The Impact of Sound Technology on Video Game Music Composition in the 1990s

Master's Thesis Applied Musicology
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Abstract

This thesis investigated how far the ongoing improvements on sound technology democratised the compositional platform for video game music. The implementation of user interfaces for music software as well as the introduction of music data standardisations (such as General MIDI) and CD technology (which connected the process of the video game music production with that of popular music) in the early 1990s made the platform accessible for musicians outside the video game industry, as less programming skills were necessary to work with said technologies. However, since computer literacy was a characteristic of video game composers prior to the democratisation, defining what is a video game composer had become more complex. For example, it is not straightforward to regard film composers who scored music for video games also as video game composers. Other video game music characteristics that waned due to improving sound technology were the audible limitations of the sound hardware in use (such as the synthetic sounds that mimic real instruments). These limitations, a "deterministic" aspect of the technology (Taylor 2001, 16), became stylistic traits of video game music, a "voluntaristic" aspect (16). Both aspects were further observed to see whether video game music is a product of its sound technology or the other way round. Lastly, I compared the development of video game music production to that of film music for their production processes are very similar. With the comparison, film music research can easily connect to and be used for video game music. The research from musicologists in the field of video games and sound production as well as the interviews that I held with video game composers who had witnessed these technological developments were used for these findings.

Contents

Introduction

> The audio of the 8-bit era games represents an interesting tension between game sound aesthetics and the series of pressures and constraints exerted by technology, by industry, by genre, and by the very nature of games themselves. Each machine had a slightly different aesthetic that grew, in part, from the technology that was available.
>
> — Karen Collins (2008, 34)

Designing hardware to support sound and music for video games was not a priority in the 1970s and the early 1980s. Surely they were an important aspect for connecting the player with the game, but the clearly synthetic sounding sound effects were a result of game designers trying to find ways for the game system to make sound—an afterthought—rather than a deliberate design of basic bleeps for *Pong* (1972) or bass ostinatos for *Space Invaders* (1978). But slowly, sound technology became an important aspect for every upcoming gaming machine. In the early 1980s, game consoles supported more sound channels and several timbres of computer-generated sounds. In the late 1980s, with the introduction of FM synthesis, more complex ways for generated sounds became possible so that they could better emulate the real instruments that they represent. Then in the early 1990s, sound hardware that could produce sound with pre-recordings of sound (samples) became more affordable and useful. This technology allowed for music of significantly higher sound quality so that the synthesized instruments almost seemed like real instruments, rather than suggesting or mimicking them. Video game music was no longer inextricably intertwined with an artificial, computer sound. Indeed, video game critic James Rolfe argues that Nintendo's SNES game console, using early 1990s' sample-based sound technology, is "the first console ever heard [which] crossed the line of video game music and just start[ed] to sound like real music" (2012, 19:26).

Moreover, the 1990s brought the CD-ROM, a hybrid of the standard CD; it could store game code as well as stream music that was pre-performed and recorded, and that a game console or personal computer (PC) only needed to play back, not "perform" like it needed to for sequenced music. Furthermore, in an era where games could only fit on one or several floppy disks of fewer than 1.5 megabytes, the default available storage on a CD-ROM of 650 megabytes seemed almost limitless at the time. Before this technology was available, game composers had to be very economical with the space used for music. Now, looping (short lengths of) music as a way of sparing valuable storage space was no longer a necessity. See figure 1 (multiple references: see section "Figure 1 Reference" in Works Cited) for a clear overview of available storage space for the game designers of the 1980s until the present.[1]

[1] The definition of a kilobyte has changed in 1998 by the International Electrotechnical Commission (IEC). Because of this, exact numbers of data storage prior to the change are technically different. For instance, a CD-ROM is now actually 650 *mebi*bytes (MiB) rather than *mega*bytes (MB). However, in practice, many formats that were made before 1998 were still referred to using the old standard. Furthermore, it would complicate my thesis unnecessarily if I were to represent every discussed storage format according to the IEC standard. As a compromise, I carefully picked out my sources for each format to be as up to date and as primary as possible (see section "Figure 1 Reference" in Works Cited). See "Prefixes for Binary Multiples" (NIST, n.d.) for more information on the IEC standard.

Nintendo Home Video Game Consoles

medium	*release*	*size*
NES Game Pak	1983	0.008–1 MB
SNES Game Pak	1990	0.25–8 MB
Nintendo 64 Game Pak	1996	4–96 MB
GameCube Game Disc	2001	1,500 MB
Wii Optical Disc	2006	4,700–8,500 MB
Wii U Optical Disc	2012	25,000 MB
Nintendo Switch Game Card	2017	1,000–32,000 MB

Personal Computer

medium	*release*	*size*
5¼-inch Floppy Disk	1982	1.2 MB
3½-inch Floppy Disk	1987	1.44 MB
CD-ROM	1988	650–780 MB
DVD-ROM	1996	4,700–8,500 MB
Blu-ray	2006	25,000–50,000 MB
Ultra HD Blu-ray	2015	50,000–100,000 MB

Figure 1. An overview of storage size throughout the years.

Additionally, advances of software technology made the production process of composing video game music more accessible. No longer was skilful programming a necessity to initiate composition, for the software could automate the implementation of composition to computer language. Music could now be transcribed using an interface in the form of a tracker, a piano roll, or even standard music notation.

Furthermore, the limitations of music technology appear to inspire game composers to be more creative and mask these limitations. Game musicologist Karen Collins argues that "technological constraints" of computer hardware and software resulted in using compositional methods to circumvent these constraints (2008, 5). These circumventions became part of the video game music "aesthetic," (5) such as the aforementioned looping (19), which Collins argues, "appears to be as much an aesthetic choice as a pre-determined factor led by technology" (34). Only the measures that have to be repeated are stored; the repetition of these measures need only to be instructed which requires little code, similar to how repeat signs can save space on printed music.

To what extent have the ongoing improvements on both hardware and software for sound democratised the compositional platform of video game music? Since a musician could now compose video game music without requiring programming skills or hardware experience, how can a video game composer be defined overall? Has the "video game composer" disappeared and now she or he is just somebody who happens to create music for video games? For instance, film composer Harry Gregson-Williams has been the main composer for the *Metal Gear Solid* video game series since its second instalment, *Sons of Liberty* (2001, PlayStation 2). The question then arises whether the *Sons of Liberty* score can be regarded as a film score for a video game or a video game score. Regarding Gregson-Williams, it appears that another discipline of music composition (film composition) entered the video game music platform. The ongoing improvements of sound technology removed the constraints that musicians had to deal with for game hardware and software of the 1980s and/or 1990s. But how much has the unique video game music "aesthetic" that Collins mentions been removed by these improvements as a result?

To answer these questions, I will investigate the growing developments of audio hardware and technology from the late 1980s up to the early 2000s and the influence it had to video game composers using supporting academic literature from prominent game musicologists such as the aforementioned Collins, academics such as Paul Théberge and Timothy D. Taylor focussed on music technology, and by interviewing acclaimed video game composers who had to deal with these shifts in hardware and software technology such as Jeroen Tel, Frank Klepacki, and Chris Hülsbeck. I will not look beyond the early 2000s, because while technology has kept on improving, it is more a matter of refinement of already used technology from the investigated period of the late 1980s to the early 2000s.

I will especially inspect that which *is* technology, how something can be defined as being technology or at least being part of technology to understand the path it takes from start to finish and see if, indeed, it determines how the consumer of said technology uses it *or* if it is subservient to how the consumer wants it to be of use. Philosopher Martin Heidegger investigated "the essence of technology," in his *Question Concerning Technology* (1977). Heidegger asserts to a certain process that needs to be in order for technology to be created, applying the Aristotelian doctrine of the four causes. The aforementioned Timothy D. Taylor discusses two main expectational views on technology in his "Music, Technology, Agency, and Practice" (2001): a "technological deterministic" view (technology directs the user) and a "voluntaristic" one (the user decides how to use technology).

Furthermore, I will compare the development of video game music production to that of film music, because I observe a similar process in it compared to video game music. Far more academic research has been done on film music which I could connect to video game music due to the relation.

CHAPTER I

Perspectives on Technology

> The marble not yet carved can hold the form
> Of every thought the greatest artist has,
> And no conception can yet come to pass
> Unless the hand obeys the intellect.
>
> — Michelangelo (2002, 36)

This excerpt above from Michelangelo's fifteenth sonnet describes how the realisation of an idea does not come into being by constructing said idea, but by removing that which obstructs it from being, such as its current material or form, to reveal the idea as a perceivable object. The reason for including this concept in this thesis is to justify the two different ways of using technology, according to interdisciplinary social scientist Timothy D. Taylor. In his "Music, Technology, Agency, and Practice," he discusses two main views on technology: a "technological deterministic" view and a "voluntaristic" one—the former being technology being used as intended where the technology directs the user to his creation, while the latter view is more an environment where the hardware seems to be subservient to the user: she or he uses the technology outside of its intended purpose (2001, 26). For instance, sampling technology changed the sound constraints for game composers. The choice of timbre and instrumentation was vastly expanded due to sample technology. As Hülsbeck mentioned, "[sample technology] expanded the musical possibilities by a lot, because you could actually sample chords and natural sounding instruments, and that would influence the compositions of the music in another way" (2017). It should be noted that according to Taylor, both a deterministic as well as a voluntaristic view go hand in hand:

> Instead of the foregoing uses or reuses of the concept of technological determinism, I prefer to follow those historians, sociologists, philosophers, and other students of technology and media in science and technology studies who view technology as neither voluntaristic nor deterministic but as caught up in a complex, fluid, variable dynamic of each. (2001, 30)

There is always a way that the practical application of a concept is different from its intention and so both views can always be had. However, I will argue that there is a degree of objectivity. A pencil is meant to write (deterministic), but it can be used as a weapon (voluntaristic). To complicate matters, sometimes, a practical application of an object that appeared to be voluntaristic at first, became its deterministic factor. For instance, Thomas Edison's phonograph (invented in 1877) was not designed to record music on, but to "replace the costly, imperfect practice of stenography, and . . . [for] preserving in perpetuity the voices of the deceased" (Alex Ross 2005). To make sense of these matters, Taylor uses Anthony Giddens's "structure and agency" concept by describing technology as a "structure" (2001, 34). This "structure" then, forms a building block for a construction that is the concept (34). These "structures," however, are not "fixed," but "mutable by" its users (36). Something else that need to be considered is the "structure" itself. While a pencil is made to write with, its material (wood) does not at all determine a design that is the pencil. Identifying technology as a "structure," gives it this indeterministic quality such as wood has to a pencil. It changes its essence from something that already has a purpose to something which purpose is created by the user. Thus, technology can be perceived as a "resource." Indeed, Taylor also describes technology as a "resource":

> Technology is a peculiar kind of structure that is made up of both schemas and resources, in which the schemas are those rules that are largely unspoken by technology's users, thereby allowing for some degree of determinism, while technology as a resource refers to what we do with it—that is, what is voluntaristic. . . . Any music technology, then, both acts on its users and is continually acted on by them. . . . (36)

Returning to Michelango's sonnet, this sonnet can be connected to philosopher Martin Heidegger's "essence of technology" in his "Question Concerning Technology" (1977, 4). Heidegger examines the relationship with technology and society—especially considering that according to him "we remain unfree and chained to technology, whether we passionately affirm or deny it" (4). He uses Aristotle's theory of causality which consists of four causes to explain the process of technology:

1. *causa materialis* (the material needed for construction);
2. *causa formalis* (the form of the construction);
3. *causa finalis* (the product);
4. *causa efficiens* (the constructor).

Heidegger makes clear the more literal meaning of *causa* than the direct translation of "cause": "[it] belongs to the verb *cadere*, 'to fall,' and means that which brings it about that something falls out as a result in such and such a way" (7). The Greek word *aition* means "that to which something else is indebted" (7). Thus, a better translation of the four causes is "the four ways of being responsible" (9). The material, the form, the constructor, and the product, are all responsible for *hypokeisthai*, "the presencing of something that presences" or *Anwesen* ("to presence") (9). In his "Gestel and the Dynamic of Co-Disclosure," philosopher Mahon O'Brien explains Heidegger's "process of causality" (97) using a modern undertaking of the Greek word *poiesis* (creative production): poetry (97). He declares:

> [P]oetry is identified with production in the sense that any activity which undertakes to *cause* certain effects and so on, with the avowed goal of a certain type of object in mind (production in general) is a kind of poetry/*poiesis* even if we do not usually think of such endeavours as *poetic*. Furthermore, poetry is the *process* whereby something that was not there, not *present*, is now created, brought forth, *pro-duced* [*sic*] and, as such, is something that is *present* for us. It has been made present to us through the modes of occasioning. (98)

Thus, the four causes are the process of forthbringing or the process of producing. Returning to the pencil metaphor: a pencil's wood (*causa materialis*) becomes a product that is the pencil (*causa finalis*) due to it being formed as one (*causa formalis*) by a pencil factory (*causa efficiens*). I would argue that functionally, the four causes can be used as well: the pencil as an object is designed to write with (*causa materialis*), but it can also be used to start growing a plant (*causa finalis*) by supporting a plant with it (*causa formalis*) by a plant lover (*causa efficiens*).

Examining the definition of the words *technology* and *art* using the Oxford English Dictionary (2018) also gives answers useful for supporting Heidegger's thought:

> **technology, n.**:
> **1.** A discourse or treatise on an art or arts; *esp.* (in later use) a treatise on a practical art or craft.
> **4.a.** The branch of knowledge dealing with the mechanical arts and applied sciences.
> **4.b.** The application of such knowledge for practical purposes, esp. in industry, manufacturing, etc.
> **4.c.** The product of such application.
>
> **art, n.**:
> **I.** Skill; its display, application, or expression.
> **1.** Skill in doing something, esp. as the result of knowledge or practice.
> **3.a.** A practical application of knowledge.

Especially the fourth definition of *technology* is similar to the theory of causality. This "practical application of knowledge" can be translated as a *realisation* of knowledge. The artistic part of the process of technology is the efficiency of this realisation of knowledge. As such, technology is the capacity to transfer a concept into the world. The better the capacity of transference, the faster and more accomplished the idea is realised. Digital technology's capacity of transference has increased tremendously over the past decades that the *hypokeisthai* process is becoming more accomplished day by day. Thus, hardware and software are an accumulation of *hypokeisthai*. They are designed to guide the user a certain way (*causa materialis*), but there is always room for straying away from this guide and be more voluntaristic (*causa formalis*). The product (*causa finalis*) has different routes as executed by the user (*causa efficiens*). Having discussed these perspectives on technology, it is time to apply these to game music technology and see to what extent the technology has influenced the compositional platform for the composer, and whether her or his music is a product of technological determinism, voluntarism, or a reconciliational approach of both. In the "Composer–Programmer" chapter, these ideas will be further examined.

CHAPTER II

An Overview of Video Game Music Technology

This chapter will demonstrate elements of video game sound technology that I deem necessary to understand my thesis. If a more detailed overview is required by the reader, I recommend the chapters "Push Start Button," (for information on sound synthesis), "Insert Quarter to Continue (for information on MIDI)," and "Press Reset" (for information on CD technology) of Karen Collins's *Game Sound* (2008). Collins gives a more historical overview of newer technology challenging the old, while I will focus on the effect it had on video game composers and what choices they had to make for the production process. Therefore, I categorise the available sound technologies of the 1990–2000 period into two processes of sound production. They involve:

1. sound synthesis: either by generating sound (modelling) or by accessing a pre-performed sound (sampling); and
2. music playback: either by directly transferring pre-performed music (streaming) or by constructing a performance through instruction of synthesised sound (sequencing).

Sound Synthesis

There are mainly two different ways to produce sound on computer hardware and software: (1) physical modelling synthesis and (2) sample-based synthesis. Physical modelling synthesis (or modelling) is sound that is generated by the electronic device. The first generation of sound chips that use such technology are programmable sound generators (or PSGs). For instance, the Nintendo Entertainment System (NES) game console—first released in 1983 in Japan as the Family Computer (or Famicom), followed by North America in 1985—has a sound chip that can generate several forms of sound waves (pulse waves and triangle waves) through three tone generators and it can generate a plethora of noises using its noise generator. The sound that comes out of the console is not stored on the sound chip, but is created by it every time it is needed. Frequency modulation synthesis (or FM synthesis) is a more complex sound generator. Generated waveforms can be further manipulated in timbre by controlling their overtones. The overtones can be made similar to that of a real sounding instrument and as a result a waveform containing those similar overtones will sound close to the real sounding instrument it is based on. The Sega Genesis—first released in 1988 in Japan as the Mega Drive, followed by North America in 1989—has both a PSG sound chip as well as an FM sound chip. Therefore, some video games on the Genesis use both chips for the video game music.

A sample is a recording of pre-performed sound or music. A sample can either be short, such as a recording of a sound effect or of a staccato piano note, or very long, such as a recording on a CD. Indeed, a CD is practically a medium that can contain a large sample, or a division of samples, of around 700 megabytes (see figure 1 on page 2). Since a sample is a pre-performed recording, the playback of sound or music from a sample will always be the same. While modern software gives more tweakability options for samples (such as Melodyne [Celemony, n.d.]), at the time basically only the playback of the samples could be altered, not the samples themselves. The standard format for audio on a CD is called CDDA (Compact Disc Digital Audio) or Red Book.

The quality of a sample is defined by its bit depth (the resolution of one capture of audio data) and its sample rate (the amount of captures of audio data within a time frame). When a sample is played back, an interpolation algorithm is used that approximates the original wave form. Therefore, a sample with a high bit depth and/or high sample rate has a higher audio quality, because the original wave form can more accurately be reproduced (see figure 2). Audio formats that use lossy compression algorithms, such as MP3, remove audio data (decreasing the file size significantly) that cannot—or barely—be perceived by human beings, either because their frequencies are out of human ears' hearing range, or because their audible presence is such that their absence would hardly be noticeable to the listener.[2] The only downside is that the process is irreversible (a file cannot be recovered to its original state if had been lossy compressed).

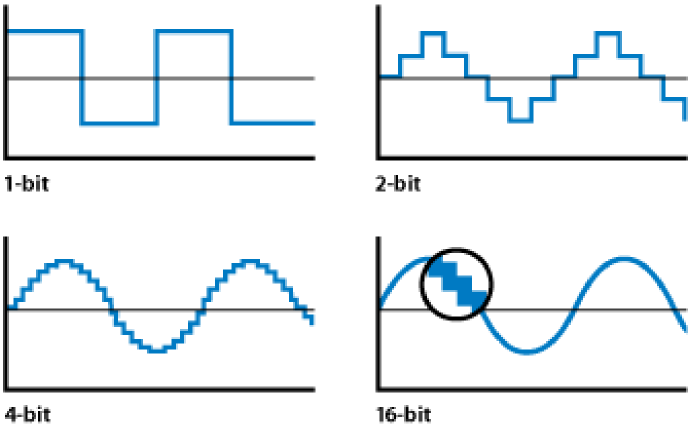

Figure 2. A sine wave digitalised in 1-bit, 2-bit, 4-bit, and 16-bit depths. Taken from the *Final Cut Pro 7 User Manual* (Apple 2010).

Music Playback

Digital storage was expensive in the 1980s. Therefore, to have music in video games, compression technologies in the form of instructions were used. Music notation is also a form of instruction (music data) to a performer such as a pianist. The pianist is the interpreter of the music data by reading, interpreting, and performing the music on the piano. Finally, the piano outputs the performance of the pianist (see figure 3).

instruction	→	**interpretation**	→	**execution**	→	**output**
music notation	→	musician	→	musical performance	→	musical instrument
music data	→	music interface	→	sound chip	→	sound system

Figure 3. A comparison of processing musical information.

MIDI is an acronym of Musical Instrument Digital Interface and it is a standardised form of such music data which was released in 1983. Again, this is similar to how music notation is standardised (with some exceptions such as the change of the standard concert pitch) and so a pianist of the twentieth century is able to read and perform a piano piece from centuries ago. A sequencer is a system (in the form of hardware or software) that can read music data as well as samples. With the sequencer, these instructions then can be manipulated and performed by the user.

General MIDI, an updated MIDI specification released in 1991, expanded standardisation even further. Most notably, 128 presets of musical instruments called Program Numbers were now standardised (see figure 4). This meant that a MIDI file written for Program Number 10 should always correspond to Glockenspiel. While the sound quality of General MIDI compatible sound hardware

[2] It is worth mentioning that even though MP3 technology was available in 1995, it was hardly used for video games during its introduction. Possible reasons for not using this, at the time very efficient, compression system might be the licensing costs that game publishers did not want to afford. In a conversation with Jeroen Tel (2018) about the subject, Tel explained that Fraunhofer did not have license options available for the video game industry. Furthermore, he mentioned that MP3 could not loop so well (there is a gap when an MP3 track restarts). Ben Waggoner discusses the issues with MP3 licensing in chapter "Miscellaneous Formats" of his *Compression for Digital Video* (2002, 352). MP3 is license-free (with some restrictions) as of April 23, 2017 (Fraunhofer Society 2017).

could be different depending on the model and the manufacturer, it should always output a Glockenspiel sound.

Piano		Chromatic Percussion		Organ	
1	Acoustic Grand Piano	9	Celesta	17	Drawbar Organ
2	Bright Acoustic Piano	10	Glockenspiel	18	Percussive Organ
3	Electric Grand Piano	11	Music Box	19	Rock Organ
4	Honky-Tonk Piano	12	Vibraphone	20	Church Organ
5	Electric Piano 1	13	Marimba	21	Reed Organ
6	Electric Piano 2	14	Xylophone	22	Accordion
7	Harpsichord	15	Tubular Bells	23	Harmonica
8	Clavinet	16	Dulcimer	24	Tango Accordion

Figure 4. The first 24 Program Numbers of a General MIDI instrument.

Figure 5 is a diagram that shows four combinations of the discussed technologies used. The fifth column, streamed playback of generated sounds or noise, can be considered a live performance, such as a player's singing on the PlayStation 2 game SingStar (Sony Computer Entertainment Europe 2004).

production				
generated	✓			✓
pre-performed		✓	✓	
playback				
sequenced	✓	✓		
streamed			✓	✓
example				
sound carrier	synthesized ringtones	sample-based digital pianos	compact disc	microphone usage
game console	NES music	SNES music	PlayStation CD-music	*SingStar* games

Figure 5. An overview on the available combinations of sound production and sound playback.

Musical Instruments as Part of the Audio Interface

MIDI was one major music technology standard that simplified the working environment for game composers. The introduction of input devices for music production software that resemble music instruments—most notably the piano—made game music composition more accessible for the musician. In some ways they connected the craft of piano playing to a digital environment, but because of that, some possibilities that music production software has cannot be triggered by such a familiarised device, while some capabilities that a piano has could not be realised by the input device and/or music software. For instance, changing the volume of a tone on a piano is not possible (only very slightly, by manipulating the damper pedal and the sostenuto pedal). Pitch and modulation wheels, nowadays standard on MIDI controllers, serve this purpose. On the other hand, striking a triad on the keyboard does not guarantee all those pressed notes to be performed; it depends on how many voices its (connected) hardware and/or software can handle simultaneously (the amount of polyphony).

For a long time, sequenced music was the obvious winner for interactivity and storage efficiency, while streamed music was far superior in the sound quality of the music, but required a lot of space—the main reason it could mainly be found on games that used CD-technology such as the Sony PlayStation and PC CD-ROM games. Furthermore, the recording production for streaming music technology, (especially CD music) was more accessible for musicians, because its music production was similar to that of the popular music industry. Furthermore, MIDI and General MIDI did simplify the process of video game music production using sequencing technology and they also connected it more to the popular music industry because it also uses MIDI technology. Game developers were dependent on the budget and their game console's capabilities. Games on cartridge-based systems such as the Nintendo 64 (N64) were far more limited on storage than games on CD-based systems such as the PlayStation (see figure 1, page 2). So even if a game developer could hire a full orchestra and a quality recording studio, if the finalised music could not fit into the game, it was of no use. In the next chapter, I will discuss the choices that video game composers could make for their video games.

CHAPTER III

Choosing the Game Audio Requirement

Having discussed the sound technologies that game composers from the late 1980s until the early 2000s could work with, this chapter will examine the choices composers (or the sound team as a whole) had to make when they were producing their games. The choices mainly had to do with creating a balance of quality and budget. I will also give two examples of game audio choices made by game creators—one project team that decided to invest valuable storage for superior quality music, the other that decided to intuitively use the technology at hand to get the most out of it. Finally, I will examine the benefits and problems that each technology has on preserving video game music. The issue is noteworthy, because incompatibility issues with new hardware or unavailability of original hardware might cause for misrepresentation of remediated video games and their music.

Game composer Bobby Prince—especially known for his *Doom* game soundtracks—discusses how to effectively work out the process of audio development for video games in his article "Determining Your Game Audio Requirement" for *Game Developer Magazine* (1997), which was a monthly magazine about professional game development. One part of the process he discusses is for the project director to figure out what music platform should be used and to be aware of the advantages and disadvantages of each option. For instance, MIDI is very flexible, but due to it being interpreted differently by different sound cards with each having different sound libraries, a choice has to be made whether to create specific MIDI files for the available sound cards to get the most out of them—for instance AdLib and Sound Blaster—or to only include one MIDI file for each track, which requires less work, but which can result in unsatisfactory results of the music on some sound cards (34). The other option would have been CD-quality audio, which has far superior sound quality and the representation of the game composers' original idea will be preserved far better, because the music will stay the same whichever sound card the player uses—only the sound output (the quality of the speakers, headphones, earbuds, etc) can somewhat affect the representation. However, storage space needs to be considered for CD-quality audio, because it takes up a lot of it (34). He concludes with the following:

> [T]he best rule of thumb seems to be to start with a platform that would be appropriate for a movie or audio CD and work down from there. If MIDI files are used in the production of Red Book tracks, it is possible to make a basically acceptable GM version of the music. If live musicians are used, it would be prudent to have them use MIDI controllers so you can record a sequence of their performance. Then, if Red Book audio has to be dumped from the project, you would have the basics for your MIDI tracks. (34)

Kevin Schilder's music for the game *Hexen* (1995) exemplifies Prince's suggestion by having both MIDI files as well as CD files included in the game. The track "Guardian of Ice" (1995) sounds significantly different with the MIDI version on a Sound Blaster card than the CD version, which is a recording of the same MIDI file performed on a different sound card. Most of the instruments on CD version–namely the piano and the timpani–are unrecognisable on the MIDI version. Not all songs in MIDI format are included in CD format, however. The reason for either options being available is likely for better compatibility since CD-audio support on a PC game at the time was not straightforward and possibly not available for some CD-ROM players connected to a PC (Chris 2017).

1. Quality over Optimisation: Streamed Music on a Game Console with Limited Storage

Sometimes, compositional choices have been made which at first glance appear to be counterintuitive and inefficient, but in actuality are very reasonable. The Nintendo 64 (N64), Nintendo's third home video game console, still used cartridges as a storage medium for its games as opposed to CDs that were used by Nintendo's competitors Sega (with the Sega Saturn) and Sony (with the PlayStation). Nintendo was dissatisfied with the fragility of CDs and the slow loading times that came with them and decided to go for the more expensive but reliable cartridge technology which was used since its first game console (the NES / Famicom).

Mark Haigh-Hutchinson, project leader of the N64 version of *Star Wars: Shadows of the Empire* (1996), discussed the development of the game in *Game Developer* (1998). He mentioned that the initial choice of using MIDI for the music was problematic. One problem was that the N64 did not have a dedicated sound chip, and therefore part of the main CPU's performance needed to be reserved for driving the MIDI tracks (Eggebrecht 1998). This meant that "each additional instrument channel would require more CPU time than [they] wanted to allocate" (Haigh-Hutchinson 1998, 58) Even without those problems, "the MIDI music . . . didn't capture the essence of the John Williams orchestral soundtrack that is so closely associated with Star Wars" (58). Haigh-Hutchinson and his team then tried to work with music of the original *Star Wars* recordings:

> The quality [that came out from using the original recordings] was extremely good, even after subsequent compression . . . . Nintendo generously agreed to increase the amount of cartridge space from 8MB to 12MB. This allowed us to include approximately 15 minutes of 16-bit, 11khz [*sic*], mono music that sounded surprisingly good. Considering that most users would listen to the music through their televisions (rather than a sophisticated audio system), the results were close to that of an audio CD, thereby justifying the extra cartridge space required. (58)

The music files of around 15 minutes on the N64 cartridge are close to 4MB in size—40 times smaller than without the compression which would have been close to 160MB.[3] On the N64, excerpts of John Williams's *Star Wars* (1977) and *The Empire Strikes Back* (1980) scores and John McNeely's *Shadows of the Empire* (1996) score are looped. What Haigh-Hutchinson did not mention was the short duration of the looped part for each level. For instance, on the N64, the music in the level "Ord Mantell Junkyard" (N64 version, 1996 / Windows version, 1997) is derived from Williams's cue "Rescue from Cloud City / Hyperspace" (1980) and just close to a minute long while on the later released CD-format version for Windows (PC) it is almost two and a half minutes long (see figure 6). However, while each level on Windows has longer music of much higher fidelity as demonstrated by gameplay footage of YouTuber EverlastingSky (2015), part of the immersion of gaming is lost due to the music fading out and restarting again, compared to the carefully connected loops on the N64 version (TheSeriousCacodemon 2009). The technology present to the player (music fading) does not stay behind the scenes, and therefore its "invisibility," one of Claudia Gorbman's film music principles at work is not maintained (1987, 73). I use a more figurative interpretation of Gorbman's principle, that the "technical apparatus" must be imperceptible or hidden to the viewer, not necessarily only visibly absent (73). For instance, I argue that sound effects that are used repeatedly affects the immersion of watching a film. While the technology used is technically invisible (visually hidden), it can still be audibly recognised by the spectator. "The Wilhelm Scream Compilation" (chrisofduke 2006) demonstrates how the Wilhelm scream sound effect

[3] I used the file size of the sound-generating code on the game's cartridge (4.064.972 bytes for 15 minutes) compared to how many megabytes a minute of CD-quality audio needs (10.584 megabytes per minute) The file size calculation of CD-quality audio was derived from AudioMountain.com: audiomountain.com/tech/audio-file-size.html.

abundantly used in Hollywood films destroys Gorbman's "invisibility" principle for these films even though it is not visual to begin with. "Inaudibility" could be a better term (technology should not be heard) but Gorbman also has an "inaudibility" principle, which has a completely different meaning: that music, while important in film, should not be a distraction to the film (76). It should stay subservient to the motion picture and dialogue (77).

level	excerpt from	CD recording	N64 version	Windows version
Ord Mantell Junkyard	"Rescue from Cloud City / Hyperspace"	9m8s, 80MB	59s, 0.26MB	2m23, 21MB

Figure 6. A comparison of time duration between the different versions of "Ord Mantell Junkyard."

2. Thinking Outside the Box: More Polyphony on the SNES

The Super Nintendo Entertainment System (SNES) has eight separate channels available for sound. This is a significant higher amount than Nintendo's previous NES console, which had three tone channels and one noise channel. The game designers had more options to preserve a continuous soundtrack of music and sound effects for their games: some channels could be reserved for the former, and other ones for the latter. Here again, the "invisibility" principle can now be maintained because of this.

Each channel on the SNES works with samples rather than with programmable generated sounds. Because of this, the "Beach" track from *Plok* has two channels producing six voices, because each channel produces a sound of a triad (see figure 7). Tim and Geoff Follin sampled a major triad in second inversion for channels 4 and 5, along with a sample of an octave for channel 3. Channels 4 and 5 each have different $^6_4$ triads. E$^6_4$ + B$^6_4$ along with the bass (channel 3) produces an E^{maj9}/B chord. Similarly, a Bm^{11} is created with D$^6_4$ + A$^6_4$ and the bass in mm. 3–4. Having created such dense jazz chords with just three channels, there is still room for an arpeggio line (channel 1) and some percussion (channel 2).

Figure 7. An excerpt of "Beach" from *Plok*. Transcribed by the author.

Other methods to imply more polyphony were to use arpeggios or compound melodies, which I discuss in my BA thesis, *Programmed Baroque 'n' Roll* (2016).

Samples also had the benefit of implying more instruments for each voice. The intro "Prologue" of the SNES game *Castlevania: Dracula X* (1995) is very orchestral and rich, while still only using eight channels, but some samples imply a group of players to make for a string section and a brass section (see figure 8). To stay within the limit of eight voices simultaneously, they are exchanged from instrument or section to another. For instance, the two lower brass voices in the third measure play for only one beat, but then they become silent so that the string section can use two voices for the downward sixteenths run. In the fourth measure, one voice of the brass section follows along with the string section, which is possible, because it is exchanged from the top voice of the brass section. Sometimes one voice is used for a reverb effect (not transcribed in the figure, but audible on the track).

Figure 8. An excerpt of “Prologue” from *Castlevania: Dracula X*. Transcribed by the author.

3. Remediation and Music Technology’s Ever-Increasing Quality in Resolution

Music of games that were released on gaming platforms that used generated sound are harder to preserve and remediate authentically, because the sound/noise generation is hardware dependent. For example, the original Sega Genesis had a Yamaha and Texas Instruments sound chips on the console. The re-release of the system as the Genesis Flashback HD, uses emulation to run the games; it does not include said sound chips, but reverse engineered replications of them. As a result, the sound and music of the included games are, though similar sounding, not the same as how they would have sounded on original hardware, as demonstrated in the video “SEGA Mega Drive vs. AtGames’ Genesis Flashback HD” by Mega Visions (2017). The re-release of the SNES, a game console that used sampling for sound production, on new hardware that also emulates the system, does not have that problem. However, while the samples are as exact as they were, the handling of those samples is not, because the SNES sound chip is also emulated. These differences, however, are negligible (Retro Rich 2017).

Furthermore, while music performed by improving sound generating hardware and samples of ever-increasing higher quality gets more convincing to real live performances, when it goes overboard in trying to replace the real rather than mimicking or suggesting it, its artificiality can be even more pronounced compared to music of lower resolution. The music of *Star Fox* (1993, SNES) is a mixture of sampled orchestral instruments—most notably a string section, a brass section, and timpani—mixed with synthesizer sounds. *Star Fox 64* (1997, N64) on the other hand consists of only orchestral samples. While each instrument on *Star Fox 64* is more similar to what it wants to represent, it becomes clearer that the score is artificial because of it. *Star Fox Assault* (2005, GameCube) makes clear how technology can affect a game score, because many reviews praised *Star Fox Assault*'s music while it is essentially the same score as that of *Star Fox 64*, but arranged for and performed by a real orchestra. On the other hand, the knowledge of recognising the real from the artificial or maybe the requirements needed to fool the player from perceiving the game's artificiality has increased over the years. The differences can be heard with the piece "Meteo" (N64 version, 1997 / GameCube version, 2005).

Another more complex example would be *Star Wars – Rogue Squadron II: Rogue Leader* (2001). Its game soundtrack consists of excerpts from John Williams's music for the original *Star Wars* trilogy (1977–1983) as well as new pre-performed sequenced music by Chris Hülsbeck. The difference between these two approaches on the same game is very clear—especially when a piece from Williams is replaced by an arrangement of Hülsbeck in "Strike at the Core" (2001, GameCube), the game's final level as demonstrated by gameplay footage of CountBleck2009 (2009). Matt Casamassina, who reviewed the game for IGN (an online video game website), acknowledges the mix of sequenced and streamed music, but experiences it as "undeniably outstanding. The orchestrated tunes are of course brilliant and Factor 5's MIDI contributions [Factor 5 was responsible for the sound and music of the game] usually blend seamlessly into the mix (with the occasional out of place horn)" (2001). A seamless blend is maybe what an average gamer would hear. Indeed, having examined the aforementioned *Star Fox* and *Star Wars* game music, it should be considered that not many gamers might have noticed the demonstrated artificialities because their listening ears were not able to distinguish them at all.

Having discussed the process of game designers and their composers having to deal with different technology options for game production, I will follow with a chapter about how these technology options had their differences as a compositional platform. For instance, initially it was hard to compose sequenced music due to the programs not being user-friendly. However, sequenced music software became more user-friendly over time—so much that it was not required at all anymore to have programming skills, which led to hiring of composers from many different fields, but which also led to a demise of specialised video game music composers and it possibly led to a radical change of sound that *was* video game music.

CHAPTER IV

The Composer–Programmer

> The democratization of musical skills has permeated all digital instruments, as they all have the ability to perform as music-boxes. . . . [T]he whole concept of musicianship has become problematic as the user is often a programmer or a composer working solely with his or her cognition, rather than a tactile player. The turn to digital musicking may leave us handicapped in more than just a metaphorical sense.
>
> — Marko Aho (2009, 25)

Technology has its capabilities but also its limitations, or as Collins calls it "technological constraints" (2008, 5). A piece of music technology's capabilities could obviously enthuse a musician to create something new with it. However, its limitations appear to facilitate a certain creativity as well. For instance, in my Bachelor's thesis *Programmed Baroque 'n' Roll* (2016), I give compositional analyses of video game music for the NES that illustrate Baroque-like influences, because Baroque is an efficient style to compose with on sound hardware that consists of no more than three tonal channels and one percussion channel. In addition to Collins's observation of "technological constraints (2008, 5) Leonard B. Meyer points out in his "Toward a Theory of Style" that "constraints" form a stylistic property of music (1989, 24). He says that these "constraints of a style" are a "result of experience in performing and listening rather than explicit formal instruction in music theory, history, or composition" (24). In this chapter, I will examine to what extent the technological constraints of sound hardware and software influence or handicap a musician's composing.

During my interview with game composer Chris Hülsbeck, when we discussed the change of game composition from the 1980s to the 1990s, he illustrated that at the dawn of video game music (the early 1980s) one had to rely on "the main elements of music, which is melody and bass and some rhythm or chords" (2017). The sounds were basic (unnatural sounding) and the expressive options of these sounds were limited (low polyphony, low dynamics, basic rhythmical options due to a low-resolution timing grid, etc.). As a result, these elements "made for a distinctive sound of those early systems. It definitely influenced the type of music that was created in the early days. The sound chips kind of dictated the style of music that would work best on them" (2017).

Another element that changed the composition environment for game composers was a far easier to use user interface. In his *Any Sound You Can Imagine*, Paul Théberge makes clear that technology that can function as a musical instrument but is physically unrecognisable as such complicates the possibility to identify it as a musical instrument for musicians in general (1997, 44). Therefore, they had to "adapt to unfamiliar sounds . . . [and] to learn an entirely foreign set of performance techniques" (44). This observation relates to game composers prior to the advent of music-streaming technology. They needed to identify the hardware as a musical instrument and be able to musically perform on it. Consequently, they needed to have programming skills to get the music the way they wanted on the machine. For instance, game composers needed to understand assembly language, machine code, which would be specific to the gaming hardware that the video game used (e.g. the Atari 2600 had a different assembly language from the Nintendo Entertainment System). Figure 9 illustrates the instructive assembly language with the help of the much more understandable standard music notation based on Anthony McSweeney's article "Rob Hubbard's Music" (1993).

assembly language

$84, $04, $24

note length
instrument
pitch

music notation

Figure 9. A comparison between the abstract assembly language and standard music notation. Assembly language example by Anthony McSweeney. Transcribed by the author.

In his “Chip Music” article, chip-tune composer Anders Carlsson (2008) makes clear how the process of composing for video games shifted from a deterministic approach (the hardware defines the sound and style of composition) to a voluntaristic one (the user chooses the sound and style of the composition independent from the hardware), in this case for composers who choose a 1980s’ game sound (chip-tune) environment on hardware that is actually capable of more: “In the 1990s sample-based chip music became more a conscious choice of style rather than a direct consequence of the hardware and software to create it” (2008, loc. 3517 of 4927). Interestingly, however, game composer Jeroen Tel (2017) argued that in a way the determination of hardware limitations enthuses the user’s creativity:

> Limitations create opportunity. I programmed in machine code. One can only hear what is done after it is assembled. Beethoven composed his greatest works when he was stone deaf. All that he wanted to hear the orchestra to perform was precisely there in his mind. The same goes for 8-bit programming. We [game composers of the 1980s] programmed it. We didn’t have a tracker for it. In the end, I knew exactly what I did.

As William H. Alamshah puts it in his article “The Conditions for Creativity,” “receptivity” or “openness” facilitates creativity by removing preconceptions (“prior stimuli or data”) from a project, bringing forth new ideas (1967, 313). Connecting that observation to limitation—meaning that something is described for what it cannot do (deterministic and pre-judged)—“receptivity” then gives inspiration: to challenge that limitation.

Indeed, Hülsbeck also sees limitations as an important part for creativity (2017). To him, a game composer’s musical work is determined by the user interface, arguing that it “influenced and limited the styles that you could do” (2017). He created the program SoundMonitor in 1986 for the Commodore 64 for which a musician could compose music through a more structured and understandable user interface (see figure 10). The fastest notes possible were 16th notes, making it “tricky to do faster runs” and “it would really lend itself to a synth-rock kind of style, instead of the freedom that you have nowadays when you just produce music in a studio and have the file play along with the game.” SoundMonitor could also play back the composition directly, even while editing. It was a “[r]ealtime-record” feature at the time as mentioned in the article “Listing des Monats: Musik wie noch nie” (Listing of the month: music like never before) of *64’er*, a German magazine with information and instructions for the Commodore 64 (1986).

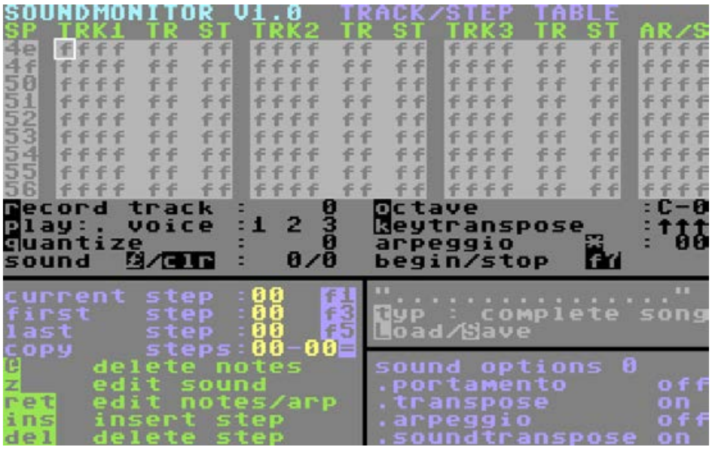

Figure 10. The interface of SoundMonitor. Screen captured by the author.

While composing directly from a keyboard was possible—the performance would be digitally recorded as music data, not audio—the performance had to be coded into the game by programming a music driver (Heineman 2015, 25:14). When I asked Hülsbeck (2017) how he considers the composing part of game music to be—for instance, (1) writing it down in music notation and then perform it using MIDI or live by musicians and (2) performing it right away and move on from there—he mentioned that he is "not a classically trained composer" and that he needs arrangers and orchestrators for the execution of the composition.

Yamaha's DX7 FM synthesis-based digital synthesizer and electronic keyboard (see figure 11), introduced in 1983, is such an instrument that improved accessibility of music composition for musicians who are barely or not at all equipped with programming skills.[4] Due to its MIDI compatibility, the DX7 could be connected to a PC. While the DX7 had synthesizer capabilities, due to it being cumbersome to program the device and because its performers "simply wanted to use it as a substitute for a piano," the main factory presets were used most of the time (DX7, n.d.).

Figure 11. The Yamaha DX7. © 1983 Yamaha Corporation.

A radical change of music output ensued after programming skills were required less and the canvas of sound options became limitless because anything could be recorded, stored, and played back using streaming technology for games. Streaming music technology became more popular to use for video games over time, as game releases on CD-capable hardware removed the issue of storage limitation and its music production was accessible for musicians with no programming skills. Storage media in general became more affordable so that audio data other than CD format which were still larger than sequenced music, became useful. In the next chapter, I will discuss the consequences of this change.

[4] Technically, the DX7 is not a true FM synthesizer. It uses phase modulation technology to mimic FM synthesis.

CHAPTER V

Composers Outside the Video Game Industry

Because of improving storage media and composing/recording options for musicians, mainly because game consoles became CD-capable, composers of fields outside the video game industry could be hired by game developers. Probably the most prominent figure who joined the video game music industry was Hollywood composer Harry Gregson-Williams, who was one of the main composers for *The Rock* (1996) and *Enemy of the State* (1998). He was hired for scoring the game *Metal Gear Solid 2* (2002, PlayStation 2) and he stayed the main composer for the *Metal Gear Solid* series up until the fifth instalment, *Ground Zeroes* (2014, Windows). It should be noted that already back in the 1980s, composers of different fields were hired for composing video game music, such as classical composer Koichi Sugiyama for *Dragon Quest* (1986, Famicom). However, sacrifices for realising the musical ideas had to be made because of the limitations of sound hardware, while the streaming music technology could retain all the intentions of the composer. For instance, during my interview with Frank Klepacki (2018), he said that the music for *Dune 2000* (1998, Windows), a remake of *Dune II* (1992, MS-DOS), was what he "ideally had in mind from the beginning [for *Dune II*]," but due to the technology limitations of the early 1990s, he was incapable of producing it that way at the time.

Furthermore, streamed music was not restricted in sound and sequenced music became more powerful over the years to being used alongside recorded audio in music production. Indeed, many digital audio workstations used for music production—such as PreSonus's Studio One (2018, Windows / macOS)—are essentially a hybrid of an audio recording tool along with a sequencer tool. Now, any sort of music could be included in video games. Game composer Tim Wright created an electronica soundtrack for the PlayStation game *WipEout* (1995) and electronica music from established musicians such as Leftfield and The Chemical Brothers were added into the European version of the game as well. In the feature "How PlayStation Changed Gaming," (Darran Jones, ed.; 2015) Colin Anderson, who was the audio director for the game company DMA Design, mentions how WipEout affected his music production for *Grand Theft Auto* (1997, Windows):

> [A]fter people started hearing tracks they recognised by the Chemical Brothers and Leftfield in their games, chipmusic [sequenced and synthetic sounding music] became unacceptable really fast. . . . When we started development [for *Grand Theft Auto*] we fully expected to be using chip-music, but within six months it became clear we needed to up our game if we wanted to compete with all the other great games that were being released. *WipEout* was the straw that finally helped me convince Dave Jones [head of DMA] that DMA needed its own music studio. (27)

In the feature "The Complete History of WipEout" (Jones, ed.; 2015) it is mentioned that in the late 1990s "the games industry's relationship with the music business was still very much in its infancy" and that *WipEout* changed all of that because of its soundtrack (92). It is further mentioned that "the two industries could be mutually beneficial to one another. Kids purchase both videogames and music, and so a good game can offer musicians a captive audience" (92). As it seems, game music that sounded anything but game-related became popular to create, partly because it gave a social connection (*WipEout*), and partly because it introduced immersion from other art disciplines into video gaming (film music for the *Metal Gear Solid* series). Game composers that could impress with their programming skills during the 1980s and early 1990s, now could only impress with their music. The moment video game music connected to the (popular) music industry seemed to have re-established how video game music and their video game music composers can be defined. It creates grey areas in how to describe certain composers. Can Harry Gregson-Williams be considered a video game composer, or a film composer hired to make a video game more cinematic? John Williams did not write a single piece for a video game, yet many video games contain his music directly extracted from the original recordings (such as *Shadows of the Empire* [N64, 1996 / Windows, 1997] as demonstrated in Chapter IV). Would then maybe only his music that is sequenced, such as the music in *Super Star Wars* (1997, SNES) be considered video game music?

A better way to look at the situation is to interpret video game as an art medium (in the form of entertainment) with music. While early video game music was aesthetically closely connected to this medium, later on music from other media was integrated to it. And this is quite similar to the musical development of the motion picture. Quentin Tarantino is well known for his films including pre-existing music. For instance, he reused film music in his *Inglourious Basterds* (2009) with "L'incontro Con La Figlia" (1965) of Ennio Morricone's score for *The Return of Ringo* (1965), and he reused popular music in *Reservoir Dogs* (1992) with "Little Green Bag" (1969) by The George Baker Selection. The sound technology that was part of the product of video game music (e.g., tone-generated sounds and limited polyphony) was in a way an aesthetic quality, which was first embraced by game composers, because it worked so well, but since the limitations were removed by streaming audio technology, the aesthetic appears to have been regarded as a technological artifact of the old (hardware). In his "Popular Song as Leitmotif in 1990s Film," music professor Ronald Rodman (2017) says about film music:

> Little has been said about musical style . . . , because it is tacitly understood that the classical film draws from the style of nineteenth-century European (especially German) Romanticism. With the rise of the popular song score . . . , we note that popular music signifies at a different level, in this case in the more popular realm of musical style . . . . Moreover, the musical style level reaches beyond the film's narrative and interacts with other competences, especially Social Practice [*sic*] . . . , as musical style distinguishes aspects of race, gender, and other traits of character. (129)

This comparison can be made to how popular music and film music is implemented in video games. They (popular music and film music) signify their musical styles and distinguishing aspects to the video game music aesthetic that initially consisted of mostly synthetic and mechanically performed music because of technological "constraints" according to Karen Collins (2008, 5) as discussed in Chapter IV. Moreover, in his *John Williams's Film Music* (2014), film musicologist Emilio Audissino argues that "the technological progress of synthesizers and music software" resulted in a "weakening of the musical language" (199) and that "it allow[ed] poorly trained or completely untrained musicians, often with the most diverse and unorthodox background, to write music" (199). He further claims that these technological developments were one of the main reasons that the "classical period" (198) as initiated by John Williams starting with his *Star Wars* (1977) score (Audisinno 76), was replaced by "[c]ontemporary film music" (199). This can also be linked with how video game music was changed by streaming technology: it allowed composers who were not specialised in the field of game music to write video game music.

These are not the only connections I could make with film music and video game music. My final chapter connects the production processes of both industries to display production became more efficient but how the creative freedom from the composers was diminished by it as a result.

CHAPTER VI

The Video Game Orchestrator

In his *John Williams's Film Music* (2014), Emilio Audissino argues that film producers hire orchestrators in addition to the main composer for the film as a time-saving measure (38). The main composer can give his full attention to his composing duties, while "all other technical and less-creative steps [are] assigned to collaborators, called 'orchestrators'" (38) The orchestrator makes a "detailed full score" out of the composer's main idea, *but* "without adding anything substantial," to not affect the main idea (38). By comparison, a game production has programmers responsible for making the sound and music work in the game engine. Their creative steps are the framing of the music in the game and the selection of the instruments (either tone-generated or sampled) for the music. Programming a working sound driver is the technical step.

In the sound-chip era, as discussed in Chapter IV, a game composer was dependent on the game's sound hardware and the program that drove it. Chris Hülsbeck points out that two main elements of producing game music were a requirement for properly managing the music production process of a game: "composition" and "implementation" (2017). A skilful composer could not make his music sound good if he did not have the programming skills to properly implement his work into the game. Conversely, a good game programmer with barely any musical skill could also lead to an unsatisfactory game music score for the listener. Indeed, game composer Rob Hubbard's reason for becoming a game composer, was that early 1980s' game music lacked musical skill, because it was usually not done by a composer, but by the programmer of the game:

> The programmer did everything in those days and some of the music was just absolutely diabolical. It was embarrassing. It was like a drunken monkey on the piano trying to play "The Blue Danube" or something. And I thought, there has to be an opening for somebody who can at least get the notes right and in the correct order, for God's sake. (2007)

This dual-tasked nature of both composing music as well as programming makes for a grey area of how much the composer can be considered a musician—especially when 1980s' game music could sound impressive by skilful programming alone. Hülsbeck describes his current position as a game composer as "much more competitive" because for this generation of game composers it is no longer a necessity to be skilled in programming and to have a thorough knowledge of sound hardware (as discussed in Chapter V). Therefore, he can compete as a composer only (2017).

A comparison between a film music process and that of game music of the sound-chip era is made in figure 12.

	Film Music	**Video Game Music**
1. writer	film composer ↓	game composer ↓
2. translator	orchestrator + conductor ↓	implementer (programmer) ↓
3. performer	performing musician ↓	sound synthesis / instrument library ↓
4. recording	recording studio + sound engineer + mixer ↓	music driver ↓
5. playback	audio hardware output	audio hardware output

Figure 12. A comparison between the production process of film music and game music.

Structurally, both film music and video game music productions have roughly a production process of five steps. The translator phase is the part where the composer's work is being reworked so that it can be performed. Playback of the performance can only be established if a recording of said performance has been initiated.

With many games of the 1980s and 1990s, the game credits do not clearly specify who dealt with what aspect of the music in the game. For instance, in the end credits for *Dune II* (1992, MS-DOS) it is stated that Paul Mudra is the audio director and both Frank Klepacki and Dwight Okahara are responsible for "Music & Sound" (Fox3913 2009, 2:24). Was this a collaboration, and who did the programming? I asked this question to Klepacki, and he responded: "At Westwood Studios [the developer for *Dune II*], I was always the composer, Dwight was the sound designer, and Paul was the audio director. However, we helped each other out as a team, and in the early days credits weren't defined as that; we were just considered the audio department" (2018).

I will give you a short part of an interview of Elfman's orchestrator Steve Bartek held by Lukas Kendall (1995, 15) to emphasise my point that the orchestrator's contribution—and in the case of video game music, the programmer's contribution—to the composer's work can give a skewed view of who is mainly responsible for the composition:

> Lukas Kendall: Danny said, "There's never been a note in one of my scores that I didn't write."
>
> Steve Bartek: Yeah.
>
> Lukas Kendall: Not even a note?
>
> Steve Bartek: No. An orchestrator's job is to take someone's stuff and make it what the composer wants it to be. In doing that you sometimes "add notes," but you don't change melodies, you don't change the harmonic structure, you don't change the composition.

Bartek also mentioned that some orchestrators who worked with Elfman changed his work too much so that Bartek and Elfman had to rework it all (Kendall 1995, 15). An orchestrator's job then, is to realise the composer's work while preserving her or his idea and/or style. Similarly, a programmer's job is to make the game composer's music work in the game while also retaining the composer's ideas of sound, which can be a difficult matter when sound hardware on gaming devices was not uniform. Therefore, technology is also a factor of game music orchestration. Unlike in film scores, game music could sound significantly different if the gamer played the game on a different gaming platform. PC gamers of the 1980s and 1990s relied on their sound cards for how the sound and music of their games would sound (the "music driver" step in figure 12), as discussed in the introduction of Chapter III. For example, the music for *Dune II* (1992, MS-DOS) was written native to the Adlib soundcard at the time. Frank Klepacki, the composer for the game did program the music so that it was compatible with certain other sound cards, such as the Roland MT-32, but a plethora of sound cards were available at the time, all having a different sound chip so that the main instruments could be significantly different. YouTube user DBob01 demonstrates how *Dune II* sounds on five different sound cards: the Roland MT-32, the Roland RAP-10, the Creative SoundBlaster Pro, the Roland SC-55, a PC speaker, and a Tandy 1000 (2016). Interestingly, three Roland sound cards are demonstrated and all of them also sound different from each other. In film music, the music performers and the recording production similarly affects the sound of the composition. Film music critic Christian Clemmensen (2015) mentions how the recording of Danny Elfman's score for *Batman* (1989) sounds remarkably different to his score for the sequel, *Batman Returns* (1992). Both the orchestra as well as the recording studio were different: Sinfonia of London at CTS Studios in England for *Batman* (IMDb, n.d.) compared to a "regular studio orchestra" at Sony Music Scoring in Los Angeles (Clemmensen 2015). Clemmensen finds the *Batman Returns* score lacks "dynamic range" and "a more inspired singing and playing force" that the original has (2015).

While improving hardware and software made both video game composing as well as film composing more accessible for any sort of composer, a composer's position for either a film or game project became more and more dependent on other parts of either sort of projects. Regarding the video game music industry, when sequenced music was mostly used, the programming and the sound hardware used for the game heavily influenced the eventual execution of the music, as demonstrated by the music for *Dune II*. When streaming music technology became more popular, the music was not dependent so much on hardware, but on the recording equipment, the quality of the performers (if part of the recording), and the quality of the file format (whether compressed or not and to what extent). This is demonstrated by the music for the N64 version of *Shadows of the Empire* (1996): high-quality recordings, with top performers (the Royal Scottish National Orchestra for John McNeely's music and the London Symphony Orchestra for John Williams's music), but with a heavily compressed file format, resulting in a low (re-)production of the music.

Conclusion

Defining technology itself has been carefully observed to see whether it commands its user a certain way. Because if it does, music composed for video games is a product of its technology and the user is just a mere agent to support the technology rather than the technology supporting the user. Aristotle's theory of causality does make technology at least part of the product (Heidegger 1977, 6). It is the material (*causa materialis*) to shape/create musical code (*causa formalis*) into a musical composition (*causa finalis*) by the user (*cause efficiens*). Taylor's interpretation of technology being a "resource" gives it a more voluntaristic definition. Technology is fuel to drive the user to create.

Indeed, the musical interface strongly affected the direction of composition because it guided the user to what was possible or easy to compose and what was very difficult if not impossible to compose (Hülsbeck 2017). Sound-generated music technology, such as on the NES, was much more dependent on hardware compared to sample-based music technology, such as on the SNES. Far more creativity in tone and timbre became possible with sample-based technology. Furthermore, live music data input through a MIDI keyboard freed the user from the very structured perfectly timed input to a more humanised approach: the very structured user interface of Hülsbeck's SoundMonitor could direct the musician to compose differently than if she or he would compose on a keyboard connected to a PC.

However, when streaming music technology was implemented into gaming PCs and gaming consoles, this niche of a compositional platform for video game music became similar to that of popular music. Indeed, digital audio workstations with high-quality sound samples connected to a MIDI keyboard work functionally the same as early game music interfaces did. The video game composer now had to compete with composers from many different fields. Because of this change, the video game music "aesthetic" as a product of technological "constraints" (Collins 2009, 5) disappeared. The period wherein the aesthetic was mainly present could be described as the primary or classic video game music period which was replaced by a secondary music period that introduced styles and genres of music outside the video game music industry, similar to how Audissino calls the film music period wherein film composition was democraticised—also due to composing being more accessible because of user-friendly software (2014, 199)—"[c]ontemporary film music" (199) which replaced the "classical period" (198). This meant that the video game music composer's definition has changed from a composer dedicated to video game music and specialised in video game technology to any composer that happens to write music for a game. Furthermore, the structure of game music production (writer, translator, performer, recording, playback) is now so similar to that of film music production. If a composer for film is a film composer, so is a composer for video games a video game composer.

Legend

CD: compact disc, a digital optical storage format co-developed by Philips and Sony. Initially the CD was a medium for music, but later the technology was applied for other purposes, such as data storage for the personal computer (CD-ROM).

Commodore 64: home computer manufactured by Commodore Business Machines (CBM), first released in August 1982.

disc: term used for optical storage. In a sense it is any storage medium that is physically round such as a CD (compact disc). While the main component of a hard disk is round (files are magnetically stored on a circular disk: the platter), the hard disk as a whole is rectangular, not round. One exception—and there could be more—is the MiniDisc (MD), which is not round, but is spelled with a c at the end.

disk: term used for mechanical storage (e.g., floppy disk, hard disk). See **disc** for more information.

DOS: Disk Operating System.

Famicom: Family Computer. It is the first game console by Nintendo, first released in Japan on July 15, 1983. The Famicom was rebranded to the Nintendo Entertainment System outside Japan.

GameCube: fourth game console by Nintendo, first released in Japan on September 14, 2001.

macOS: operating system by Apple.

MP3: MPEG-1 Audio Layer III or MPEG-2 Audio Layer III. Digital audio coding format developed by Moving Picture Experts Group.

MS-DOS: Microsoft Disk Operating System.

N64: Nintendo 64. It is the third game console by Nintendo, first released on June 23, 1996, in Japan.

NES: Nintendo Entertainment System. It is the first game console by Nintendo, first released on October 18, 1995. See **Famicom** for more information.

PC: personal computer.

PlayStation: First game console by Sony, first released on December 3, 1994, in Japan. The PlayStation was initially a co-development by Sony and Nintendo.

PlayStation 2: Second game console by Sony, first released in Japan on March 4, 2000.

ROM: read-only memory. This memory has been pre-recorded and cannot be rewritten.

SNES: Super Nintendo Entertainment System. It is the second game console by Nintendo, first released in North America on August 23, 1991.

Windows: operating system by Microsoft.

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