselves coherently in a difficult piece like Rachmaninov's 2nd Piano Concerto, must be able to perform scales in thirds rapidly.

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[64] *Amplitude :: PlayStation 2 :: Review :: DreamStation.cc,* 2003 <http://www.dreamstation.cc/reviews/playstation_2/amplitude>

[65] P. Gee, "High Score Education: Games Not School are Teaching Kids to Think", *Wired.com,* May 2003 <http://www.wired.com/wired/archive/11.05/view.html?pg=1>

In existing audio controlled games, linking the concept of musical success and success in a game presents a problem. Typically, a composer might solve this by determining how frequency and amplitude output from a musical instrument is mapped to specific game actions. This may link a performer's proficiency on their musical instrument to their success in the game. However, a player's sense of musicality is not engaged in order to play the game. Instead, their instrument becomes an emotionally neutral mechanical controller.

Linking the concept of musical success and success in a game tends to diminish a player's interaction with a game for musical production. One needs to focus less on the ability to press buttons (in a specific order) accurately and repeatedly, and more on possibilities for new musical experiences when interacting with a game system; "…a familiar structure that allows one to play with the unfamiliar."[66] This shift of emphasis introduces the possibility for new music being created by combining a player's sense of game play with musicality. How this relationship can be realised in a concert context will be described in Chapter 4, *From Metris to Battle Metris*.

3.2.1 *Medium Racing*

Both *Metris* and *Battle Metris* were preceded by *Medium Racing*, the author's first attempt to develop an audio controlled game for musically expressive performance. This work highlights the problematic nature of the relationship between audio input and game actions. In *Medium Racing*,[67] frequency and amplitude information extracted from live performance on a saxophone controls the progression of an Xbox game called 'Project Gotham Racing 2' (discussed in Chapter 1). In *Medium Racing*, an audience is engaged by the fact that a musical

[66] J. S. Hans, *The Play of the World* (Boston: University of Massachusetts Press, 1981), p. 37.
[67] Performed at Sonic Connections, University of Wollongong, Australia (2004) <http://www.uow.edu.au/crearts/SonicConnections.html>

performer controls the progression of the game by playing a musical instrument. At the heart of this performance is a Pure Data[68] patch, which does three things: it extracts pitch and amplitude of the live player, it maps pitch and amplitude to game actions, and it provides an accompanying soundtrack which complements the sound effects created by the Xbox.[69]

A Pd patch (see appendix) was designed by the author to extract frequency and amplitude information from the musical instrument signal. This information is then transmitted as MIDI messages to a purpose-built device known as the MIDI2Xbox which was designed and built by the author, show in Figure 12.

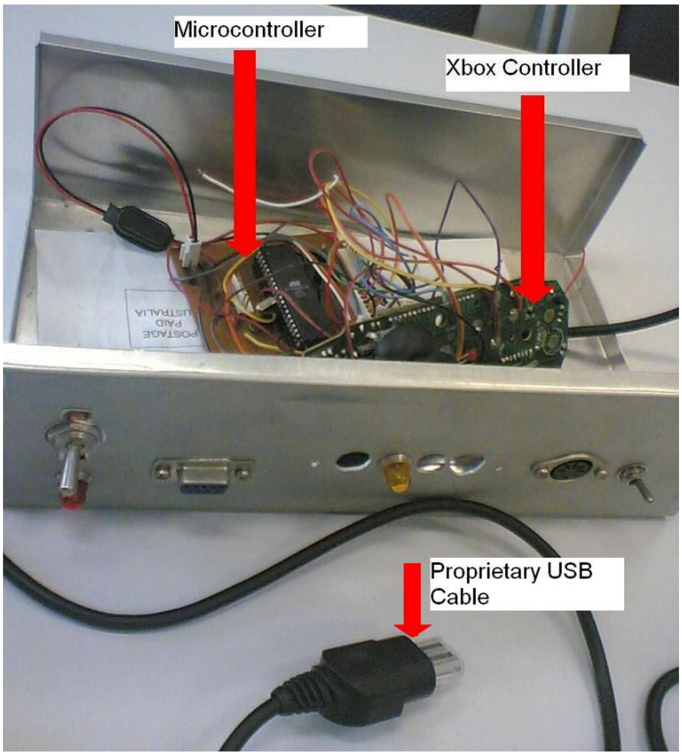

Figure 12: MIDI2Xbox; built by the author which converts MIDI messages into Xbox commands.

[68] M. Puckette "Pure Data." *Proceedings, International Computer Music Conference* (San Francisco, 1996) pp. 269-272.
[69] Xbox <http://www.xbox.com/en-AU> Date viewed: July, 2006

At the heart of the MIDI2Xbox is an AVR AT90S8535 microcontroller[70] which is also programmed by the author in assembly language. The program was compiled and tested using AVR Studio 4.[71] The microcontroller is connected to a 'hacked' Xbox controller, as shown in Figure 12. The MIDI2Xbox is connected to an Xbox using the cable from the hacked controller, which is a proprietary USB connection.

MIDI messages transmitted by the Pd patch are either note on or note off messages. These are received on the microcontroller UART port; note values received are then compared to a set of note values stored in memory. MIDI note values determine which game action the Xbox will execute.

Output pins of the microcontroller are connected using small wires soldered directly onto the circuit board of the hacked Xbox controller. Alternating the state of an output pin applies or removes 5 volts; the Xbox controller sees this as a substitute for a physical joystick action and transmits the corresponding message to an Xbox. The MIDI2Xbox is powered from the Xbox using the USB connection show in Figures 12 and 13.

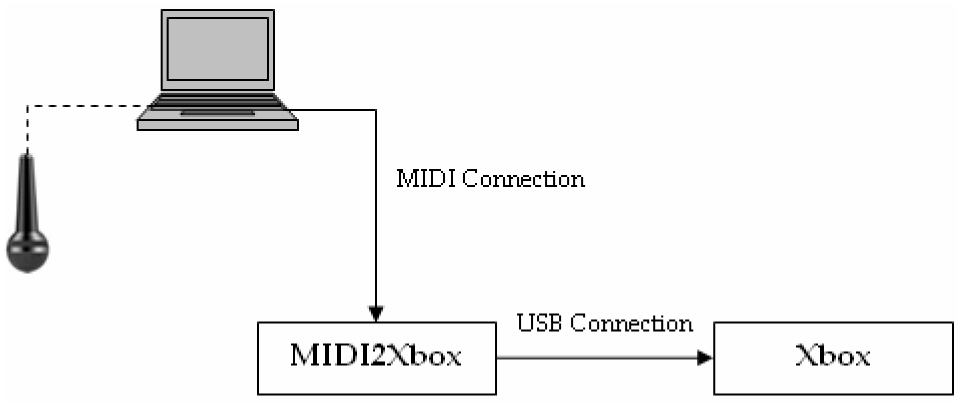

Figure 13: Connections between devices in *Medium Racing*. A musical instrument signal is captured by a microphone and analysed by a pd patch. The pd patch transmits MIDI signals to the MIDI2Xbox which transmits USB signals to an Xbox. The MIDI2Xbox is powered from the Xbox.

[70] G. Schiemer, M. Havryliv, "Wearable Firmware: the Singing Jacket" *Proceedings of the Australasian Computer Music Conference 2004*. Victoria University of Wellington, 2004.
[71] *AVR Studio 4*, 2005 <http://www.ateml.com/dyn/products/tools_card.asp?tool_id=2725>

Medium Racing maps the performance of pitch to steering and amplitude to acceleration. Seven notes are predetermined by the composer as 'pivot' notes. The notes are: B, C#, F, E, D G and A. These notes may be played in any octave by the performer. In *Medium Racing*, by performing one of these notes a player indicates to the Pd patch that they intend to change the direction of the racing car. Once a pivot note is played, if the next note played is above the pivot note the car will turn left; if the next note played is below the pivot note, the car will turn right. If the pivot note is repeated, the car continues in a straight line. Once the Pd patch has recognised whether the game move involves turning left, turning right or continuing straight, it communicates these game actions to the Xbox as a MIDI message packet consisting of several Note On-Note Off messages.

The amplitude of the saxophone signal is sampled by Pd every 100 milliseconds. Average amplitude is calculated over the most recent 3 seconds; this is used to determine the velocity of the car. The amplitude also determines the musical characteristics of the accompanying soundtrack generated by Pd. Every time the saxophonist plays a pivot note the Pd patch generates a sine tone chord based on the pitch of the pivot note. This chord is held until the pivot note is played again.

Mapping pitch and amplitude to game actions proved to be counter-intuitive and because other capabilities of the instrument were under-utilised, this made the game experience less meaningful in the concert context. Even though the performance was entertaining for the audience, it provided little opportunity for musical expression. The instrumentalist's musicality diminished as the instrument was reduced to a simple controller.

In light of the experience of *Medium Racing*, I now recognise that music must be an intrinsic part of the game rules in an audio controlled game; a player's sense of musicality needs to be built into the rule set in order to create its formal structure. As well as the non-musical motivations in standard game play, those associated with music and musical performance become part of the greater game design. The consequent musical experience for observers and participants is a mixture of the individual participant's musicality and sense of game play. This combination creates new possibilities for musical expression. In the next section, *Metris* is presented as a game which uses a player's musical response to control game performance.

3.3 *Metris*

Based on 'Tetris', *Metris*[72] associates musical responses with specific game actions. Music forms part of the formal structure in *Metris* by integrating an additional layer of rules into the existing rules of 'Tetris'. Additional rules in *Metris* are best described as a cybernetic system; music production is designed to regulate a player's sense of competition as it is normally expressed in 'Tetris'. These rules will be discussed in more detail in Chapter 3, *Battle Metris*. Music production also alters the player's experience of the game system which in turn is coloured by their style of game play.

Musical output is a direct result of game play; the organisation of pitch and timbre creates a *soundtrack*, something larger than the memory of individual events. Musical responses to events are crafted so that the sound is affected in different ways depending on the nature of the game event. Minor events affect the sound in a subtle, repeatable way; an example is the microtonal pitch bends that occur when a game block is rotated. Major events have a more dramatic effect on the entire sound design;

[72] M. Havryliv and T. Narushima, "Metris: a Game Environment for Music Performance", *Proceedings of the 3rd International Symposium on Computer Music Modeling and Retrieval*, Pisa, Italy, 2005, 26-34. To be published in *Lecture Notes in Computer Science* (Springer Verlag, 2005). (Paper included in Appendix).

an example is the modification of texture that occurs when a row of blocks is removed.

Metris consists of four principle game actions and musical responses:

- **Landing a Game Piece**

  When a game piece is landed, a synthesised bell strikes. This bell is a realisation of a synthesis model developed by Terumi Narushima.[73] It bears many similarities to Jean-Claude Risset's additive synthesis model.[74] Risset's Bell is created by summing the output of 11 partials, "each with its own relative amplitude, frequency and duration."[75] This is represented in Bell Editor,[76] an application developed to simplify the creation and maintenance of different bell timbres for *Metris*, shown in Figure 14.

  The pitch of the bell is determined by which piece was landed. Figure 15 shows the game pieces associated with different pitches.

[73] T. Narushima, *Composing for Carillon: Exploring the Relationship Between Tuning and Timbre* (MMus thesis, University of Sydney, 2003).
[74] C. Dodge and T. A. Jerse, *Computer music: synthesis, composition, and performance* (New York: Schirmer, 1985), p. 94.
[75] M. Puckette, *Theories and Techniques of Electronic Music* (draft, 2003), p. 111.
[76] See *Bell Editor* in Appendix.

Please see print copy for Figure 14

Figure 14: A screenshot of Bell Editor for Metris, showing the 6 partials which constitute Narushima's 'Japanese Temple Bell'. The first column contains the relative frequency of each partial; this controls each partial's frequency as a multiple of the fundamental. The remaining five columns describe the amplitude envelope in a manner following Csound's *linseg* opcode: start amplitude, attack time, target amplitude, decay time and end amplitude.

Please see print copy for Figure 15

Figure 15: Pitches of original scale played when the associated game block lands in the bottom five rows of the Metris screen.

- **Rotating a Game Piece**

  When the player rotates a game piece, the fundamental partial of the bell previously struck is transposed. The game piece can be rotated 90 degrees in either direction. The frequency of the bell partial is adjusted above or below by 3Hz. The direction of microtonal pitch shift is determined by the direction of rotation: a clockwise rotation raises the pitch by 3Hz; a counter-clockwise rotation lowers the pitch by 3Hz.

- **Completing a Row**

  When the player succeeds in completing an entire row of game pieces, 20 random sine tones are played over a range proportional to the number of rows removed. This causes the bell tones to interact with the sine tones, thereby destabilising them.

- **Modulation Regions**

  The *Metris* game screen consists of 20 rows divided into four subsections, each consisting of five rows. Each subsection defines a region of harmonic modulation (as shown in Figure 16). If a game piece lands somewhere within the lowest subsection, notes from the original scale will sound; if a game piece lands in a different subsection, pitches from another harmonic region will sound. This is intended to reward the 'risky' player who lands a game piece higher on the screen while bell tones sounded when a game piece lands lower on the screen are still audible.

  The term *modulation* already has a specific meaning in music. In equal temperament, modulation causes pitches to shift to different degrees of the same scale. Here, where just intonation tuning is involved, non-uniform interval sizes cause pitches to shift to positions not audible in the original (un-transposed) scale.

  Presented in 2005 at the Computer Music, Modeling and Retrieval conference in Pisa, *Metris: A Game Environment for Music Performance* (see appendix) is a more in-depth exposition on transposition in just intonation systems.

Please see print copy for Figure 16

Figure 16: Modulation regions in Metris: pitches from different scales are heard depending on where a game piece happens to land. Pitches are represented as just intonation ratios where an interval between two pitches on the harmonic series is expressed as a separation between a higher harmonic (numerator) and a lower harmonic (denominator). Transposition is achieved by multiplying the tonic frequency (scale degree 0) with linear factors (calculated by dividing the denominator into the numerator).

The music production system regulates the manner in which a player plays the game. Certain types of play are naturally discouraged by the rules, i.e. if a player lands game pieces too quickly, the soundtrack is overwhelmed.

Metris retains the formal structure and representational universe of Tetris, ensuring that a player is interacting with this game system in the same way they react to a standard game. The game experience is not simulated; the natural responses of a player are retained. However, part of the formal structure of *Metris* is defined by a player's musicality. Music is not simply a way in which a player may interact with a game's formal structure, as in 'Taiko: Drum Master', nor is it goal-based motivator, as in 'Amplitude'. In *Metris*, a player's musicality defines the exact nature of the formal structure; no 'ideal' musical product is insisted upon by the game's developers. The game system invites a player to interact musically with the other parts of the game's formal structure, allowing the possibility for new music to be created within the familiar structure of a game.

4 From *Metris* to *Battle Metris*

Battle Metris is a version of *Metris* adapted for two-players. It is a game designed especially for concert performance; Figure 17 shows the performance set-up for a performance of *Battle Metris* at 1/4_inch, University of Wollongong, 20th October, 2005. *Battle Metris* was built with entirely original Java code which takes advantage of an object oriented view of Tetris, enabling greater analysis of game play. The default bell sound is Terumi Narushima's 'Japanese Temple Bell'.

Please see print copy for Figure 17

Figure 17: The performance set-up for *Battle Metris*. The two players sit facing each other at desks on the left and right hand sides of the stage, with their profile to the audience. The TCP/IP connection between players can either be a cabled or wireless network. A speaker is assigned to each player, and each player's screen is projected onto their half of the projector screen.

4.1 Music as an Intrinsic Motivator

Unlike *Duel* and *Stratégie*, as described in the previous chapter, music is an intrinsic motivator in Metris; conflict is created between the player's sense of musicality and the competitive game context. In *Battle Metris*, additional motivations invoked by a concert performance context are built into the game's rules. The resulting game play and music is the dynamic resolution of this conflict; this dynamic resolution becomes the primary motivation in the game. It is an *implied rule* that the player's sense of musicality affects their game play.

Cultural and social contexts form a large part of the implicit rule base, as described by Salen and Zimmerman:

> Implicit rules arise via cultural custom, tradition, and player experience. They directly link the formal and cultural aspects of a game, creating a bridge between the forms of authority that exist inside and outside of a game's space of play.[77]

In *Battle Metris*, implied rules are one of three types of rules which define the "formal essence"[78] of a game; the other two types of rules are *operational rules*, which are the "guidelines players require in order to play",[79] and the *constitutive rules*, which are the "underlying formal structures that exist 'below the surface' of the rules presented to the players."[80] Within the world created by the game, a concept which Huizinga refers to as the *magic circle*, a "temporary world within the ordinary world, dedicated to the performance of an act apart",[81] the authority of these rules holds sway.

In *Battle Metris*, as with *Metris*, the implied rules are created by the relationship between game play and music. Game play is regulated by positive and negative feedback systems.

[77] Salen and Zimmerman, *ibid*., p. 573.
[78] *ibid*.
[79] *ibid*., p. 130.
[80] *ibid*.
[81] J. Huizinga, *Homo Ludens: A Study of the Play Element in Culture* (Boston: Beacon Press, 1955), p. 10.

4.2 Positive and Negative Feedback - a Cybernetic System

Games typically make use of *positive feedback*[82] systems "for dramatic effect or to bring a game to conclusion."[83] Positive feedback is built into the rules of *Battle Metris*; these are rules it inherits from Battle Tetris.

4.2.1 Positive and Negative Feedback in Game Play

As show in Figure 18 and Figure 19, when Player A removes two or more rows from the screen, the same number of rows appear at the bottom of their opponent B's screen. Player B is now closer to the end of the game while Player A is further from the end of the game. Positive feedback rewards Player A by punishing Player B. This magnifies the success of Player A, making the game prone to ending quickly if Player A continues to punish Player B.

Please see print copy for Figure 18

Figure 18: Two *Battle Metris* screens before Player A lands the red 'S' shape. When this shape lands, the bottom two rows on Player A's screen will disappear and two grey coloured rows will appear at the bottom of Player B's screen.

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[82] Marc LeBlanc, presentation at Game Developer's Conference, 1999, in Salen and Zimmerman, *ibid*., p. 224.
[83] Salen and Zimmerman, *ibid*., p. 227.

Please see print copy for Figure 19

Figure 19: The same two screens as shown in Figure 18 after Player A landed the red ‘S’ shape; two grey coloured rows have been added to the bottom of Player B’s screen.

A *negative feedback*[84] system is often used to counteract the effects of a positive feedback system. In both *Metris* (single-player) and *Battle Metris* (two-player), the music constitutes a large part of that negative feedback system. The music generated can only be understood in the context of these two feedback systems.

4.2.2 Music as Positive and Negative Feedback in *Metris*

Specific examples of negative feedback in *Metris* include:

- Long and dense bell tones discourage rapid and aggressive game play.

  Each bell tone contains 7 partials and has a duration of 20 seconds; when it rings in rapid succession, it quickly overwhelms the texture of the soundtrack and the relationship between game play and music becomes obscured.

- As rows are removed from a player’s screen, the player is rewarded with sound; the reward is related to the number of rows removed and the sound is

[84] M. LeBlanc, *ibid*.

richer in texture and dissonance as more rows are removed. This encourages players to react more slowly and thoughtfully, as they attempt to anticipate game circumstances that will remove several rows in a single game action.

- As a block is rotated on a player's screen it produces a pitch bend in the last played bell. Because the pitch bend focuses listening on a single moving fundamental within an otherwise stable sound texture, it discourages rapid play; if the texture is dense a pitch bend will have little effect.

Specific examples of positive feedback include:

- Different regions of harmonic modulation, as described in Section 3.3, *Metris*, correspond to visual placement of objects on the screen.

  More dissonant modulation results when the player lands an object in a higher row while more consonant modulation results from landing an object in a lower row. However, more dissonant modulation is associated with conditions that increase the likelihood of ending the game.

- The position of game pieces placed on the screen determines the next game piece, and therefore determines the next bell pitch selected.

  Although the capacity to select the next block seems neither a positive or negative form of feedback, experience has shown that the conflict between game play and production of sound is heightened by associating selection of visual objects with selection of pitch. This forces a player to rationalise the conflict between making an awkward move or never getting the desired sound outcome.

4.2.3 Music as Positive and Negative Feedback in *Battle Metris*

Battle Metris allows the game played by one player to alter the constraints placed on the other player; the music is a sonic realisation of the conflict between players. Each sound event has meaning in the magic circle of the performance: it represents a player's fortunes in the game and thus links both the players' and audience's perception of the game's progression.

When Player A stacks rows at the bottom of their opponent B's screen, as show in Figure 19, Player B's soundtrack is altered. A signal created from the amplitude-modulated sum of the partials (the *AM signal*) is added to the audio mix.

The AM signal is implemented in *Battle Metris* by multiplying all the partials from each bell. However, the amplitude envelopes of the partials are ignored; a partial is included in the signal multiplication at full amplitude until it is due to end. As a bell sound is characterised equally by its amplitude envelopes and partial relationships, not implementing the envelopes creates a significant distinction between the Japanese Temple Bell sounds and the AM signal.

The volume of the existing signal, the sum of the bells, is decreased to accommodate the volume of the AM signal, which is determined by the number of rows added. The partials used to create the AM signal no longer implement their amplitude envelopes; this creates a rich sound with sidebands of high and low frequencies. As the frequency of one of the sine tones slowly rises, these sidebands move in contrary motion to produce an effect reminiscent of the endless glissandi of Risset's implementation of a Shepard tone.[85] In the context of this game, the aural effect of the endless glissandi puts the player under pressure in a

[85] R. N. Shepard, "Circularity in judgments of relative pitch", *Journal of the Acoustical Society of America* 36 (1964), pp. 2345-2353.

similar way to how a player responds to a count-down timer in a conventional electronic game.

Please see print copy for Figure 20

Figure 20: The Penrose Stairway, a visual equivalent of a Shepard tone. "An impossible figure in which a stairway in the shape of a square appears to circulate indefinitely while still possessing normal steps"[86]

Player B can only decrease the volume of the AM signal by removing rows. The dense sidebands in the AM signal set up beating patterns with the output of Player A's channel. This is sonically exciting for the audience and Player A; experience has shown it increases the level of stress in Player B, as their immediate focus shifts to reducing the level of the AM signal in their mix. The oppressiveness of the AM signal complements the addition of rows as a negative effect on Player B's performance.

This addition to the music production rules in *Battle Metris* functions as both a positive and negative feedback mechanism.

Player A is rewarded in three ways each time a row is: a row is removed from Player A's screen; a row is added to Player B's screen; a new musical source – Player B's AM signal – is created with which Player A can interact. This is the positive feedback system. However, there is a maximum point to which Player A can punish Player B.

[86] E. W. Weisstein, *Penrose Stairway,* MathWorld--A Wolfram Web Resource <http://mathworld.wolfram.com/PenroseStairway.html>

- Player B's mix is saturated by the AM signal after the addition of only five rows
- If Player B does not remove any rows at this point, Player A ceases to receive a sonic reward for the punishment of Player B
- If Player B does remove a row, it is added to the bottom of Player A's screen and Player B's mix becomes less dense
- Because Player A is constantly vulnerable to attack from Player B, no matter how much Player B has been punished, there is significantly less incentive to continue punishing Player B after the point of AM signal saturation.

At this point, a sonic reward is no longer available to Player A. It is tactical for Player A to prepare a defence against possible attack rather than single-mindedly pursuing the punishment of Player B. This feature of *Battle Metris* encourages aggressive play until a certain point, then removes itself as an incentive; it acts as both a positive and negative feedback system.

4.2.4 Implied Rules and the Magic Circle in *Battle Metris*

In *Battle Metris*, music and musical performance become part of the magic circle of the game. The performance context is part of the implied rules of the game.

Stephen Sniderman, in his essay "Unwritten Rules", looks closely at implied rules:

> [Players] intuitively understand and respond to the 'real-life' *context* in which the game is being played – i.e. the social, cultural, economic, political, and moral consequences of the result (e.g. whether someone's livelihood or self-esteem depends on the outcome).[87]

[87] S. Sniderman, *Unwritten Rules* <http://www.gamepuzzles.com/tlog/tlog3.htm>

The ‘real-life context’ of *Battle Metris* is a concert performance. The relationship between the rules of the game and the social and cultural context completes the set of negative and positive feedback systems which comprise the competitive motivations in *Battle Metris*. The players’ resolution of this complex set of impulses, incentives and disincentives is their performance. What began as Tetris has now become *Battle Metris*, in which music is the intrinsic motivator. The players do not need explicit instruction on how to play a ‘piece’ as they would in a conventional i.e. composed work. It is not necessary to enunciate the implicit rules of the context; no formal codification of the nature of the improvisation is required. The players are intrinsically motivated to play together.

An implied rule at a concert may be the length of a performance; this rule can only be satisfied by explicit cooperation between the performers. Regardless of any notion of what constitutes the definition of a successful performance, a *Battle Metris* performance is always the combination of:

- Each player’s dynamic resolution of the conflict created by the positive and negative feedback mechanisms implemented in the music and built into the rules of the game; and
- The impact of the implied rules of a musical performance on this dynamic resolution.

Reiner Knizia, designer of the ‘Lord of the Rings’ board-game, recognises the importance of intrinsic motivation in a game, and provides an appropriate metaphor for Battle Metris:

> The story starts with the hobbits leaving their home to venture into unknown lands. I decided that each player would represent a hobbit, aided by the good characters and peoples in Middle Earth. Of course their only chance was to cooperate. To do

> Tolkien’s masterpiece justice, the players would have to play together. *But the rules could not simply demand cooperative play: the game system had to intrinsically motivate this type of play.* [Italics mine] Even the most competitive players would soon realise that the game system threw so many dangers at the players that they would naturally have to support each other to maintain a strong front against their common enemy.[88]

One may replace the world of Middle Earth with a performance venue, and the common enemy with the implied rules of *Battle Metris*. At this point, the metaphor is complete. Each player retains their own motivations: winning a game; playing music they like; playing the game well. But neither of them alone can satisfy the implied rule of a successful performance. While a successful performance is subjective, it may be defined in terms of the ‘magic circle’ of the game experience; participants and spectators may agree on implied and/or explicit rules which have meaning only within in the magic circle.

[88] R. Knizia, “The Design and Testing of the Board Game – Lord of the Rings”, commissioned essay in Salen and Zimmerman, *ibid*., pp. 22-23.

5 Epilogue

Battle Metris, discussed in the previous chapter, represents a nexus between musicality and game play. Performance of the work involves musical outcomes focused on interaction between the tuning of bell partials and closely spaced pitches found in microtonal scales. These outcomes are controlled by algorithms initiated by the performer's game actions. So far, these actions have been limited to pressing keys on the terminal of a laptop computer and much work is needed before the audio synthesis algorithm can reach the level of complexity where sounds can either be initiated or controlled in a more expressive way using a musical instrument.

One of the next steps needed is the development of a more sophisticated synthesis algorithm where the relationship between the game actions and musical performance is more complex than a simple mechanistic response to the actions of a player.

Mark's Egregious Game of Life has been developed as a framework for audio synthesis using Cellular Automata, in particular, the Game of Life. This framework is a development of emergent systems, and especially CA algorithms, which were discussed in Chapter 2, section 2.3.3. Even though this framework has not yet been used in performance or publicly presented, a working version is discussed here.

The current working version of *Mark's Egregious Game of Life* has these features:

- The audio engine supports the control of up to 300 simple oscillators, each of which can be associated with a cell or group of cells.
- Its design is more heavily Object-Oriented than the design of *Battle Metris* allowing more complex relationships to be created between cell properties and audio synthesis. Each cell retains information about its state, state history, neighbour mask and neighbour count, as shown in Figure 21.
- The capacity to import and export CA patterns in a standard format. The '.lif' format, as used in 'Mirek's Cellebration', was chosen because its flexible ascii-based file format allows information about the current grid generation to be recorded and easily manipulated.

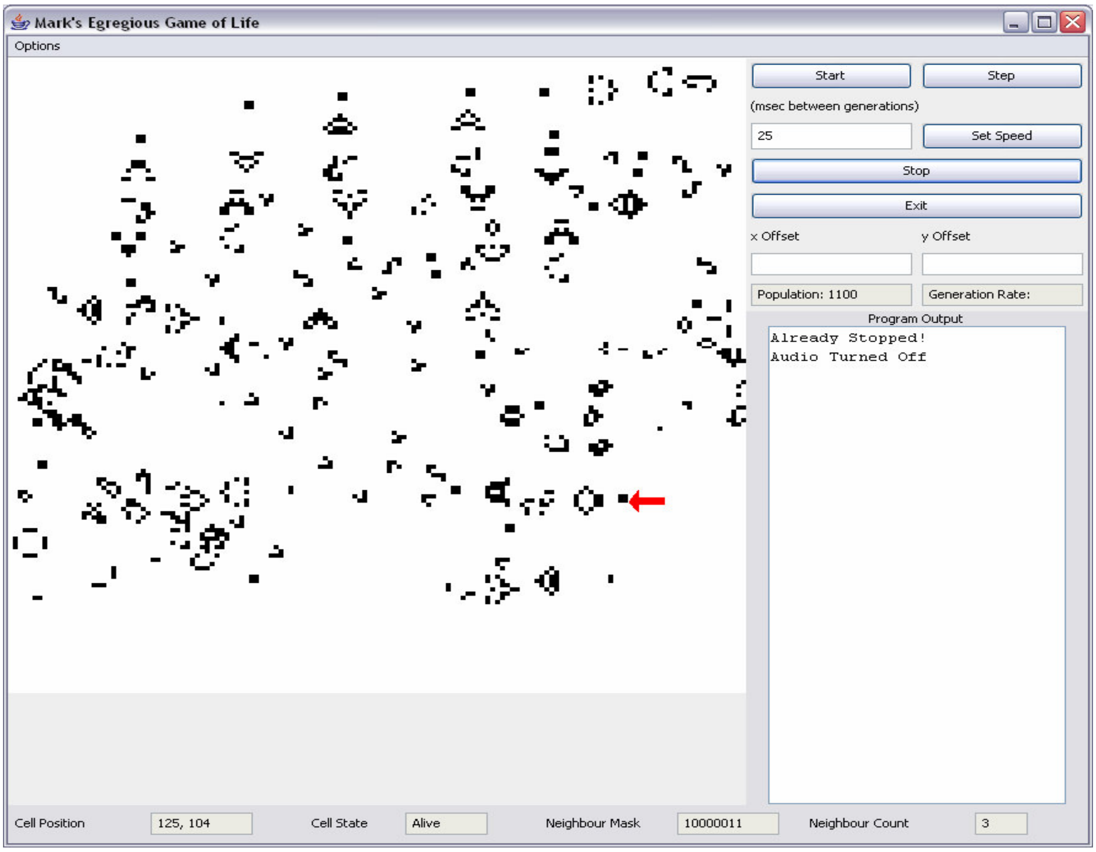

Figure 21: A screenshot of *Mark's Egregious Game of Life*. The arrow shown in the bottom right hand corner refers to a cell whose cell position, cell state, neighbour mask and neighbour count are displayed in four text boxes at the bottom of the screen. The neighbour mask is an 8-bit value related to each cell indicating which of its neighbours are alive, starting from above and moving clockwise.

As mobile technology becomes more capable of supporting this level of software, more intelligent algorithms will find new applications in mobile contexts as games technology move from the desktop computing environment to hand held devices. Mobile games no longer require the manufacture of purpose-built mobile hardware such as 'Tamagotchi'. Games have found their way into more generic handheld communications devices such as mobile phones. Indeed, games are becoming an important part of the marketing appeal for such devices.

With mobile phone applications in mind, new java tools have been created to export computer musical applications. *Pd2j2me* allows musical compositions, created in an object-oriented graphical music composition language such as Pd, to be exported to Java 2 Micro Edition –- or J2ME -- devices. The tools in Pd2j2me are currently limited to composition applications in Pd but may potentially include applications created using Max/MSP[89] and the Smart Controller Workbench.[90] A refereed article on pd2j2me entitled "Pocket Gamelan: a Pure Data interface for mobile phones", was published in the *Proceedings of the 2005 International Conference on New Interfaces for Musical Expression.* Vancouver, BC, Canada, 2005.

In time, the ideas in this thesis may lead to the development of games for large numbers of people. Bluetooth strategies developed in the Pocket Gamelan project are described in a refereed article entitled "Pocket Gamelan: A Blueprint for Performance Using Wireless Devices", published in *Conference Proceedings International Computer Music Conference 2005*. Barcelona, Spain, 2005. These strategies open the door to multi-player mobile audio gaming.

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89 "Max/MSP" <http://www.cycling74.com/products/maxmsp.html>
90 A. Fraietta, "The Smart Controller Workbench", *Proceedings of the 2005 International Conference on New Interfaces for Musical Expression* (Vancouver, BC, Canada, 2005), p. 46.

Massively multi-player online games currently use wired technology[91]. A new generation of game console – represented by Xbox 360 and Playstation 3 – supports not only wired Ethernet but Bluetooth 2 and WIFI 802.11b/g connectivity. These are the communication protocols required to transform standard game consoles into portable musical instruments.

[91] C.D. Nguyen, F. Safaei, P. Boustead "A Distributed Server Architecture for Providing Immersive Audio Communication to Massively Multi-Player Online Games", *2004 IEEE 12th International Conference on Networks, IEEE, USA*.

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