Designing a game for music: Integrated design approaches for Ludic music and Interactivity.

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Motivations for play : Music and needs satisfaction

The question of how interactive music should function in games is perhaps a misleading one, as there are many different types of games and many different types of players. One of the most compelling explanations for the huge popularity of video games is that they meet people's intrinsic psychological needs quickly, with consistency, and with great frequency (Rigby, 2010). The apparent drivers of the development of games and their marketing--such as the fidelity of graphics and audio, or as the popular press would have us imagine, the degree of violence--are far less significant factors than the drive to increase our sense of well-being through meeting the basic needs of competence (or mastery), autonomy (or volition) and relatedness (social connection) (Przblinkski, 2009) or the desire to become immersed in narrative worlds (Cairns, 2006). Since it is clear that player satisfaction is a product of "needs met" over "needs", it is important that we recognize that music should operate in different ways in different circumstances.

Players will choose a genre of game that best matches their intrinsic needs (Madigan, 2012) and they will also adopt different gameplay strategies according to their personality type (Bartle, 1996). A players desire for relatedness or fellowship (Hunicke, 2004) (termed "the people factor" by Lazzaro, 2008), might be met through music that rewards cooperative play (Kristian & Girard, 2011) or allows them the ability to perform music with others (Collins, 2007) but is also likely to be met by hearing music of their preferred genre. Given the importance of music to a sense of social identity and group membership and the links between personality type and musical preference (North and Hargreaves, 2007), it is perhaps not surprising that there appears to be a strong correlation between game genre and musical style (Summers, 2011). So the next time we complain about the marketing department conducting its research on Facebook to identify the bands to use on the soundtrack to the latest racing game (Baysted, 2012), perhaps we are missing the point. A comprehensive assessment of the psychological needs of the player and how these can best be met by music in games is beyond the scope of this chapter, but we raise this in our opening remarks to highlight that, although the remainder of the chapter will be focusing on "interactive" music, we appreciate that music should function according to the needs of the game and of the player, and that some of these needs may be perfectly well met by traditionally linear music.

Of the player needs mentioned above, the "innate desire to grow our abilities and gain mastery of new situations and challenges" (Rigby, 2010) is seen by many to be the most important determinant of enjoyment in games (Vorderer & Bryant 2006). Termed "hard fun" by Lazzaro (2008), the success of this "voluntary effort to overcome unnecessary obstacles" (Suits, 2005), is thought to produce a release of chemicals in the brain (Bateman & Nacke, 2010), strongly associated with reinforcement and motivation (Salimpoor et al, 2011).

Finding oneself at the optimal point between being suitably challenged and having the skills to master those challenges is referred to as being within the highly desirable and immersive state of ““Flow”“ (Csíkszentmihályi, 1992). The emotional state of ““Fiero”“ (or triumph over adversity (Ekman, 2004)) brought about by overcoming obstacles (also referred to as ““Epiphany”“ by MacTavish (2002)), contributes to maintaining a state of flow by providing the positive reinforcement the player needs to continue to meet the increasing challenge, and is recognized as an important source of pleasure or ““Fun”“ (Koster, 2005).

In contrast to meeting players social needs (where the focus is on musical genre) or the narratologically immersive needs (met through the evocation of time, place and mood), music that contributes to flow by helping players to achieve competence, (by providing information, or by motivating and rewarding us) or music that guides and supports players by making them feel like they are acting of their own volition, and that their actions are meaningful (fulfilling the need for autonomy) must be synchronized tightly to game events. The requirements to ensure that feedback is immediate (Bond & Beale, 2009; Laitinen, 2008) and that music is congruent with the game action (Wharton & Collins, 2011) represents the inherent conflict between interactivity and musical form. The compromise between “contextual responsiveness and musical integrity” (Bajakian, 2010) continues to challenge composers and implementers trying to avoid awkward or clumsy musical results (Munday, 2007; Bessell, 2002). Such game specific, Ludic (van Elferen, 2011) or Metonymic (Whalen, 2004) music and the issues that arise out of music synchronization within an interactive medium will be the focus of this chapter.

Musical structures vs. interactivity

There are many ways in which music can evoke or induce emotions (Juslin & Sloboda, 2011) but there is clear evidence that strong or “peak” emotions in response to music (such as chills, lump in the throat, etc.) are associated with the creation of, and confirmation or violation of, expectancy (Sloboda, 1991). Given that musical training unsurprisingly leads to a heightened sensitivity (Dellacherie, 2011), it may be that many commentators with a background in music (such as ourselves) are prone to exaggerate the problems that arise when such patterns of expectancy are interrupted by the need to respond to game events, but there is strong evidence that no formal training is required to make automatic predictions of chord functions (Koelsch, 2011), to be acutely aware of phrase boundaries (Nan, Knosche & Friederici, 2009) and expectations of metrical or pitch patterns (Huron, 2006), and that breaking these patterns of expectation can cause disorientation (Margulis, 2007) and negative responses (Steinbeis, Koelsch & Sloboda, 2006).

It is of course possible to evoke a variety of emotions through musical styles that are not heavily expectation-based, and that rather than relying upon schematic expectations

(derived through familiarity with the musical syntax of style), expectations may be the product of familiarity with the specific piece, or dynamically generated from the piece itself (Huron, 2006). Indeed in some genres (such as platformers), it can be seen that learned schematic expectations (the "Ludoliteracy" referred to by Poulsen & Gatzidis, 2010) have allowed musical forms which are much more flexible, responsive and cartoon-like. In the horror genre, where the lack of a tonal centre or metrical pulse is often used to destabilize the audience/player (Summers, 2011) or parallel the characters psychological crisis (Whalen 2004), the crossfading between atonal, arrhythmic music of different intensities can induce the appropriate emotional effects without breaking any musical expectations, since the musical form itself (or lack of it) does not imply any. Likewise static tonality or drone based music can make it much easier to transition between different segments without upsetting the implicit expectations of chordal progressions (Stuart, 2010).

Whilst there are many exceptions, such as those outlined above, it must be recognized that the players significant exposure to the paradigms of film and television music (Nielsen, 2011) and the wish to activate the strongly associated cultural codes (Gorbman, 1987) mean that many games based within fictional narratives bring with them the expectations of a Hollywood style soundtrack (Jackson, 2011), a strongly tonal and expectation based form almost uniquely unsuited to the temporal uncertainty of games.

A fundamental form of musical expectancy that can be easily "broken" through the need to represent, or at least remain congruent with, game events is that of pulse. Using parallel forms (sometimes referred to as vertical re-orchestration (Collins, 2009)), where layers or ""stems"" are composed such that they work in vertical combination, can be very effective in maintaining musical continuity whilst allowing for significant changes in texture and instrumentation (see Figure 2). In *Splinter Cell : Chaos Theory*, the layers act as a warning to indicate the proximity of enemies and in *Fallout: New Vegas*, concentric circles of triggers attached to musical stems help the player to navigate the Wasteland (Lawlor, 2012). Layers can tell the player whether special modes are active, notify them of the alertness state or current health of NPC's[1], or represent overall progress through a puzzle (*Portal 2*) or battle (*Tom Clancy"s EndWar*). The attenuation of different layers of music to represent different game states or continuous variables can be highly effective in providing the player with information to support success (enhancing their skill within the flow state) and can increase layers of tension (to heighten the impression of challenge). However given that its musical form is pre-determined (composed to be essentially "static" and allowing the game to generate its dynamics (IGN, 2006)) it is less suited to providing reward (enhancing fiero) since it lacks the ability to respond to game events with specific timed musical gestures.

[1] Non-Player Characters

Feedback on actions or game events can be transmitted via music using ornamental (Figure 1), or transitional forms (Figure 3). It is frequently the case that we want to acknowledge events in the game but they are not significant enough to warrant a whole scale change in music. In this case, games typically use an ornamental "Flourish" (*FMOD* (Firelight Technologies, 2012) or "Stinger" (*Wwise* (Audiokinetic, 2012), that might reward a successful jump (*Uncharted 3*), a successful attack (*The Legend of Zelda: Skyward* Sword) or shot (*The Operative: No One Lives Forever*). Typically these are not aligned to musical pulse but happen immediately over the top of the currently playing musical bed (*CryEngine3* (Crytek, 2012)).

The function of musical feedback could be viewed from a human-computer interaction perspective (indicating confirmation or rejection of action (Jorgensen, 2010)), but it also carries an implicit emotional message. The Ludic or Metonymic is not separable from the metaphoric (that which relates to the game as a story or world) (Whalen, 2004). A piece of music may confirm that an action has been successful (defeat of the enemy) and thus provide the positive reinforcement important to flow, but at the same time the music is also providing an insight into character, as it does in film (Hoeckner et al, 2011). Since the player is the character, this music is informing them of their place in the fictional world, their heroism, and their role in shaping the events of the world around them, supporting the players' sense of autonomy by making their choices appear meaningful. Given the audio-visual expectations formed from a lifetime of narrative media mentioned above, we expect these musical responses to be both synchronized and dramatic.

The simple transitional cross-fade can work if music is composed in such a way as to avoid or at least lessen musical expectations[2], or musical transitions can be masked with sound effects (Porter, 2010), but the most effective way to maintain musical expectations within transitional forms is to restrict the changes to musically appropriate times. By carefully constructing matrices of possible transitions between sections of music that take account of potential entry / exit points and the types of transition permitted (immediate, next measure, next beat, etc. (Selfon, 2004a; Wall, 2012)), it is possible to construct highly "musical" scores (that maintain musical expectations). However the by-product of this musicality is that there is a "lag" between game events and the music's response (Collins, 2007). Again we are attempting to "*adhere to the sound of film music while losing sight of its raison d'etre; the heightened emotional impact provided by the close synchronisation of musical and visual events."* (Munday, 2007).

It is acknowledged by many in the game music industry that "interactivity = modularity" (Ashby, 2008) and a focus on temporally aware cells of music (Figure 4) or

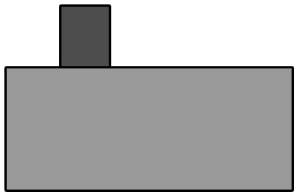
[2] Composers talk of the pressures to "avoid bold musical choices" (Wintory, 2012), or avoiding melody (Tong, 2011; de Man quoted in Finch, 2011).

"micro scores" (Folmann, 2006) can allow music to more quickly respond to events whilst maintaining musical flow. However the production of such cellular forms remains problematic as when transitioning from one cell to another the musical parts need to retain their natural decay portions or "tails" in order to sound natural (Selfon, 2009; Stevens & Raybould, 2011). Certain styles of music that have rigid time based structures and short percussive elements (e.g. some 'Pop' music) can move effectively between segments or cells using short crossfades (Durity & Macanulty, 2010). Other approaches such as Whitmore's dovetail technique[3] or applying reverbs to smooth over transitions (by artificially creating decay tails in real time), can also work well but these are rarely satisfactory for acoustic instrumental forms as getting musicians to perform in short chunks (so you can capture the authentic decay within the correct acoustic space) is both time consuming and unnatural. The highly modular, or "granular", note level approach of MIDI + sample-based systems resolves the decay problem (since the tail exists authentically within each sampled note) and also provides for the kind of parametric control ideally suited to interactivity (Collins, 2009), but it has fallen spectacularly out of fashion within many genres as a victim of the quest for a Hollywood sound (Collins, 2008). Senior figures within the game audio industry agree that the return of note level or MIDI control in some form is the inevitable response to addressing questions of musical interactivity (Page & Kelly, 2007), and others have suggested that the development of cloud-based processing and streaming might mitigate the perceived quality issues (in terms of addressing RAM for high quality samples and processing for mastering) (Drescher, 2010). There is an innate reluctance to replace activities seen as innately human, such as music composition, with processes or algorithms (Cope, 2000) (Figure 5) but the potential for musical models (McAlpine, 2009), stochastic (or generative) approaches (Weir, 2011), and parameterized control (Livingstone & Brown, 2005) adds weight to the need to move beyond the stereo wave file or the pre-rendered stem.

Although the return of granular, note-level control within games would undoubtedly improve the ability of the music to respond to, and support, game events more elegantly it still remains a theoretical impossibility to align expectation-based musical structures with unpredictable events. If we imagine the music system as a black box containing a highly talented silent movie piano player we can appreciate that he could quickly adapt the music to the action on the screen, using his highly evolved knowledge of musical harmony and form to neatly segue, via an appropriate passing chord or note, into a new "piece" or state. But it would not be immediate and irrespective of his skill: he could never build towards an anticipated event and synchronize precisely with the climatic point. In other words the synchronization of game fiero and musical "peaks", paralleling the highly rewarding climax of many a Hollywood chase sequence, cannot happen, unless we reconsider the nature of the relationship between game design and music.

[3] In this techniques the music cells start and end at performance boundaries that encapsulate a pre and post section, rather than simply containing the musical section itself. This means that the cells overlap when transitioning, allowing the decay of the current phrase to finish naturally (Whitmore,2003).

<insert Figure 1 about here. Caption: "Ornamental Forms">



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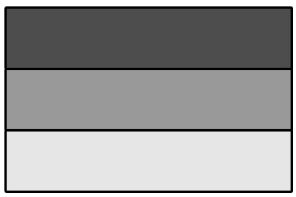

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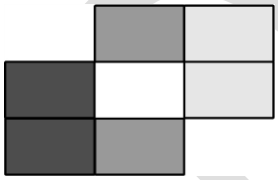

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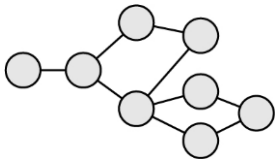


Interactivity ?

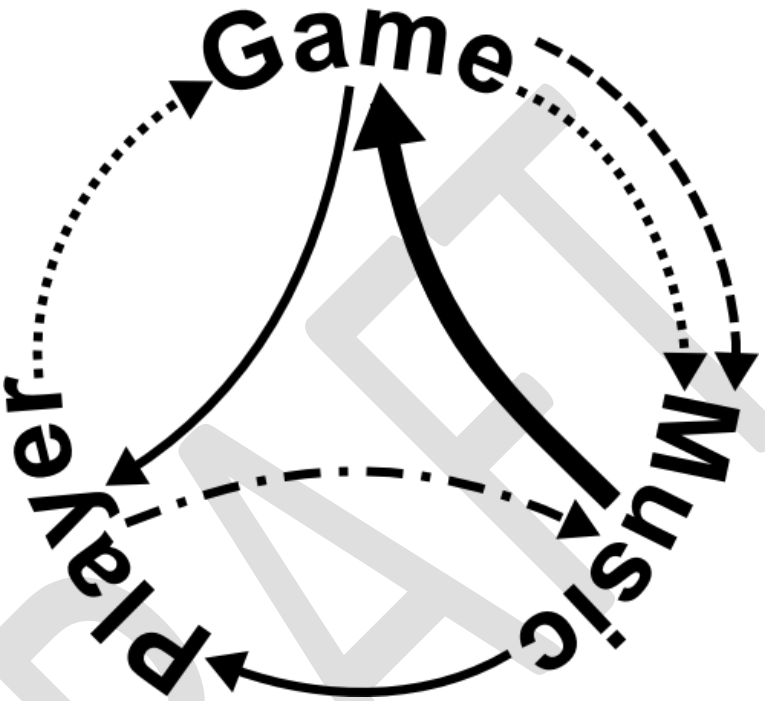
Although there is general agreement that the umbrella term "Dynamic" music somehow differs from the "Linear" music of film (Collins, 2009), the remaining terminology with regards to music in video games is varied and confusing. The term interactive when applied to this field has a long history of ambiguity (Ross, 2001; Miller, 1997) and although there is an inclination to use the term "adaptive" where the music may respond to game events without any direct input from the player (Fay, 2004; Hiromichi, 2011; Bernstein, 1997; Collins, 2009), (or at least when there is a degree of abstraction or a layer of interpretation between the player actions and the output (Farnell, 2007; O"Donnell, 2011; Harland, 2000; Clark, 2007) the usage of these terms (along with "emergent" (Spector, 2012)) is often interchangeable or contradictory . The shifting, or at least poorly defined, meaning of the term "interactive" is not unique to video games (Aarseth, 2003; Jensen, 1998) and although there is little to gain from trying to impose a meaning here, it is worth pursuing briefly, as a number of definitions call for a reappraisal of what we might currently call interactive.

Although some commentators might consider any engagement with media to be interactive in some sense (Manovich, 2002), our current common usage of the term within game audio to encompass all audio events that respond to user input (Selfon, 2004b) can detract from the idea of interactivity as a continuum, within which there are there are differing degrees. At one end of this scale is the notion, as yet unconsidered in many games, that interactivity is a cyclical process (Crawford, 2003) where the agents within a system act upon each other (inter + act (Harper, 2012)), that the receiver can also act as a transmitter (Gianetti, 2007). McQuail (2005) defines interactivity as "*The capacity for reciprocal, two-way communication attributable to a communication medium or relationship. Interactivity allows for mutual adjustment, co-orientation, finer control and greater efficiency in most communication relationships and processes.*" (p497), and that we might describe the degree of interactivity as being "*indicated by the ratio of response or initiative on the part of the user to the "offer" of the source/sender*" (p144). If we consider the music, player and game as components of a system, we can see that most current practice within music for games could be considered as simply "Reactive", acting in response to events from the player, mediated by the game engine (shown as the dotted line in Figure 6), or in direct response to the game engine itself "Adaptive" (the dashed line in Figure 6). [4]**Error! Bookmark not defined.**

By reserving the use of the term "Interactive" for systems that are truly bi-directional, where the game's decision making processes also take input from the music system as to its current

[4] There is an additional form described in Figure 6 where the player acts directly on the musical form such as in rhythm action games, termed here 'Performative' (dot + dashed line).

state (indicated by the thick arrow in Figure 6), we raise the possibility of approaching the seemingly intractable interactivity vs. musical structure problem in a new way.



<insert Figure 6 about here. Caption: "Game Music Systems">

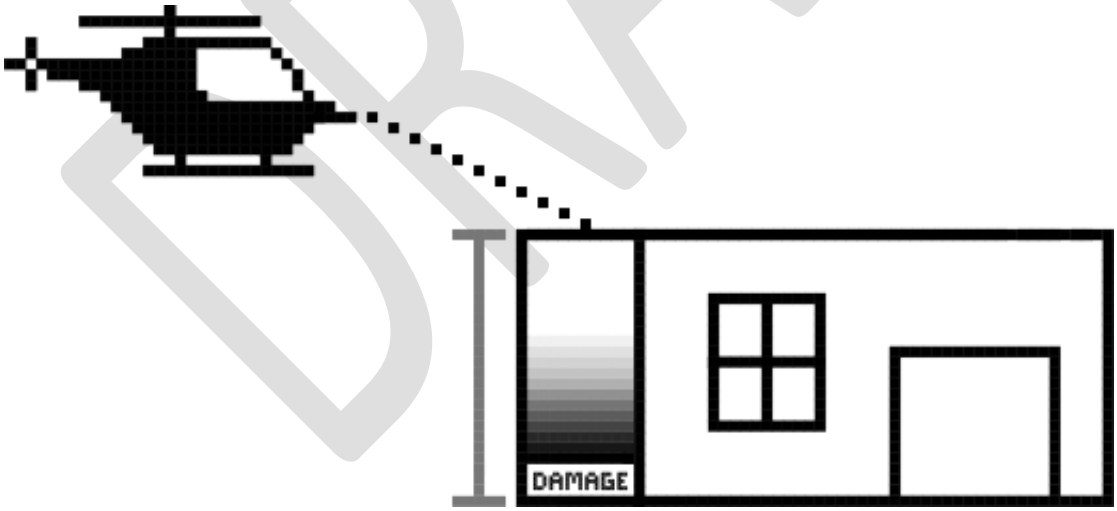
Thresholds, windows and notifications

The game designer Clint Hocking refers to the design challenge of the "threshold problem" as being "*any problem that arises as a result of a discrete state change that occurs at an arbitrary, designer-defined threshold in an analogue range*" (Hocking, 2012), and points out that in order to avoid frustration these need to be clearly communicated to the player, or made "sticky", so that if they get near enough to the value they are automatically snapped to it.

In order to facilitate greater "Interactivity" between the music and game state (so that moments of fiero can be heightened by synchronization with pleasurable structural points in music) we'd like to suggest that these arbitrary thresholds might instead be considered as ""Windows"" of opportunity. When the game state is looking to take an action (the window is open) it might look at the condition of the music (which would be inputting its current state) to inform when that action might actually occur. This process would require a more integrated approach to music and game design which we will illustrate below with a few examples.

Example 1 : Helicopter Gunship

You are in a helicopter attacking a fuel depot at the entrance to an enemy compound. The game system is set up so that it takes 100 direct hits with your weapon to destroy the depot.



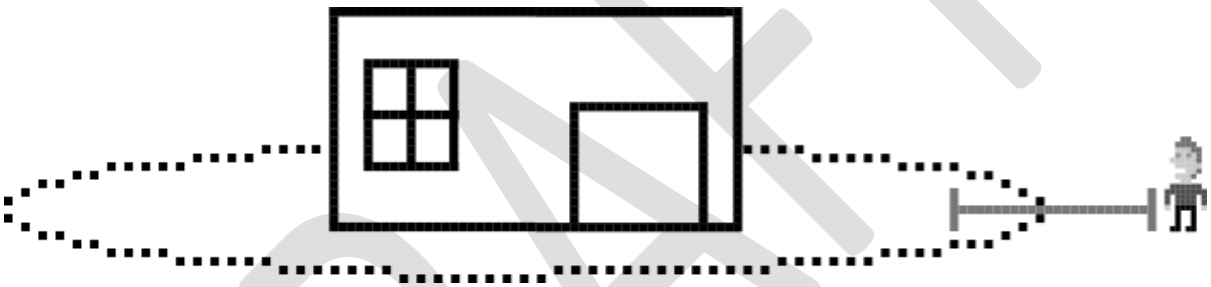
<insert Figure 7 about here. Caption: "Gunship">

Within a normal "reactive" system when the direct hit variable equals 100 the depot explode animation is triggered. The currently playing music is cut off immediately and the triumphant brass music cue is played. "Interactively" when the direct hit variable equals 100 the game engine checks the music state. It sees that the music is currently at the 4th beat of the bar and,

given that it knows the ideal (most pleasurable) musical transition point would be on beat 1, it continues taking additional direct hits, until a musically appropriate musical time. Then the triumphant brass cue is played, and the depot explode animation is triggered simultaneously. The moment of fiero produced by the triumph coincides with the musical expectation implied by the 4/4 time signature and therefore the pleasure is heightened. To take this one step further, it might be appropriate to consider that a window may open up around the threshold (direct hits =100), meaning that, if musically appropriate, the event may actually take place slightly earlier than the threshold point (e.g. direct hits = 97).

Example 2 : Find the Enemy

Having gained entry to the enemy compound you need to find and detain the chief bad guy. On approaching the hut where he's hiding out, the game will jump to an in-game cut scene that shows your final steps up to the door, you kicking in the door and gracefully leaping through, to the bad guys surprise and horror.



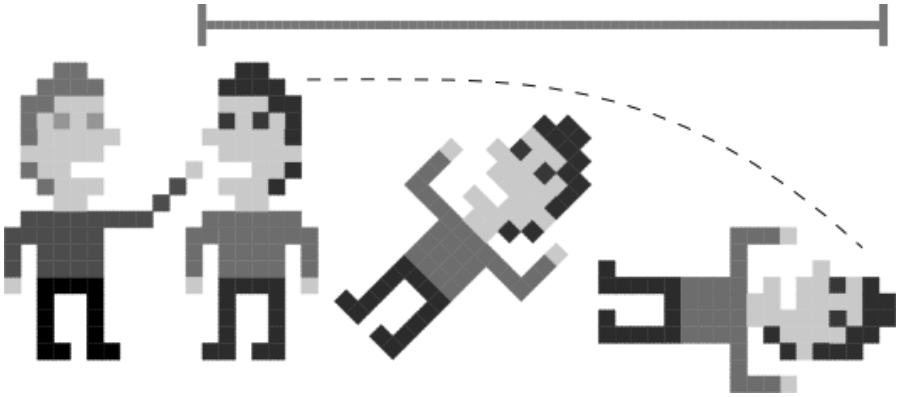
<insert Figure 8 about here. Caption: "Cut-Scene">

As a reactive system when the player passes the threshold (illustrated by the circle trigger around the hut) the in-game cutscene is triggered. The currently playing music is cut off immediately and the cutscene music is played. "Interactively" we consider a window around the threshold point (indicated by the grey symbol) where the game state starts to look at the music state. Whenever the music state reaches the next appropriate musical juncture (for example approaching beat 1 of the bar again) the cutscene is triggered to coincide with the musical change it also instigates at this moment.

Timing and animation

Example 3 : NPC death and collapse

Unsurprisingly, the bad guy's henchman rushes to his aid. A thick-set man with an aggressive nature, he has a threshold of 20 blows before he will collapse and die.

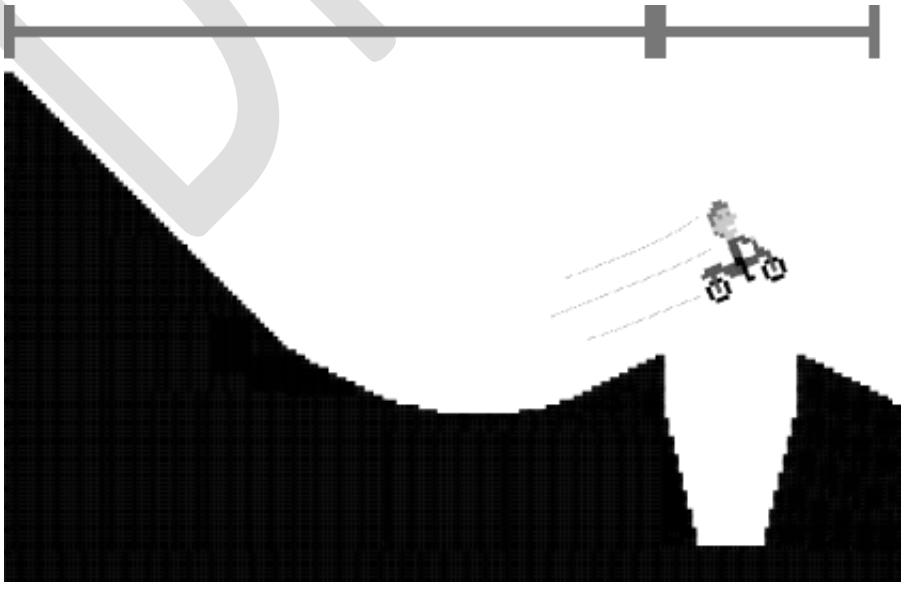


<insert Figure 9 about here. Caption: "Death">

"Interactively" this could do the same as Example 1 above, and actually trigger the event (death) to happen at 19 or 20 blows, when close to a musical juncture. However the player may be attuned to the strength of the enemy and feel that this somehow does not feel right. Instead it may be possible to adapt the "collapse" animation, speeding up or slowing it down by interpolating differently between key frames, looking to the music system for timing, so that the impact onto the ground is timed to coincide with the appropriate transition point within the musical structure.

Example 4 : Jump

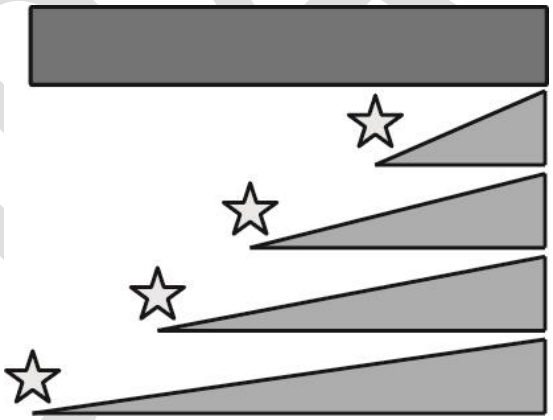
In pursuit of the chief bad guy, who has now left the compound on a motor bike, you speed downhill towards a gaping chasm. We want to accompany your leap off, and landing, with an appropriately dramatic music cue, but you are weaving through a number of trees on your way down so we can only make a rough guess at your arrival time.



<insert Figure 10 about here. Caption: "Jump">

“Interactively” we could calculate the exact time required to hit the leap at an appropriate musical point. We then manipulate (constantly update) the speed of the vehicle to compensate for the player’s turns so that they hit the jump in synchrony with the music, then also adjust their air speed and trajectory so that they land with a satisfying, musical, bump.

With the examples above we hope we have communicated some simple ways in which a more “Interactive” and integrated approach to game design could exploit the pleasurable benefits of aligning game events and musical structure, however they also probably raise concerns as to the effect on the players sense of autonomy or agency, raising the risk of this becoming another type of frustration-inducing ‘Quick Time Event’ (Miller, 2010). The danger is that the satisfaction produced from the musical synchronization of game events will not be powerful enough to outweigh any frustrations that this wresting of control may induce. Anecdotal evidence from people already innovating in the area of integrated game and music design suggests that as long as players feel that their actions have been acknowledged, through some form of audio or visual feedback, they are happy to accept a momentary pause before action (Kastbauer, 2011). This feedback could be as simple as the rumble of a depot about to explode or the groan of an enemy about to die. This could also be accomplished with music through the introduction of a short stinger (star) and the fading in of a percussive part (ramp) that leads into the event measure (as illustrated below).



<insert Figure 11 about here. Caption: "Feedback">

The manipulation of animation and event timings, and the use of opportunity windows rather than discrete thresholds, are simple concepts to support two-way interactivity between game and music systems. In order to generate and support more innovation around this idea it is vital that attitudes, production processes, and tools are re-examined and developed.

Requirements for change

Attitudes and the production process

Excluded in part by music's cultural status as the mysterious preserve of specialists (Margulis, 2008), in part by the sound isolation and acoustic treatment required for music production (Bridgett, 2012), and poorly served by the game design literature[5], it is perhaps unfair to expect producers and game designers to be experts in understanding the contribution that music can make to games.

In the film-making process, the opportunity for the composer to play a role in offering their insight and suggestions is provided through the spotting process (Larsen, 2007), and the ability for the director to try out different approaches in a hands-on way themselves is enabled through the common use of temp tracks throughout the editing process (Sadoff, 2006). However, in games, the frequent outsourcing of music--often to composers from a linear film background--exacerbates the lack of integration between game design and music.

We've outlined above why we think there could be benefits to the game experience by aligning moments of fiero with structurally significant musical points in order to induce a heightened sense of pleasure in the player. The implementation of this concept requires a shift in both attitudes and production processes. To some, it is self-evident that the challenge of interactive music for games lies with the composer and that the implementation design should inform composition (Bajakian, 2010), that one must spend hands-on time with a game in order to recognize its intrinsic rhythms (Kondo, 2007) and that "*The ability to understand game technologies and mechanics is becoming increasingly important for the composer"* (Folmann quoted in Latta, 2006). However, there appear to be a large number of composers who have little knowledge of games (Steighner, 2011; Sheffield, 2008), and do not consider it part of their remit to learn or understand the implementation tools (Graves, 2011). Even if it were not for the inherent incentives in triple-A game development to go for the safest possible choice, using music in the tried and (un)tested way it has been used in previous titles within the genre, it is perhaps not surprising, given the common practice for such composers to be working remotely based on images (Inglis, 2012; Usher, 2011; Horan, 2012), or a few lines of instruction on a spreadsheet (Pham, 2008), that more integrated design approaches are rare.

[5] In an admittedly slightly arbitrary selection of game design books consulted during the writing of this chapter none had more than a few pages for both sound and music and those that did contained the usual insights such as music being "the language of the soul".

Although there are some companies that appreciate the importance of the in-house composer in creating a more integrated design approach (Broomhall, 2011), there is much evidence that the problematic attitudes of the composers working in "the linear style that comes naturally" (Project BBQ, 2000) for the production and delivery of "assets" or "content" (usually "stems") remain. Although in-house integrators may be (and often are), highly talented musicians themselves, it remains evident that it would be preferable for the composer to be more closely involved in the process of understanding how game variables might be translated into musical meaning. Furthermore they should not consider themselves to be above such "minutiae" (Mayer & Leary, 2008) if music is to be composed with the medium in mind, rather than relying on the manipulation of pre-made assets. The claim that they *"don't want interactivity to have a detrimental effect on the creativity of the composer*" (Garry Schyman quoted in Pham, 2008) appears to parallel similar historical arguments from composers and theorists about the injurious effects on musical structure arising from having to compose to film events (Cooke, 2008). Like the concert hall composers before them who moved into film, the film composers who are now moving into games must also reappraise the role of music within the medium and become more involved in an integrated approach to finding solutions. As Whitmore points out :

"If a composer simply supplies long, linear musical pieces for a game, that composer is not "scoring" the game; they are just providing music that is in the correct genre and style. Imagine if a film composer did the same thing - created music that had nothing to do with the images and action on screen. That composer would be fired! Scoring to picture is half the art in film composing, and the same applies to game scores." (Whitmore, 2003)

Although we can be critical of the willful ignorance of film composers hired for marketing considerations, or a producer's personal preference (Broomhall, 2012), it has long been recognized that judging music in isolation from the medium for which it is intended can be misleading (Gorbman, 1987). The inclination to think that music should somehow be able to "stand alone" (Dabl, 2010), and the commercial incentives in promoting the game "soundtrack" as a product (Napolitano, 2012; Kärjä, 2008), further exacerbate the problems of considering music properly within its game context that are already extant given the lack of integration between the content creation tools and implementation tools (Taylor, 2012).

Tools

Although there have been significant advances in audio middleware tools in recent years, game development remains a fundamentally iterative process, and it is desirable that the time necessary to test and iterate be as short as possible (Fullerton, 2008; Gregory, 2008).

The concept of affordances and constraints explores how the design of objects conveys messages about their possible uses, and influences our abilities to carry out tasks with them (Norman, 1998). The practice of contemporary composition is almost without exception carried out within what is commonly referred to as a Digital Audio Workstation (DAW)[6]. By examining the spectrum of affordance (what is easy, and thus more likely, to what is difficult, and therefore less likely) (Mooney, 2010) of a DAW it can be seen to be highly unlikely to produce music suited to interactivity, and that the production of interactive music is in spite of the tools, not because of them[7]. The DAW has the granular note and parameter level controls ideally suited to interactivity but lacks the stochastic capabilities and game engine integration of the middleware, whilst the wave file-based middleware lacks the granular control. This means that the iteration process involves, at the very least, the time consuming rendering of all assets to wave files, importing of the wave files into middleware, the construction of interactive systems within the middleware, and the setting up of, and receipt of, the appropriate "hooks" (game variables) from the game itself. Any changes to the music itself after evaluation will then require a return to the DAW to modify and re-export the musical assets. It is worth reiterating that this is a best-case scenario: more typically this process is further worsened by the composer working remotely, involving live recording of musicians rather than the rendering from DAW, and the evaluation process being undertaken without the composer"s involvement (Graves, 2012). The original system within which the music is composed contains all of the control that is desirable for the iteration process (and for use in the final game) and yet the existing tools and processes involve rendering out material to the inflexible mediums such as Wave, MP3 or Ogg format files (Marks, 2008).

To enable faster iteration and deeper integration of music in the game design process there is a clear need to allow game engine variables to plug directly into DAWs, and for those DAWs to develop the compositional mechanisms and export formats to translate music into flexible formats for use in games. The aims of the interactive XMF (iXMF) working group (IASIG, 2012)[8] to establish a universal transfer format appears to have stalled, but perhaps there are initiatives to come from the new IASIG DAW working group, from the younger DAW pretenders (Kirn, 2009) or indeed from the more unexpected direction of web audio (Rogers, 2012).

[6] Rarely, as the name might suggest, a piece of hardware but in fact a personal computer and combined software sequencer and audio editing package.

[7] It is worth noting that the unique and iconic style that is generally referred to when speaking of "game music", i.e. that of the 8-bit chip-tune era, is very much a product of the affordances and constraints of the sound chips on early games consoles (Collins, 2008).

[8] The Interactive Audio Special Interest Group (IASIG) was formed in 1994 as a forum to exchange ideas about improving the state of the art in interactive audio and has been influential in the development of audio standards, features, and APIs for desktop and mobile platforms. The iXMF workgroup was established in 2002 in order to develop a specification for a new interactive audio file format based on the XMF (eXtensible Music Format) of the MIDI Manufacturers association.

Conclusion

Although we may question and debate the directness of the mapping of game information or actions to music from an aesthetic point of view (paralleling the arguments about "Mickey Mousing" that have long raged in cinema (Kaliniak, 1992; Morton, 2005)), there are times at which the Ludic function of music in providing information and motivational reward to the player, or the narrative function of enhancing the players actions so they are seen to have a "spectacular influence" on the game (Nielsen, 2008) emphasizes the need for it to be congruent with game events.

Through parallel forms we can provide information to the player within musical structures, and through ornamental gestures we can provide micro rewards to motivate and enhance the pleasurable "flow" state, but enhancing the peak emotion of triumph (fiero) when overcoming the frustration or stress invoked by major obstacles in the game (Hazlett, 2006) requires the more powerful emotional responses associated with musical form. No matter what level of granularity or complexity of algorithm involved, it is, and always will be, theoretically impossible to reconcile the indeterminate actions of the player with the kinds of expectation-based musical structures that induce such peak moments of pleasure.

We appreciate that a huge range of fascinating and brilliant games such as platformers, explicitly music-based games, or games that have audio-visual synaesthesia ideas as a core mechanic, already treat music as a highly integrated design element. However, within more narrative-situated games there are certain moments that deserve to deliver the powerful emotions associated with their Hollywood archetypes. Without the right tools, better integration of music into the iterative game design process is difficult, and without the right personnel and attitudes the kind of *Gesamkunstwerk* anticipated from the medium (Bridgett, 2005) seems elusive, but by invoking a more nuanced interpretation of interactivity, that encompasses a range of possible exchanges, rather than accepting music in a purely "reactive" role, it is possible that new, as yet unexplored, possibilities will arise. It is our hope that the first game to fully utilize this "Interactivity" to emotionally engage the player will provoke a paradigm shift in thinking about games and music.

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