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# Game Scoring: Towards a Broader Theory

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# GAME SCORING: TOWARDS A BROADER THEORY

by

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*Abstract*

“Game scoring,” that is, the act of composing music for and through gaming, is distinct from other types of scoring. To begin with, unlike other scoring activities, game scoring depends on — in fact, it arguably *is* — software programming. The game scorer’s choices are thus first-and-foremost limited by available gaming technology, and the “programmability” of their musical ideas given that technology, at any given historical moment. Moreover, game scores are unique in that they must allow for an unprecedented level of musical flexibility, given the high degree of user interactivity the video game medium enables and encourages. As such, game scoring necessarily constitutes an at least partially aleatoric compositional activity, the final score being determined as much through gameplay as traditional composition. This thesis demonstrates this through case studies of the Nintendo Entertainment System sound hardware configuration, and game scores, including the canonic score for *Super Mario Bros.* (1985).

Keywords: game scoring, video game music, ludo-musicology, music composition, gaming, software programming, aleatoric composition, music technology, interactive media.

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# *Chapter 1*

## *Introduction*

In this thesis, I examine an emerging compositional mode which I call "game scoring," that is, composing music for and through gaming. As with film scoring, game scoring supports, complements and elucidates the visual aspects of a broader narrative medium, namely, the medium of video games. However, any further resemblance between game scoring and film scoring is illusory, despite a glut of research which treats the two compositional modes as genetically related.[1]

A host of technical and aesthetic priorities, values, obstacles and concerns faces the game scorer, which simply do not influence composition for other media. Most fundamentally, game scorers must accommodate unprecedented levels of interactivity in their compositions. Game scores are only ever *realized* — they only ever exist as something other than imperceptible digital bits — through gameplay, after all. So, too, must game scorers compose for particular sound hardware configurations. Their compositional activity is structured in its entirety, then, by the very limited set of aesthetic possibilities each console's peculiar Audio Processing Unit (APU) affords. *If it*

[1] Work that approaches game scoring via film studies tools and concepts includes, but is not limited to: Arrasvuori (2006); Boyd (2003); Chan (2007); Collins (2007d; 2008c); Hoover (2010); Jørgensen (2004; 2006; 2007a; 2007b; 2008b; 2009; 2010); Kamp (2014); Mera (2009a); Munday (2007); van Elferen (2011); Whalen (2004; 2007); Wilhelmsson and Wallén (2010); Wood et al. (2009); and Zehnder and Lipscomb (2004; 2006), among others.

*cannot be programmed into a console's APU, it simply cannot exist as part of a game score.* As such, game scoring most closely resembles software programming.[2]

In fact, game scoring *is* software programming. Drawing an aesthetic distinction between music composition and game scoring is only possible if one insists on maintaining outdated conservatory assumptions about what musical composition ought to be.[3] To see game scoring as no less musical an artistic activity than, say, composing a symphony, analysts need only adjust their analytic prejudices to include a host of modern activities that may indeed appear unmusical on first glance, such as software programming, coding, and gaming.

Game scoring is not composing a symphony, to be sure. And I make no claims in this thesis that game scores are somehow aesthetically equal to the ostensibly "great" works of the Western Art Music canon, even if I prefer Koji Kondo to Beethoven most days. My argument is that game scoring comprises a unique compositional mode which is structured entirely by gaming technology and, thus, which remains always inherently

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[2] Work which relates game scoring to software programming more often comes from the computer science discipline, such as: Aav (2005); Alves and Roque (2011); Baccigalupo (2003); Berndt (2009; 2011); Berndt and Hartmann (2007; 2008); Berndt et al. (2006); Boer (2003); Borchers and Mulhauser (1998); Childs IV (2007); Collins et al. (2011); Cunningham et al. (2011); Droumeva (2011); Ekman and Lankoski (2009); Farnell (2007; 2011); Fay (2004); Friberg and Gärdenfors (2004); Grimshaw (2007; 2010); Grimshaw and Schott (2007; 2008); Grimshaw et al. (2008); Havryliv and Vergara-Richards (2006); Hoffert (2007); Holtar et al. (2013); Hug (2011); Huiberts (2010; 2011); Jørgensen (2004; 2006; 2007a; 2007b; 2008a; 2008b; 2009; 2010); Kayali (2008a; 2008b); Kayali et al. (2008); Knight (1987); Lendino (1998); Lieberman (2006); Liljedahl (2011); Marks (2009); Mullan (2010); Murphy and Neff (2010); Nacke et al. (2010); Pichlmair and Kayali (2007); Reiter (2010); Roux-Girard (2009; 2010); Sanger (2003); Sanders (2010); Stockberger (2003); Tinwell et al. (2010); Toprac and Abdel-Meguid (2010); Villareal III (2009): Weske (2002); Whitmore (2004); Wilde (2004); Wilhelmsson and Wallén (2010); and Wooller et al. (2005), among others.

[3] Since scoring is a form of music composition, I treat game scoring as music composition in this thesis. Here, however, I differentiate my usage of "composition" with narrower uses of the term which do not allow for activities involved in game scoring. For example, see: Demuth (1951); Dunstan (1909); Eisler (1951); Ouseley (1886); and Perle (1963), among others.

"aleatoric," that is, "chance" music. I devote myself most fundamentally to demonstrating and elucidating this thesis in what follows.

Since little is written about game scoring as an unique compositional activity, little published research exists to situate my research. Ludo-musicological[4] studies of video game music are plentiful, of course, but these tend to consider game scoring as an offshoot of film scoring, and they seldom address the technical structure undergirding game scoring and the "aleatoric" nature of the musical works that structure enables.[5] Musicologists have likewise examined game scoring,[6] as have media theorists,[7]

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[4] Ludo-musicology is a relatively new field of research which focuses exclusively on video game music, which differs from music composed for the non-performative visual arts or non-interactive film, for instance. For more on this see: Ludomusicology.org.

[5] Ludo-musicological studies of video game music include, but are certainly not limited to: Belinkie (1999); Berndt (2009; 2011); Berndt and Hartmann (2007; 2008); Berndt et al. (2006); Brame (2011); Bridgett (2010); Chan (2007); Childs IV (2007); Collins (2005; 2006; 2007a; 2007b; 2007c; 2007d; 2008a; 2009); d'Escrivan (2007); DeCastro (2007); Deutsch (2003); Farnell (2007); Fay (2004); Furlong (2004); Gibbons (2009); Herber (2008); Hermans (2013); Hoffert (2007); Kaae (2008); Knight (1987); Lendino (1998); Lieberman (2006); Marks (2009); Mera (2009a; 2009b); Sanger (2003); Schmidt (1989); Sweeney (2011); Van Geelen (2008); Whitmore (2004); and Wooller et al. (2005).

[6] For examples of musicological studies of game scoring, see: Allouche et al. (2007); Arrasvuori (2006); Arsenault (2008); Baxa (2008); Belinkie (1999); Bridgett (2008); Carlsson (2008); Cassidy (2009); Chan (2007); Collins (2005; 2006; 2007a; 2007b; 2007c; 2007d; 2008a; 2008b; 2008c; 2009; 2013); Collins et al. (2007); Crathorne (2010); d' Escrivan (2007); Deutsch (2003); Fritsch and Strötgen (2012); Fritsch (2013); Furlong (2004); Gibbons (2009; 2011); Guerraz (2008); Herber (2008); Hermans (2013); Jørgensen (2008b); Kaae (2008); Kamp (2009; 2014); Kärjä (2008); Mera (2009a; 2009b); Miller (2007; 2008a; 2008b; 2009); Munday (2007); Pichlmair and Kayali (2007); Reale (2011); Schütze (2008); Shultz (2008); Smith (2004); Summers (2011); Svec (2008); Sweeney (2011); Tessler (2008); van Geelen (2008); Western (2011); Whalen (2004; 2007); Wood, Harper, and Doughty (2009); and Youngdahl (2010), among others.

[7] For more work on game scoring from media studies, see: Jones (2008); Thornham (2013); Waggoner (2009); Wolf and Perron (2013); Crawford, Gosling and Light (2013); Domsch (2013); Egenfeldt-Nielsen, Smith and Tosca (2013); Ensslin (2011); Gamboa (2012); Garrelts (2005); Huntemann and Aslinger (2012); Juul (2011); Ruggill and McAllister (2011); Whalen and Taylor (2008); Paul (2012); and Newman (2012); among others.

sociologists,[8] and a host of researchers working in related disciplines,[9] but these scholars tend to consider game scoring vis-à-vis film scoring, rather than on its own terms, and they very often neglect the actual compositional procedure of game scoring *per se*.[10] As such, I offer the following case study — specifically, of Richard Vreeland's game score for the 2012 Xbox Live Arcade "puzzle-platform" game *FEZ* — as a means of elucidating and concretizing the theoretical terrain I intend to cover in this thesis. This theoretical terrain is drawn largely from work by Zach Whalen (2004) and Karen Collins (2013), both of whom pose salient questions about the interactive nature of game scoring. Whalen's (2004: 2) "Play Along – An Approach to Videogame Music" relates the concept of player immersion to game scoring:

> The interactive element of videogames requires its own analysis […] Cognitive theories of perception and questions of immersion versus engagement as a means of understanding 'flow' or pleasurability in games allows for a richer understanding of the complex communication involved in videogame music.[11]

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[8] For examples of sociological research on game scoring, see: Kohler (2005); Crawford, Gosling and Light (2013); Miller (2007; 2008a; 2008b; 2009); Schmidt (1989); Smith (2004); Svec (2008); and Demers (2006), among others.

[9] For example, much research on video game music comes from a relatively new field called interactive sound studies. For more on this see: Collins (2005; 2006; 2007a; 2007b; 2007c; 2007d; 2008a; 2008b; 2008c; 2009; 2013); Jones (2008); Thornham (2011); Waggoner (2009); Wolf and Perron (2013); Crawford, Gosling and Light (2013); Domsch (2013); Egenfeldt-Nielsen, Smith and Tosca (2013); Ensslin (2011); Gamboa (2012); Garrelts (2005); Huntemann and Aslinger (2012); Juul (2011); Ruggill and McAllister (2011); Whalen and Taylor (2008); Paul (2012); and Newman (2012), among others. In addition, a host of scholars have employed concepts from the field of psychology to analyze video game music: Cassidy (2009); Jørgensen (2008b); Kamp (2014); Nacke and Grimshaw (2010); Nacke et al. (2010); Sanders (2010); Tan (2010); Whalen (2004); and Zehnder and Lipscomb (2004; 2006), among others.

[10] For example, analysts, casual listeners and even gamers often confuse "video game soundtracks" with actual game scores. Video game soundtracks are officially-released and licensed as recordings which contain music from video games. The music contained on a video game soundtrack, however, differs from game scores since it is offered as a fixed sequence of audio information. I explore this distinction in-depth in Chapter 3 of this thesis.

[11] Mihaly Csikszentmihalyi (1990) defines "flow" as a state of complete involvement or immersion in an activity. To achieve a flow state, there must be a balance between the challenge of the task and the skill of the performer. If the task is too easy or too difficult, flow cannot occur. Game developers desire the cultivation of "flow" in the gamer because it is a pleasurable state.

Collins (2013) suggests that new media, such as video games, provide instances of interactive sound which are unique for their diffused sources of composition. In interactive sound design, she argues, not only the composer has a hand in the compositional process, but also the designer, programmer, and even the gamer. Like Whalen (2004), Collins (2013: 5) argues it is the very interactivity of gameplay which produces immersion, given the dialectic of "feedback and control mechanisms" in the gameplay experience. Collins' (2013) argument is useful as a basis for a study of video game music composition and will thus provide a primary model for the ludo-musicological analysis of game scoring I perform here.

## *Disasterpeace and* FEZ *: A Case Study of Game Scoring*

In what follows, I examine some aspects of the compositional process Richard Vreeland undertook to compose his celebrated score for *FEZ*, a puzzle-platformer video game released for Xbox Live Arcade in 2012. All of what follows, including screenshots of, and technical information about the music system for *FEZ*, is drawn from a conference presentation entitled "Philosophy of Music Design in Games," given by Vreeland himself at the 2012 Game Audio Network Guild Summit.[12] This is by no means an exhaustive examination, nor is it intended to be. The point of what follows is

[12] Screenshots of actual gameplay are created by the author.

simply to examine some aspects of game scoring, and to demonstrate that they resemble software programming more than anything traditionally described by the moniker of "music composition."

*FEZ* was developed by the independent software company Polytron Corporation, which includes the game's creator and designer Phil Fish, and its programmer Renaud Bédard. The latter were responsible for most of the development of the game. Fish determined the creative vision for the project, while Bédard made that vision a reality through programming. It was only until after the game's visuals were designed and programmed that Vreeland was invited to compose and produce the game's celebrated score, in fact. Therefore his task was to musically elucidate a pre-conceived visual world with its own spatial limitations, mechanics, aesthetics and logic, and to provide a score to represent, complement and sonically realize that world.

The world of *FEZ* is highly dynamic. Its "levels" consist of non-Euclidean[13] spaces known as "Rooms." At the outset of the game, Gomez, the game's "protagonist," is a two-dimensional creature who lives in a two-dimensional world. Much like the protagonist in the classic 8- and 16-bit *Super Mario Bros.* series, Gomez has impressive jumping abilities, which serve as the main element of gameplay in a world composed of various types of platforms. Eventually, after a short "tutorial" introduction, Gomez encounters a mysterious being known as the Hexahedron, who grants him a "magical fez hat" that allows him to perceive a third dimension, which rotates the gamer's perspective at will. As Gomez experiments with his new ability, the Hexahedron unexpectedly

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[13] Non-Euclidean space is space which cannot be measured by Euclidean geometry, which is the study of flat space. Non-Euclidean geometries introduce fundamental changes to our concept of space, as in *FEZ*.

fractures and explodes, causing the game to glitch, freeze and reboot, complete with BIOS screen. Gomez awakens in his room with his ability to perceive and manipulate a third dimension intact, and is charged with the task of recovering the scattered fragments of the Hexahedron before the world is torn apart.

Even after Gomez acquires the ability to perceive the third dimension, gameplay in *FEZ* remains largely two-dimensional. Depth, or the Z-axis, is only visible to the player in the rotation of perspectives, and is not a factor in the actual obstacles and chasms which Gomez must traverse. The player must manipulate these perspectives to explore the world of *FEZ* and collect thirty-two cubes in the form of “cube bits,” “whole cubes” or “anti-cubes.” In so doing, Gomez performs actions that would normally be impossible in a truly three-dimensional world. For example, he may be on a platform in which a rotation of perspective moves it to the other side of the screen, even though he has not moved at all. Figures 1 and 2 are gameplay screenshots from *FEZ*, which exemplify this mechanic.

**Fig. 1**: Gomez atop a tree, unable to reach a higher ledge.

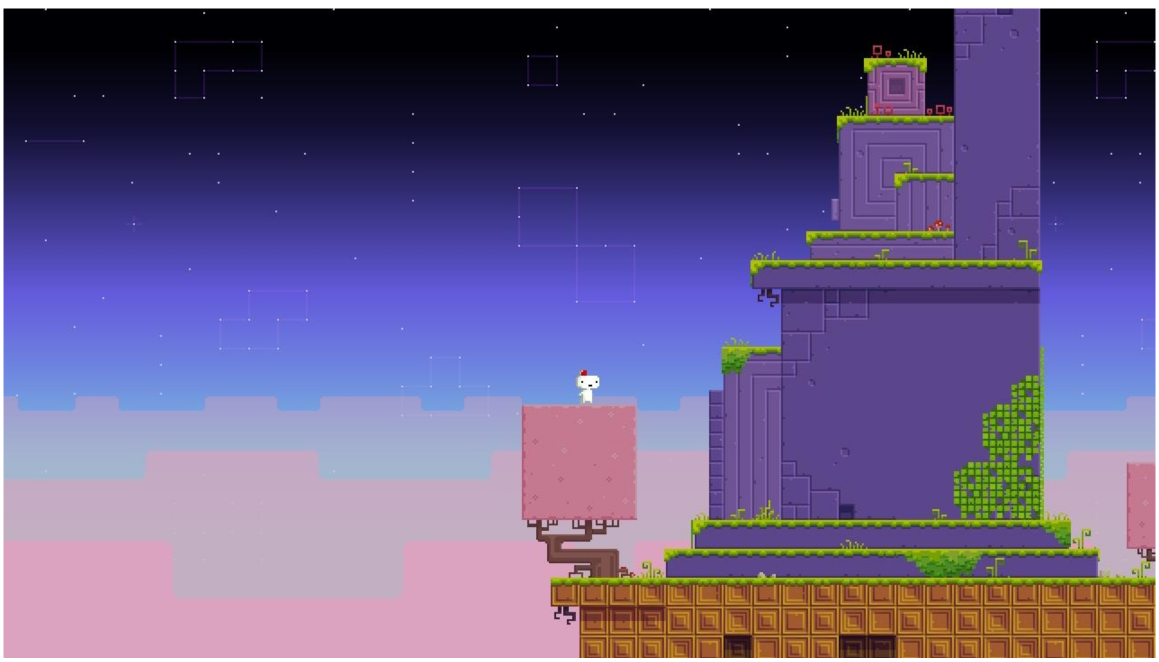

**Fig. 2**: Gomez atop the same tree as Fig. 1 with the perspective rotated once, ninety degrees clockwise. He is now able to ascend the tower.

Players of *FEZ* must conceive of space in a different way than usual in order to navigate its world. One of the first people who was allowed to explore this world, silently, was Rich Vreeland. Not only did Vreeland have to conceive of space differently in this initial run-through of *FEZ*, he was also forced to conceive of composition in a new way. The incorporation of the music system into *Fezzer*, the game's programming system developed by Renaud Bédard, allowed for this new compositional approach. Moreover, *Fezzer* was no less dynamic than the world it was used to create: as he composed, Vreeland was invited to propose ideas for the music system, which Bédard would then implement into his programming. The music system they eventually developed took the form of various tools and techniques integrated into *Fezzer* itself. Thus, the production and composition of the score for *FEZ* was inextricably linked with the development of gameplay and design. The three tools and techniques from *Fezzer* which I will explain now are (i) the sequence context menu; (ii) the scripts browser; and (iii) the main composition sequencer. These are names which I have given to these tools and techniques, and not what Vreeland or Bédard may have called them.

*Music System Overview: Sequence Context Menu*


**Fig. 3**: The sequence context menu in *Fezzer*. One of the appearing and disappearing blocks in one of the Music Rooms is right-clicked, prompting the context menu. (Vreeland [2012])

*Fezzer* allows the user to physically explore every aspect of *FEZ* as an omniscient observer. Manipulation of perspectives is not necessary here as the user can already view any area in three dimensions. Right-clicking on any element in the game world, such as the block in Figure 3, prompts the sequence context menu. The sequence context menu is a tool specifically for the assignment of sounds to physical elements within the game. It is used for either sound effects or music given the scenario, or both as in the instance of Figure 3. The "Sequence…" button allows the user to load a sample, piece of music or sound effect into the menu. In the above example, Vreeland has loaded "3x_03" and "3x_04" into the context menu as usable sound elements. These refer to the bright and bit-crushed synth arrays that coincide with the appearance and disappearance of bright red blocks in the Music Rooms.

This particular example involved considerable collaboration between Bédard and Vreeland. The former had to adapt the gameplay to the rhythm of the music composed by the latter. The blocks thus not only appear with the synth arrays, but appear on beat with the level's score. Vreeland said that this process involved thinking about music in terms of proximity rather than order, or in terms of spatiality rather than temporality.

The ability to visualize the implementation of music in *Fezzer* was indispensable in Vreeland's (2012) composition process, as he could now think about "which notes do I want to happen near other notes so that they sound pleasing." The word "near" in Vreeland's quote does not denote a nearness in time, but in (spatial) proximity between elements in the world of *FEZ*. Bédard's music system allows for a spatial conception of music through its incorporation into the programming software itself. Right-clicking an element and assigning it a sound may seem like a simple task, but it also prompts a new way of thinking about music production and composition.

*Music System Overview: Scripts Browser*

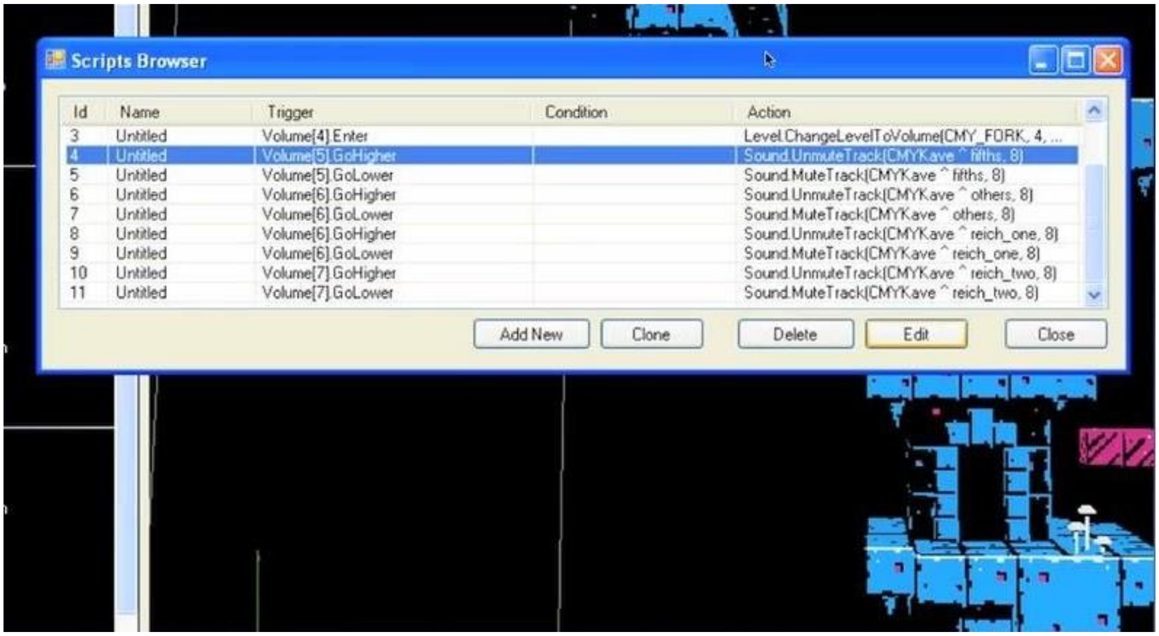


**Fig. 4**: The scripts browser window in *Fezzer*. This example is again from one of the Music Rooms, but the window may be pulled up in any area, as with the sequence context menu. (Vreeland [2012])

Unlike the sequence context menu, the scripts browser window in *Fezzer* affects an entire room rather than just any one single element. Scripts are programs which are written for a specific run-time environment that can read and execute tasks in an automated fashion. In other words, scripts are sets of tasks that can be performed by programs that can interpret them, hence *Fezzer* deals with its own specific type of scripts. The general nature of this definition points towards the wealth of possibilities with scripts, as they can perform almost any function so long as the host program can interpret them.

The scripts browser window in *Fezzer* is dominated by the presence of a table which lists each script's "Id," "Name," "Trigger," "Condition" and "Action." The "Id" of a script is simply an identifying number, while the "Name" column serves largely the same function. In Figure 4 it is safe to assume that Vreeland left the "Id" and "Name" fields at their default values. The "Trigger" of a script is generally self-explanatory as that which sets the execution of a script in motion, but its implementation becomes more complicated in specific cases. Figure 4 shows a scripts browser window with scripts for one of the Music Rooms, which incorporates altitude-sensitive musical elements. As Gomez ascends higher in the Music Rooms in *FEZ*, as in Figure 5, different musical elements are added to and subtracted from the mix. Each trigger therefore indicates an altitude, signified by the "Volume[x]" condition.

Furthermore, there is another condition which signifies whether Gomez is higher or lower than the specified altitude. For example, script four has "Volume[5], GoHigher" as its trigger value, so any time Gomez goes higher than an altitude of "5," the script is triggered. The numbers which denote altitude are arbitrarily assigned to invisible blocks in the Music Room, which are positioned by Bédard. The "Condition" column of the scripts browser allows for any other conditions to be entered, such as time of day or perhaps the amount of cube bits Gomez has acquired. In Figure 4 no extra conditions are necessary, so the column remains unused. Finally, the "Action" column refers to what action will be taken when the trigger's conditions are met.

It may be helpful here to reiterate the flexibility of scripts, and note that they are governed by their own scripting language. "Volume[x]" thus refers to altitude in the trigger field, rather than the volume of a sound, for example. The "Action" column uses this same scripting language in the form of "[Target type].[Action][Target type 2]([Name], [Number of bars]," where "Target type" is the type of element being acted upon, “Action” is the action to be taken, “Target type 2” is the sub-type of element being acted upon, “Name” is the name of that element and “Number of bars” is simply the length of the element. Script four, for instance, performs the unmute function on the loop “CMYKave ^ fifths,” which is 8 bars long.

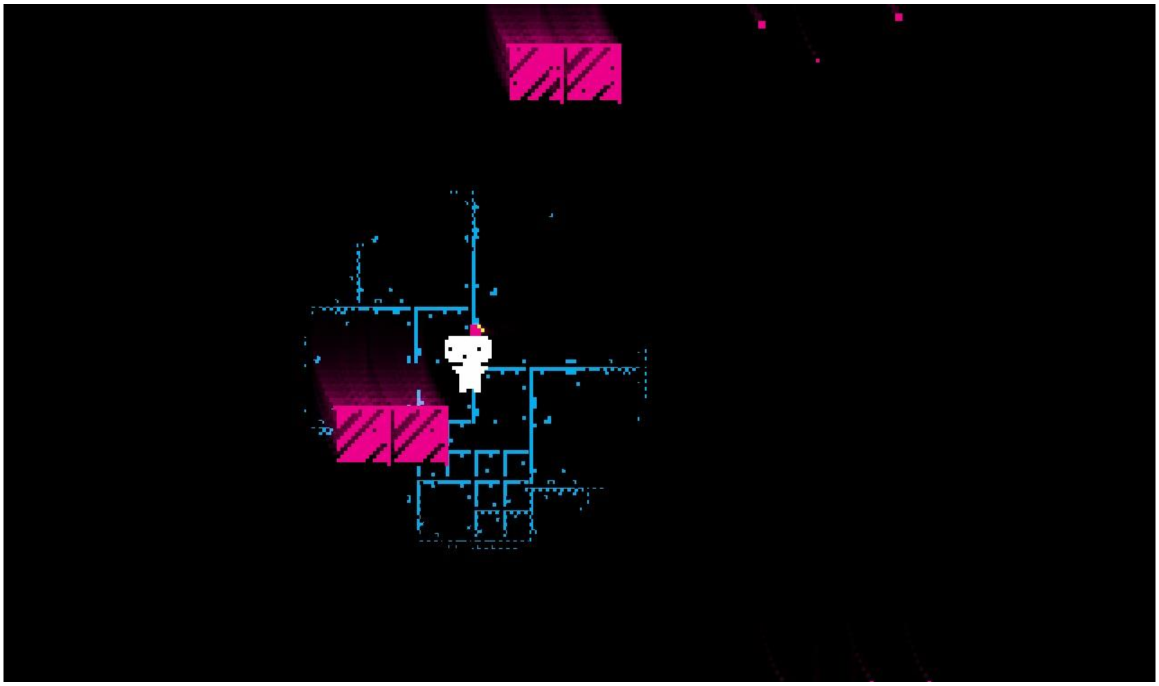

**Fig. 5**: Gomez ascends the first Music Room by jumping to bright red blocks as they appear.

If Gomez ascends higher than the altitude marked by an invisible block as “5,” a new musical element will therefore enter the mix, and it will remain there unless Gomez descends lower than the marked altitude. When this happens — that is, when Gomez descends below the designated altitude — gamers hear the opposite effect: the loop is muted again. In this sense, Vreeland’s “composition” for the game is actually interactive, what Vreeland calls “Music Gameplay.” Progress in the Music Rooms is signified by the soundtrack, which rewards players with more elements of the song as they approach the summit.

*Music System Overview: Main Composition Sequencer*

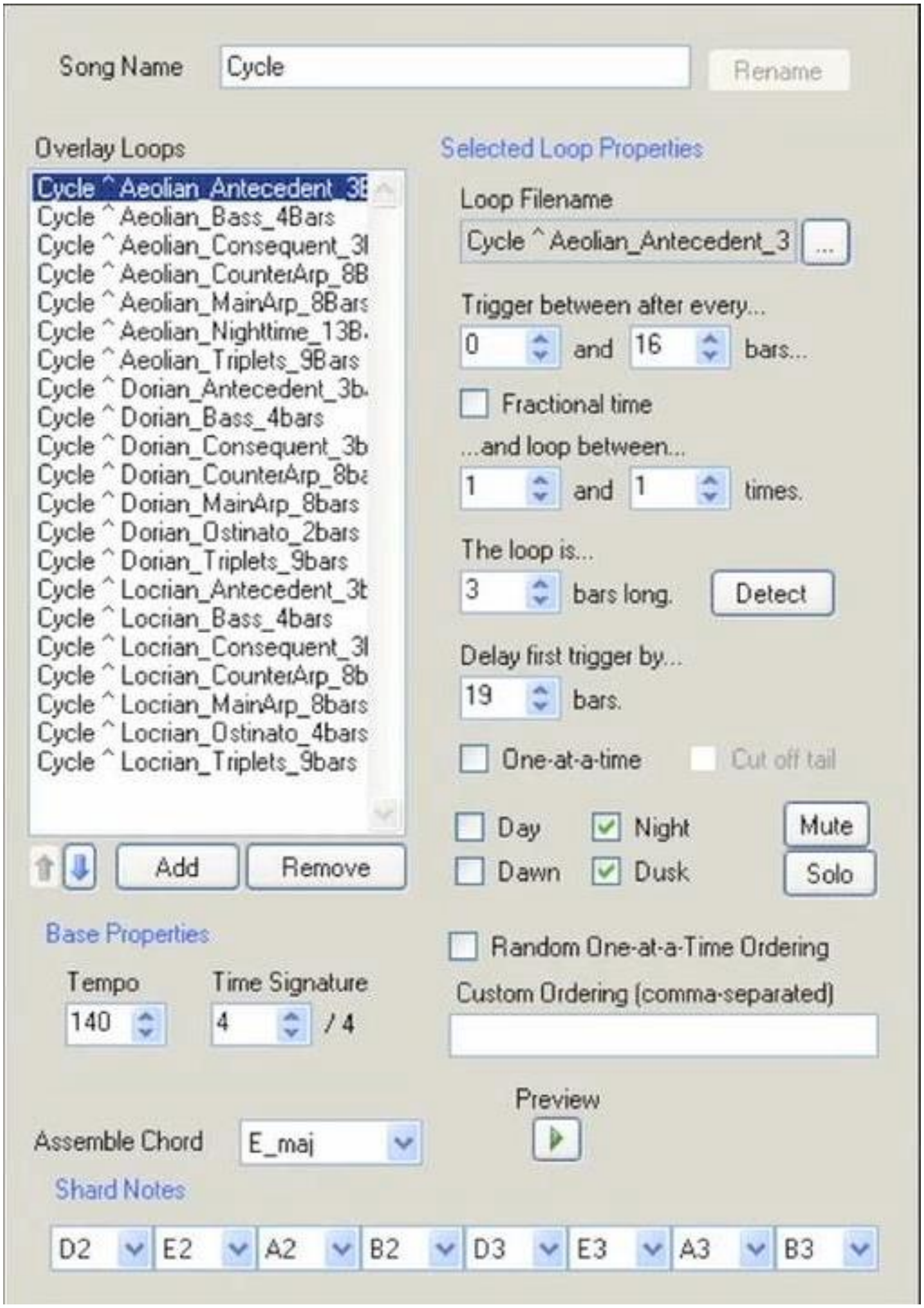


**Fig. 6**: The main composition sequencer window. This example is from work on one of the Puzzle Rooms, which uses the song "Cycle." (Vreeland [2012])

The main composition sequencer window is used mostly to determine the timing logic of the elements in one of Vreeland's "songs." Like the scripts browser, the main composition sequencer can make changes that affect an entire level, but also, like the sequence context menu, it can be used to tweak single musical elements. The song name can be entered or re-entered at the top of the window. The "Overlay Loops" list box displays all the loops that can be in a level's song, which can be added, removed and reordered with the buttons at the bottom.

Although it is not readily evident in Figure 6, I assume that you may select and manipulate more than one loop at a time for faster workflow. Vreeland's naming style for his loops can be seen in the above example, and takes the form of "[Song Name] ^ [Mode]_[Musical Element]_[Amount of bars]bars." All the information of a given loop is in the file name, so there is no guesswork necessary to determine which loop is which. It is notable that the "Musical Element" field does not adhere to any specific type of musical aspect, but instead serves solely to help programmers identify the loop. In some cases, it identifies a type of instrument featured, as in "Bass," while in other cases it identifies a melodic phrase in relation to others, such as "antecedent" and "consequent."

The "Selected Loop Properties" area serves most of the functionality of the main composition sequencer window. The "Loop Filename" is visible at the top, with a browse button beside the text field. The "Trigger between after every…" area has two text fields, with scroll arrow buttons, where a range of bars may be entered. In Figure 6 the song "Cycle" is split into many overlay loops, which play in the Puzzle Rooms according to the settings entered here. The "Trigger" section, for instance, denotes where the selected loop will play, within a given range if desired. This makes the actual song heard during gameplay slightly unpredictable, or aleatoric, as loops may come and go anywhere within these set ranges.

Below, the “Fractional time” checkbox allows for irregular time signatures to be used in the deployment of loops. The “…and loop between…” section includes another pair of text fields with scroll arrow buttons. These can be set to a range of the amount of times the selected loop will play — another instance of aleatoric composition involving chance operations. The length of the selected loop may be entered in the “The loop is…” field, or it may be automatically supplied by the “Detect” button. Vreeland’s naming style incorporates the length of the loop in bars, so it is likely that he never uses the “Detect” button. The “Delay first trigger by…” field can be set to denote the number of bars after which the loop is played the first time. In this case, loops may be staggered in order to adhere more to the logic of a traditional song form.

The “One-at-a-time” checkbox is oddly placed, as its setting applies to the entire song “system,” instead of just the selected loop. This setting works in conjunction with the “Custom Ordering” text field below it, and allows the user to restrict the song to play only one loop at any given time, while the “Custom Ordering” field dictates the order of those loops. Alternatively, “Random One-at-a-Time Ordering” precludes the need for a custom order, as it plays loops one at a time at random. The “Mute,” “Solo” and “Preview” buttons are used to preview the song or selected loop within the main composition sequencer window. Finally, the time of day checkboxes “Day,” “Night,” “Dawn” and “Dusk” may be checked to specify when the selected loop may play according to the game’s time system.

The “Base Properties” section of the composition sequencer allows for song-wide changes to be made to tempo and time signature. As with many settings in this window, these are musical elements which would normally be set in the compositional stages of writing music. In non-interactive sources of music such as records, the tempo and time signature are ordinarily set early in composition because they can dramatically change the form of the song. This follows a more traditional approach to composition because it is built upon the notion of a song’s “essence” which can be represented as notation (or sheet music). In *FEZ*, the “essence” of the song is in gameplay, as it were, because it is inextricably linked to it. Settings such as tempo and time signature must therefore remain malleable even late into the composition process. Alternatively, perhaps a better way to express this difference would be simply to say that the composition process must remain extended and “open,” right until the video game itself is complete.

The bottom section of the main composition sequencer actually deals with sound effects, as Vreeland wanted the eight cube bits that make up a full cube to have corresponding sounds that make up a full musical scale. The “Assemble Chord” drop-down menu allows the user to choose the chord to be assembled, while each drop-down menu in the “Shard Notes” area allows the user to choose a note for each cube bit to play.

*The Primary Research Question: How is Game Scoring Unique?*

As should now be evident, "game scoring," that is, composing music for video games, depends on — in fact, it arguably *is* — software programming. The game scorer's choices are thus limited by available gaming technology, and the "programmability" of their musical ideas given that technology. Moreover, game scores are unique in that they must allow for an unprecedented level of musical flexibility, given the high degree of user interactivity the gaming medium enables and encourages. As such, game scoring necessarily constitutes an at least partially "aleatoric" compositional activity, the final score being determined as much through chance gameplay as traditional composition.[14] Despite these unique attributes, though, and despite the recent proliferation of game scoring in general, very little is written by scholars about game scoring as an unique compositional activity.[15]

Though game scoring likely requires volumes of research to comprehensively analyze, in what follows I begin the process of considering the musical process of game

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[14] Aleatoric music is music in which some element of the composition is left to chance, and/or some degree of freedom is afforded its performer. For more on this, see Rubin (2005) and Antokoletz (2014).

[15] This is not to say the scholars do not write about music for video games. Rather, I argue that they treat it as a cousin of film scoring, primarily, when game scoring requires consideration as a completely unique compositional activity. See, for instance: Belinkie (1999); Berndt (2009; 2011); Berndt and Hartmann (2007; 2008); Berndt et al. (2006); Brame (2011); Bridgett (2010); Chan (2007); Childs IV (2007); Collins (2005; 2006; 2007a; 2007b; 2007c; 2007d; 2008a; 2009); d'Escrivan (2007); DeCastro (2007); Deutsch (2003); Farnell (2007); Fay (2004); Furlong (2004); Gibbons (2009); Herber (2008); Hermans (2013); Hoffert (2007); Kaae (2008); Knight (1987); Lendino (1998); Lieberman (2006); Marks (2009); Mera (2009a; 2009b); Sanger (2003); Schmidt (1989); Sweeney (2011); Van Geelen (2008); Whitmore (2004); and Wooller et al. (2005), among others.

scoring on its own terms.[16] To do this, I model a so-called "ludo-musicological" analysis of game scoring. Ludo-musicology is a relatively new field of research, which focuses exclusively on music composed for video games. This analytic perspective acknowledges the "performative" and "interactive" aspects of video games, which create the unique challenges and concerns that game scorers, and analysts of game scoring, must address through their work.[17] Indeed, as Collins (2013: 1) explains, "[video] games, mobile phones, and other modern digital media alter the traditional relationships between creator and consumer, audience and performance when the audience takes a participatory role in instigating sound events."[18]

In fact, game scorers arguably *collaborate* with players to produce the final score for a game. In *Super Mario Bros.* (1985), for instance, the thematic content of each composition's conclusion is determined by whether or not players successfully complete a level. If players "beat" a level, the score triggers the "Flagpole Fanfare" theme, a triumphant ascending melody (see Figure 7 below). Players who fail to conquer that same level, on the other hand, hear the "Death Sound," a comedic descending riff instead (see Figure 8 below).[19] Thus, whether or not the "Flagpole Fanfare" theme ever sounds,

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[16] Enns (2014).

[17] For more on this see http://www.Ludomusicology.org.

[18] Though this project will indeed place a significant focus on the gamer, it will not be a reception-based discussion of the cultural ramifications of interactive media. Instead I offer a broader analytic of game scoring from a purely musicological perspective. A review of important work on interactive media from cultural studies would have to include: Collins (2005; 2006; 2007a; 2007b; 2007c; 2007d; 2008a; 2008b; 2008c; 2009; 2013); Jones (2008); Thornham (2011); Waggoner (2009); Wolf and Perron (2013); Crawford, Gosling and Light (2013); Domsch (2013); Egenfeldt-Nielsen, Smith and Tosca (2013); Ensslin (2011); Gamboa (2012); Garrelts (2005); Huntemann and Aslinger (2012); Juul (2011); Ruggill and McAllister (2011); Whalen and Taylor (2008); Paul (2012); and Newman (2012), among others.

[19] "Flagpole Fanfare" may be played at http://www.youtube.com/watch?v=3BsBXp6VkvU. The "Death Sound" is playable at http://www.youtube.com/watch?v=M6KOEMJKdEI.

and how often, is up to the gamer, even while it is the game scorer who determines what that theme ultimately sounds like.

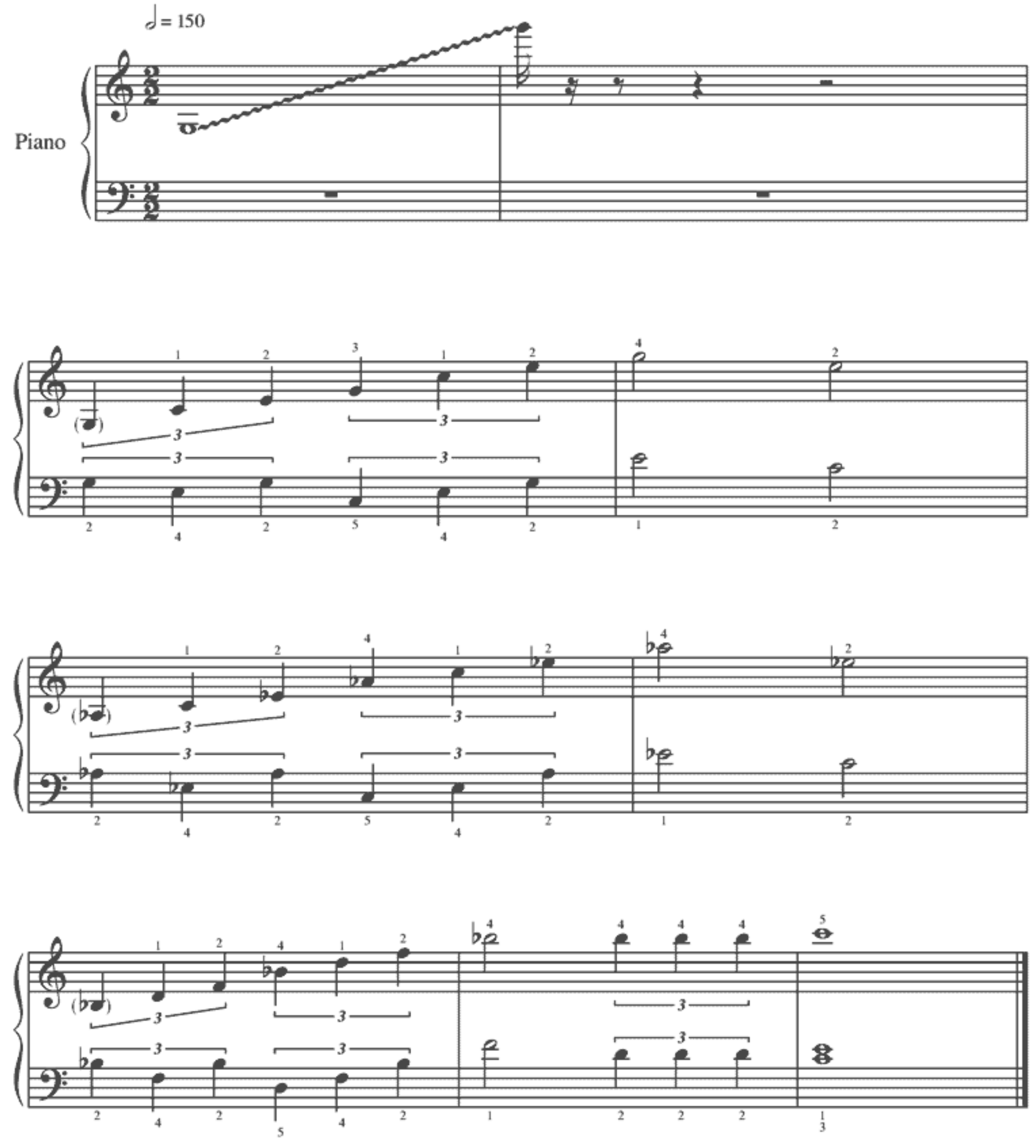


**Fig. 7**: A piano transcription of the "Flagpole Fanfare" theme heard when a player successfully completes a level in *Super Mario Bros.* The ascending melody has a triumphant or victorious thematic content. ("Flagpole Fanfare")


**Fig. 8**: A piano transcription of the “Death Sound” which plays when a player loses a life and fails to “beat” a level. The descending riff evokes disappointment, but is notably shorter than the “Flagpole Fanfare” theme and adds a comedic element through syncopated percussion. The “Death Sound” in *SMB* is archetypal for its effectiveness in encouraging the player to attempt the level again, even after “dying” multiple times. (“Death Sound”)

An obvious research question thus arises: *how exactly is game scoring distinct from scoring for other media*? Before I can explain how I will answer this question, I will first have to quickly consider scoring for non-interactive media. While film seems to be a suitable medium for this comparison, to better elucidate game scoring’s more subtle peculiarities I choose to analyze a medium that analysts, casual listeners, and even gamers, chronically confuse with actual game scores: video game soundtracks. Video game soundtracks are officially-released and licensed as recordings which contain music from video games. The music contained on a video game soundtrack, however, differs from game scores in that it is fixed and subject only to playback and equalization listens. Moreover, it is composed through a terminable scoring process, unlike game scores, which are composed through gameplay (as I argue in Chapter 3 of this thesis).

Video game soundtracks are not open to aesthetic permutations given distinct gameplay experiences, in other words. They have the same formal contours every time they are played. Video game soundtracks are, in other words, ontologically "closed."[20] In effect, they are "idealized" versions of game scores, and in many cases impossible to reproduce by gameplay itself, whereas game scoring remains ontologically "open." It depends entirely on, and remains completely responsive to, gameplay and, thus, no single definitive game score can ever actually be said to exist.

*Methodology & Structure*

This thesis includes four chapters in total. In Chapter 1, I have offered a critical orientation to the subject of my thesis, namely, game scoring. This required providing a broad survey of ludo-musicology and its primary subject (ie., game scores). I performed a case study of the game scoring process for *FEZ*, in order to concretize the theoretical terrain I examine in Chapters 2 and 3. I should note that a major aim of this research project is to develop a working methodology for the study of game scores. In other words, the methodology of this thesis will constitute an outcome, rather than just basis of my work. This methodology runs roughly as follows:

1. Examine the musical ability of the gaming technology (ie., the sound hardware configuration) used to produce the game score.

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[20] I use the term "ontological" here as Martin Heidegger uses it, who notes that "ontological inquiries in philosophy are concerned with [being]" (qtd. in Munday [2009]: "Ontology"). Thus, an ontological inquiry into popular music scoring would analyze where such a process exists. Such an inquiry would reveal that the process only exists and terminates in the production of the record. It is ontologically closed because scoring does not continue in the playback of said record.

2. Examine compositional strategies undertook in response to the musical ability (and limitations) of the gaming technology used to produce the game score.
3. Produce game scores (play the video game).
4. Examine game scores for all musical outcomes, and analyze the gameplay states which "trigger" these outcomes.
5. Relate (1) and (2) to (4) by examining the compositional activity involved in gameplay itself (with a focus on chance operations and any degree of performer freedom involved therein).

In Chapter 2, I argue that game scoring is distinct from other scoring, because it is structured entirely by gaming technology. I demonstrate this through a case study of the NES APU, wherein I survey this gaming technology's musical possibilities and limitations. I choose this as the subject of my case study because it is simply instructive. That is, the NES APU is an ideal subject because it has relatively simple musical abilities. This is true of all my case studies, such as the choice of levels in Chapter 3, for instance. With these findings, I am able to discuss specific compositional strategies NES game scorers developed in response to the technology of the NES APU. This reveals how NES game scoring is structured by NES technology, and, more importantly, how game scoring in general is structured by gaming technology.

In Chapter 3, I argue game scoring is distinct from other scoring, because it constitutes a kind of aleatoric compositional activity. To do this, I first provide a brief case study of a canonic aleatoric composition, namely, John Cage's *TV Köln* (1958), in order to survey the aleatoric tradition, which developed long before the release of the first video game. Here I outline the basic tenets of aleatoric music, such as the loss of composer control, through specific reference to Cage's piece. Importantly, *TV Köln* — as well as much of the aleatoric repertoire — includes a recognition and integration of sounds which analysts would normally consider "extramusical sound effects." I use this to model my consideration of sound effects as a component of a game score just as crucial as its "music." Game scorers must recognize, integrate, and in many cases "compose" sound effects as they work, and game scores are marked by many instances of such sounds.

With an understanding of the aleatoric tradition, I am able to begin an analysis of the "performance" of aleatoric music in video games. This will involve a case study of "World 6-2," one "level" of *Super Mario Bros.* for NES. I analyze game scores produced by my own gameplay, and I expect to find many "chance operations" and opportunities for "performer freedom" in my scores for this level. Finally, I elucidate these and game scoring's aleatoric nature through a comparison of my game scores for World 6-2 to the officially-released soundtracks for *Super Mario Bros*.

In Chapter 4, I provide a brief summary of my findings, and I consider some future directions for continuing my research. I expect the results of this research to prove that game scoring is an unique compositional activity which is distinct from other scoring. I conclude by considering the significance of the completed research to the field of ludo-musicology, and its implications for future research on game scoring.

# *Chapter 2*

## *The Technological Structure of Game Scoring: A Case Study of the Nintendo Entertainment System's Audio Processing Unit*

### *Introduction*

"Game scoring," that is, composing music for video games, is distinct from other types of scoring, because it is structured entirely by gaming technology. Indeed, video game music exists within, and as a part of, a much larger medium, namely, the medium of video games.[21] As such, a host of priorities, values and concerns peculiar to that medium inhere in the game scoring process, which do not inhere in other compositional activities.

Video game developers have historically exhibited a visual bias in resource allocation during game development, for instance. This "ocularcentrism" has had

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[21] This thesis focuses exclusively on game scoring. For more on gaming culture *per se* consult: Schott and Horrell (2000); Carr (2005); Jansz, Avis, and Vosmeer (2010); Kontour (2012); Condis (2014); Chen (2014); Williams, Hendricks, and Winkler (2006); Kirkpatrick (2012); Schleiner (2001); Bryce and Rutter (2002); Morris (2004); Natale (2002); Steinkuehler (2005); Holbert and Wilensky (2010); Taylor (2003); Maguire et al. (2002); Schleiner (1999); Kücklich (2005); Wirman (2014); Deuze, Martin, and Allen (2007); Gros (2007); Örnebring (2007); Kennedy (2002); Sotamaa (2003); Sich (2006); Nieborg (2005); Salen (2007); Daniels and Lalone (2012); Cover (2006); Lin (2008); Murray (2006); Corneliussen and Rettberg (2008); Kingma (1996); and Jakobsson (2011), among many others.

perhaps the most profound influence on game scoring.[22] Music is routinely subordinated to graphics when games are produced, even if players have cited music as a crucial facet of the gaming experience since the advent of home gaming consoles.[23] The compositional process is thus fundamentally structured for game scorers in a peculiar way: musical ideas must be "programmable," as it were, even as the hardware and software resources earmarked for musical programming are chronically scarce. Koji Kondo (2010: n.p.), who composed the scores for the epochal *Super Mario* and *Legend of Zelda* games, speaks to the game scorer's peculiar predicament:

> Due to the differing capabilities of game systems, the way I make music has changed. The Famicom could only produce 3 tones and didn't have a large variety of sounds, so I had to do a lot of scheming. There wasn't a lot of memory, either, so I had songs where I couldn't fit everything in, and I made songs with a limited number of sounds. When the Super Famicom came along, it had 8 tracks to work with.[24]

Kondo suggests that different gaming consoles present different possibilities for scoring, and that composers must adjust their scoring strategies accordingly. In other words, each console provides a particular set of rules and limitations which fundamentally structures the game scorer's compositional ideation and practice in unique ways. *If there is no means to program a musical idea, the game scorer must consider other options.* This has ever been the case. Indeed, technology is likely to structure and

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[22] For more on ocularcentrism and acoustic space see, for instance, Sterne (1997) and Hodgson (2007).

[23] Game scores — such as the soundtracks for, to name some better known examples, *Super Mario Bros.* (Koji Kondo, 1985), *Ice Climber* (Akito Nakatsuka, 1985), *The Legend of Zelda* (Koji Kondo, 1986), *Metroid* (Hirokazu Tanaka, 1986), *Mega Man* (Manami Matsumae, 1987), and *Mega Man II* (Takashi Tateishi, 1988) — have been celebrated on their own merits since their release. For more on this, see: Murphy (2012); Campbell (2013); and Hannigan (2014), among many others.

[24] The Nintendo Family Computer, or "Famicom," is a video game console released in Japan in 1983. Its North American counterpart, the Nintendo Entertainment System, or "NES," was released in 1985.

restrain the game scorer's compositional process for as long as such technology is required to actualize a game score.[25] Kondo (Ibid.) continues:

> Even now I compose with the amount of memory in mind. So I can't say the process is entirely without limitations. On *Mario Galaxy*, for example, I didn't use a live orchestra, I made the music to match up with the game, so by synchronizing with the on-screen action the songs changed interactively. For the boss battles, you power up and become stronger when you take damage, right? At that point, the orchestra grows fuller, the chorus comes in… that's game music for you.[26]

A significant research question arises: how *specifically* does gaming technology structure game scoring? Which *particular* technological limitations — which *specific* restraints on the compositional process — do game scorers navigate when they work? To answer this question, I will provide a detailed case study of game scoring for the Nintendo Entertainment System (NES), surveying how that technology structures the compositional process for NES games in particular. This requires examination of that console's sound hardware configuration, with an eye to uncovering the musical possibilities and limitations it presents to composers. As part of this examination, I survey well known moments when game scorers have, to borrow Kondo's term, "schemed" *within* the NES' sound hardware configuration to produce their celebrated game scores, consciously compromising and adjusting certain aesthetic concepts to better suit the NES hardware. I focus in particular on the way game scorers have "schemed", or navigated, the crucial first step of the scoring process, namely, so-called "orchestration"

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[25] This restraint is further exacerbated by the ocularcentrism inherent in gaming culture, as resources are allocated to visual ends.

[26] The citation refers to *Super Mario Galaxy*, a 3D platform game developed and released by Nintendo in 2007, whose score Kondo composed with Mahito Yokota.

(i.e., selection of musical instruments or timbres for different musical ends). In fact, orchestration in game scoring is radically different from orchestration in other genres, and it is game scoring's fundamental structuring by gaming technology which specifically accounts for this difference.

### *Case Study — The Nintendo Entertainment System's Sound Hardware Configuration*

The following case study considers the Audio Processing Unit (APU) of the Nintendo Entertainment System (NES) from a specifically compositional point-of-view. By considering the musical nature of each of the NES APU's five available channels for scoring, I will elucidate game scoring's general technological structure. That is, by demonstrating that all aesthetic possibilities in game scoring for the NES are in the first instance determined by the NES' sound hardware configuration, that composers are free only insofar as they may assemble and superimpose only those musical terms that the NES APU can generate, I will concomitantly demonstrate that, in general, all compositional ideation in game scoring must occur within a broader hierarchy of technologically structured possibilities — a hierarchy that ultimately begins and ends with an idea's "programmability" (Hodgson [2006]). If musical ideas cannot be programmed, they simply cannot exist; and whether or not a musical idea can exist in game scoring is determined *in toto* by the sound hardware configuration used to actualize it.

The NES sound hardware configuration is known as the APU, which is a processing unit implemented in the NES' Central Processing Unit (CPU).[27] The APU is comprised of five discreet channels: two pulse wave generators (PWC), a triangle wave generator (TWC), a noise generator (NC), and a delta modulation channel (DMC) which triggers low-resolution (i.e., shorter bit-depth) audio samples. According to the official NES development Wiki (NES-Dev: "APU"):

> Each channel has a variable-rate timer clocking a waveform generator, and various modulators driven by low-frequency clocks from the frame counter. The DMC plays samples while the other channels play waveforms.

The APU's operation depends, most fundamentally, on processing units called "timers," which are "clocked" by an overarching "word-clock" count from the CPU.[28] Timers are responsible for clocking the actual waveform generators in each sound channel, and they provide modulation (i.e., sound processing) parameters for each available channel in the APU.[29] The main difference between the APU's waveform channels, and its DMC, is that the former generate their own sounds in "realtime," via analogue monophonic synthesizers, while the latter stores, recalls and triggers digital

[27] The CPU for the NTSC (North America and Japan) Famicom and NES was the Ricoh 2A03, or RP2A03, and for the PAL (Europe and Australia) NES, the Ricoh 2A07, or RP2A07. Further technological specifications will always be for the NTSC NES, except where noted. Purely technical information is taken from the official NES development Wiki.

[28] This term refers to frequency, where "clock speed" would indicate the frequency at which a CPU is running, for instance. "Clocking" another processing unit such as a timer would then refer to providing information at regular intervals, at some fraction of the frequency which the CPU is running at.

[29] According to Truax (1999: "MODULATION"): "Whenever a parameter of a sound or audio signal […] is varied systematically, the signal is said to be modulated."

audio samples from memory. I now turn my attention to considering each individual channel in the APU in greater detail, in turn, in the section immediately following.

### *Channel Overview: Pulse Wave Channels*

The NES APU contains two identical pulse wave channels. These channels have a "bright" and "sharp" timbre, which is to say, they oscillate frequencies falling in the midrange and upper-midrange of human hearing (ie., roughly 700 Hz to 12 kHz). As such, composers tend to use these channels to convey the primary melodies of their game scores (Schartmann [2013]). Moreover, since they have two *identical* PWCs at their disposal, scorers will often orchestrate their melodies as a unison, shared between both PWCs. When composers see fit to use other channels to convey their melodies, they typically use the PWCs in tandem to generate rudimentary chordal accompaniment.[30]

A total of sixteen dynamic settings, ranging from silence to "full-scale," or maximum volume, and three different "volume envelope shapes," are available in the NES APU.[31] These envelope shapes include: (i) constant; (ii) linear decreasing; and (iii) looping linear decreasing, or, "sawtooth" (see Figure 9 below). However, game scorers

[30] For example, see Koji Kondo's "Dungeon Theme" for *The Legend of Zelda* (1986), which uses the triangle wave for its main melody to frightening effect.

[31] An "envelope shape" is the shape generated by a graph of one parameter of sound, such as volume, versus time. A sound's volume envelope is related to its "ADSR." As White (1987: "ADSR") notes: "[ADSR is short for] 'Attack decay sustain release,' time constants associated with signals generated by electronic music synthesizers. The attack time is the time it takes the signal level to rise from zero to its maximum value. The decay time is the time required for the level to fall to the sustain value, and the sustain time is the time it remains at this value. The release time is the time it takes for the level to fall to zero after the sustain time is elapsed […] The ADSR actually defines the envelope of the generated signal."

seldom use a "constant" envelope shape *per se* ((i) in Figure 9 below). This envelope shape is deployed so that, later on, a more sophisticated envelope generator can be used to modulate it, producing a more complex shape. The "linear decreasing" shape ((ii) in Figure 9 below), on the other hand, is typically deployed to emulate the decay and release of acoustic instruments, that is, to simulate the manner in which acoustic instruments fade to silence.[32] Finally, the "sawtooth" envelope shape ((iii) in Figure 1 below) is used to produce a variety of results such as, to name a celebrated example, the electric guitar timbre heard in Takashi Tateishi's "Opening" theme for *Mega Man II*.[33]

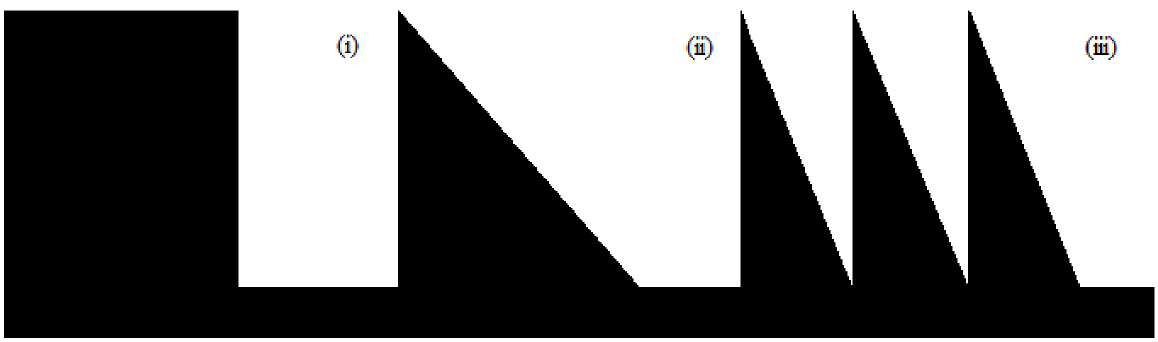


**Fig. 9**: The three envelope shapes generated by the PWCs in the NES APU. These are (i) "constant;" (ii) "linear decreasing;" and (iii) "sawtooth."

Aside from these envelope shapes, the NES APU's two PWCs have three distinct timbres available, due to a feature known as "variable duty cycles:"

> Duty cycle is the fraction of time that a system is in an "active" state. The duty cycle of a square wave is 0.5, or 50%. Some music synthesizers, including square

[32] This said, the volume envelope of acoustic instruments seldom decrease in a linear fashion. The NES is, of course, incapable of emulating such sounds in a verité manner.

[33] Tateishi is credited by the alias "Ogeretsu Kun" in the game's credits, for some reason unbeknownst to the author.

> channels of 2A03[34] and VRC6,[35] can vary the duty cycle of their audio-frequency oscillators to obtain a subtle effect on the tone colors ("Duty cycle")

The "system" in this definition simply refers to a sound wave, while "active state" refers to the state of a waveform above the horizontal axis. Changes in duty cycle alter the timbre of any given sound. Game scorers have four variable duty cycles available to them through the NES APU's PWCs: 12.5%, 25%, 50%, and 75%. Figure 10 shows these duty cycles as they appear after a single pulse wave.

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[34] The NES' CPU, developed by Ricoh, also referred to as the "RP2A03."

[35] The VRC6 (Virtual Rom Controller, revision 6) is a memory management controller developed by Konami primarily for *Castlevania III: Dracula's Curse* (originally released as *Akumajō Densetsu* in Japan, 1989), released for the NES in 1990. Memory management controllers comprise many kinds of special chips designed by video game developers and implemented in NES and Famicom game cartridges, to extend the abilities of the stock NES and Famicom consoles. The Japanese Famicom, unlike the North American NES, had the ability to generate extra sound channels with these chips. For example, Konami's VRC6 added the ability to generate two extra square waves and one sawtooth wave for the score of *Akumajō Densetsu*. The scores for *Castlevania III* and *Akumajō Densetsu* are markedly different due to different scoring structures provided by different technological configurations — which pertain to musical capabilities in particular — while the games retain nearly identical visuals and gameplay.

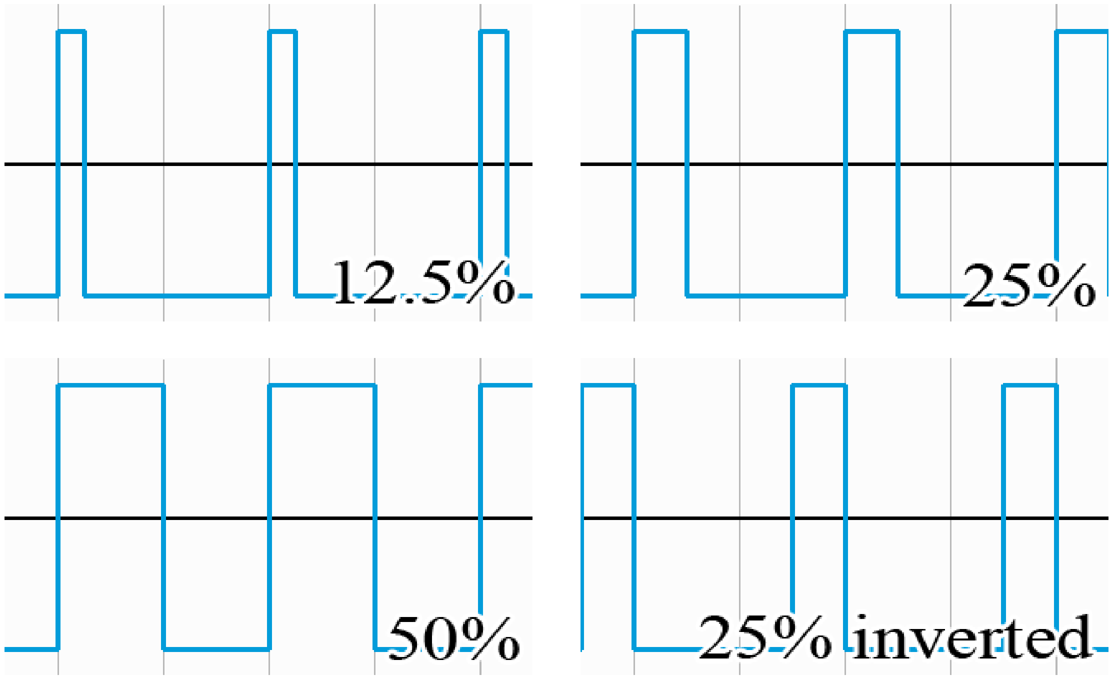


**Fig. 10**: The duty cycles available to the NES APU pulse wave channels. The 75% duty cycle is instead offered as an inverted 25% duty cycle to illustrate that it has a nearly identical (in fact, indistinguishable to the human ear) timbral quality to a normal 25% duty cycle. Thus, the NES, for musical purposes, only has three distinguishable duty cycles for its two pulse wave channels. (“Duty Cycle”)

A lower duty cycle produces a thinner, “sharper” timbre, while a higher cycle produces a fuller, “smoother” timbre. A 50% duty cycle thus produces the fullest and smoothest sound available through the PWCs, a 12.5% duty cycle produces its thinnest and sharpest sound, and a 25% duty cycle falls directly between these timbral extremes.[36] The NES game scorer is not strictly limited to using only one or another duty cycle, however. Composers can program the APU to produce variations in duty cycle at any given moment, even when one of the PWCs is in the midst of oscillating a particular frequency (“mid-note,” as it were), which increases the score’s timbral potential

[36] A “pulse wave” with a 50% duty cycle is more commonly referred to as a “square wave,” since its active and inactive states are of equal length.

exponentially. More often, though, as Schartmann (2013) explains, duty cycles are switched to demarcate different musical sections, to change instrument, and to generate simple textural variety. Schartmann (2013: 44) cites an excellent example:

> The introduction to "Wood Man's Theme" in *Mega Man 2* (1989)…. begins with a low-percentage duty cycle, only shifting to 50% — a much "rounder" sound — when the theme begins in earnest. Thus the music's introductory measures are played by a different "instrument" than the principal theme.

Finally, pitch-bending is available through the PWCs, thanks to the APU's "sweep unit." The "sweep unit" increases or decreases a PWC's "period," that is, its rate of oscillation, which in turn determines the frequency or "pitch" of the sound the PWC produces (higher periods of oscillation produce higher frequencies, while lower periods produce lower frequencies). Pitch-bending is most often used by NES game scorers to create a "vibrato" effect, as can be heard in Koji Kondo's "Flute" melody for *The Legend of Zelda* (1986).[37]

### *Channel Overview: Triangle Wave Channel*

The Triangle Wave Channel (TWC) has only a limited range of musical capabilities. This channel is most often used by game scorers to generate low frequencies, that is, frequencies below 450 Hz, typically to set bass parts in a score. Though square waves are generally considered an ideal synthesized bass timbre, given

[37] Sound effect or music? Do sound effects count as game scoring? I address these broader questions in Chapter 3.

their constant amplitude and harmonic structure, triangle waves are better-suited for this task than any other waveform available in the NES APU.[38] A triangle wave generally sounds much "smoother" and "rounder" than a pulse wave, for instance, because it alone features a regularly cyclical envelope shape and, consequently, it outputs a preponderance of odd-ordered harmonics. Moreover, the triangle wave features a less intense harmonic structure, and a longer period of decay, than do pulse waves, meaning that the TWC alone generates fundamental frequencies below 450Hz without concomitantly outputting loud harmonic content above about 7 kHz (See Figure 11 below).[39]

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[38] According to White (1987: "Overtones"): "[overtones] are tones produced by a musical instrument which are higher in frequency than the fundamental […] All musical instruments produce complex sound waveforms which repeat at their fundamental [or lowest] frequency."

[39] To be clear, the TWC produces fundamental frequencies up to, and beyond, the supersonic limit of human hearing (20kHz). I am talking exclusively about harmonic content in this statement, that is, the harmonics comprising a (fundamental) frequency's overtone content.

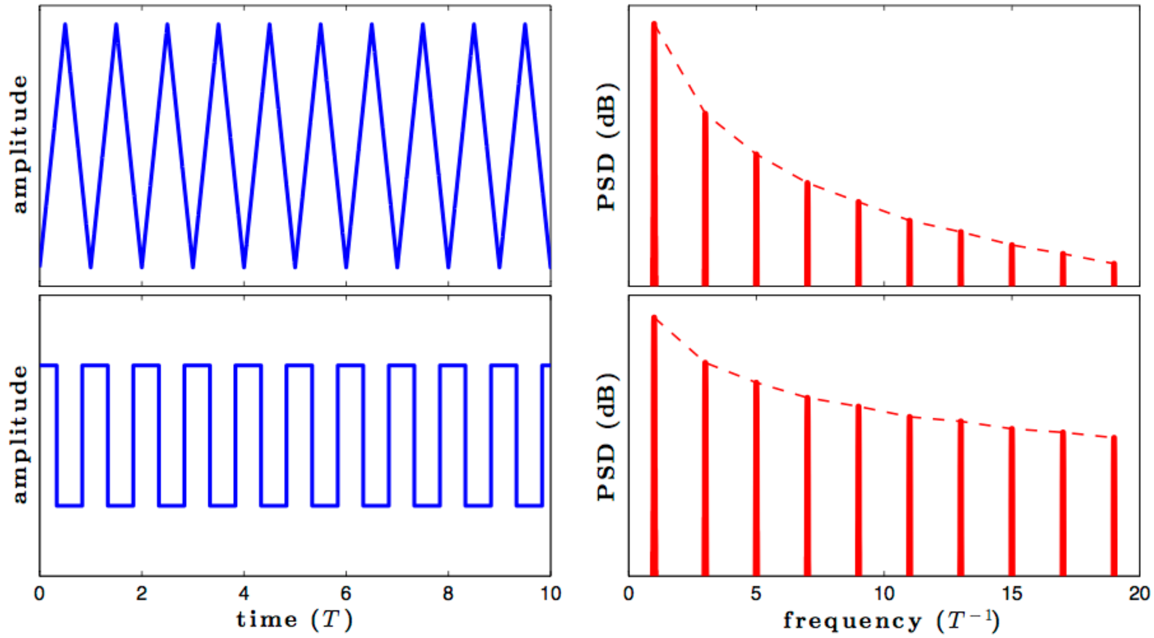


**Fig. 11**: A comparison of the dynamic envelopes of a triangle wave and a square wave. "T" is the period value. The left charts show the waveforms in terms of amplitude and time, while the right charts show each waveform's harmonics in terms of decibels and frequency. Note that while each contain odd-ordered harmonics, those of the triangle wave "roll off" much faster than those of the square wave. ("NDLs Vs. Linear Filters: An Illustration")

As noted, game scorers frequently use the TWC to produce a reliably "smooth" and "round" bass line. However, the channel can also be used to generate frequencies above 450 Hz, resulting in a timbre most closely resembling that of a flute (this flute sound is featured prominently in the "Title" theme from *The Legend of Zelda*). The TWC can also generate a sound like a tom-tom drum, when used to oscillate a rapidly descending glissando. This sound is heard in various songs throughout the *Mega Man II* soundtrack, most notably in the "Get a Weapon," "Bubbleman," "Crashman," "Heatman," and "Dr. Wily Stage 1" themes.[40]

[40] This is not an exhaustive list of possible uses for the TWC, obviously. At this point, being interested in primarily surveying the manner by which the NES APU structures game scoring for it, I am interested only in surveying the TWC's most common uses in relation to its technological capacities.

The TWC can generate higher frequencies than the PWC generates, because of its special timer. That said, we shall see that these frequencies are typically used to produce a "glitch" effect. The highest frequency that the NES PWC can generate is approximately 12.4 kHz.[41] Humans are only capable of hearing frequencies from 20 Hz to 20 kHz, and even then most hearing humans older than eighteen years of age do not hear very well above 16 kHz. This means that the PWCs are not capable of servicing the upper expanses of human hearing (ie., 12-20 kHz). The TWC, on the other hand, can generate supersonic frequencies (ie., frequencies over 20 kHz), because its timer is clocked by the CPU rather than the APU.[42]

Oscillating supersonic frequencies comprises a compositional technique for silencing the triangle channel, without sacrificing valuable CPU cycles from the 2A03[43] for a "silence" request.[44] When game scorers experimented with this technique, however, they found that an oddly percussive sonic artifact — ie., a "popping" noise — sounded whenever the TWC returned to oscillating in the audible range. The supersonic frequency is initially generated when scorers write a timer value of zero which, according to the programming equation $f_{tri} = f_{CPU}/(32*(t + 1))$ (where "$f_{tri}$" is the resultant frequency

---

[41] Determined by the equation $f_{pulse} = f_{CPU}/(16*(t+1))$ where "$f_{pulse}$" is the resultant frequency of the pulse wave, "$f_{CPU}$" is the base frequency of the CPU (1.78977267 MHz for a North American NES) and "t" is the timer value.

[42] "Clocking" simply refers to the process of providing information at regular intervals, in this case at some fraction of the frequency which the NES CPU is running at. The TWC's maximum frequency on a North American NES is actually 55.9 kHz. This value is determined by the equation $f_{tri} = f_{CPU}/(32*(t + 1))$ where "$f_{tri}$" is the resultant frequency of the triangle wave, "$f_{CPU}$" is the base frequency of the CPU and "t" is the timer value.

[43] The 2A03, also referred to as the "RP2A03," is the name of the NES' CPU developed by Ricoh.

[44] Perhaps more than any other technique I examine, this technique encapsulates game scoring. To compose a tacit section for a particular instrument, the scorer must actually compose frequencies above the human audible threshold, that is, supersonic frequencies.

of the triangle wave, "$f_{CPU}$" is the base frequency of the CPU and "t" is the timer value), generates the channel's highest available frequency. This frequency is so high, however, that the mixer receives an irregular and abrupt sequencer value, for which it cannot compensate. This results in "artefacting," that is, audible distortion, most closely resembling a "popping" noise. This "popping" can be heard in the score for *Mega Man II*, most notably in the "Crash Man" theme.

The TWC has a rhythmic advantage over the other APU channels, because of the accuracy of its timer. Developers of the NES APU felt it necessary to imbue only the TWC with the clocking accuracy required to achieve "pinpoint" rhythmic precision, that is, developers deemed it necessary to devote a crucial portion of only the TWC's CPU-load to achieving rhythmic rather than textural precision. This additional feature thus technologically structures — it provides the only technical means for achieving — the TWC's primary compositional function, namely, setting bass parts.

As noted, the NES APU's two PWCs are more likely to be used to set tracks with sustained pitches and upper-midrange frequency content, which is to say, for setting melody and rhythm section parts. The bass section in NES game scores, however, are often very repetitive and melodically simple, and require rhythmic accuracy over and above anything else. This said, I should quickly note that this does not mean that composers can only use the TWC to provide bass support for upper-register melodies. Some composers have even gone so far as to use a TWC bass line for the primary melody. This inversion of compositional convention can most notably be heard in the "Underworld" theme from Kondo's score for *Super Mario Bros.* (1985).

*Channel Overview: Noise Channel*

The NES APU Noise Generator Channel (NGC) oscillates "noise," that is, sound featuring an irregular or "random" waveform. Actually, the NGC outputs two different kinds of noise: "white noise" and "periodic noise."[45] Most commonly, however, the NGC is set to "white noise mode" and used to set the percussive elements of a game score. In fact, scores most often use the NGC to orchestrate the components of a typical "trap" drum set: kick drum, snare drum, hi-hat, *et cetera*. The sound of a snare drum ((i) in Figure 12 below), for instance, emerges when scorers set the NGC to "white noise" mode, and shape its dynamic envelope so it features a rapid "attack" and gradual "decay" and "release" contours. An open hi-hat ((ii) in Figure 12 below), on the other hand, emerges when scorers filter the NGC's "white noise" through an envelope featuring gradual "attack" *and* "release" phases, while the sound of a closed hi-hat ((iii) in Figure 12 below) emerges from exactly the same envelope contour, but with a rapid "release" replacing the open hi-hat's gradual contour.

[45] According to Kaernbach (2000: pgh. 1): "Noise is a sound with an irregular, random waveform. Unlike a musical or speech sound, it contains a lot of different frequencies. It is called "white noise" if all audible sound frequencies are represented with the same strength. This designation is in analogy to vision: white light contains all visible frequencies of light." Similarly, periodic noise is a sound with many different frequencies, though these frequencies eventually repeat, unlike with white noise. The NES NGC is not capable of producing "true" white noise, as its frequency pattern does repeat after 32767 steps. This pattern, however, is too long for the human ear to notice its regularity, and it ends up sounding like white noise anyway. The NGC generates periodic noise through a frequency pattern either 93 or 31 steps long, depending on where it is in the 32767-step sequence when it is triggered.

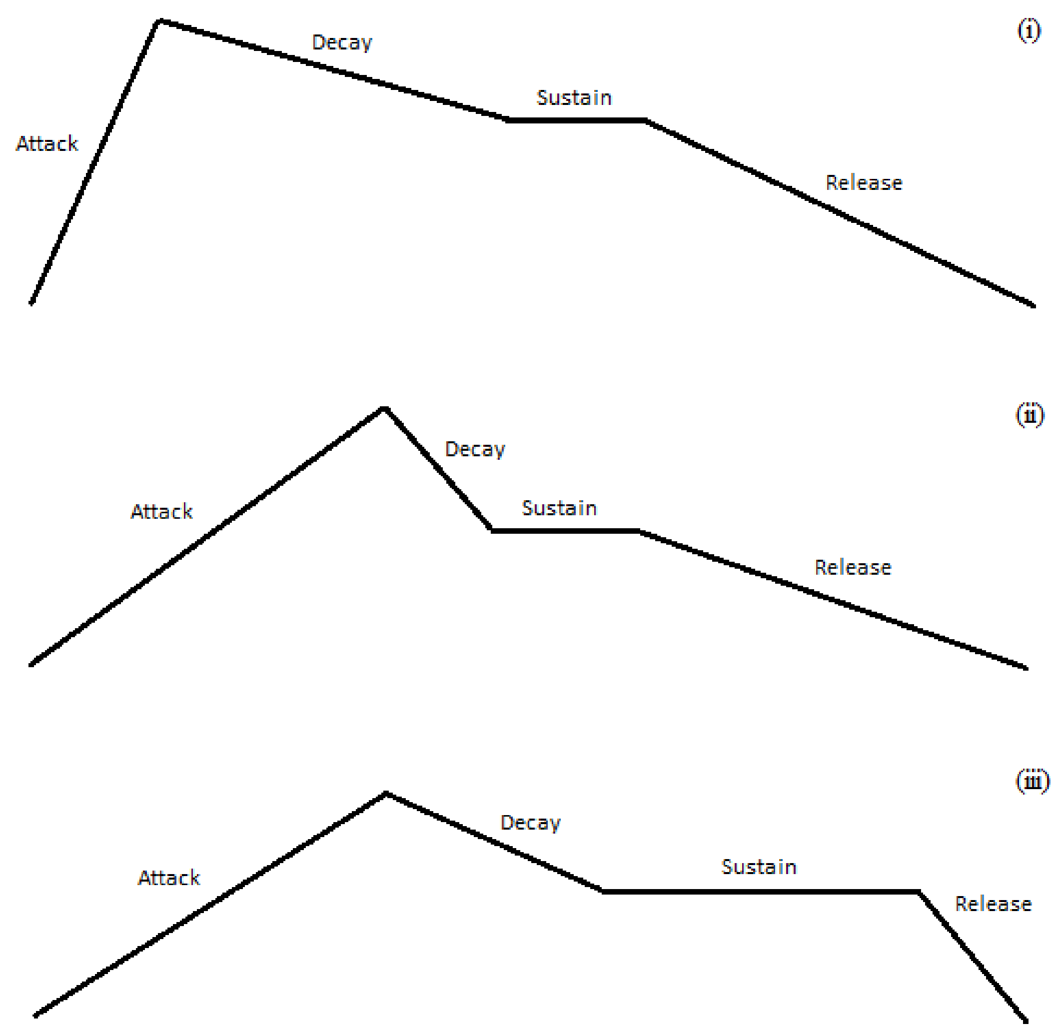


**Fig. 12**: The three dynamic envelopes mentioned in the paragraph above. They are (i) a snare drum, (ii) an open hi-hat, and (iii) a closed hi-hat.

The NGC's "periodic noise" mode is less frequently evoked by game scorers, and it is seldom used to orchestrate the percussion elements of a score because of its generally harsher, more metallic texture. Periodic noise is a sound with an irregular waveform generated by a series of frequencies that repeat, which results in a more "structured" sound than white noise, for instance, and which may even sound melodic. In fact, scorers occasionally even use the mode to set a score's melody. NES game scorers simply prefer the NGC's "white noise" mode for setting percussive elements because it has less pitched content and, thus, sounds more like acoustic percussion instruments. This said, braver NES game scorers have occasionally experimented with using the NGC's "periodic" mode to produce unprecedented effects. A good example can be heard in the "Quick Man" theme from *Mega Man II*. In this case, the NGC switches rapidly back and forth between "white noise" and "periodic noise" modes, to produce a complex rhythmic pattern. The music thus underscores and heightens the intensity of the gameplay, even as Tateishi incrementally increases the tempo all the while.

### *Channel Overview: Delta Modulation Channel*

The Delta Modulation Channel (DMC) is unique amongst all the channels comprising the NES APU, in that it triggers rather than oscillates, that is, it is used to sequence audio samples stored in its memory. Though the NES sequencing capacities are primitive by modern standards, the very fact that the NES featured a DMC for triggering samples when the NES was first released, in 1985, was extraordinary for any home video game console of its time.[46] Moreover, the DMC expanded the breadth of sounds a game scorer could produce exponentially.

[46] For more on the history of sound technology in gaming, see Belinkie (1999) and Grimshaw (2010).

Through the technology of the DMC, NES game scorers buttress their compositions using any (sampled) sounds they want, albeit in compromised "quality."[47] Game scorers most often use the DMC to produce sound effects, vocal "bites" and percussion.[48] Koji Kondo, for instance, used the DMC extensively in his score for *Super Mario Bros. 3* (1988 in Japan; 1990 in North America), mainly to sample the percussion instruments (i.e., bongos, timpani and tom-toms) heard in the eight different "World Map" themes players access sequentially as they progress through the game. This allowed Kondo to produce increasingly exotic orchestrations and rhythmic arrangements for each map theme.

## *NES Game Scoring Techniques*

Now that I have surveyed some of the capacities of each of the five channels which comprise the NES APU, whose sonic capacities in turn comprise the entire sonic palette available to NES game scorers, I turn my attention to exploring some of the more conventional compositional uses game scorers devise for these channels. In so doing, I elucidate "the sound" of game scoring's technological structure, as it were. I examine, in turn, so-called: (i) "2-channel Echo;" (ii) "1-channel Echo;" (iii) "arpeggios;" (iv) "triangle kick drums;" and (v) "melodic samples." After I have done this, I will briefly

[47] I would contend that 1-bit samples also have their own aesthetic, so "compromised quality" is used here only to denote the radical simplification of audio information performed by the DMC, and the fact that a 1-bit sample features a significantly lower "figurative" resolution than, say, a 24-bit sample.

[48] A vocal "bite" is simply a brief sample of a vocal phrase, whether musical or not.

demonstrate how game scorers draw all of these disparate musical terms together, into a cohesive sonic unity, using the NES APU's mixer.

To be clear, many of the game scoring techniques detailed below would ramify in traditional musicological analyses as "sound effects" or post-production editing devices. At present, we are accustomed to the ability to apply effects such as "echo" or "reverb" with the click of a button in a modern Digital Audio Workstation (DAW) such as Apple's Logic Pro. At least in the case of the NES APU, game scorers do not have such a luxury. Furthermore, in the case of all game scoring, the ability to generate such effects depends entirely on the capacities of the gaming technology at hand.

This phenomenon is not entirely new, though, as echo effects appear in many programmatic orchestral works. Baroque scores from the 17$^{th}$ and 18$^{th}$ Centuries, such as J.S. Bach's *French Suites*, often contained echoes as imitative devices, whereby a musical motto was played by an orchestra and then repeated immediately afterwards much more quietly. Similarly, game scorers do not simply sample and replicate echoes but, rather, create echo effects through musical means. Sound effects, in game scoring, then, are musical devices, even if traditional musicological analyses would dismiss them as mere ornamentation for broader melodic and harmonic constructions.

### *NES Game Scoring Techniques: 2-Channel Echo*

One of the most common game scoring techniques for the NES APU is so-called "two-channel echo." As an acoustic phenomenon, echo is difficult to produce for NES game scores because so few channels are available to orchestrate it.[49] In fact, the only channels composers can use to create a two-channel echo are the PWCs, since the phenomenon requires identical sounds to be played at decreasing volumes and ever lengthening delay rates. And the same is true, of course, for reverberation effects.[50]

Scorers can generate a reverberation or echo effect by setting a melody between both PWCs, each successive iteration played in alternating channels at successively lower amplitudes and ever lengthening delay rates. The "African Mines" theme, composed by Hiroshige Tonomura for *Ducktales* (1989), provides a clear example of this effect in game scoring, in this case deployed to evoke the reverberant acoustics of an underground mine.[51] Neil Baldwin likewise uses the effect in his "Puzzle Room" theme for *Magician* (1990), the effect here evoking the cramped, dark and confusing landscapes of each puzzle level. As its name suggests, however, two-channel echo requires a significant amount of the NES APU's available resources, monopolizing two of only five available channels. Game scorers thus developed a technique for creating echo and reverberation effect using only one voice very early on in the NES' development. I explain this next.

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[49] Echo is a reflection of sound which arrives at the listener at least 25 milliseconds after the direct sound.

[50] According to Izhaki (2008, qtd. in Hodgson [2010: 171]), "reverb" is: "the collective name given to the sound created by bounced reflections from room boundaries … In modern times, we use reverb emulators, either hardware or software plug-ins, to simulate this natural phenomenon."

[51] Developed by Capcom, the company which also develops the *Mega Man* series. Key personnel from that series were tasked with developing *Ducktales* for the NES and the Game Boy, and handheld video game console developed and released by Nintendo in 1989. The Game Boy version utilizes the Game Boy sound hardware, similar to the NES APU, in order to create the same effect with two pulse waves.

**Table 1**: A few NES tracks which prominently feature 2-channel echo.

| ***Composer*** | ***Track*** | ***Game (Year)*** |
|---|---|---|
| Nobuyuki Hara<br>Shinichi Seya<br>Naoki Kodaka | "Title" | *Journey to Silius* (1990) |
| Nobuyuki Hara<br>Shinichi Seya<br>Naoki Kodaka | "Stage 1 ~ Stage 5" | *Journey to Silius* (1990) |
| Hiroshige Tonomura | "African Mines" | *Ducktales* (1989) |
| Neil Baldwin | "Puzzle Room" | *Magician* (1990) |
| Takashi Tateishi | "Flash Man" | *Mega Man II* (1988) |
| Hiroyuki Masuno | "Main Theme" | *Déjà Vu* (1990) |
| Koji Kondo | "Title" | *The Legend of Zelda* (1986) |

### *NES Game Scoring Techniques: Single Channel Echo*

Using various methods, each developed by individual scorers to conserve APU resources, NES game scorers create "echo-like" sounds using only one channel. Geoff Follin, for instance, achieves this effect by combining dramatic dynamic leaps with pitch bends (downward glissandi). The effect can be heard clearly in Follin's score for *Wolverine* (1991), a licensed action video game based on the Marvel Comics superhero of the same name. Follin's theme for "Level 1" includes descending melodic accents from one of the PWCs. Follin adjusts the volume envelope of each accent to decay rapidly at first, but release slowly, and he deploys downward pitch-bends to emphasize the lengthened release time. This results in an eerie pulse wave, accompanied by what sounds like an echo, thereby audifying *Wolverine*'s dystopic surroundings.

Tim Follin, Geoff Follin's brother, provides another good example of single-channel echo, and the highly individuated nature of its compositional production in game scoring. In this case, the effect appears in Follin's score for the feature film-licensed game, *Indiana Jones and the Last Crusade* (1991, Taito).[52] Instead of using repeating and diminishing dynamic leaps combined with pitch bends to create the effect, however, as his brother did in the score for *Wolverine*, Tim Follin here exploited the psychoacoustic phenomenon known as "subjective loudness," whereby lower register pitches have less subjective loudness than higher pitches.[53] In the "Tank – Cutscene" theme, for instance, Follins sets repeating downward pitch bends in one PWC to create a single-channel echo. Each pitch of the theme thus sounds as though its volume swells, even though each pitch features a slow, constant fade throughout. This, combined with the downward pitch bends, creates a reverberant effect using only a single PWC.

Neil Baldwin developed yet another method for producing single-channel echo in his score for *Hero Quest*, an unreleased NES game developed in 1991. While the above examples involve single-channel echoes applied to sustaining pitches, Baldwin wanted to apply echo to a pattern of changing eighth notes for the "Final Track" theme of *Hero Quest* (1991). This required a different technique. Baldwin thus decided to compose

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[52] The "Follin Bros." have collaborated on game scores and are collectively known as such in gaming culture. They are celebrated by chip music enthusiasts for developing techniques such as single-channel echo.

[53] The ear is not equally sensitive to all frequencies, particularly in the higher and lower ranges. In 1933, Fletcher and Munson charted the response to frequencies across the entire audio range, as a set of curves showing the sound levels of tones perceived as equally loud. These curves are called "equal loudness contours" or "Fletcher-Munson curves." According to White (1987: "Fletcher-Munson Effect"): "The most sensitive range of human hearing is between 3kHz and 4kHz; the sensitivity falls off rapidly at lower frequencies and somewhat more slowly at higher frequencies. In other words, sounds must be more powerful at lower and higher frequencies than 3 to 4kHz in order to be heard at the lowest audible levels."

quieter duplicates of each note of the melody, delayed by roughly an eighth note. This produces a much larger sense of space in the "Final Track" than elsewhere in the score, an effect further reinforced by the deployment of strong "transient" instrumentation, such as percussion.

**Table 2**: A few NES tracks which prominently feature single channel echo.

| ***Composer(s)*** | ***Track*** | ***Game (Year)*** |
|---|---|---|
| Iku Mizutani<br>Kouichi Yamanishi | "Prologue" | *Shadow of the Ninja* (1991) |
| Iku Mizutani<br>Kouichi Yamanishi | "Stage 2: Underground Sewers" | *Shadow of the Ninja* (1991) |
| Tsukasa Tawada | "Stage 1: Evil Forest" | *Moon Crystal* (1992) |
| Geoff Follin | "Level 1" | *Wolverine* (1991) |
| Tim Follin | "Tank – Cutscene" | *Indiana Jones and the Last Crusade* (1991) |
| Tim Follin<br>Geoff Follin | "Title Screen" | *Silver Surfer* (1990) |
| David Warhol<br>George Sanger<br>David Hayes | "Wendy's Theme" | *Maniac Mansion* (1990) |

*NES Game Scoring Techniques: Arpeggio & Psychoacoustic Block Chords*

An arpeggio is sometimes referred to as a "broken chord," since its component pitches are articulated sequentially rather than simultaneously. Arpeggios are extremely important in NES game scoring but difficult to produce, again because of the limited number of channels available in the NES APU. Triadic chords are simply impossible to produce via the NES APU, in fact, because only two of its channels, namely, the PWCS, are capable of producing identical timbres simultaneously. Game scorers thus face yet another technical dilemma: triadic chords are fundamental to the music they compose, yet they lack the technical means to produce them. To solve this dilemma, NES game scorers produce triadic block chords psychoacoustically, as it were. That is, rather than sounding all three pitches of a triadic chord simultaneously, game scorers arpeggiate the pitches so quickly that the human ear is incapable of distinguishing one waveform from another. Consequently, the ear "sums" the component waveforms into a single triadic unity.

As a musical figure, these "psychoacoustic triads" are more typically associated by historians with Commodore 64 game scores and its MOS Technology Sound Interface Device (SID).[54] However, facing similar technical limitations, NES game scorers — particularly those working in Europe, where the SID remains popular — have adopted "psychoacoustic" arpeggiated chords. The technique can be heard in, among other scores, *Silver Surfer* (Tim and Geoff Follin, 1990), *Magician* (Neil Baldwin, 1990), *Skate or Die 2* (Ron Hubbard, 1990), *Solstice* (Tim Follin, 1990), *Darkman* (Jonathan Dunn, 1991), *M.C. Kids* (Charles Deenan, 1992), and *Asterix* (Alberto González, 1993).

[54] For a history of video game music up until 1999, see Belinkie (1999).

**Table 3**: NES tracks which feature arpeggio and psychoacoustic block chords prominently.

| ***Composer(s)*** | ***Track*** | ***Game (Year)*** |
|---|---|---|
| Yoshinori Sasaki<br>Jun Funahashi<br>Yukie Morimoto | "Rising" | *Castlevania III* (1990) |
| Tim Follin<br>Geoff Follin | "BGM 1" | *Silver Surfer* (1990) |
| Neil Baldwin | "Level 2" | *James Bond Jr.* (1991) |
| Alberto Gonzalez | "Title Screen" | *Asterix* (1993) |
| Ron Hubbard | "Level 1: The Streets" | *Skate or Die 2* (1990) |
| Alberto Gonzalez | "Act 6: The Mountains" | *The Smurfs* (1994) |
| Charles Deenan | "Title Screen" | *M.C. Kids* (1992) |

*NES Game Scoring Techniques: TWC Kick Drum Sounds*

As noted, percussion in NES game scores is typically set using the NC and the DMC. Game scorers wanting to give their kick drums extra "punch," for instance, pair noise from the NC with audio samples of a kick drum triggered in the DMC. However, the latter may require simply too much storage memory to be a feasible component of a game score, so composers must resort to other means to produce the effect. One such means involves oscillating a triangle wave bass part in the TWC, but rapidly bending its pitches downwards, that is, by orchestrating extremely fast downward glissandi in a bass line produced by the TWC. These glissandi, when filtered through an extremely short sustain and release envelope, produce a sound more like a kick drum than a low frequency triangle wave. Like the "psychoacoustic block chord" technique elucidated in the section immediately above, this "kick drum" technique is also especially popular in

European game scores for the NES, and can be heard in scores for *Hero Quest*, *Silver Surfer*, and *Robocop 3* (Jeroen Tel, 1993).[55]

**Table 4**: NES tracks which prominently feature the TWC kick drum technique.

| ***Composer(s)*** | ***Track*** | ***Game (Year)*** |
|---|---|---|
| Neil Baldwin | "Unused Music 1" | *Hero Quest* (1991, unreleased) |
| Neil Baldwin | "Unused Music 2" | *Hero Quest* (1991, unreleased) |
| Tim Follin<br>Geoff Follin | "BGM 1" | *Silver Surfer* (1990 |
| Jeroen Tel | "Title Theme" | *Robocop 3* (1992) |
| Alberto Gonzalez | "Act 6: The Mountains" | *The Smurfs* (1994) |
| Mari Yamaguchi | "Charge Man" | *Mega Man V* (1992) |
| Mari Yamaguchi | "Get a Weapon" | *Mega Man V* (1992) |

*NES Game Scoring Techniques: Melodic Samples*

NES game scorers use the DMC mostly to trigger audio samples of vocals, percussion and sound effects. It is simpler to use the DMC to produce these sounds, because they rely less on pitch than timbre and timing to produce their musical effects. Using the DMC melodically is much more complicated than using the NES APU's other four channels, because the DMC has specific limitations with regard to "re-pitching" samples:

[55] This technique is most commonly used for kick drums, to be sure. However, it is possible to use it to create other drum sounds, such as a woodblock, by incorporating the same technique at higher frequencies.

1) samples may only be lowered in pitch;
2) lowering a sample's pitch results in a slower playback speed;
3) sixteen pitches are available, including the original sample's pitch, though these are not arranged chromatically
4) some notes output slightly sharp or flat.[56]

Because of these limitations, each of the highest DMC pitches in an NES game score requires their own samples. Lowering the pitch of these samples causes them to sound at a slower rate, producing distortion and significant "tonal artefacting" (i.e., detuning). A full chromatic scale is difficult to obtain through re-pitching, because the fifteen other set pitches are not arranged chromatically, even when starting with a tonic of C4. Retro Game Audio (2012: "NES Audio: Sunsoft Bass and Melodic Samples") outlines the resultant pitches with a starting sample at a pitch of C in the fourth octave:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C4 | G3 | E3 | C3 | A2 | G2 | F2 | D2 |
| C2 | B1 | A1 | G1 | F1 | E1 | D1 | C1 |

Yet even these notes are not exactly correct, as some notes output sharp or flat. The following is the pitch table for the DMC from NES-Dev:

| | Period Hex Value | Frequency | Note |
|---|---|---|---|
| 1 | $1AC | 4181.71 Hz | C-8 -1.78c |
| 2 | $17C | 4709.93 Hz | D-8 +4.16c |
| 3 | $154 | 5264.04 Hz | E-8 -3.29c |
| 4 | $140 | 5593.04 Hz | F-8 +1.67c |
| 5 | $11E | 6257.95 Hz | G-8 -3.86c |
| 6 | $0FE | 7046.35 Hz | A-8 +1.56c |

[56] Retro Game Audio (2012: "NES Audio: Sunsoft Bass and Melodic Samples").

| | | | |
|---|---|---|---|
| 7 | $0E2 | 7919.35 Hz | B-8 +3.77c |
| 8 | $0D6 | 8363.42 Hz | C-9 -1.78c |
| 9 | $0BE | 9419.86 Hz | D-9 +4.16c |
| 10 | $0A0 | 11186.1 Hz | F-9 +1.67c |
| 11 | $08E | 12604.0 Hz | G-9 +8.29c |
| 12 | $080 | 13982.6 Hz | A-9 -12.0c |
| 13 | $06A | 16884.6 Hz | C-10 +14.5c |
| 14 | $054 | 21306.8 Hz | E-10 +17.2c |
| 15 | $048 | 24858.0 Hz | G-10 -15.9c |
| 16 | $036 | 33143.9 Hz | C-11 -17.9c |

The "period hex values" correspond to information read by the DMC memory reader as waveform period lengths. In the table above, these periods are converted to frequencies in Hz and finally notes with deviation given in cents, where one cent is 1/100 of a semitone. NES game scorers may play their desired samples at only these frequencies.

The games created by Sunsoft during the latter half of the NES' shelf life contained some of the few scores to use DMC samples melodically. *Batman: Return of the Joker* (1991), *Hebereke* (1991), *Journey to Silius* (1990), *Gremlins 2* (1990), *Gimmick!* (1992) and *Super Spy Hunter* (1992) all use DPCM samples primarily to add definition to the bass sections of their scores. In these scores, a real electric bass guitar was sampled by Sunsoft composer Naoki Kodaka, and played back through DPCM. These samples accompany a triangle wave bass, and the combination of these two channels results in a sound with the smooth and round timbre of a triangle wave but bearing the characteristic textural markers of an electric bass guitar.

In order to accomplish this, however, a chromatic scale was necessary for the sampled bass section. Kodaka responded to the strange pitch table of the NES DMC by sampling the bass at five different notes:

A# B C C# D

From these five notes he could then use the re-pitch function of the DMC to lower these samples, resulting in something close to a full chromatic scale. Since these samples mimic the notes of the TWC, the discrepancies in pitch and timing — as stated, lowering pitch is not an exact process and causes slower playback — created by the DMC are less noticeable to the listener. In fact, these discrepancies are more likely to be interpreted as musically interesting, rather than inaccurate, if they are noticed by the listener.

**Table 5**: A few NES tracks which feature melodic samples.

| ***Composer(s)*** | ***Track*** | ***Game (Year)*** |
|---|---|---|
| Masashi Kageyama<br>Naohisa Morota | “Strange Memories of Death” | *Gimmick!* (1992) |
| Nobuyuki Hara<br>Shinichi Seya<br>Naoki Kodaka | “Stage 3” | *Journey to Silius* (1990) |
| Nobuyuki Hara<br>Shinichi Seya<br>Naoki Kodaka | “Hebe Adventure” | *Hebereke* (1991) |
| Nobuyuki Hara<br>Shinichi Seya<br>Naoki Kodaka | “Stages 2 & 6: Desert of Doom / Weapons Factory” | *Super Spy Hunter* (1992) |
| Naoki Kodaka | “Title Screen / Ending” | *Fester’s Quest* (1989) |
| Hidenori Maezawa | “Stage 1 - Lightning and Grenades” | *Super C* (1990) |
| Ryuichi Nitta | “World 1: Ice Rock Island” | *Fire ‘n Ice* (1993) |

### *Putting It All Together: The APU Mixer*

Exact calculation of the resultant amplitude of all the channels in the NES is almost impossible, due to the APU's non-linear mixing scheme. Each channel contains its own digital-to-analog converter, or DAC, to convert digital information to an analog audio signal. These DACs are implemented in such a way that produces non-linear interactions between channels. For example, a high value in the DMC output unit will reduce the volume of the TWC and NC, while a high TWC output has no effect on the volume of the DMC.

Koji Kondo used this peculiarity of the NES APU to his advantage in the score he produced for *Super Mario Bros.* (1985). Kondo re-set the dynamic output of the DMC simply to limit the TWC's dynamic output. In fact, Kondo did not even use the DMC to trigger samples, as is its intended function. Rather, he used it as a limiter.[57] This example is not meant to be taken as a unique case, though, as the non-linear nature of the NES APU mixer affects every decision the NES game scorer makes. Since the manipulation of one channel will likely affect another's output, the entire arrangement changes with, say, a duty cycle change on the PWC. NES game scorers must know not only how their orchestrations will affect the output of a single channel, but also how that output influences the output of every other channel as well.

[57] According to White (1987: "Limiter"): A "limiter" is "a special type of compressor which prevents the signal from exceeding a certain preset level." White (1987: "Compressor") also notes that a "compressor" is an "audio device which reduces the dynamic range of a signal."

*Chapter Summary*

As a case study of the NES APU, and the way it structures game scoring for the NES, this chapter is by no means exhaustive. It is not meant to be. Neither is it meant to stand alone as a work dedicated to increasing knowledge about NES hardware. It should be taken simply as an elucidation of the technical structure of game scoring in general, concretized through a case study of the NES APU.

I hope I have demonstrated in this chapter that, when they compose, game scorers think musically in relation to a particular sound configuration hardware, which limits the possibilities they can imagine for composition in very particular ways. Indeed, musical ideation is structured by the technology — the sound hardware configuration — for which game scorers compose. This is not to say that musical ideation and creativity in game scoring is technologically determined. Rather, it is simply to say that musical ideation and creativity is *structured* in game scoring by particular sound hardware configurations. In this chapter I have sought to elucidate this structure using the NES APU as a case study, paying particularly close attention to some of the better known musical possibilities that game scorers have gleaned — or, to borrow Kondo's phrase, "schemed" — from that particular sound configuration hardware. In the next chapter, I scrutinize the aesthetic product of this process, namely, game scores *per se*, especially as they exist in gameplay.

# *Chapter 3*

## *Game Scoring: Gameplay as Performance of Aleatoric Composition*

### *Introduction*

"Game scoring," that is, composing music for video games, is distinct from other types of scoring, because it is always an at least partially aleatoric compositional activity, given the nature of the gaming medium. Most crucially, video games are *interactive*, meaning that the gamer actively *performs* the gaming experience, though their actions are orchestrated within a set of predetermined possibilities. Collins (2013: 1) explains:

> Video games, mobile phones, and other modern digital media alter the traditional relationships between creator and consumer, audience and performance when the audience takes a participatory role in instigating sound events. When using such media audiences may, through their actions, be responsible for evoking sounds, selecting them, altering or shaping them, or creating new sounds, thus playing an active role in the composition of their own soundscapes. This active role of the audience raises interesting questions about the ways in which we theorize sound in media. What does it mean to interact with sound? Who is the audience, and who is the creator of such co-creative, interactive sonic constructions?

While Collins raises questions salient to interactive media studies in general, I examine these issues strictly with regards to game scoring, that is, from a strictly ludo-musicological perspective.[58] Game scoring is structured first-and-foremost by gaming technology, and game scores are programmed by composers, designers and programmers, but a game score is only ever finally *realized* through gameplay. The gamer is a crucial partner in the game scoring process, serving as its primary performer, insofar as their gameplay realizes and, in so doing, dictates the final compositional structure of a game score.

The duration of any game score, for instance, is always determined by the duration of a given gameplay session. I may play *Super Mario Bros.* (1985) for three hours, the result of which would be a long, fragmented score punctuated by gameplay sounds of failure and/or triumph. Alternatively, I may instead play the game for only thirty seconds, the result of which is a very different piece.[59] Koji Kondo is primarily responsible for composing (in a traditional sense) the various fragments which I have heard in both these instances, but the order in which these fragments sounded would depend entirely on my gameplay choices. Thus the harmonic and melodic design of the game score emerges in real-time alongside my gameplay.

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[58] Like ludo-musicology, interactive media studies is a burgeoning field at present. Work from this discipline with a focus on game audio includes, but is certainly not limited to: Allouche et al. (2007); Berndt et al. (2006); Berndt and Hartmann (2008); Berndt (2009); Berndt (2011); Borchers and Mulhauser (1998); Bridgett (2008); Fay (2004); Fish (2003); Guerraz (2008); Herber (2008); Hoffert (2007); Jørgensen (2006; 2008); Kaae (2008); Rayman (2014); Collins (2005; 2006; 2007a; 2007b; 2007c; 2007d; 2008a; 2008b; 2008c; 2009; 2013); Jones (2008); Thornham (2011); Waggoner (2009); Wolf and Perron (2013); Crawford, Gosling and Light (2013); Domsch (2013); Egenfeldt-Nielsen, Smith and Tosca (2013); Ensslin (2011); Gamboa (2012); Garrelts (2005); Huntemann and Aslinger (2012); Juul (2011); Ruggill and McAllister (2011); Whalen and Taylor (2008); Paul (2012); and Newman (2012), among others.

[59] These examples may be taken to further extremes. If I leave any game running in any state for an entire year, the score I have helped compose is one year long, and so on.

Given the role of gameplay in game scoring, I argue that it should be understood as a variety of so-called “aleatoric composition.”[60] Aleatoric composition includes all compositional activity in which one or more musical elements are left to chance, as well as compositions in which some degree of improvisational freedom is afforded performers. *Musikalisches Würfelspiel* (“musical dice game”), for instance, qualifies as aleatoric because it uses dice to randomly “generate” music from pre-composed options.[61] In this case, the chance operation involved in the music’s composition is a roll of the dice, and the element of composition chance determines is the order in which the pre-composed sections of the piece are performed.[62] Similarly, any composition with improvisatory sequences is at least partially aleatoric.[63]

I argue that game scoring synthesizes both of these “types” of aleatoric composition. That is, I argue that a game score involves both chance operations *and* a degree of improvisation. In fact, game scoring is a peculiar type of composition because the “performer” of a game score is not a musical performer but a “ludal” one, that is, a “gamer” ostensibly involved in specifically non-musical activity. Sound, visuals and

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[60] Work which relates video game music to aleatoric composition includes: Collins (2009); Lieberman (2006); Philips (2014); Rayman (2014); Summers (2011); Paterson et al. (2011); Young (2012); Paul (2013); Custodis (2013); Pannerden et al. (2011); Lerner (2014); d’Escrivan (2007); Bullerjahn (2010); Hermans (2013); and Mitchell (2014).

[61] The word “aleatory” or “aleatoric” is derived from the Latin word *alea*, which actually means “dice.”

[62] For example, see: *Der Allezeit Fertige Menuetten- und Polonaisencomponist* (German for “The Ever-Ready Minuet and Polonaise Composer”) (1757) composed by Johann Philip Kirnberger; *Einfall Einin Doppelten Contrapunct in der Octave von sechs Tacten zu Machen ohne die Regeln Davon zu Wissen* (German for “A method for making six bars of double counterpoint at the octave without knowing the rules”) (1758) composed by C.P.E. Bach; and *Table pour Composer des Minuets et des Trios à la Infinie; avec deux dez à Jouer* (French for “A table for composing minuets and trios to infinity, by playing with two dice”) (1780).

[63] For example, Ornette Coleman’s *Free Jazz* (1961) was the first album-length improvisation, making it at least partially aleatoric.

haptics inform the gamer's gameplay choices, so game scores are subject to improvised chance operations which only the combination of these phenomena enable.

This chapter will elucidate game scoring's "aleatoriality" by examining chance operations and "performer freedom" embedded within game scores.[64] This will require study of actual gameplay. Given the limited space I have here, however, and given the breadth of scoring possibilities available through even the simplest of video games, I shall only examine one part, or "level," of a game, namely, the 22nd level of *Super Mario Bros.* I do this to elucidate how gameplay patterns determine the final game score a gamer hears during each gameplay. I shall compare the game scores I produce for *Super Mario Bros.* to a non-aleatoric musical source, which is the game's "official soundtrack." Video game soundtracks differ from game scores because they are fixed, "idealized" game scores, divorced from gameplay itself. Before I do any of this, though, I briefly survey the aleatoric tradition in Western Art Music, to provide an historical and analytical context for game scoring. I do this by scrutinizing John Cage's *TV Köln* (1958) in detail.

## *Before Video Games: The Aleatoric Tradition*

While composers such as Henry Cowell, John Cage, and Christian Wolff took the first decisive steps towards the creation of an aleatoric compositional style in the early 1950s, there exist many examples of aleatoric music which pre-date the twentieth century. As Antokoletz (2014: 385) explains:

[64] Roig-Francoli (2008) coined the term "aleatoriality" to designate the degree of chance in a composition.

> There has always been some degree of rhythmic, harmonic, and formal freedom for both the composer and the performer throughout earlier centuries, as manifested in the use of rubato or *ad libitum* indications, fermatas and grand pauses, improvisation in cadenza-like passages, realization of figured bass, and even the elimination of the barline resulting in metric freedom, as in keyboard fantasias of C.P.E. Bach.

In the early part of the twentieth century, composers such as Arnold Schoenberg, for instance, made more radical attempts to “free the performer” from the rigid structures of fixed composition. Antokoletz (Ibid.) notes:

> The use of tone clusters and the elimination of the barline in works of Ives and Cowell resulted in both harmonic and rhythmic indeterminacy, while the use of *Sprechstimme* permitted a degree of pitch and harmonic indeterminacy in works of Schoenberg and others.

Meanwhile, many composers moved toward “integral serialism,” an opposing style founded on the idea of total composer control over all aspects of the performance of a composition. From the early twentieth century on, an ever-increasing gap formed between the tenets of integral serialism and the principles of aleatoric composition. These two compositional styles reached their most extreme polarization in the early 1950s, when the American composer John Cage began to compose pieces in which the performer had almost total freedom over the score.

In fact, according to Antokoletz (Ibid.), many of the main principles of aleatoric composition formed specifically in reaction to the principles of integral serialism:

> [Several] distinctions may be observed in the approach to aleatoric composition. These include the elimination of rational composer control over content and/or form in producing a composition that is nevertheless fixed as far as the performer is concerned, use of special indications and notation (either conventional or newly invented) leading to a shift toward performer determination in the generation and ordering of events, and the elimination of both composer and performer control leading to randomness and indeterminacy.

The American composer John Cage was the first to fully incorporate chance operations in his compositions from the early 1950s. Cage was influenced by the improvisational opportunities afforded by certain scalar and rhythmic formulae, namely, *ragas* and *talas*, which he took from Carnatic and Hindustani music traditions. Moreover, his philosophy of music derived from his interest in Zen Buddhism. Cage (1973: n.p.) explains:

> We need first of all a music in which not only sounds are just sounds but in which people are just people, not subject, that is, to laws established by any one of them, even if he is "the composer" or the "conductor." […] The situation relates to individuals differently, because attention isn't focused in one direction. Freedom of movement is basic to both this art and this society.

Thus Cage advocated both for a relinquishment of control on the part of the composer and a degree of indeterminacy for the performer. In this way, both roles, as we would normally conceptualize them, are problematized by Cage's music from this time.

In 1958, Cage composed *TV Köln,* one of his first works to introduce indeterminacy in the realm of performance. Figure 13 shows the score for this piece. The score for *TV Köln* incorporates both traditional Western notation and a notation system of Cage's own invention. The piece is divided into four sections, which Cage explains are of equal duration, though he does not specify their absolute durations.[65]

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[65] In effect, the piece can be of any duration, similar to a game score, as noted above.

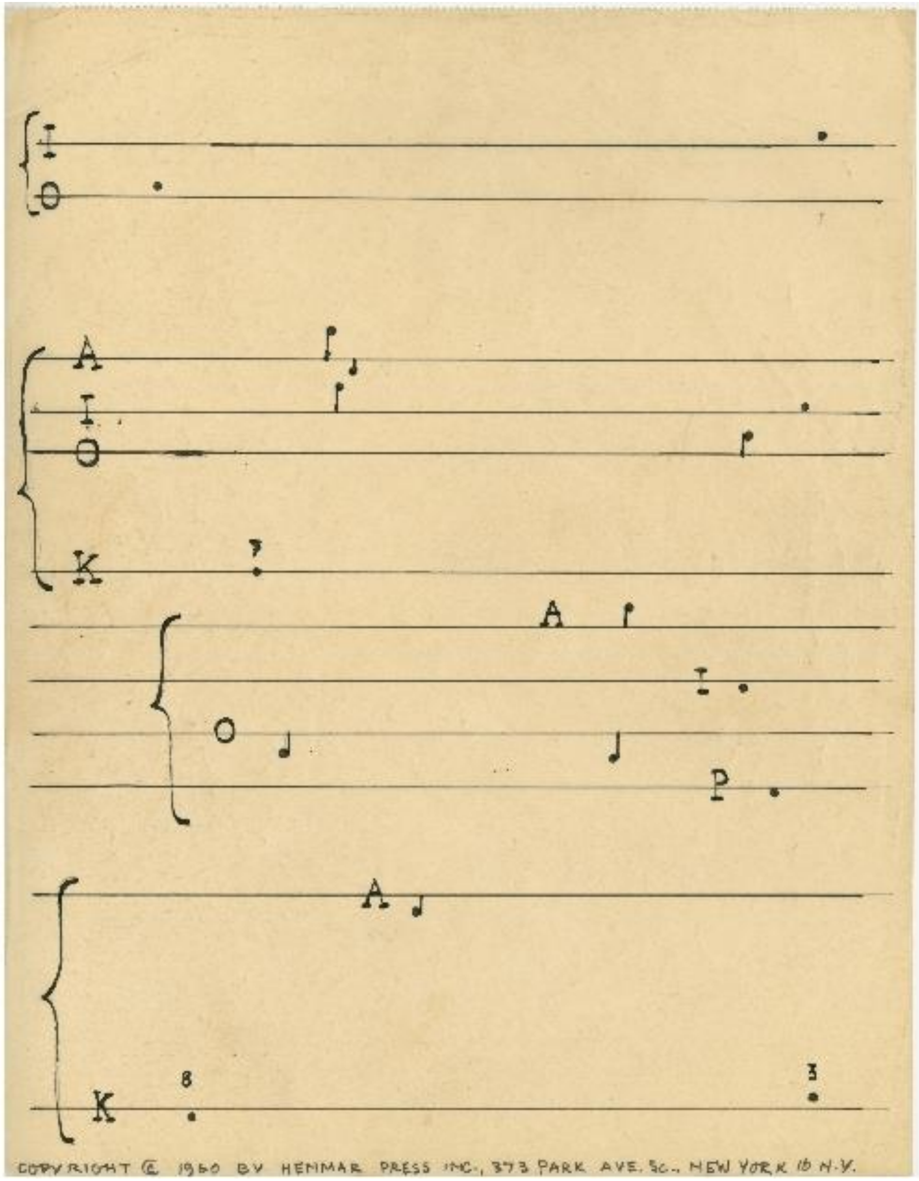


**Fig. 13**: The score for *TV Köln*. This was accompanied by a page of instructions which explain Cage's peculiar notation system. ("*TV-Köln* 1960")

The instruction sheet accompanying the score provides a legend for four of the capital letters written on the staves:

I = Interior Piano Construction
O = Exterior Piano Construction
A = Auxiliary Noise
K = Keyboard (Numbers = Number of Keys)

Morgan (1991: 317) explains:

> [The] lines [of each section], unlike the staves of traditional piano music, do not separate bass and treble clef, or right hand and left hand, but distinguish the type of sound played or — more accurately — where that sound is produced: on the keys (K), inside the piano (I), on the piano's exterior surface (O), or somewhere other than the piano (A).

Strangely, Cage did not provide an explanation for the letter "P," which appears on the fifth line of the third section. Finally, Cage instructs that a note's proximity to a line may indicate either its relative pitch, duration or amplitude.

*TV Köln*'s score is unique in that it does not instruct performers to play particular sounds, but indicates the way that sounds should be produced. As Morgan (1991: 317) notes, what "is indicated are essentially actions, not musical events." Cage creates a general musical structure for the performer to follow, though he leaves considerable room for that performer's agency. The score for *TV Köln* allows for "freedom of movement," as Cage puts it, meaning that many of its compositional parameters are left to the agency of the performer. For example, the absolute duration of any musical event in the piece is unspecified, and a single notational element refers to three completely independent parameters (pitch, duration, amplitude), thereby leaving those to the performer's discretion. Each letter corresponds to an increasingly vaguely-defined action, from "K" which corresponds to pressing a piano key, to "A" which corresponds to almost any action, to "P" which could signify anything. Finally, the difference between stemmed and unstemmed note heads is also unexplained, leaving performers to interpret it themselves, however they see fit. Yet, as Morgan (1991: 318) suggests, despite all these compositional uncertainties, *TV Köln*

> has a definite “shape,” because the events that constitute it have been arranged in a given temporal relationship with one another. This shape even has, however inadvertently, a certain traditional quality. The piece opens with a single isolated event; continues […] with a relatively quick succession of events […] and closes with two more isolated events.

In future compositions, Cage would endeavour to avoid any defined “shape” through various means, all of which granted the performer greater agency, and the score itself greater indeterminacy. Cage’s inclusion of “non-musical” sounds in his scores — such as the “auxiliary” sounds he indicates in *TV Köln* — is salient to the current analysis of game scoring, particularly with respect to “sound effects.” Cage’s score “musicalizes” sounds which would ordinarily register as “extramusical” in traditional musicological analyses. Similarly, as the next section will demonstrate, game scoring includes a recognition, accommodation and, even, an orchestration of sound effects which ordinarily might also be considered “extramusical” to the untrained ear.

### *A Note on Sound Effects*

Before I investigate examples of actual game scores, I should clarify the role of sound effects in game scores, and the way I intend to conceptualize sound effects in this thesis. One might equate video game sound effects to extraneous sounds heard in the orchestra pit of a ballet recital, for instance, such as the squeaks of chairs or the coughs of performers. This analogy is unsuitable for video game sound effects, however. In the example of sounds heard in the orchestra pit, the composer of the piece does not take these extraneous noises into account. They are considered “extramusical,” as it were.

The instruments which make "music" are not the same objects which produce these sounds, in this instance.

In contrast, game scorers must consider "extramusical" sounds in a video game as not only an inevitable but a complementary musical device. After all, a game score may only be *realized* through the act of gameplay, a state which contains many more sounds than those programmed as "music" *per se*. Game scorers must be highly aware of these sounds, to the extent that their scoring process is tailored significantly to accommodate them. Moreover, they are "scored" precisely as, say, a triangle-wave bass line would be. Whereas the ballet orchestra composer only tolerates incidental sounds as extramusical accidents, the game scorer thus integrates sound effects into the compositional process. In short, the game scorer *composes* sound effects, and thus they must be fully aware of the parameters under which sound effects "intrude" upon their scores. Koji Kondo (2010: n.p.) explains:

> The thing I consider to be most important is making the game more fun. There are three things I keep in mind. First of all, each game has a unique rhythm or tempo, so I try to capture that and compose music that fits the game's rhythm. Second of all, the balance. For games, it isn't just the music, one also has to consider sound effects, the balance of the volume, the balance between left and right channels, and make sure the sound effects [are] more prominent. Third, putting in variations in the music to fit with the interactivity of the game. For example, speeding up the tempo when time is running out or changing the music that plays depending on the player's location.

Kondo considers sound effects every time he scores a game. They must be louder than the background music he composes, he notes. Even if Kondo does not consider sound effects "music," then, their presence heavily informs his scoring choices. In fact, I would argue that the musical consequences of video game sound effects — that is, how game scorers accommodate these phenomena in the composition of their own "music" — are too significant to ignore in analyses of any game score.

When a player directs Mario to collect a coin in *Super Mario Bros.* (*SMB*), for instance, a satisfying "ching!" effect sounds. This sound effect is of primary importance to the "fun" of the game, as it serves as an "aural reward" each time players direct Mario to collect a coin. In addition, this sound effect directly affects the orchestration of the background music in *SMB.* It is created by the two pulse wave channels of the NES, so any melody which utilizes either or both of those channels is attenuated each time Mario collects a coin. For a very brief period, as this sound effect plays, the background music contains only a bass line, provided by the TWC, and a drum loop, provided by the NC. In effect, the orchestrations of the "Overworld," "Underworld," "Underwater," and "Castle" themes change each time Mario grabs a coin. This effect was used more prominently for the U.S. version of *Super Mario Bros. 2,* where the pulse channels are muted each time the player pauses the game, leaving only the triangle and noise channels to play bass and percussion on the "pause screen."

Game scorers work with, and alongside, sound effects to produce a coherent aural world for games. Sound effects must match the music's aesthetic, and *vice versa*. The analytic categories of "sound effects" and "music" are only useful, then, in the categorization of sounds in a game score, but neither is more central or crucial to a game score. One does not belong to the world of the game score, while the other belongs to the world of gameplay, for instance. A game score is a product of gameplay, after all. To demonstrate this, I now turn my attention to the game score for "World 6-2" of *SMB.*

## *Case Study:* Super Mario Bros. *(World 6-2)*

This case study examines the game score for the 22nd level of *SMB*, namely, “World 6-2.” I use *SMB* as the setting for this game score because of its simplicity and relatively recognizable structure. In addition, *SMB* is an NES game, so Chapter 2’s case study of the NES sound hardware configuration will inform this analysis. I shall examine each section of the level, starting with a visual overview of each section. Figure 14 is an overview of the “overworld” section of “World 6-2” of *Super Mario Bros.*

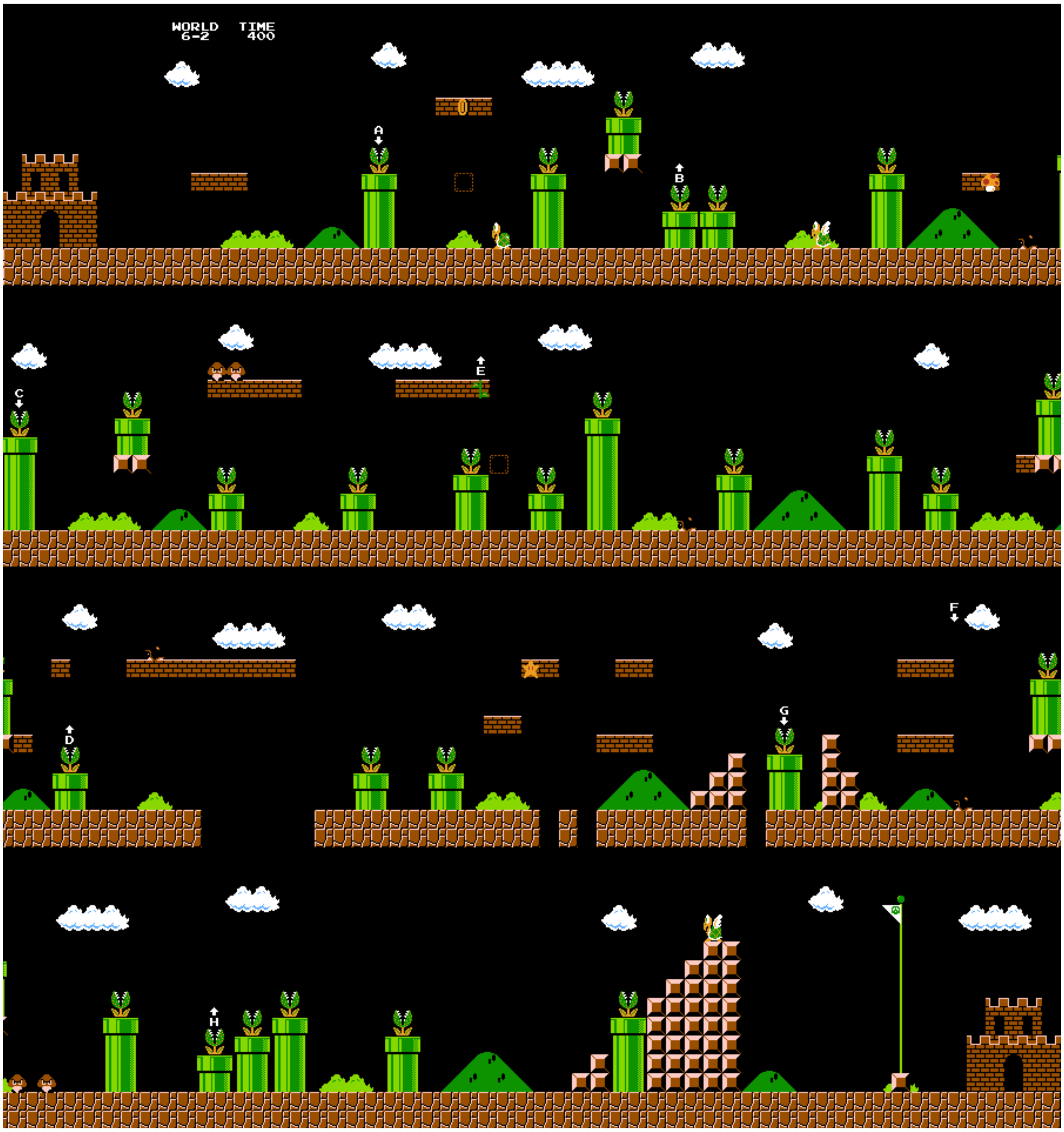


**Fig. 14**: "World 6-2" of *Super Mario Bros.* During gameplay, the gamer may only see a small section of this level. The pipe labelled "A" leads to an "underworld" area, while the "B" pipe takes Mario back to the "overworld." The "C" pipe leads to an "underwater" area, while the pipe labelled "D" takes Mario back to the overworld. Point "E" is a secret "beanstalk" which Mario may climb up to a "bonus" area, while "F" is where Mario may fall back to the overworld. Finally, pipe "G" leads to another underworld area, which has the "H" pipe as its exit back to the overworld. ("*Super Mario Bros.* Maps")

In *SMB*, players must navigate Mario through "worlds" or levels by using his basic abilities of walking, running, jumping, "stomping" on enemies, and throwing fireballs, depending on whether he has a "Fire Flower" "power-up." Mario may also travel down "secret" pipes, and up hidden "beanstalks," to embedded micro-levels. Enemies such as "Piranha Plants" intermittently block his way down pipes, while "Goombas" (brown mushroom-like creatures), "Koopa Troopas" (turtle-like creatures with green shells, and "Buzzy Beetles" (turtle-like creatures with harder, darker shells), all threaten Mario's survival.

An almost infinite number of game score variations may result from any given "playthrough" of World 6-2 of *SMB*. Musically, the beginning of the level is always the same: Mario starts outside the castle from the previous level, and the first notes of the "Overworld" theme play. From here, the game score for the level may conclude at any point in which Mario "dies," an action which triggers the "Death Sound," a comedic descending riff punctuated by what sounds like bongos from the NC. A number of actions result in Mario's death: running into any enemy while in "small Mario" form, falling down "pits," or allowing the time limit to expire, which, in World 6-2, is 400 "seconds."[66] A game score can be cut short by any of these occurrences, or it may be extended indefinitely if at any time players press the "Start" button, which pauses the game and silences all of the APU's channels.

If players choose to progress through the level normally, the game score will usually be accented with the "Boing!" sound effect produced when Mario jumps, an

[66] One "second" in *Super Mario Bros.* is equal to 0.4 seconds in real life, so the actual time limit for World 6-2 is 160 seconds.

action crucial to navigating the game world. This sound effect plays through one of the pulse channels in such a way that it does not normally affect the melody of the song, as with the “Coin” sound effect. The latter, as noted before, uses both pulse channels of the NES APU, so the main melody of the “Overworld” theme, also requiring both PWCs, is muted every time Mario collects a coin.

In the overworld of World 6-2, there are only three blocks which contain coins. Two of them are invisible and yield one coin each, and they are indicated by the dotted square outlines in Figure 14 on p.71 of this thesis. The last of these is a “Ten-Coin Block,” indicated by a coin inside a brick block just past the first pipe, accessible only by finding and jumping on the invisible coin block beneath it, and avoiding or killing the Koopa Troopa below. A Ten-Coin Block may yield anywhere from one to ten coins, depending on how fast the player can repeatedly make Mario jump into it. Hitting this block triggers both a “thud” sound effect, presumably meant to signify Mario’s head or hand hitting the block, and of course the sound effect for collecting a coin. If the player repeatedly hits the block — as they are encouraged to by the “Ching!” sound — this can significantly change the game score for the level. In that case, the melody of the “Overworld” theme is attenuated, and its bass line is similarly interrupted by the numerous “thuds” of Mario hitting the block, which require the TWC’s resources. The sound effect of Mario’s jumps will play at this time as well, so in this instance the score is pervaded by sound effects. Whether or not these sound effects ever sound in Kondo’s score for *SMB* is determined completely by each gameplay, as is the tempo and number of sound effects.

In this same area, a Koopa Troopa poses a threat below the invisible coin block. If Mario jumps on this Koopa Troopa, the “Stomp” sound effect plays, and the Koopa hides in his shell. The player may then navigate Mario towards the shell, which makes him kick it and send it sliding across the ground, bouncing off any obstacles and killing any enemies in its path, as well as Mario. This has varying musical consequences. If I make Mario kick the shell between the first two pipes, for instance, the shell will rapidly bounce back and forth, triggering a “Thud!” sound — a sound louder than the “thud” heard when Mario hits a block — each time it hits a pipe, thereby adding an offbeat percussive section to the score for the duration of this event.

Other sound effects are triggered when Mario obtains a “power-up” like a “Super Mushroom” or “Fire Flower,” or if he takes damage while “powered up” by either of these items. Appropriately, the “power-up sound” is an ascending melody, while the “damage sound” is composed of the same notes in the reverse order. Power-ups carry over from level to level in *SMB*, and since World 6-2 is a later level in the game, Mario may already have a Super Mushroom or a Fire Flower, effectively changing the possibilities of such sound effects even occurring. Furthermore, Mario’s Fire ability, obtained through collecting the Fire Flower power-up, has its own sound effect which sounds each time Mario throws a fireball, and is a means of killing enemies from a distance.

The “Starman” power-up, an erratically bouncing star which grants temporary invincibility to Mario, is available in the overworld of World 6-2, and is indicated by a star in a brick block after the twentieth pipe in Figure 14. When Mario is invincible in *SMB*, the background music switches entirely from whatever theme is playing to the

"Invincibility" theme, a fast-tempo piece with a strong percussive element and a repetitive "danceable" melody. Players have considerable control over if and when this piece plays. In fact, it is gameplay that dictates if and when Mario collects the Starman power-up, and thus whether or not the "Invincibility" theme ever even sounds. Given the Starman's erratic movements, however, the player may wish to make Mario collect the Starman and fail, in which case whichever theme is currently playing simply continues.

World 6-2 has four hidden areas, accessible to Mario via pipe or beanstalk, each with their own background music. The entrance to the first of these, an underworld area stocked with coins, is the pipe labelled "A" in Figure 14. Figure 15 below shows this underworld area.

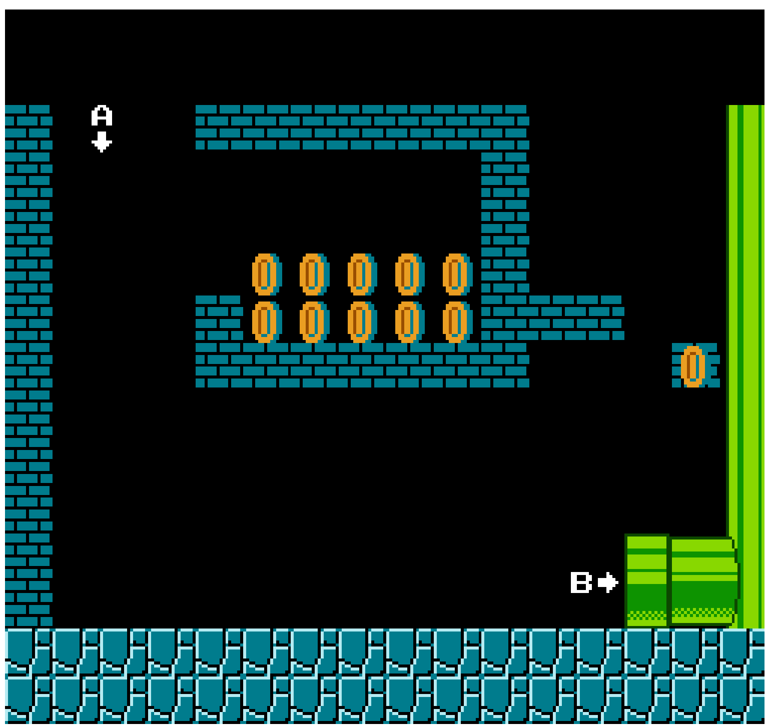


**Fig. 15**: The secret underworld area of World 6-2 in *Super Mario Bros.* When the player navigates Mario down the pipe labelled "A" in Figure 2, he falls from the top of this screen at the position labelled "A" here. Ten coins and one Ten-Coin Block await Mario in this area. ("*Super Mario Bros.* Maps")

When players navigate Mario to the underworld in World 6-2, the background music changes entirely to the "Underworld" theme. This piece contains short, punctuated, sporadic-sounding riffs on the pulse channel, each divided by large sections of silence. At the end of each loop there is a longer, descending melody composed of these quick notes, which resolves the tension created by the heavy use of silence. These punctuated sequences evoke the feeling of claustrophobia, aurally complementing the cramped underworld areas in *Super Mario Bros.* In the first underworld area of World 6-2, the player may make Mario jump on the pipe and hit the Ten-Coin Block for up to ten coins. They may also jump up, run over, and jump into the brick structure housing the other ten coins. Again, whenever Mario grabs a coin, the pulse channels sound the "Ching!" effect instead of the melody. Alternatively, players may choose to bypass the coins altogether and make Mario head straight for the pipe, effectively cutting the "Underworld" theme section of the score short. Finally, the player may remain in this area for the remainder of the time limit, which would result in a game score concluding with the "Underworld" theme and finally the "Death Sound." Traversing the "B" pipe leads Mario back to the pipe labelled "B" in Figure 14, which once again triggers the "Overworld" theme to play.

If players navigate Mario down the pipe labelled "C" in Figure 14, he ends up in an "underwater" area, reproduced in Figure 16. Travelling to the underwater area triggers the background music to switch to the "Underwater" theme. The "Underwater" theme, unlike the other themes in *Super Mario Bros*., is a slow waltz-like melody, perhaps meant to evoke the motion of Mario gracefully swimming past obstacles and enemies. Again, any occurrence of the “Coin” sound effect interrupts the melody line of the “Underwater” theme, as it does with the other themes. Mario has a new sound effect, similar to his “jump” sound effect but shorter, quieter, and lower in pitch, which plays whenever he takes a stroke through the water, which he does whenever the player presses the “A” button. In order to avoid being sucked down by the currents, the player must rapidly press “A” to make Mario swim vigorously, whenever he is over the “pits.” Naturally, this produces many instances of the “swim stroke” sound effect. If a player “dies” here, then the game score of course ends with the “Underwater” theme and, finally, the “Death Sound.”

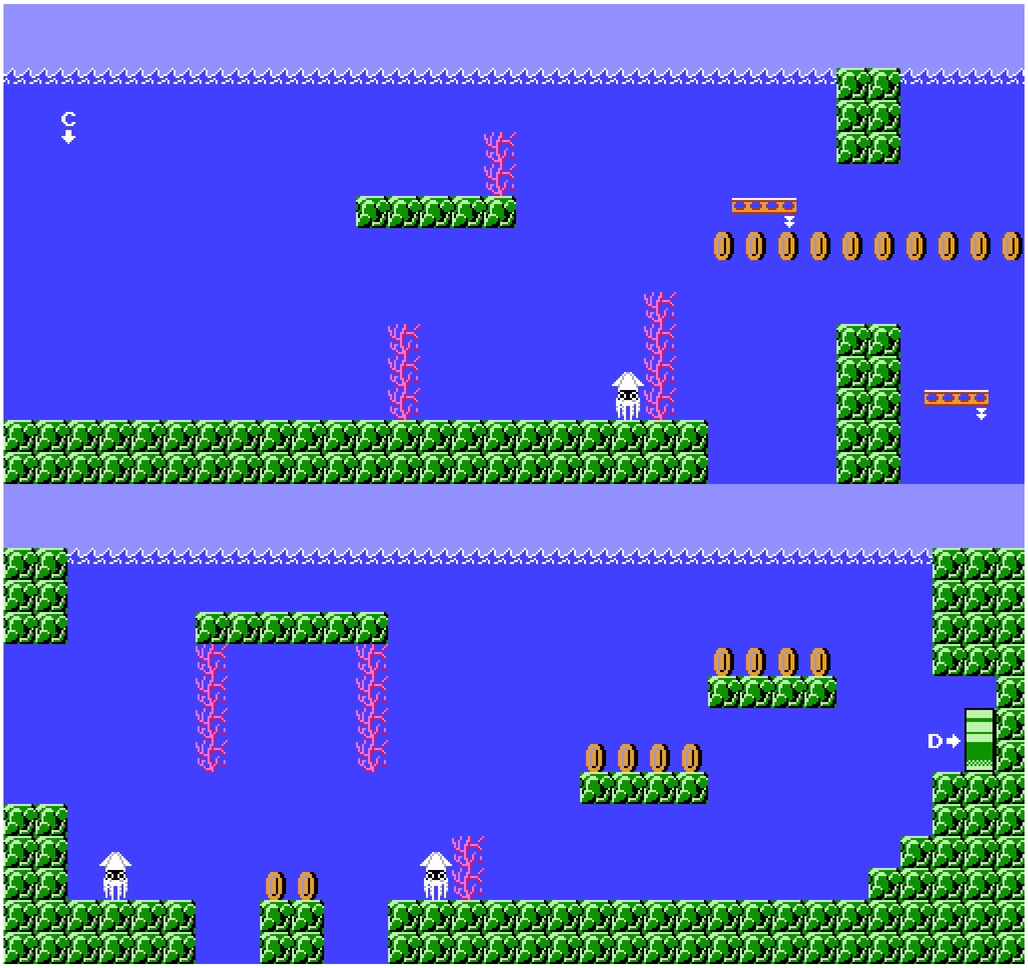


**Fig. 16**: The hidden underwater area in World 6-2 of *Super Mario Bros.* Threats to Mario include squid-like creatures known as "Bloopers," and more pits, which this time have currents which pull him downward. Mario sinks downward from the point labelled "C," if he travels down the pipe labelled "C" in Figure 14. ("*Super Mario Bros.* Maps")

The third and final type of hidden area accessible in World 6-2 of *Super Mario Bros*. is the "bonus stage." This area is only accessible if the player makes Mario find the beanstalk hidden in a brick block just above the eleventh pipe of the overworld. If Mario climbs the beanstalk at the point labelled "E" in Figure 14, he ends up at point "E" of the bonus stage, pictured in Figure 17.

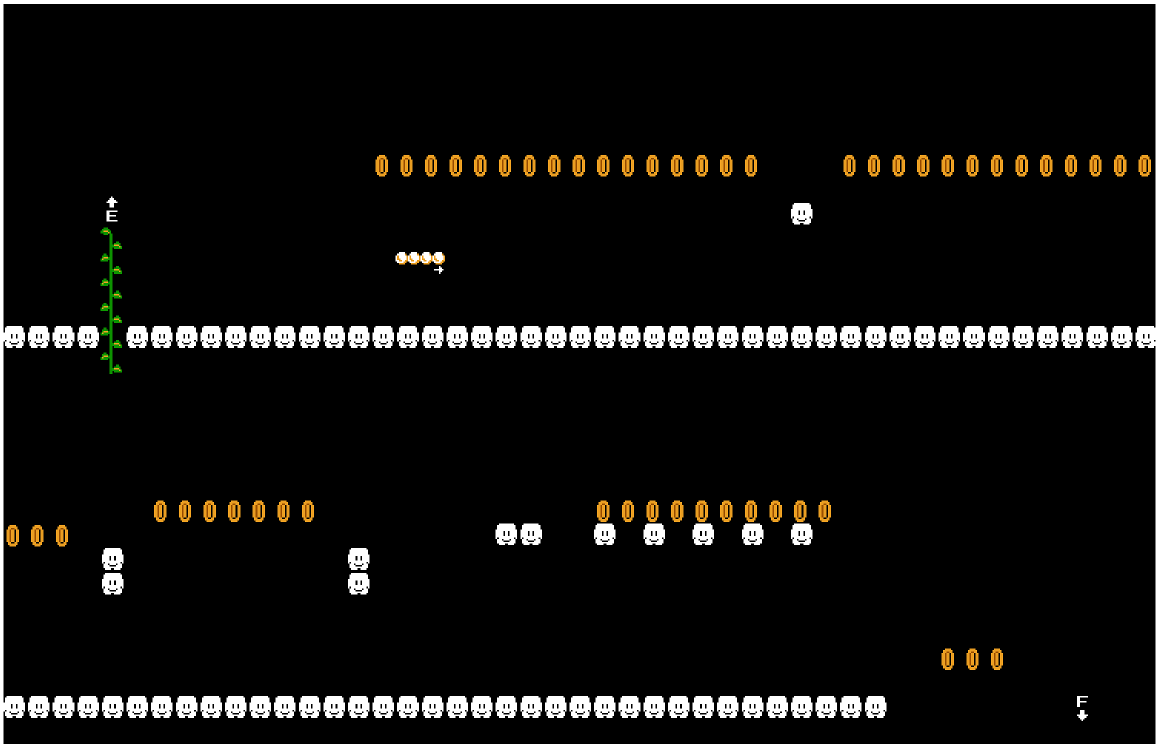


**Fig. 17**: The "bonus stage" of World 6-2 of *Super Mario Bros.* In order to reach the coins arranged in the sky, the player must make Mario jump onto a cloud platform, which promptly begins moving horizontally to the right, all the way to the end, where it finally leaves the screen. To exit the area, Mario simply has to fall back down to the overworld at the point labelled "F," which returns him to the point labelled "F" in Figure 14. ("*Super Mario Bros.* Maps")

Bonus stages in *SMB* have the same theme as the "Invincibility" theme. The only difference is that while the "Invincibility" theme has a set duration — the duration being the specific period of Mario's invincibility — the "Bonus Stage" theme may continue for as long as Mario is in the bonus stage, a duration which the player has control over. There are many coins in bonus stages, so the pulse channels must often rapidly switch between playing the melody of the "Bonus Stage" theme and playing the coin sound effect, as players make Mario jump (triggering the "Jump" sound effect) up and down from the cloud platform. The only way to "die" in a bonus stage is to run out of time, which would result in the game score for this level ending with the “Bonus Stage” theme and finally the “Death Sound.”

Players of *Super Mario Bros.* may complete World 6-2 by successfully progressing to the end of the level, marked by a flag, which, if Mario touches it, triggers the “flag” sound effect and finally the “Course Clear Fanfare” theme, a triumphant ascending melody. The “flag” sound effect is a slide from low to high frequencies on the two PWCs. This sound effect increases in length, and its final pitch increases, the higher the player makes Mario jump onto the flagpole. Furthermore, if the timer’s last digit is a “1,” “3,” or “6,” then the respective amount of fireworks will appear over the castle, which have their own “explosion” sound effect provided by the NC. In effect, the ending of a level can contain many different arrangements of sounds, all of which depend upon gameplay patterns.

Finally, if at any time during the level the timer reaches “100,” the “Hurry Up!” jingle plays, and the song currently playing then increases to a faster tempo. Each theme in *Super Mario Bros.* therefore has a “Hurry Up!” variation, which can occur at any physical point in the level. For example, I may choose not to move Mario in World 6-2 until the timer has reached “100,” which would produce a fast version of the “Overworld” theme. Similarly, if I am running out of time in the underwater area, the “Underwater” waltz will play at a faster rate. Even the already fast tempo of the “Invincibility” theme doubles when this happens, resulting in an especially frenetic piece.

## *Game Scores Vs. Game Soundtracks:* Super Mario Bros. *on CD*

Despite its ubiquitous and archetypical status, the complete game score for *SMB* may not be found on any single officially-released music album. *Famicom Sound History Series: Mario the Music* (2004) is one of a handful of releases which contain all the background music pieces from *SMB*, though it contains none of the game's sound effects. Those wishing to own an album which contains these sound effects must seek out *Super Mario History 1985-2010* (2010), a booklet and soundtrack CD bundle which is only included with the game *Super Mario All-Stars Limited Edition* (2010) for the Nintendo Wii. Unlike actual game scores, officially-released video game soundtracks rarely contain every sound from their respective games.

The most important difference between game soundtracks and game scores, for my purposes, is that while game scores are inherently interactive, game soundtracks are almost completely non-interactive. Whereas a game score's musical structure is dependent upon gameplay patterns, a game soundtrack exists as a fixed sequence of audio information. One listens to game soundtracks, while one *performs* game scores. Table 6 is a partial track list for *Famicom Sound History Series: Mario the Music*.

**Table 6**: Tracks 4-11 of *Famicom Sound History Series: Mario the Music*, which includes all of the background music from *Super Mario Bros.*, as well as the "Death Sound," which, arguably, may be considered a sound effect.

| Track No. | Title | Length |
|---|---|---|
| 4. | Aboveground BGM ~ Warning ~ Aboveground BGM (Hurry Up!) | 5:17 |
| 5. | Course Clear Fanfare ~ Scene Change BGM | 0:13 |
| 6. | Underground BGM ~ Warning ~ Underground BGM (Hurry Up!) | 1:07 |
| 7. | Bonus Stage / Invincible BGM ~ Warning ~ Bonus Stage BGM (Hurry Up!) | 0:46 |
| 8. | Miss ~ Game Over | 0:14 |
| 9. | Underwater BGM ~ Warning ~ Underwater BGM (Hurry Up!) | 1:55 |
| 10. | Koopa Stage BGM ~ Warning ~ Koopa Stage BGM (Hurry Up!) ~ Koopa Defeated Fanfare | 1:04 |
| 11. | Ending BGM | 0:37 |

Each *SMB* background music track on *Famicom Sound History* is composed in a similar manner. The "normal" version of the theme plays at its normal tempo, then, after it has looped a few times, the "Warning" sound plays, and the so-called "Hurry Up!" variation on the theme plays at its faster tempo. Each track thus includes sounds which one might hear when playing the game, though the compositional structure of each track never changes. While I may navigate Mario to die after 5 seconds of playing World 6-2 of SMB, resulting in a brief game score, the tracks contained on *Famicom Sound History* are always the same compositionally, each time I play them.

Aurally, the most obvious difference between playing *SMB* and playing *Famicom Sound History* is the lack of sound effects in the latter. Game scoring involves a recognition and integration of sound effects into the musical process, and game scores contain many instances of sound effects which are triggered as a direct result of gameplay patterns. A game soundtrack typically contains musical themes unaccompanied by the usual sound effects heard in-game, for a more “pure” presentation of the music. If a game soundtrack offers a game’s sound effects at all, they are typically bunched together under one “Sound Effects” track, or, as with *Super Mario History*, they are offered as individual tracks. Table 7 is a partial track list of *Super Mario History*.

**Table 7**: Tracks 11-20 of *Super Mario History 1985-2010*, which includes most, but not all of the sound effects in *SMB*.

| Track No. | Title | Length |
|---|---|---|
| 11. | *Super Mario Bros.* – Coin | 0:05 |
| 12. | *Super Mario Bros.* – Small Mario Jump | 0:05 |
| 13. | *Super Mario Bros.* – Power-up | 0:05 |
| 14. | *Super Mario Bros.* – 1-Up | 0:05 |
| 15. | *Super Mario Bros.* – Pipe Travel / Power Down | 0:05 |
| 16. | *Super Mario Bros.* – Hurry Up | 0:05 |
| 17. | *Super Mario Bros.* – Lose a Life | 0:05 |
| 18. | *Super Mario Bros.* – Game Over | 0:06 |
| 19. | *Super Mario Bros.* – Course Clear | 0:07 |
| 20. | *Super Mario Bros.* – World Clear | 0:07 |

The sound effects of *SMB* are offered on *Super Mario History* unaccompanied. Oddly, the game score for *SMB* is unable to even produce sound effects in this manner. Background music is always playing during gameplay, which is the only state which may produce such sound effects in-game. Not only is a game score capable of orchestrations not possible on a game soundtrack, then, a game soundtrack may similarly contain orchestrations not possible in a game score.

*Conclusion*

Game scoring deserves classification as a new type of aleatoric composition, because of its dependence on chance operations and gameplay. In this chapter, I have examined game scoring on its own terms, by analyzing actual game scores, resulting from my own gameplay of *Super Mario Bros.* Just as John Cage wrote rules for how sounds are to be produced in his scores, game scorers like Koji Kondo are cognizant of, and in many cases determine, the parameters under which sounds and music are triggered in gameplay. For example, during one playthrough of World 6-2, I had directed Mario to the bonus stage with less than 100 seconds left on the timer. The “Bonus Stage” theme was triggered by my entrance to the area, and it played at a faster tempo because of the current state of the timer. As I proceeded to collect as many coins as possible, the background music only played the frenetic TWC bass line and NC drum loop, both PWCs’ resources exhausted by numerous instances of the “Coin” sound effect. The creation of this strange soundscape is only possible through my own gameplay patterns.

Game scoring’s “moment of reception” occurs as an active state of performance. In fact, game scores are only ever materially realized by gamers, through gameplay. Game soundtracks, as I hope I have shown, are simply fixed sequences of audio information, unresponsive to anything resembling gameplay. In fact, the aforementioned game scoring example is impossible to hear on any soundtrack for *SMB*, because game soundtracks lack the interactivity involved in game scoring. Game scoring exists as part of gaming, *per se*, a medium which is inherently interactive, so it follows that game scoring itself is interactive.

# *Chapter 4*

## *Game Scoring: Conclusion*

### *Summary*

In this thesis I have examined an emerging compositional mode which I call "game scoring," that is, composing music for and through gaming. As I hope I have shown, game scoring involves a host of technical and aesthetic priorities, values, obstacles and concerns which do not influence scoring for other media. Most fundamentally, game scorers must accommodate unprecedented levels of interactivity in their compositions, as game scores are only ever *realized* through gameplay. Accordingly, game scorers compose for particular sound hardware configurations, and their scoring process is thus structured entirely by gaming technology.

I elucidated the technological structure of game scoring in Chapter 2 of this thesis, through a case study of a particular gaming sound hardware configuration: the NES APU. Just as a game scorer would approach this sound hardware technology, I examined the APU for its musical abilities. As Koji Kondo suggests, the NES sound hardware configuration structures NES game scoring in its own peculiar way, which is different from other gaming sound hardware configurations. For example, the NES APU offered only five discrete sound channels, while the later SNES sound hardware had eight.

As it turns out, NES game scorers developed unique and innovative compositional strategies in order to program musical ideas into the APU (which in many cases would be impossible otherwise). After examining the NES APU's musical possibilities and limitations, I surveyed well-known examples of NES game scorers "scheming" within this sound hardware configuration's abilities and limitations. These examples were meant to demonstrate both the technological structure of game scoring, and the broader point that this compositional activity resembles software programming more than any traditional compositional mode.

In fact, a fundamental argument of this thesis is that game scoring *is* software programming, though this should not be taken as indicative of game scoring's "unmusical" nature. Programming, coding and gaming are involved in game scoring, and these activities are no less musical than writing notes on a staff. I forego the outdated distinction between programming and composition, and instead suggest that game scoring comprises a unique compositional mode which is characterized by the activity of software programming itself.

In Chapter 3, I demonstrated that game scoring is ultimately only realized through gameplay (the duration of any game score, for instance, is always determined by the duration of a given gameplay session), thereby making it an inherently aleatoric compositional activity. I began by providing a brief case study of a canonic aleatoric composition by John Cage: *TV Köln*. I used *TV Köln* to simply define aleatoric composition, and to demonstrate the main principles of the aleatoric tradition. To my unexpected benefit, Cage composed "sound effects" for this piece, which would normally be considered "extramusical" in traditional musical composition. Similarly, game scorers expect, integrate and even compose sound effects into their scores. I used this similarity between game scoring and aleatoric composition to argue that the distinction between "music" and "sound effects" is irrelevant to the game scoring analyst. Game scorers program video game sound effects just as they program video game music, so I considered both as "game scoring" in this thesis.

I then performed an in-depth case study of World 6-2 of *SMB* to elucidate game scoring's aleatoric nature. While I expected to find a breadth of musical consequences for my gameplay choices in World 6-2, I did not expect to find so many. Even in an early game for the NES (an earlier home gaming technology by today's standards), Koji Kondo had to program numerous musical ideas for numerous gameplay states in *SMB*. For example, when I direct Mario to collect the "Starman" power-up, the game score switches entirely to the "Invincibility" theme. I outlined all the ways in which my gameplay could affect the game score for World 6-2, in an effort to demonstrate that the realization of any game score is ultimately dependent on gameplay itself.

In order to elucidate game scoring's aleatoric nature, I then compared my game scores for World 6-2 to a non-aleatoric musical source, namely, officially-released sountracks for *SMB*. This comparison highlighted both the "fixed" nature of video game soundtracks, as well as the "unfixed" nature of game scores. Game scoring is aleatoric because the gamer presents "chance" and a degree of "performer" freedom to the final composition. As expected, the video game soundtracks for *SMB* were only "idealized" renditions of game scores, and were even impossible to produce by gameplay itself. This revealed game scoring as an inherently aleatoric compositional activity.

*Future Directions*

With this thesis, I have many directions in which to take my research. I find the interaction between the game scorer (and the gamer[67]) and gaming technology most fascinating, since it is a wholly unique interaction. The game scorer devises compositional strategies in response to the abilities of particular sound hardware configurations, just as the gamer develops ludal strategies in response to the world, rules and mechanics of a game (which is only experienced through gaming technology). In fact, game scoring may affect the latter in a peculiar way. Beyond greed, my motives for directing Mario to repeatedly collect coin after coin — especially in the bonus stage — stem from a "circular causal" relationship generated by the system of visuals, haptics, and most importantly for my purposes, sound of *Super Mario Bros.* In this case, the "Coin" sound effect exists as both a feedback and control mechanism, because it is both a reward and a motive for my gameplay patterns (Whalen: 2010). I am, in effect, involved in a kind of "closed signaling loop" which constitutes my experience of the game.

Similarly, the act of game scoring, that is, scoring in a traditional sense, by a video game music "composer," involves a circular-causal relationship with gaming technology. For example, Koji Kondo composed the score for *Super Mario Bros.* in a music editor program he wrote himself in *Family BASIC*, a dialect of the *BASIC* programming language[68] that is used to program the Famicom. As such, his written

[67] By now it should be clear that the gamer is, in fact, part game scorer.

[68] Beginner's All-purpose Symbolic Instruction Code, or "BASIC," is a family of general-purpose, high-level programming languages.

“score” for *SMB* exists as code in the *Family BASIC* language, which he could make changes to, in order to effect various musical outcomes (one of which is the realtime re-orchestration of APU channels in the event Mario collects a coin). Kondo’s feedback and control mechanisms are the sounds he is able to produce from the NES APU through this code, as they constitute his motive and reward. As such, this “closed signaling loop” is indicative of a “cybernetic system,” which is any system which involves this kind of “circular-causal” relationship.

Future directions for my research could involve discussing the “closed signaling loop” involved in the cybernetic systems of gameplay and game scoring. This would build upon the examination of the technological structuration of game scoring I performed in Chapter 2, and the discussion of gameplay as performance of aleatoric composition I conducted in Chapter 3 of this thesis, thus making it an ideal academic avenue.

## *Significance*

Though this thesis contributes to ludology, ludo-musicology, and interactive media studies in kind, its most significant contribution is within the field of ludo-musicology. As stated, ludo-musicology is still forming as a field, so there is much work yet to be done on game scoring *per se*.[69] This thesis is relatively unique in that it

[69] Examples of work on game scoring that currently exist include, but are certainly not limited to: Belinkie (1999); Berndt (2009; 2011); Berndt and Hartmann (2007; 2008); Berndt et al. (2006); Brame (2011); Bridgett (2010); Chan (2007); Childs IV (2007); Collins (2005; 2006; 2007a; 2007b; 2007c; 2007d; 2008a; 2009); d’Escrivan (2007); DeCastro (2007); Deutsch (2003); Farnell (2007); Fay (2004); Furlong (2004);

concerns itself with video game music from a "scoring" perspective. Indeed, recent studies of interactive media have tended to overlook the act of game scoring itself, fixating instead on the product of that process.[70] Most fundamentally, then, this thesis is significant simply because it focuses exclusively on a form of musical activity which, though culturally significant, remains conspicuously absent from the lion's share of research on modern scoring activity.

The ludo-musicological analysis of game scoring I have performed here, that is, a ludology informed by musicological scholarship, revealed that current analytic approaches to film scores are unsuitable for studying game scoring. Despite attempts by scholars to make terms and concepts from film studies fit in studies of game scores, such as "diegetic" and "non-diegetic," for instance, it is my opinion that concepts developed to analyze other media map clumsily onto the video game medium, and may even work to obfuscate the affect of certain game scoring gestures.[71]

Moreover, analysts, non-academic writers, and gamers alike often confuse video game soundtracks with actual game scores. In this thesis I drew a technological distinction between these two media: a video game soundtrack is a record, realized by

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Gibbons (2009); Herber (2008); Hermans (2013); Hoffert (2007); Kaae (2008); Knight (1987); Lendino (1998); Lieberman (2006); Marks (2009); Mera (2009a; 2009b); Sanger (2003); Schmidt (1989); Sweeney (2011); Van Geelen (2008); Whitmore (2004); and Wooller et al. (2005).

[70] Examples include, but are certainly not limited to: Jones (2008); Thornham (2011); Waggoner (2009); Wolf and Perron (2013); Crawford, Gosling and Light (2013); Domsch (2013); Egenfeldt-Nielsen, Smith and Tosca (2013); Ensslin (2011); Gamboa (2012); Garrelts (2005); Huntemann and Aslinger (2012); Juul (2011); Ruggill and McAllister (2011); Whalen and Taylor (2008); Paul (2012); and Newman (2012), among others.

[71] Work that approaches game scoring via film scoring analysis models includes, but is not limited to: Arrasvuori (2006); Boyd (2003); Chan (2007); Collins (2007d; 2008c); Hoover (2010); Jørgensen (2004; 2006; 2007a; 2007b; 2008b; 2009; 2010); Kamp (2014); Mera (2009a); Munday (2007); van Elferen (2011); Whalen (2004; 2007); Wilhelmsson and Wallén (2010); Wood et al. (2009); and Zehnder and Lipscomb (2004; 2006), among others.

playback functions of audio technology, and produced by recording technology, while a game score is only realized through gameplay, and produced by gaming technology. This thesis is an analytic model designed to examine game scoring vis-a-vis concepts drawn directly from gaming rather than borrowed from other cultural forms (such as modern record production), so it is significant simply for this distinction.

## *Implications*

The act of game scoring can be analyzed through a multitude of theoretical lenses. I intended for my thesis to be an attempt at constructing a broader theory of this activity, and its result is a working methodology for analyzing game scoring via a ludo-musicological research framework. More specifically, one of the outcomes of this thesis was a methodology for analyzing any particular game score. While I chose to analyze the NES APU for its relative simplicity, and my scores for *SMB* for my familiarity with its "world," my research methods may be applied to all gaming technologies and game scores, regardless of their complexity. As I have shown, game scores must be analyzed first-and-foremost in terms of their technology, and then through the gameplay used to realize them. The methodology I developed in this thesis allows for such an analysis.

One undeniably major force in gaming at present is the proliferation of mobile devices, which, with advancements in handheld technology, are fully-capable gaming machines in their own right. Mobile gaming is growing more and more popular each day, though very little research has been conducted on the process of "mobile game scoring." Mobile devices present yet another technology for the game scorer to orchestrate, though they present very different aesthetic challenges than, say, the NES APU. Most significantly, mobile video games are developed for numerous different devices, so their game scores are structured by numerous different sound hardware configurations, and realized by numerous different gameplay scenarios. Even the choice of wearing headphones has its effects on the realization of a mobile game score. My methodology allows for an analysis of this peculiar type of game score, too, since it approaches game scoring from a broad perspective, and certainly includes scoring for mobile games.

Sociological and psychological research on video game music may also benefit from my analysis of game scoring. For instance, many studies from these fields on video game music focus on the widespread use of electronic gambling machines.[72] These studies tend to analyze sounds and music used in these machines, as "feedback" and "control" mechanisms which encourage playing (and spending). As noted, the nature of these mechanisms is dependent on the nature of the game scoring process, which itself is structured entirely by gaming technology. Just as gaming consoles vary in musical ability, the sound hardware configuration is often unique to a particular electronic gambling machine, and thus structures the game scoring process in a unique way. Since music is posited by these researchers as a crucial element in encouraging play, they may use a ludo-musicological analysis of game scoring to better understand how these

[72] For significant examples, see: Collins et al. (2011); Noseworthy (2009); and Dixon, Trigg and Griffiths (2007), among others.

machines, and their games, are scored. This may reveal more aspects of game scores which facilitate more explicit capitalistic intentions than do "regular" game scores.

Research from psychology, sociology, media studies and cultural studies alike have begun to address the extremely "gendered" identity of the average gamer.[73] While the proliferation of mobile gaming may have increased the amount of female gamers in recent years, the gender identity of gaming remains predominately masculine. Moreover, this phenomenon was much more pronounced in earlier gaming eras. How has game scoring affected, facilitated and/or resisted this phenomenon? My methodology allows for analyses of gender politics in video game music to be grounded in an understanding of how that music is created in the first place, thus allowing for a more thorough examination.

## *Conclusion*

To be sure, "video game music" differs from game scoring, in that the former is a "thing," while the latter remains an ongoing *activity*. While video game music may be analyzed as an ontologically terminable, or "fixed" product, game scoring remains

[73] For example, see: Brown et al. (1997); Eden et al. (2010); Feng et al. (2007); Chess (2011); Ferguson, Cruz and Rueda (2008); Greenberg et al. (2010); Jantzen and Jensen (1993); Homer et al. (2012); Behm-Morawitz (2014); Dietz (1998); Cruea and Park (2012); Scharrer (2004); Miller and Summers (2007); Perry (2011); Hamlen (2010); Williams et al. (2009); Ogletree and Drake (2007); Gailey (1993); Ivory (2006); and Soukup (2007), among many others.

ontologically "open." In this thesis, I have attempted to develop a working methodology for the study of game scoring as such.

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## EDUCATION

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## HONOURS & AWARDS

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## WORK EXPERIENCE

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| 2013-present | Graduate Teaching Assistant, Don Wright Faculty of Music, University of Western Ontario |
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## PUBLICATIONS

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