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Playing with Audio: Towards a Genuine Relationship between Game Play and Music

Abstract

A musical composition is like a game in that the rules and parameters controlling 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 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. In light of this, a game experience can be viewed as an exceptionally rich data source: a product of the designed dynamics of a game world and a player's traversal, or interpretation, of this world. This product has rich musical and experiential possibilities.

While many new electronic games prominently feature music, very few attempt to produce a genuinely original musical experience derived from the manner in which the game is played. Game play as a data source is left untapped.

This paper argues that an interdisciplinary understanding of game design theory provides the tools for analysing and interacting with game play as a data source; music can be linked to the underlying design of a game rather than merely its visual representation. A composer can design games in which a player's sense of musicality forms part of the game rules; games in which a player's sense of game play shapes a musical experience. The author's Battle Metris is presented as a 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.

Introduction

Composers and game designers have created works which attempt to link game play and music. This is no accident, as there are a number of important similarities. Both musical compositions and games create a virtual world and extract their subjects from the real world; the subjects are at once players and observers. In a game, players determine their own progression through its virtual world. However, in a musical composition, a composer pre-determines a musical trajectory over time, except where the composition involves musical decisions made by the player at the time of performance. Like games, improvised musical compositions create a familiar structure through which players can explore the unfamiliar.

With few notable exceptions, most attempts at linking music and games have been relatively singular; either the game or the music, by virtue of a simplistic implementation, is subservient to the other. The relationship is not sufficiently complex to generate meaningful game play or musical expression. This is a problem shared with many methods of sonification; the myriad complexity of the data source does not imbue the audification with a similar level of complexity if the understanding of the nature of data is not sufficiently complex.

Game Design Theory

An understanding of game design theory is necessary to create complex relationships between music and games. In *Rules of Play* (Salen and Zimmerman, 2004), 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." 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.

These three schemas not only provide a framework for understanding game design as outlined by 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.

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 (Iannis Xenakis); match (Mauricio 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.

The physical representation of some games constitutes part of their rule set. Shown in Figure 1, the physical representation of 'Connect 4'forms a large part of its formal structure, as the constraints of the game are permanently altered each time a piece is physically landed.

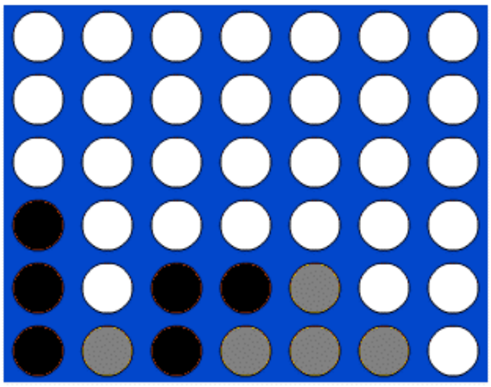


Figure 1. *'Connect 4'; its physical representation constitutes a large part of the formal structure*

The distinction between a games' formal structure and physical representation is often neglected in music compositions that are in some way based on games. In a similar problem to other methods of sonification, the underlying structures inherent in a data source like a game are often lost when merely the visual representation is used to derive audio output. Also, a lack of understanding of a games' design, the intricacies of its formal structure and how it creates a game experience, will limit any attempt to make a genuinely musical game.

Instrumental Works Incorporating Games

Composers including Wolfgang Mozart, Iannis Xenakis, John Cage, Mauricio Kagel, John Zorn and John White have incorporated game design in their works. However, while game design theory recognises "…a game is a set of parts that interrelate to form a whole" (Salen and Zimmerman, 2004), 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. In these compositions the relationship between performers will be coloured by extra-musical competition; the performer's experience of the musical piece/game system is defined by both musicality and playfulness.

Further, 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.

While these works engage the player's and audience with the idea of gaming, it is uncommon for a complex relationship to have been established between the music and a game. The physical representation and symbolism of the game usually contributes to the theatricality and efficacy of the performance.

John Cage *Reunion* (1968)

Reunion is the sonification of a live game of chess between John Cage and Marcel Duchamp (Cross, 1999), one of the most noted music game performances. In *Reunion*, players' moves on a chess board are mapped to sounds through a set of light-dependant resistors mounted in each square. Cage hoped that "elegant games of chess could bring forth elegant musical structures" (Cross, 1999). However, theatricality plays a large part in the performance; the success of the performance is dependant on the engagement of an audience by the playing of a game of chess. 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 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.

Iannis Xenakis *Duel* (1959) and *Stratégie* (1962)

Game theory was introduced into music by Xenakis in *Duel* (1959) and *Strátegie* (1962) (Xenakis, 1992). These works are not based on any existing games; game theory is a branch of economics that concentrates on managing possible outcomes and conflicts which result from decision making when both parties operate on the basis of each party's self-interest.

In both works, game theory is used to create and manage conflict between two conductors, each in charge of an orchestra. Each conductor accumulates points, the allocation of which is determined by a progression of respective musical deployments. Each conductor has six types of music which can be played; a *payoff matrix* details relative strengths of different musical passages. Xenakis also provides probability ratios for each conductor which guide them in devising a long-term strategy. This is shown in Figure 2.

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.

Conductor X \ Conductor Y	I	II	III	IV	V	VI	
I	−1	+1	+3	−1	+1	−1	14/56
II	+1	−1	−1	−1	+1	−1	6/56
III	+3	−1	−3	+5	+1	−3	6/56
IV	−1	+3	+3	−1	−1	−1	6/56
V	+1	−1	+1	+1	−1	−1	8/56
VI	−1	−1	−3	−1	−1	+3	16/56
	19/56	7/56	6/56	1/56	7/56	16/56	

Figure 2. *The payoff matrix, with probability ratios, for Duel.*

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. Each conductor's musical deployment is the result of a purely tactical mindset. The musical passages in these works form the physical representation of the formal structure, but it has been ignored that, unlike a conventional game, the game 'pieces' – the musical passages – have an inherent value outside 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, and every time she has to move a chess piece would much rather move the horse than any other piece. She must resolve her love of horses with the move which is most strategic.

In *Duel* and *Stratégie*, a performer is not asked to truly consider the musical implications of a tactical decision; Xenakis, as composer, has determined the strengths of each passage despite each conductor having their own views on which passages are more musically favourable. In both works, the victory condition is the realisation of an 'ideal', partly inflexible strategy.

Xenakis' works have this 'victory condition' paradigm strongly in common with contemporary electronic games which are explicitly related to music and music performance. Xenakis has determined that a victorious game outcome is the desired result in his works; game developers have determined that *their* conception of an ideal 'music' performance is the goal.

Electronic 'Music' Games

In many electronic games music is used as part of the motivation, reward system or cultural attraction. Games like 'Amplitude', 'Frequency' and 'Taiko: Drum Master' attempt to enhance the degree of player immersion by engaging the player musically.

Figure 3. *'Taiko: Drum Master', the player must hit a drum controller when indicated by the visual cues; playing 'music' well wins the game*

These games can be categorised in two ways:

- games in which a player must play music to win the game; and
- games in which the relationships between a game and the player is strengthened by the capacity given to a player to play with musical consequences and the cultural significance of the music being manipulated.

'Taiko: Drum Master'

'Taiko: Drum Master', or 'Taiko', falls into the first of these categories. 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. A player accumulates points by performing the prompted drum stroke on cue; the cues are always determined by the rhythms in the song.

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.

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.

'Amplitude'

In 'Amplitude', an example of the second category, music does not form a significant part of the game's formal structure as it does in 'Taiko'. A conventional game controller is used to "activate sequences of notes placed on tracks in futuristic tunnel-shaped settings" (Blaine, 2004). As a player progresses, more musical tracks are unlocked; game manoeuvres can be performed in response to these tracks (i.e. extra drum parts may be added, a bass line may be sped up etc.)

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.

Creating music based on game play

While musical compositions based on games suffer from a shallow understanding of the game on which they are based, electronic music games make no real attempt to understand what may constitute a genuinely musical experience. Generally, game developers determine particular musical outcomes desirable, and the game player must reach these conditions to succeed in the game.

Both 'Taiko' and 'Amplitude' 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" (Gee, 2003). This approach attempts to keep game play and musical interaction rewarding at all levels of play. However, it also makes it 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.

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.

Systems for specialised interaction between audio and games

More specialised game systems have been created which use audio (musical or not) as an input and/or output. Games may combine audio with other technologies like haptic feedback (Rodet et al, 2005), three-dimensional visual worlds and gesture (physical and musical) analysis; players are invited to control, or 'sculpt', audio output through the culturally accessible context of a game.

Typically, games which use audio as a discrete output method are developed cautiously; such a game will usually draw its rationale from a small set of universally palatable, and relatively achievable, concerns:

- Pedagogical – "[audio games] could provide a vehicle for the acquisition of skills, memory and concentration" (Targett et al, 2003; Hämäläinen et al, 2004)
- Therapeutic – blind or partially-sighted players are empowered to enjoy game play in which success or immersion is not dependant on visual interaction (Bryan, 2005)
- Social – participants must learn to co-operate with fellow participants in order to manage audio (and/or physical (Rinman et al, 2003)) gestures which facilitate game actions
- Fun – engaging an audience and players with the novelty of either replacing visual feedback with audio, or controlling the progression of a game with audio (Hindman, 2005; Havryliv, 2003).

When these concerns form part of the primary or secondary objectives in a musical game, the potential for a musical outcome is invariably lessened. They make is too simple for a designer to view the game as a tool for another purpose rather than seeing the game experience as a rich source of data in its own right.

As discussed in Section 1, a game is capable of the same experiential depths as a musical composition; a well-developed game is already a system for determining an aesthetic experience in its entirety. The structure of this experience can be analysed using game design theory, from which point music can then be built into the structure; music can be an inherent motivator in a game.

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 next section, *Battle Metris*.

New Musical Games: *Metris* & *Battle Metris*

Based on 'Tetris', *Metris* 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 (Salen and Zimmerman, 2004); music production is designed to regulate a player's sense of competition as it is normally expressed in 'Tetris'. 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; an example is the modification of texture that occurs when a row of blocks is removed.

Music in *Metris*

Metris consists of four principle game actions and musical responses:

Landing a game piece

- When a game piece is landed, a synthesised bell strikes (Narushima, 2003). Bearing many similarities to Jean-Claude Risset's Bell (Dodge et al, 1985), it is created by summing the output of 11 partials, each with its own relative amplitude, frequency and duration. The pitch of the bell is determined by which piece was landed; shown in Figure 4, the pitches are based on a just intonation scale derived from the frequency of the bell's partials.

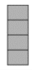
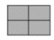
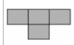
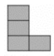
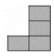
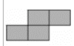
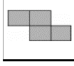
Block	Ratio	Interval above tonic	Linear factor
	1/1	unison, perfect prime	1.000000000
	9/8	major whole tone	1.125000000
	5/4	major third	1.250000000
	81/64	Pythagorean major third	1.265625000
	45/32	diatonic tritone	1.406250000
	7/4	harmonic seventh	1.750000000
	63/32	octave-septimal comma	1.968750000

Figure 4. *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 above or below its current pitch by 3Hz. This creates beatings with the timbre and pitch of other bells which are still sounding.

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. 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. 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.

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 a 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

Music as an intrinsic motivator

Battle Metris is a version of *Metris* adapted for two players. It is a game designed especially for concert performance; Figure 5 shows the performance set-up for performance of *Battle Metris* at 1/4_inch, University of Wollongong, 20th October, 2005 (Hull, 2005).

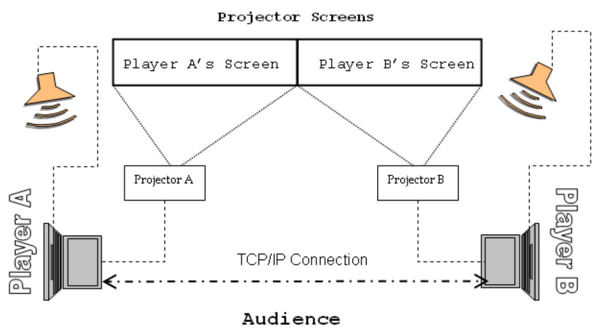


Figure 4. *The performance set-up for Battle Metris. The two players sit facing each other at desks on the left and right hand sides of the stage, with their profile to the audience. The TCP/IP connection between players can either be a cabled or wireless network. A speaker is assigned to each player, and each player's screen is projected onto their half of the projector screen.*

Unlike *Duel* and *Stratégie*, as described in Section 2, 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. (Salen and Zimmerman, 2004)

In *Battle Metris*, implied rules are one of three types of rules which define the formal essence of a game; the other two types of rules are *operational rules*, which are the "guidelines players require in order to play" (Salen and Zimmerman, 2004), and the *constitutive rules*, which are the underlying formal structures that exist 'below the surface' of the rules presented to the players. 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" (Huizinga, 1955), 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.

Positive and negative feedback systems – a Cybernetic System

Games typically make use of *positive feedback* (LeBlanc, 1999) systems for dramatic effect or to bring a game to conclusion. Positive feedback is built into the rules of *Battle Metris*; these are rules it inherits from Battle Tetris.

Positive and Negative Feedback in Game Play

As shown in Figure 6 and Figure 7, 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.

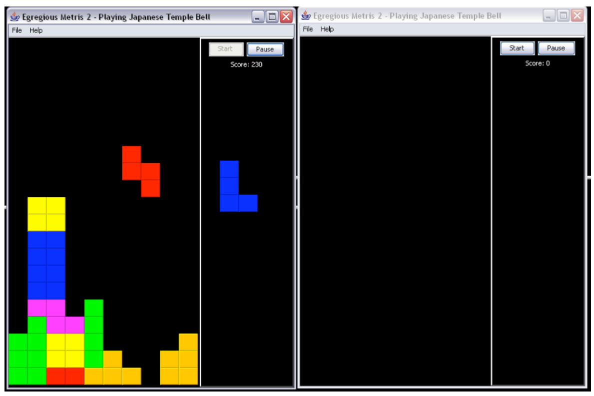


Figure 6. *Two Battle Metris screens before Player A lands the red 'S' shape. When this shape lands the bottom two rows on Player A's screen will dis appear and two grey coloured rows will appear at the bottom of Player B's screen.*

A *negative feedback* 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.

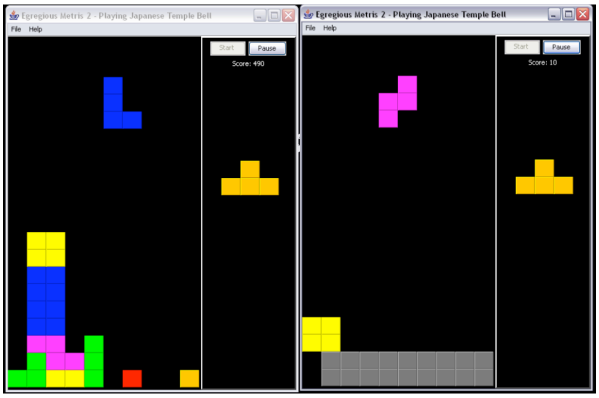


Figure 7. *The same two screens as shown in Figure 5 after Player A landed the red 'S' shape; two grey coloured rows have been added to the bottom of Player B's screen.*

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 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 4.1, 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.

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 7, 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 (Shepard, 1984). In the context of this game, the aural effect of the endless glissandi puts the player under pressure in a similar way to how a player responds to a count-down timer in a conventional electronic game.

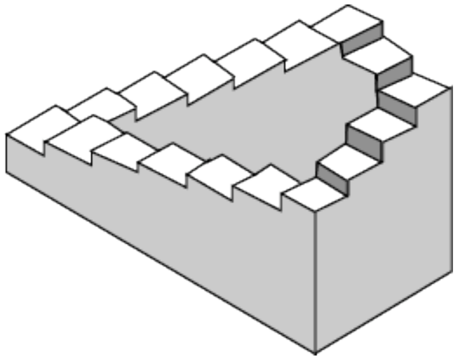


Figure 8. *The Penrose Stairway, a visual equivalent of a Shepard tone. "An impossible figure in which a stairway in the shape of a square appears to circulate indefinitely while still possessing normal steps" (Weisstein, 2005)*

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 they clear a row: Player A is one row further from possible demise; a row is added to Player B's screen; and 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.

- 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.

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, while the performance context is part of its implied rules.

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). (Sniderman, 2004)

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 per formance 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. (Knizia, 2004)

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.

Conclusion

Battle Metris, discussed in the previous section, 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.

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