Music in Liquid Forms: A Framework for the Creation of Reactive Music Recordings

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Declaration

I hereby declare that this thesis is entirely my own work; no part of it has been submitted as an exercise for a degree at this, or any other, University. I agree that the library of Trinity College Dublin may lend or copy this thesis upon request.

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Summary

The aim of this thesis is to research and propose possible methods and models for the creation and dissemination of what shall be defined as *liquid* music recordings. This will result in the establishment of a sound theoretical basis for the creation of such works, with practical demonstrations provided to showcase the proposed approach and methodology.

It was initially intended that this thesis would focus on the creation of one liquid music authoring system or standard. However, after researching the field, it is apparent that the creation of a single liquid system or format is of little import or benefit. A number of previous efforts have been made, each offering only one viewpoint on the compositional paradigm of liquid music and necessarily limited in some way. What is needed for the field is a broader overview. For example, the proposition of the BRONZE format (see Chapter Three) as a new format for music, though laudable, falls short due to the nature of the work: offering only a single inherent style of generative music, this programming imparts a limited aesthetic onto any musical work written for it. This is commendable in the production of a single work, but less so as further works are created with the same tools. A format such as the vinyl record or MP3 file does not impact on the style of the music disseminated; neither, then, should any liquid music be impacted by its format.

Instead, this thesis looks to establish a firm theoretical basis for liquid music in any of its potential forms, which should prove of greater lasting benefit to the field. By discussing theory and approaches, not limited by specific tools or formats, any number of potential works or sub-genres of liquid music might develop, driven by future researchers and creators who are supported by a clear creation model, and a codified and established theory.

In Chapter One, the concept of 'liquid music' is proposed and defined. A number of overlapping and ill-defined terms such as interactive, adaptive, generative plague the

literature. Future discussion and development of liquid music can be greatly helped by drawing on the mostly widely accepted definitions and constructing a clear framework.

Chapter Two reviews the relevant literature. Different media or forms of work that utilize interactive audio – compositions, games, instruments – are addressed, as the nature of interactivity can blur the lines between these classifications, and for development it is important to provide clear boundaries to liquid music. The existence of liquid music is reviewed, with precedents to be found in contemporary popular music, video game music and art music. Existing works of popular music and video games are reviewed and analysed in order to establish the state of the art at the time of writing, with a case study made of *Biophilia* (2011).

Chapter Three details the methodology of developing and testing a creation-model for liquid music. The technology for production, from traditional music production systems to interactive audio tools and video game audio systems, are evaluated. As a result, potential creation methods for liquid music are clarified and suggested. Interface design and the potential paths for dissemination of liquid music are touched on, while previous attempts at creating standard formats or platforms for liquid music in some form are also examined.

The different strands of research are drawn together to inform a creation-model for liquid music. This model provides an approach adaptable to any genre or aesthetic, and any hardware or software tools. Chapter Three also presents detailed description of the aims, development and functionality of the portfolio of works accompanying this thesis, as demonstrations of the creation model and the supporting research. This culminates in a large form work entitled *The Liquid EP.* Conclusions and summation of the thesis are provided in Chapter Four.

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Chapter One Introduction

This thesis is concerned with exploring a field, an art form, or a paradigm, that can be titled *liquid music*. This is an epithet proposed here to cover something that music programmer Aaron McLaren terms 'composition, but in a new paradigm,'[1] and relatable to the 'liquid properties' of many modern cultural and media practices, including 'the production of ground-breaking, unconventional new media formulas, hybrid genres, transmedia strategies, and complex and demanding storytelling formats.'[2] The term that many people would be familiar with in regards to this field is *interactive*—a word that has itself been misused and overused in so many contexts (especially in relation to media and the arts) that it is at times almost nonsensical, a meaningless buzzword in the hands of those responsible for marketing and promotion; this word, along with a number of others, must necessarily be properly defined as one of the first steps in this discussion (see Chapter Two).

Liquid music, or interactive music, can definitively be shown to already exist, though it cannot be seen as a developed, centralised or standardized practice. Rather, it is a paradigm that has begun to develop through advances in music and audio-related technology (though its conceptual roots and precedents can be traced back centuries). It exists in a number of places and a number of forms.

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[1] Aaron McLaren and Kent Jolly, 'Procedural music in S*pore,*' talk given at *Game Developers'*
[2] Henry Jenkins and Mark Deuze, 'Editorial: Convergence Culture' in *Convergence: The International Journal of Research into New Media Technologies* 14/1 (Sage Publications, 2008): 5-12.

Liquid music, therefore, can be discovered, experienced and engaged with by anyone. Music exists, broadly speaking, in either a performance setting or as an audio recording:[3] Turino (2008) lays out four fields of music making, two of which are performance-based and two recorded.[4] Specific "live" or performed works may exhibit the characteristics and match the definition of liquid music (indeed, in one way, each musical performance is unique, though this is not a defining quality of liquid music).

This thesis, however, is concerned primarily with *audio recordings*—music over the last century has been engaged with by placing records on turntables, cassettes into tape decks, CDs into CD players, or playing digital audio files through a computer or portable music player. What each of these approaches has in common is that they are designed to play fixed, static, non-interactive—what might be called *solid*—music. There is no capacity with a static audio recording for the music to change in any way from one playing to the next. Never when listening to Nirvana's 'Smells Like Teen Spirit' (1991), for instance, has the user been able to cut short or extend the guitar solo as they see fit;[5] never while listening to 'Psycho Killer' could the user alternate to an acoustic guitar and beatbox arrangement.[6] Vinyl, cassette tapes, CDs and digital audio files all play material from start to finish in a single, unchangeable form, and no part of the hardware or software involved has been designed with

[3] In terms of the popular music industry, this can be highlighted by the divide between music publishing and mechanical copyright, or the score and the recording.
[4] Thomas Turino, *Music as Social Life: The Politics of Participation* (Chicago: University of Chicago Press, 2008), 26.
[5] For the single release of the song, the band did just this, removing two sections in order to shorten each part of the guitar solo by half (turning AABB into AB). Nirvana, 'Smells Like Teen Spirit (Edit)', Sub Pop CD DGCDS-21673, 1991.
[6] A version performed live by David Byrne, recorded in Los Angeles in 1983 (https://www.youtube.com/watch?v=phvKAm_v5og, 2 January 2016).

anything else in mind. While these formats can of course be played *with*, especially in performative contexts such as DJing, there is a clear distinction between such practices and the fixed, linear nature of the music recording itself. This is likely one major reason why liquid music has yet to become widely recognized or adopted, due to the inherent difficulty with distribution and commercialization. For it to spread, methods whereby listeners can easily obtain and engage with it, without the need for expensive specialist tools, would be required.

It is likely that many people will have little interest in listening to, or creating, liquid music, which remains perfectly acceptable. Liquid music will probably never be a replacement for traditional, static music; nor can it be argued that it is necessarily in any way better. It is simply an alternative: a new way to create music, or as described a new paradigm for composition—most excitingly, one which has an enormous unexplored potential.

In contemporary Western society there would seem to be a place for liquid music, based on the emergence of a widespread technological and participatory culture.[7] Music recordings are no longer seen as immutable consumed objects, nor as the preserve of professional artists and record labels—instead creation of, and engagement with, recorded audio has become a popular amateur pursuit thanks to the abundance of cheap and widely available digital audio software. Interactivity appears to be growing in nearly every medium at the present time, a trend which is being actively encouraged and aided by artists, developers, programmers—musicians need be no different, as

[7] See relevant commentaries from cultural studies fields, for example Henry Jenkins, *Convergence Culture: Where Old and New Media Collide* (New York: NYU Press, 2006).

the circumstances necessary for realizing the creative potential of liquid music already exist. Illustrating these circumstances, and providing both wider perspective and comprehensive discussion of this relatively new field—which to date has been largely focused on individual, specific works, drawn from a variety of sources—is central to the aims of thesis.

1.1 Participatory Culture

The idea that art of any kind can be digitized and mass-produced is a relatively recent concept, one that has changed the way art is both considered and engaged with.[8] This bears particular relevance to the music and recording industries, which have dictated the means and methods of production and distribution since the early twentieth century. The models of the last century, wherein a large company would be responsible for locating, developing, promoting, financing and even dictating the musical aesthetic of an artist or group, are now somewhat falling by the wayside as a new production model for the twenty-first century takes shape: one in which music is created largely by DAW-based studios, often working with cheaper recording equipment;[9] one driven by the availability of music technology and by the online culture that allows musicians to promote and disseminate their music, organize gigs, network with promoters or other artists, and build a successful career. As Paul

[8] Paul Draper, 'How Online Social Networks Are Redefining Knowledge, Power, 21st Century Music-making and Higher Education', *Journal of Music Research Online* 1/1 (May 2009): 1–20 (1).
[9] Matthew Homer, 'Beyond the Studio: the Impact of Home Recording Technologies on Music Creation and Consumption,' *Nebula* 6/3 (Sep 2009): 85–99.

Draper writes, the Internet is 'framing new kinds of interactions between musicians and audiences.'[10]

I have deliberately included this quote for its use of the word 'interactions'—referring in this case not to the capabilities of any new hardware or software, but simply to the ways in which musicians reach their audiences, and how those audiences in turn seek out and listen to new music. Yet the quote remains just as valid if the word in question were to be taken as a reference to other, technological advances. Hardware devices such as smartphones and tablets have seen huge sales over recent years, and offer new interfaces with touch screens, accelerometers, GPS locators and many more tools. They have continued an evolution from portable CD and MP3 players in altering music listeners' habits, whilst opening up the potential for music-based applications and software to take advantage of these new hardware controllers. Web-based technologies and browser plug-ins have seen a similar advance over the last few years: frameworks such as Adobe Flash, Shockwave and Java are all platform-independent (or nearly so) and offer programmers the capacity to implement and run any number of interactive media programs, whatever form they may take.[11]

Besides these technological advances, the changing nature of the public's engagement with the Internet has also co-developed with a drive and desire for interactivity or user participation in media and multimedia. *Web 2.0* is the term used to describe the current user-driven Internet culture, one which first

[10] Draper, 'How Online Social Networks…', 1.
[11] For a good summary of these plug-ins, specifically related to audio, see Benjamin Crawford, 'SuperConductors: Handbook for a New Democratic Music' (Ph.D. diss., Duke University, 2011).

appeared in 2004. Tim O'Reilly, involved with coining the term, has written on several occasions concerning the definition of this phenomenon and how it can be differentiated from the older ideas and models of 'web 1.0.'[12] After the so-called 'dot-com bubble' burst at the start of the decade, file sharing, social networking and sites driven by user-created content have all become major elements of the online environment; O'Reilly describes this new phenomenon as:

> …software as a continually-updated service that gets better the more people use it, consuming and remixing data from multiple sources, including individual users, while providing their own data and services in a form that allows remixing by others, creating network effects through an 'architecture of participation,' and going beyond the page metaphor of Web 1.0 to deliver rich user experiences.[13]

Illustrations of this can be found in the inescapably popular user-generated resources Wikipedia and YouTube, the contents of which are created and maintained entirely by registered users, the latter boasting to have one billion unique visitors every month.[14] This desire for user-driven content and participatory media has led to all art, be it textual, audio, video, or other, being subject to reuse and re-appropriation (whether legal or illegal) in almost any context.

Tied to this, 'participatory culture' is something that has been defined and discussed at great length by cultural and media scholars such as Henry Jenkins.[15] Knobel and Lankshear (2010) cite Jenkins as they discuss how consumers 'become actively involved in contributing to cultural development

[12] Tim O'Reilly, 'What is Web 2.0?' (http://oreilly.com/web2/archive/what-is-web-20.html, 29 July 2013).
[13] Tim O'Reilly, 'Web 2.0: compact definition'. (http://radar.oreilly.com/archives/2005/10/web_20_compact_definition.html, 29 July 2013).
[14] *YouTube Press Room* (http://www.youtube.com/yt/press/en-GB/, 12 May 2014).
[15] Amongst other publications, see Jenkins, *Convergence Culture.*

through creating media, sharing it, and responding to it'.[16] The role of consumer is thereby altered as 'participation, in this sense, describes how consumers themselves can be media producers, side-stepping, or, at least, reconfiguring traditional relationships with broadcast media companies that previously placed consumers in passive, receiver roles.'[17] In his 1980 work *The Third Wave*, Alvin Toffler hybridized 'producer' with 'consumer' to coin the term *prosumers* for those who produce their own goods and services, an appellation which has been taken up by many commentators on participatory culture.[18] However, the more familiar term *user* will be employed in this thesis.

1.2 HERM, and Liquid or Solid Music

A brief anecdote may help to further elucidate the background and aims of this thesis. In November 2012, the author was present at several recording sessions for the second album by Dublin-based musician HERM.[19] Over the course of an afternoon spent in the control room of the studio with the engineer and the artist I listened to a number of musicians: string players, vocalists, percussionists, recording parts for different songs. For each musician, the engineer would fashion a different mix to aid their recording, balancing the levels of, or even excluding entirely, the previously recorded drums, vocals and other parts.[20] Different mixes for the control room were also in constant flux as

[16] Michele Knobel and Colin Lankshear (eds.), *DIY Media: Creating, Sharing and Learning with New Technologies* (New York: Peter Lang, 2010), 14.
[17] *Ibid.*, 14
[18] Alvin Toffler, *The Third Wave* (New York: William Morrow, 1980).
[19] HERM, *Make It Up* (Catchy Go Go Records, t.b.r.).
[20] These "headphone mixes" are common in recording sessions, as bass players may ask to hear more drums as they play, singers may ask for more harmonic instruments; any musician will request the mix that will enable them to give the best performance.

parts were added and the engineer played with different arrangements of the songs, highlighting different instrument groups and suggesting possibilities for future mixes to the artist.

My research never far from my mind, I readily identified these ever-changing mixes of a small number of songs as a similar experience to that potentially offered by an interactive musical work. The songs were continually altered and changed in subtle ways, never remaining the same from one playback to the next yet always recognisably constituted by the same material. One song in particular, 'Shotgun',[21] had the drum and rhythm guitar tracks muted at one stage, allowing the strings and vocals to take prominence over a consistent low beat. The engineer suggested this as a possible mix to the artist, who agreed that it sounded good, yet seemed reluctant to leave out the remaining tracks from the final mix. The entire album would, of course, be fixed into a single iteration, mixed and mastered for release in traditional formats. From my privileged position in the control room, however, I could experience the songs as shifting, mutating works. Rather than reducing each song to a final set of decisions made by the producer, why could the album not be released in such a way as to leave some selected decisions to the listener, within a musical context which still clearly represented the composer's artistic desires, and enable those listeners to share a similar experience to mine: to hear all of the valid possibilities of this music, rather than just one?

[21] Though still unreleased at the time of submission, this song is available online with an accompanying video: Kevin Herm Connolly, *Shotgun*, Hugh Rodgers (dir.) (https://vimeo.com/112106355, 18 February 2015).

Those sessions highlighted for me some of the practical possibilities for liquid music, by removing the complicated mixing features from my control and simply giving me an experience similar to the user of a potential liquid music system (or perhaps the person sitting next to the user, as I had no control over the music in this situation). Such liquid forms could throw new elements of a given song into perspective, shifting the focus from one iteration to the next and engaging the listener in a new way. This would never be a replacement for traditional static musical forms, but opens a broad new area of possibility for composers and musicians to explore, creating new kinds of musical experiences.

1.3 Research Aims and Placement within Existing Fields

This thesis offers, first and foremost, **a comprehensive theoretical framework for the emerging paradigm of liquid music.** Deriving from this, it makes explicit **a three-stage creation-model** which must necessarily be followed when developing works of liquid music. This creation-model is then tested rigorously by the development of **a portfolio of practical demonstrations**, utilizing a broad scope of tools and approaches to the creation of such works, and aimed at extrapolating the factors which should be considered in liquid music creation.

This is a thesis situated primarily within the fields of musicology and music technology. It is intended for musicians and music creators, and as such is written for those with a background in music rather than computer science, programming, cultural studies or other areas. The purpose of the research,

conclusions and demonstrations presented throughout is to bring a specifically musical focus to broader discussions of interactive audio, especially by providing music creators with a taxonomy, overview, and creation-model for liquid music. The cultural contexts and reasons behind any movement towards interactive music and multimedia are not engaged with in depth.

Numerous popular musicians are attempting to engage with interactive audio as part of a new artistic style—or, from a more cynical viewpoint, as a new marketing ploy. Other multimedia forms, in particular video games, use sophisticated audio interactions which may include recorded music in some manner. Though interactive audio works with music as the primary focus do exist, most musicians and composers are still highly unlikely to release liquid music in the same way that they might release static music. One reason for this is that there is simply no standard way in which to do so, while another may be the lack of commercially successful precedents. The research herein retains an ultimate focus on the creation of *stand-alone musical works*, rather than any other forms of audio or music in a multimedia context.

Further boundaries for the scope of this discussion are necessarily set out over the following chapters: some can be stated explicitly at this stage. The particular forms of liquid music, or interactions with music, with which this thesis is concerned are not to be found in a performance setting. They are not represented by concerts, performance art, live installations, or other one-off events. Liquid music *recordings* are the focus of this work—that is, artefacts which are constructed as recorded objects and can be listened to or engaged

with as often as the listener desires, in any location or setting (within reason).[22] As an overview of liquid music, this thesis focuses predominantly on recorded music rather than live performance. Tied to this, while all styles of music will be broadly considered, it also focuses on *popular music*, as will be defined further below. For these reasons developments in contemporary art music, both aesthetically and technologically, are largely beyond the scope of discussion.

Creating liquid music works and processes without a defined aesthetic—indeed, creating any new musical forms or paradigms without an aesthetic—means that any sonic results are broadly viable. However, as a measure of the usability, the potential popularity or commercial success, and as a likely area for further development of such works, focusing the current discussion on popular music sets a benchmark for both the theories and practical examples contained herein to be measured against. Future research could be tested against the different aesthetics of contemporary art music, or the alternate and varied challenges presented by jazz, Classical music or other styles. Audio (or audio-visual) installation work, which can be broadly seen as part of art music, is excluded for both these reasons, and for others defined in the following chapter.

The aim of laying a foundational discussion of liquid or interactive music is also addressed. This is a topic that has been approached by many writers, and in order for the field to progress properly, a clear and accepted basis for academic discussion needs to be accepted (so that terms like 'interactive' are not debated and re-defined in every new publication). However, most existing researchers have limited their focus to particular areas of multimedia, video

[22] A primary reason for this focus is because 'the cultural conception of music has shifted toward recordings'. Turino, *Music as Social Life* (2008), 25.

games, art music or popular music. This thesis aims to provide an overarching framework that can be applied to *all* music in any such context. To this end, Chapter Two presents a framework for liquid music which is drawn from the literature and offers to the field a platform from which future work might be built. A clear delineation of the boundaries between types of work (composition, instrument, game) is also offered as a key part of this.

1.4 Definition of Terms

While the nature of how we interact with music should remain open to discussion, clear meanings can be established for terms which recur frequently in the literature. Such a glossary might provide a useful basis for both creation and discussion of liquid music and, it is hoped, can lend greater clarity to any and all future writings on the topic by researchers.[23] The term itself, *liquid music*, is proposed here as a title for an identifiable emerging paradigm of music, elements or facets of which are elsewhere referred to as 'interactive', 'dynamic' or by other epithets.

As the market for interactive media has grown, companies like Apple have misappropriated the term *interactive* and used it describe musical releases which are not truly procedural in any way (regardless of claims that Apple's 'interactive albums' are 'not just a bunch of PDFs').[24] The word interactive is

[23] While many terms are drawn from game audio and the literature thereon, the nature of interactions with music in a multimedia environment may demand a slightly more complex or open-ended taxonomy. That presented here is comprehensive with regards to liquid music, as a subset of procedural audio and a stand-alone medium.
[24] Eliot Van Buskirk, 'Apple Readies Interactive Album Applications,' *Wired,* 2 September 2008 (http://www.wired.com/listening_post/2008/09/apple-readying, 7 October 2013).

employed liberally, yet within the current discussion this word and a number of others related to it require concrete definitions.[25] In his major work *The Language of New Media* (2001), Manovitch describes 'interactivity' as having two possible meanings: one literal and one psychological. It is the latter on which he focuses as an element of new media, a process whereby the user fills in or engages with the work on a psychological level, thereby fulfilling its very function as a media work.[26] Manovitch's other, literal description of interaction—the physical acts of looking at screens, pressing buttons, moving cursors and so on—is more accurately descriptive of the type of "interaction" with which most creative artists or developers would be concerned. While elements of psychological interaction may be required for interactive art, it can be argued that the more literal reading of the term does not adhere to Manovitch's line of reasoning that all forms of media, both old and new, are interactive in a number of ways.[27] Watching a film may require psychological interaction in order to string a sequence of edited and disconnected images into a comprehensive narrative, yet this can be countered by the fact that the viewer can sit physically motionless throughout in the knowledge that no action they might take (beyond, perhaps, damaging the projector) will alter the film and how it unfolds.

Polaine (2005) also leaves aside Manovitch's definition in order to focus on the more physical nature of interaction, writing:

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[25] Espen Aarseth labels *interactivity* '…that silly and abused term'; Espen Aarseth, 'Genre Trouble: Narrativism and the Art of Simulation', in *First Person: New Media as Story, Performance and Game*, Noah Wardrip-Fruin and Pat Harrigan (eds.) (Cambridge: MIT Press, 2004), 45–55 (52).
[26] Lev Manovich, *The Language of New Media* (Cambridge: MIT Press, 2001).
[27] *Ibid.*, 71.

> An 'interactor' makes a change to the device presented to them (usually to elements on a screen, but not exclusively) which in turn changes his or her own behaviour. In a complete interaction the participant's changed behaviour creates another change in the device's reaction, which results in another change in the interactor's behaviour, thus producing a feedback loop of interaction.[28]

This definition of interaction can be applied to the work of many artists. Two parties are required to complete an interactive loop: a device, which may contain the work or its components, and a user or interactor. The device will present the work to the user, who can reciprocally provide the device with information or input through some form of interface. The user is driven to give input in response to elements or aspects of the work being presented. The work is in some way changed to a new state by this input. This presents a new output to the user, who in turn reacts to the new state by providing further input. A loop is thereby created, in which the behaviour of each participant (device and user) affects, and is in turn affected by, the other. A well designed interactive pattern of this kind might lead to what has been described as a *flow* experience.

The *flow* experience has been famously described in several writings by Csikszentmihalyi,[29] and refers to a phenomenological experience wherein a person can become immersed in an activity and achieve a sense of pleasure from this immersion; an essential attribute of what we understand as *play* or *games*. The key to creating such an experience is to maintain sufficient balance between the challenge presented to a user and their level of skill for a given

[28] Andrew Polaine, 'The Flow Principle in Interactivity', *Proceedings of the Second Australian Conference on Interactive Entertainment* (November 2005) (Sydney: Creative & Cognition Studios Press, 2005): 151–158 (152).
[29] Mihaly Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (New York: HarperCollins, 1991).

interaction. This thesis does not seek to engage with these ideas of *flow* and *immersion*, but it is nonetheless important to note that 'the key to creating engaging interactivity is setting up the correct rules for a playful flow experience.'[30] While not necessarily designed, immersion may be a product of the creation of interactive musical works. The capacity to create a flow experience can only be of value, and may at a later stage inform judgements on the relative success of such works.

With specific regard to music and audio, Polaine's discussion of interactivity as a feedback loop driven by the input of both the work and its user(s) can form the basis of an acceptable definition within a discussion of liquid music. However, the nature of interactive audio has been discussed and debated at length in the field of video game audio research, as the only medium which to date has seen the sustained and regular implementation of high quality, interactive audio. Reference to the literature from that field can provide valuable further definition.

Many researchers have highlighted the need for universally accepted terminology and semiotics for a field in which:

> …*adaptive* and *interactive*, words that seem to be able to have the same meaning according to some, and be regarded as completely separate categories by others, are used too ambiguously to yield a satisfying or workable set of uses and definitions.[31]

Collins, one of the leading writers in the field, proposes in numerous writings an approach to categorizing game audio which is based upon distinguishing different types of interactive and participatory functions. With the exception of

[30] Polaine, 'The Flow Principle in Interactivity', 153.
[31] Rik Nieuwdorp, 'Adapt!: Towards a Comprehensive Discourse Surrounding Adaptive Music in Games' (M.A. Diss., Utrecht School of Arts, 2007), 37.

pre-rendered 'cut-scenes' (sections of video games where the player has no little or no input, while a linear section of video and audio plays, often providing exposition or plot development within the game narrative), she states that the vast majority of game audio is *dynamic*.[32] Though this is a term used elsewhere in music and audio production,[33] Collins applies it to indicate 'audio which reacts to changes in the gameplay environment *or* in response to a user.'[34] She then sub-divides *dynamic* audio into the categories of *interactive* and *adaptive* audio:

> When it is (part of) a goal within the game to create music, then that would be called *interactive music*. When adaptation or instigation of music itself does not coincide with a goal of the game, but follows change within the game situation that can be a result of player input, then that music would be *adaptive music*.[35]

In his thesis of 2007, Nieuwdorp produces a comprehensive review of the semiotics of video game audio. After examining how the words *interactive* and *adaptive* have been used to fit a variety of definitions and approaches, he outlines several key elements to which these words usually refer: changes in audio that are triggered by parameters or events in the gameplay; changes in audio that can take place at any given moment, or in *real-time*; and changes in audio that should be appropriate to both changes in the gameplay and changes in the players' emotional reactions.[36] Nieuwdorp feels that Collins' definitions of

[32] Karen Collins, 'An Introduction to the Participatory and Non-Linear Aspects of Video Game Audio', in *Essays on Sound and Vision* (Stan Hawkins and John Richardson, eds.) (Helsinki: Helsinki University Press, 2007): 263–298 (264).
[33] 'Dynamics' relate to changes in volume within the sphere of music performance; to amplitude adjustments in mixing, especially with regards to compression, limiting and similar processes; and also to a style of microphone built around a moving magnetic coil.
[34] Collins, 'An Introduction to the Participatory and Non-Linear Aspects of Video Game Audio', 264.
[35] Rik Nieuwdorp, 'Adapt!', 39.
[36] *Ibid.*, 14.

the two words seem to be the most suitable and clear-cut, as well as being those gaining greatest acceptance in the field.

Though his discussion is concerned with audio of all kinds, Nieuwdorp also focuses particularly on how these terms can apply to music, pointing out that the word 'adapt' literally means 'to conform to a new set of conditions'. This implies an indirect consequence. When related to game music, this means that 'the music follows game events that may or may not be caused by the actions of the player'.[37] The player (user) takes an action which effects a change in the music: though the main purpose of the action is not to effect this change, but rather is focused on some element of gameplay or other interaction, it is this element which in turn effects the musical change. Equally, there can be a change in the game state without any action or input from the player, due to elapsed time, other game characters' actions or so forth. 'It does not matter *why* the situation in the game changes, its change is the trigger for the adaptation of the music';[38] this is what can be defined as *adaptive music*.

In other circumstances or other games, it is possible that the player's input *will* be directly linked with changes in the music: whether in games with a musical theme such as the *Guitar Hero* series, or within games from another genre such as *The Legend of Zelda* series (which frequently and prominently features musical instruments), 'the game music is a part of the gameplay, and therefore the game's interactive possibilities'.[39] This is what can be defined as *interactive music*. Bajakian *et al* (2003) also use these two terms in their report

[37] *Ibid.*, 38.
[38] *Ibid.*, 38.
[39] *Ibid.*, 38.

on interactive music, highlighting the key difference between *interactive* and *adaptive* by describing the nature of the musical change in response to 'direct or indirect input stimuli',[40] thereby agreeing with the definitions given by Collins.

Further detailed classifications of game audio have been proposed elsewhere: for example, Huiberts and Van Tol (2007).[41] These frameworks are, however, usually concerned with all facets of sound design within the medium of the video game. Collins' 'interactive/adaptive' terminology, aside from becoming widely recognised within that specific field, has the merit of clarity when applied specifically to music outside of a game context. By extracting these definitions from the field of video game audio and applying them to music, a set of definitions can be created covering any music that is composed with inherent changeability from one iteration to the next.

While *dynamic* as a term proposed by Collins has received 'general agreement' within academic circles,[42] *procedural* is another frequently occurring term which may offer an alternative: Farnell (2007) uses it in a manner roughly equivalent to *dynamic* as defined by Collins, positing that it is easier to define procedural audio by what it is *not*—not pre-sequenced, not pre-recorded, and working in real-time.[43] Collins, meanwhile, defines a procedural work as one 'that evolves in real-time according to a specific set of rules or

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[40] Bajakian *et al*, 'Group Report: What is Interactive Audio? And What Should it Be?,' *Eighth Annual Interactive Music Conference Project Bar-B-Q*, 2003 (http://www.projectbarbq.com/bbq03/bbq03r5.html, 25 October 2011).
[41] Sander Huiberts and Richard Van Tol, 'IEZA: A Framework for Game Audio', January 2008 (http://www.gamasutra.com/view/feature/3509/ieza_a_framework_for_game_audio, 7 April 2014).
[42] Richard Stevens and Dave Raybould, 'Designing a Game for Music: Integrated Design Approaches for Ludic Music and Interactivity,' in *The Oxford Handbook of Interactive Audio*, Collins, Kapralos and Tessler (eds.) (Oxford: Oxford University Press, 2014), 147–166 (152).
[43] Andy Farnell, 'An Introduction to Procedural Audio and its Application in Computer Games', Sep 2007 (http://obiwannabe.co.uk/html/papers/proc-audio/proc-audio.pdf, 13 January 2014), 12.

control logics',[44] distinguishing loosely between Wooler *et al*'s 'transformational' and 'generative' forms of procedural music.[45] While unclear how she relates this to her own definition of 'dynamic' music, she does state that all game audio is arguably procedural, thereby potentially equating the two terms.[46]

Audio which changes in real-time, in response either to changes in the state of the program or to direct user input, can be called *procedural* (or *dynamic*); audio which changes due, indirectly, to user input, is termed *adaptive*, while audio which changes as a direct result of user input is termed *interactive*. Accepting these three definitions leaves a requirement for one further category of liquid music, wherein audio can change procedurally without any user input whatsoever, based purely upon the programming controlling it. Such audio would not fit the definition of *interactive*, as there is no loop created without user input, nor does it fit the definition for *adaptive*. I therefore propose to use the term *generative* audio to describe systems that are procedural, but which do not accept any user input beyond their initial state. Farnell writes in 'An Introduction to Procedural Audio and its Application in Computer Games' (2007) that 'a generative piece requires no input, or the input is given only as initial conditions prior to execution… generative sound is not interactive.'[47]

Returning to the definition from Wooler *et al* of transformational and generative types of procedural music, the latter coincides with the usage of the

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[44] Karen Collins, 'An Introduction to Procedural Music in Video Games', *Contemporary Music Review* 28/1 (February 2009): 5–15 (13).
[45] These terms taken originally from Rene Wooler *et al*, 'A Framework for Comparison of Process in Algorithmic Music Systems', *Generative Arts Practice*, University of Technology, Sydney (December 2005): 109–124.
[46] Collins, 'An Introduction to Procedural Music in Video Games', 5.
[47] Farnell, 'An Introduction to Procedural Audio and its Application in Computer Games', 3.

term *generative* herein, while the former relates to *interactive* and *adaptive* music. We can also collectively term these latter categories *reactive* music (reacting to either user input or system states), a term used with slightly varied meanings in commercial releases, such as the RjDj music apps,[48] and academic texts, such as Stevens and Raybould's discussion of interactivity in *The Oxford Handbook of Interactive Audio* (2014).[49]

1.4.1 Generative Music and Metacreation

Generative music is a term first coined in 1996 by musician Brian Eno, with the release of *Generative 1*, a collection of twelve generative works published on floppy disk for Windows systems.[50] Speaking in the same year, Eno explained that:

> Generative music is unpredictable, classical music is predicted. Generative unrepeatable, classical repeatable. Generative music is unfinished, that's to say, when you use generative you implicitly don't know what the end of this is.[51]

The term was quickly popularized, and has since become an established field in its own right, one which can as shown be incorporated into the paradigm of liquid music.

Generative music can also be related to the concept of 'metacreation', as proposed by Whitelaw (2004), in which new media artists adapt and implement

[48] *Rjdj—PD Community Site* (https://puredata.info/downloads/rjdj, 5 November 2015).
[49] Stevens and Raybould, 'Designing a Game for Music,' 153.
[50] *Generative Music* (http://www.intermorphic.com/sseyo/koan/generativemusic1, 21 June 2016).
[51] Brian Eno, 'Generative Music' (In Motion Magazine, 7 July 1996 (http://www.inmotionmagazine.com/eno1.html, 21 June 2016).

ideas from artificial life science, artificial intelligence and machine learning.[52] This emphasis on process, evolutionary systems and undefined results can be seen explicitly in video games such as *Spore* (2008) and the recent *No Man's Sky* (2016) from Hello Games, the latter promising an 'infinite procedurally generated galaxy'.[53] Each of these games has also prominently featured generative music, the first in collaboration with Brian Eno, while composer Paul Weir worked on *No Man's Sky.*

Metacreation is highly applicable to music, specifically with the aim of developing 'software systems that are creative on their own'.[54] Within a broader liquid music framework, generative elements may be incorporated alongside reactive programming, so that different iterations of a given work are not produced solely by a designed process, but are also affected in some manner by direct or indirect input from the user or environment. This will be emphasized by liquid music works reviewed in the following chapter.

Musical metacreation built from artificial life systems is a field which will benefit from continuing research and development. However, the majority of liquid music is not so focused on process, instead often exhibiting more authored outcomes, within a delineated scope of possible iterations. As such, these branches of generative music remain somewhat outside the scope of this thesis, though highly relevant to future work in the field of liquid music.

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[52] Michael Whitelaw, *Metacreation: Art and Artificial Life* (Massachusetts: MIT Press, 2004).
[53] *About: No Man's Sky* (http://www.no-mans-sky.com/about/, 5 February 2016).
[54] Arnier Eigenfeldt and Phillipe Pasquier, 'Evolving Structures for Electronic Dance Music', *Proceedings of the 15th Annual Conference on Genetic and Evolutionary Computation* (2013): 319–326 (319).

1.4.2 Popular Music

Having stated that this thesis will be focused solely on popular music aesthetics for the discussion and creation of liquid music, it is essential to provide a working definition for "popular music" in this context. This is a task with which commentators from a variety of academic fields engage: a sociologist may define the term different to a cultural studies scholar, and either differently to a musicologist. A variety of factors are at play, including the lyrical context, technological mediation and social context of both production and dissemination, the intended function(s) and commercial aims of the music, and, last but not least, the musical aesthetics.

Leach (2009) holds an excellent discussion on the problems inherent to providing a definition, before settling on "the music that is present in popular culture," an extremely broad definition rooted firmly in a cultural, rather than musicological, standpoint.[55] Frith (2001) offers a similarly broad concept for popular music.[56] Birrer (1985) offers four key points for defining popular music, including the social aspect of 'popular' as music belonging to a particular group or class, and the negative stance that it is simply whatever is not Classical, folk or another kind of music.[57] Birrer also states that popular music relates to mass communications, something debated by Middleton (1993),[58] but which may

[55] Elizabeth Eva Leach, 'Popular Music', in *An Introduction to Music Studies*, Harper-Scott and Samson (eds.) (Cambridge: Cambridge University Press, 2009), 188–199 (190).
[56] Simon Frith, 'The Popular Music Industry', in *The Cambridge Companion to Pop and Rock*, Frith, Straw and Street (eds.) (Cambridge: Cambridge University Press, 2001), 26–52.
[57] Birrer, Frans, 'Definitions and Research Orientation: Do We Need a Definition of Popular Music?' in *Popular Music Perspectives 2*, David Horn (ed.), (Exeter: IASPM, 1985), 99-105.
[58] Richard Middleton, 'Popular Music Analysis and Muscology: Bridging the Gap,' in *Popular Music* 12/2 (Cambridge University Press 1993): 177-190.

hold merit, especially in the context of Frith's assertion that 'the music industry is an aspect of popular music culture.'[59]

For the current purposes, social and cultural concerns of popular music can be largely disregarded. A standpoint based loosely on musicological, economical and media theories can be proposed, one which follows the "work concept" referred to by Leach. This view is of popular music as an 'idealized sonic work that is manifested completely neither in any particular score copy nor in any single performance.' [60] The implication of mutability is interesting when viewed through the lens of liquid music, and in actual fact it may be that the primacy of the recorded work, as discussed by Moore (2010),[61] rather than the *lack* of primacy for score or performance, could be seen as a defining feature of "popular music". This is also supported by Tagg's positioning of popular music in opposition to 'art' and 'folk' music.[62]

'Popular music' will therefore be taken in this thesis to refer to any musical work for which the primary artefact is the recording, disseminated for broadly commercial reasons through the mass media. This is not intended to be strict or exclusionary, but broadly defines a limit for 'popular music,' based on existing scholarship, that allows discussion of a wide range of musical styles.

[59] Frith, 'The Popular Music Industry', 27.
[60] Leach, 'Popular Music', 189-190.
[61] Allan Moore, 'The Track', in *Recorded Music: Performance, Culture and Technology,* Amanda Bayley (ed.) (Cambridge: Cambridge University Press, 2010), 252–268 (258).
[62] Philip Tagg, 'Analysing Popular Music: Theory, Method and Practice,' in *Popular Music 2* (Cambridge University Press, 1982): 37-67.

1.4.3 Summary

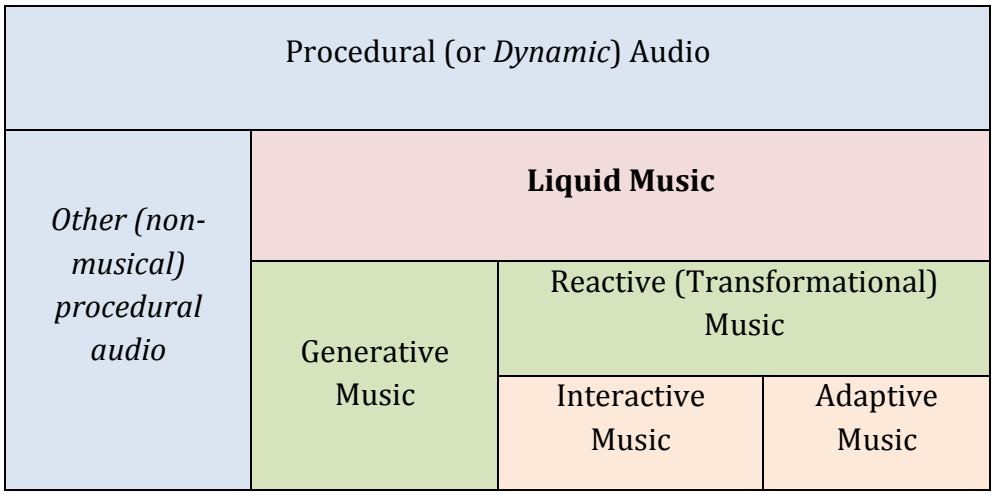

FIGURE 1.1—Hierarchy of terms used in discussion of liquid music

The key definitions established in this section relate to procedural audio—equatable with dynamic audio—and its subset of liquid music, which can be divided into reactive or generative forms; reactive music can sub-divide further into interactive and adaptive (see FIGURE 1.1). As stated above, the purpose of the hierarchy proposed here is to provide and coherent and consistent means of describing *liquid music*, or any recorded musical work which will alter from one playback to the next. Procedural audio, as described, is a broader term which may apply to fields beyond liquid music and the topics covered in this thesis: especially video games, multimedia, and other areas excluded from the current study. However, liquid music is a medium in which all works are inherently procedural, and therefore sits comfortably within the broader definitions provided here.

Liquid music might be described as any musical work written with an explicit and inherent potential to differ from one playback or iteration to the next, as an integral facet of the work. This does not include the variation of

minor details that will inevitably occur from repeated live performances of a work, as these variations are not composed or intentional. *Liquid music* is created with a deliberate sphere or framework of possible iterations, while always retaining a definable character, or what Navas (2010) terms the 'spectacular aura'.[63] It predominantly makes use of digital audio production and playback technologies which have emerged over recent decades, to create works that allow program states, real-time system changes and/or direct input from users (as an active participant, rather than a passive 'listener') to influence the musical output. While this thesis focuses on recorded musical works using these technologies, liquid music works may also be performance-based or exist as musical scores; this approach to the paradigm will be addressed in passing in Chapter Two, through examination and reference to a number of works within the sphere of art music. In short, *liquid music* is for the purposes of this thesis: **any (recorded) musical work which is composed with the deliberate and inherent potential to differ from one playback or iteration to the next.**

1.5 Thesis Structure

In order to achieve the stated aims, this thesis is laid out in such a way as to provide a cohesive flow to the research undertaken, and to show how this feeds the ideas and conclusions presented.

The key terms and definitions associated with liquid music have been reviewed and established here in Chapter One. Chapter Two then reviews the

[63] Eduardo Navas, *Remix Theory: The Aesthetics of Sampling* (New York: Springer-Verlag/Wien 2012), 65.

literature from a number of related fields, and provides the background research necessary for the thesis aims. The classifications of work that may include liquid music, as well as the technical terms used to describe them, are outlined. The unfixed and mutable nature of music, from previous centuries through to modern technologically mediated practices, is examined as both aesthetic basis and justification for the emergence of the liquid music paradigm. The existence of liquid music works or ideas in the field of popular music is reviewed and various pertinent examples analysed. The appearance of interactive music in video games, including the use of licensed popular music, is also codified and discussed.

Chapter Three provides a methodological discussion of how liquid music might be created. A brief discussion of interaction design issues in undertaken, though this area remains largely beyond the scope of the thesis. Previous attempts to create 'interactive audio' standards or platforms, and the inherent drawbacks or limitations to such approaches, are outlined. The chapter then focuses on the technology involved in the creation of liquid music as a recorded artefact: popular music production technologies are reviewed before turning to video game audio technology and systems from other research fields.

Following this, an over-arching framework in the form of a three-stage creation-model for works of liquid music is presented. This is drawn from the foregoing research, and represents original work at the core of this thesis, as a framework which provides a foundation and working method for all future development in liquid music, something which has not been fully expressed anywhere else in the literature.

The compositional issues and approaches inherent to the creation of liquid music are discussed in reference to the creation-model. The essential division between *vertical* and *horizontal* alteration is elaborated upon, and further aspects unique to procedural and non-linear audio creation are discussed. The use of input from users, systems, or inherently changeable programming, are also placed in the discussion. Finally, a portfolio of practical demonstration works of liquid music, created to accompany this thesis, is presented. These serve as examples and potential workings of the creation-model, rigorous testing of the efficacy of the model, and as methods of illustrating the issues and approaches discussed throughout the thesis. This culminates in a large-scale work (comparable in scale to a popular music EP release) entitled *The Liquid EP*, which is intended as an investigation of all of the standardized concepts included in this framework. Finally, Chapter Four summarizes and reflects on the work undertaken, and lays out clear conclusions to the thesis.

Chapter Two Literature Review

This chapter provides background research from fields associated with liquid music, in order to better delineate the paradigm and to shape the development of a creation model and practical demonstration works.

The first section of this chapter will review literature related to procedural audio in its broadest sense, specifically with the aim of establishing the boundaries of 'liquid music' in opposition to other multimedia artefacts that may more accurately be classified as 'instruments', 'games' or other. This will be followed by a review of the existing community of practice, firstly through any popular music releases that may be categorized as liquid music, then through an examination of relevant similar works within other musical genres, and in the field of video games. This review aims to provide a solid overview of existing theory and praxis that relates to, and forms a foundation for, the paradigm of liquid music, while also offering potential influences and avenues of exploration for the creation of future works in the field.

2.1 Classifications of Procedural Audio

In reviewing the existing field of procedural audio (often referred to, as discussed previously, by other epithets such as 'interactive audio'), it is noteworthy that there are a large number of artefacts which implement procedural audio, spread across different media and multimedia forms. Procedural audio is not a neatly contained field, but rather, a practice which can

be implemented with a variety of purposes and functionalities in different media contexts. Varied combinations of hardware and software systems may be used to implement procedural audio, yet categorizing exactly what type of work has been produced in any individual instance can be a surprisingly difficult endeavour. Broadly similar ideas are present in the creation of musical compositions, new types of musical instrument, video games and electronic games of different sorts, as well as an array of relatively less complex applications and software releases. A key source for the field is found in *The Oxford Handbook of Interactive Audio* (2014).[64] This text includes chapters that cover interactive sound art, video games, psychology and emotional impact, performance, tools and techniques for interactive audio creation.

Distinguishing between these classifications can be difficult, though an attempt to do so provides a useful step by classifying liquid music in opposition to other instances and forms of procedural audio. Many musicians, artists and developers are creating works which incorporate procedural audio, yet are not easily classified. The traditional boundaries between, for example, a composition and an instrument, have become more blurred in recent years,[65] while new works that may demand a recalibration of such boundaries are regularly forthcoming in the rapidly developing creative industries. Advances in audio technology, in combination with the broader fields of digital humanities and information technology, are enabling a larger number of creators to develop artefacts with procedural audio elements, irrespective of their intended

[64] *The Oxford Handbook of Interactive Audio*, Collins, Kapralos & Tessler (eds.) (Oxford: Oxford University Press, 2014).
[65] See for example Norbert Herber, 'The Composition-Instrument: Emergence, Improvisation and Interaction in Games and New Media', in *From Pac-Man to Pop Music*, Karen Collins (ed.), (Aldershot: Ashgate, 2008), 103–125.

function or any labels applied to them. With creation, rather than classification, often being the aim, it is understandable that the scope of procedural audio can be difficult to neatly categorize.

Many instances of procedural audio do, however, exhibit important boundaries and differences that allow for distinction between artefacts classifiable as composition, instrument, or game. Each of these distinctions are discussed in this section in more detail, and illustrated with examples. Similarly, much of the relevant literature is drawn from the fields of music technology, electroacoustic composition, video game audio. Even the terms used for the person interacting with the artefact differ from one classification to the next: user, listener, player. While these terms are indicative of the varied nature of different artefacts, and the requirement for different categories to be delineated, this thesis will refer consistently to the "user", as a catch-all term for a person who engages with an artefact, irrespective of classification. This engagement is always formed by some combination of listening and acting, be it with an interface of greater or lesser complexity, with greater or lesser expressive potential. The term "listener" implies a passivity not present in such action, while the term "player" (though often standard for instruments and games) carries unwanted connotations related to the act of "play". "User", therefore, offers a neutral term that can be applied across the board.

2.1.1 Composition

The first classification to be examined is that of the *composition*, specifically in this case the *liquid music composition*, as defined in the previous chapter. Any musical composition which includes procedural elements will, by definition, be a liquid musical work.

In the broadest sense, a composition could be defined as a piece of music written by a composer (or composers); it may be performed, notated in some form of score, or recorded, and once created the work remains largely fixed in its musical material, which develops or progresses over time and retains a distinct and clearly identifiable character of its own.[66] The *New Grove Dictionary of Music and Musicians* defines a composition as 'the activity or process of creating music, and the product of such activity', while also noting that since the sixteenth century the term has been applied to 'pieces of music that remain recognisable in different performances', these aspects of creation and interpretation being distinct from improvisation.[67] Elsewhere, composition has been defined more literally as 'the act of assembling elements and of putting them into a structural relation'.[68] However, once any element of procedural behaviour, be it generative, interactive or adaptive, is introduced, the issue becomes less clear. How much of a fixed structural relation, or distinct and identifiable character, does a composition retain if a user, or software programming, are given a level of control over the final musical creation?

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[66] Earle Browne has said that 'there must be a fixed (even if flexible) sound-content, to establish the *character* of the work.' Michael Nyman, *Experimental Music: Cage and Beyond* (Cambridge: Cambridge University Press, 1999), 70.
[67] Stephen Blum, 'Composition' in *The New Grove Dictionary of Music and Musicians*, Stanley Sadie and John Tyrrell (eds.), 2nd edn, vol. 6 (London: Macmillan, 2001), 186–201 (186).
[68] Claude Cadoz, 'Instrumental Gesture and Musical Composition', *Proceedings of the International Computer Music Conference (ICMC)*, Germany (Cologne: 1988): 1–12 (2).

Interactivity and adaptivity disrupt the fixity of traditional composition. Writing music has been described as making a series of choices (from high level ones such as key and meter, right down to individual notes and performance markings), with a composition resulting from a selection of available possibilities:[69] a liquid music composition simply leaves some of these possibilities open, some of these choices unmade. This need not reduce a composition to an unfinished or incomplete work in any way, however: procedural elements offer the composer an ability to guide and shape the choices of a user or program, to explore a larger number of musical options than may have been possible within in a fixed work. If the user is presented with too many choices, the character of the work may begin to dissipate: procedural elements therefore must still allow—even require—this greater range of possibilities to be framed in an aesthetic way, given a traceable structure and a clear or definable character.[70] This character is what Navas (2010) refers to as the 'spectacular aura' of a work.[71]

In his informative chapter 'The Composition-Instrument' (2008),[72] Herber acknowledges a 'blurring' between the genres of composition and instrument brought about by the addition of procedural audio, identifying a framework in which a work can be seen to exhibit elements of both classifications provided that three requisite elements are in place: a participant (or user), a generative system, and an environment. The perturbations and

[69] Leonard Meyer, *Style and Music: Theory, History and Ideology* (Chicago: University of Chicago Press, 1989), 3–8.
[70] Without this aesthetic or clear musical character, a composition might arguably be deemed incomplete according to Earle Brown's statement; Nyman, *Experimental Music*, 70.
[71] Navas, *Remix Theory: The Aesthetics of Sampling*.
[72] Herber, 'The Composition-Instrument', 110.

interactions between these three constituent parts give rise to a musical work that Herber describes as 'composition-instrument'.

Introducing procedural elements during live performance is a process which has received considerable attention in the context of contemporary composition. In one sense, any live performance is procedural, as performing musicians will never play a piece exactly the same way a second time (a possibility which only exists through recorded media). Improvisations such as those found in rock, jazz, and many non-Western musical traditions can add further alterations to a live performance. Often however within the scope of popular music, and Western music more broadly, a composition exists as a fixed score object, to be interpreted through performance.[73] Twentieth-century composers began to alter and disrupt this idea, as artists such as John Cage (1912–1992) created new works which are necessarily different each time they are performed; the procedural element is explicitly inherent in the score. The famous *4.33* (1952) provides an extreme example: the work requires an environment or ambience within which to exist, and any performance will by definition be noticeably different as this environment and the audience themselves provide the final sound of the composition, often 'inadvertent rather than intentional'.[74]

One strong example of a liquid music composition is Gwilym Gold's *Tender Metal* (2011), an album released for iOS devices.[75] Each song is designed

[73] See for example, Dahlhaus' description of Rossini's scores as a 'recipe for performance.' Dahlhaus, Carl, *Nineteenth-Century Music*, J. Bradford Robinson (trans.) (Berkeley: University of California Press, 1989), 9.
[74] Aaron Oldenburg, 'Sonic Mechanics: Audio as Gameplay', *Game Studies* 13/1 (Sep 2013) (http://gamestudies.org/1301/articles/oldenburg_sonic_mechanics, 20 August 2014).
[75] Gold, Gwilym, *Tender Metal*, iOS app (Bronze Music, 2012)

with an assortment of choices that are made for every iteration or playback, all controlled in generative fashion by the programming of the BRONZE format. Despite taking the form of a musical recording, it is comparable to the performed works of John Cage referenced above, in that it will be different every time it is played. The differences between iterations are not enough to disrupt the clearly defined character or 'aura' of the song in question, which is apparent through the recorded vocal, lyrics, structural frameworks and textural palette. The scope of choices and options available within the procedural programming has been carefully selected and shaped by the composer, with seemingly as much thought and care as the recorded musical material which makes up the work.

The manner in which many composers and compositions make use of procedural functionality to extend their sphere of possible iterations beyond those found in a fixed composition serves to demonstrate how we can classify a liquid music composition. An arrangement or structure is required, whether linear or non-linear, into which the musical material is formed, a defined progression over time. This material exhibits an identifiable character at all times, whether through the limitation of possibilities, recognisable timbral, melodic, harmonic or rhythmic elements, or another means. The incorporation of procedural functionality into a composition is a further option or approach, another paradigm available to composers with which to compose their music.

2.1.2 Instrument

In contrast to a liquid music composition, an instrument does not exhibit a defined musical character across time, with recognisable musical material. Instead, it offers the user a far broader and less restricted range of options for musical interaction. Herber (2008) describes the process of composition as 'the conception and organization of musical ideas, whereas an instrument provides the equipment necessary to realize such a work'.[76] A piano, it can be said, is not a composition, not exhibiting structure or offering an organized development over time. Though it has a distinct timbre, the piano is not inherently limited to a given key, meter, rhythm or tempo; it does not repeat recognisable melodic or harmonic material. While limited to a range of pitches, these pitches span the breadth of what is commonly used for any composition. Boulez, writing about the role of timbre in composition, mentions that instruments are constructed mostly 'without reference to any stylistic criteria'.[77] A violin, therefore, can be used to play more than just Baroque music; a clarinet might be played within a choral society or a symphony orchestra, and a guitar in a classical or popular setting.

Many instruments are 'acoustic,' physical objects, but procedural audio has been used to develop software instruments which have narrowed the divide between this classification and those of composition, or game. Physical instruments might be classified either by the mode of sound-excitation employed (as shown by the designation "wind instruments") or by the nature of

[76] Herber, 'The Composition-Instrument', 103.
[77] Pierre Boulez, 'Timbre and Composition–Timbre and Language', *Contemporary Music Review 2/1* (London: Routledge, 1987): 161–171 (162).

the vibrating substance (as with "string instruments").[78] The firmly established Hornbostel-Sachs classification system for instruments takes the latter feature as its primary division:[79] instruments are thereby grouped as idiophones, membranophones, chordophones or aerophones. This system has been updated and revised by other researchers and groups since initial publication, including the Musical Instrument Museums Online (MIMO) consortium, who notably included a fifth grouping of 'electrophones' to cover instruments that produce sound through electrical signals passed to a loudspeaker.[80]

The production of sound by mechanical means, or automata, grew throughout the eighteenth century.[81] These mechanical devices were the precursors to early electronic instruments such as Thaddeus Cahill's Telharmonium.[82] Other instruments followed which offered the user a means of control over electronically produced sound, through interfaces unlike existing acoustic instruments: the Theremin (originally named 'etherphone', and invented by Leon Theremin in 1920) is perhaps the most famous example, allowing for an early form of gestural control.[83] The first electronic synthesizer, which gave rise to a whole new wave of instruments, was created by Robert Moog in 1964, using voltage control.[84] Digital synthesizers followed in the

[78] Erich von Hornbostel and Curt Sachs, 'Classification of Musical Instruments', Anthony Baines and Klaus P. Wachsmann (trans.), *The Galpin Society Journal* 14 (March 1961): 3–29 (6).
[79] *Ibid.*, 6.
[80] 'Revision of the Hornbostel-Sachs Classification of Musical Instruments by the MIMO Consortium,' (www.mimo-international.com/documents/HornbostelSachs.pdf, 8 July 2011).
[81] Andrew Hugill, 'The Origins of Electronic Music', in *The Cambridge Companion to Electronic Music*, Nick Collins and Julio d'Escrivan (eds.) (Cambridge: Cambridge University Press, 2007), 7–23 (10).
[82] *Ibid.*, 14.
[83] Albert Glinsky, *Theremin: Ether Music and Espionage* (University of Illinois Press, 2000), 26.
[84] The workings of this instrument were first presented in Robert A. Moog, 'Voltage-Controlled Electronic Music Modules', *Journal of the Audio Engineering Society* 13/3 (July 1965): 200–206.

1970s, and achieved a commercial breakthrough with the Yamaha DX7, a frequency modulation (FM) synth released in 1983.[85]

Digital software developments in instrument design have allowed for new approaches including, most importantly, the separation of sound-excitation from a vibrating substance. When recorded audio files or digital synthesis engines are used to produce sound, the construction of physical controllers to manipulate these sounds needs bear no relation to acoustic methods of producing sound, instead allowing for a focus on the development of new interfaces and methods of user interaction. Wanderley *et al* (1998) highlight the divide between a 'synthesis engine' and the 'gestural controller' used to produce sound, and these two elements are combined by an abstract layer of parameter mappings: 'this separation allows a flexible choice of controllers and/or sound synthesis methods'.[86] The result is what they term 'composed instruments'.[87] Wanderley *et al*'s definition, including this separation of sound sources from gestural controllers (which they state may be either instrument-like, such as a MIDI keyboard, or 'alternate'),[88] highlights how instruments using procedural audio can be classified and distinguished. An instrument of any kind retains the important feature of not being limited to the performance or interpretation of a single musical work, but rather can be used to play many individual

[85] Mark Jenkins, *Analog Synthesizers: Understanding, Performing, Buying: From the Legacy of Moog to Software Synthesis* (Taylor & Francis, 2007), 76.
[86] Marcelo Wanderley, Norbert Schnell and Joseph Rovan, 'ESCHER: Modeling and Performing Composed Instruments in Real-Time', *IEEE Symposium on Systems, Man and Cybernetics* vol.2 (October 1998): 1080–1084 (1080).
[87] *Ibid.*, 1081.
[88] *Ibid*., 1081.

compositions (as Boulez described, even more broadly, when noting that instruments are not limited to one style).[89]

The boundaries between compositions and instruments do see some blurring, however, as there are times when a specific digital instrument may be indelibly linked to a composition, often in some procedural or generative manner. As mentioned in the previous section, Herber discusses both a framework for, and examples of, specific works such as these, which he terms 'composition–instruments';[90] Bahn *et al*, in their discussion of 'composed instruments' (a potentially confusing, if illustrative, term), declare the creation of electronic instruments controlled by performative actions to be 'very much an act of "composition", in the traditional sense'.[91] Within popular music, especially in genres such as electronica or ambient music where electronic timbres are prevalent, these boundaries are also often stretched. While compositions will retain the characteristics discussed above, specific timbres and synthesized sounds may become intrinsically linked with a single composition, the unique electronically created and/or manipulated timbre defining the nature of the composition to the same extent as the pitches, rhythms and other musical elements.[92] The creation of such works is possible due to both the advance of multitrack recording to the level of a compositional

[89] Boulez, 'Timbre and Composition–Timbre and Language', 162.
[90] Herber, 'The Composition-Instrument'.
[91] The writers also note that 'composed instruments,' being largely set up for specific works, proved unsuitable in improvisatory contexts where changes to dynamics, tempo and gestural musical communication could not be executed with any fluency. Bahn *et al*, 'Physicality and Feedback: A Focus on the Body in the Performance of Electronic Music', *Proceedings of the International Computer Music Conference* (2001): 44–51 (46).
[92] One example to illustrate this fact would be 'Treefingers' by Radiohead, an instrumental piece with slow-moving harmony, defined primarily by the ambient timbre created by the recorded guitar and layered effects: Jay Goodman, 'A Referential Analysis of "Treefingers" by Radiohead' (http://jaygoodmanbass.wordpress.com/2009/05/11/referential-analysis-of-%E2%80%9Ctreefingers%E2%80%9D-by-radiohead/, 16 January 2014).

process in its own right,[93] and the complementary emergence of the recording as the primary artefact of popular music,[94] ensuring that the creation and recording of unique timbres has validity as a compositional element.

Instruments making use of digital sound production must offer some method of control to the user, often taking the form of a gestural controller: these may fall under the headings of 'instrument-like controllers', resembling existing acoustic instruments (the keyboard being the most frequently used), or 'alternate controllers', which may take any non-traditional form.[95] Examples of the latter include Rubin and McAvinney's optical 'Videoharp' controller,[96] or Buchla's 'Lightning' controller, which tracks the movement of two handheld wands.[97]

An interesting development of the use of 'alternate controllers' for 'composed instruments', crossing the boundaries between instruments and other classifications, can also be seen in the emergence of works which use in some form the representation of a score or sequencer as the method of interface between user and sound production.[98] Pichlmair and Kayali (2007) have dubbed works utilizing this approach 'Active Score Music',[99] another term which may fall under a number of different classifications including instruments,

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[93] Brian Eno, quoted in Paul Theberge, 'Plugged In: Technology and Popular Music', in *The Cambridge Companion to Pop and Rock,* Simon Frith, Will Straw and John Street (eds.) (Cambridge: Cambridge University Press, 2001), 3–25 (9).
[94] Allan Moore, 'The Track'.
[95] Wanderley *et al*, 'ESCHER: Modeling and Performing Composed Instruments', 1080.
[96] Dean Rubine and Paul McAvinney, 'The Videoharp: an Optical Scanning MIDI Controller', *Contemporary Music Review* 6/1 (Harwood, 1991): 31–46.
[97] Robert Rich, 'Buchla lightning MIDI controller: a powerful new MIDI controller is nothing to shake a stick at', *Electronic Musician* 7/10 (ACT III: October 1991): 102–108.
[98] Wanderley *et al*, 'ESCHER: Modeling and Performing Composed Instruments', 1080.
[99] The term 'Active Score Music' originally comes from a performance given in 2000: Martin Pichlmair and Fares Kayali, 'Levels of Sound: On the Principles of Interactivity in Music Video Games', *Situated Play: Proceedings of DiGRA 2007 Conference* (Tokyo: September 2007): 424–430 (424).

games, and toys. Perhaps the most well-known example of an 'Active Score' instrument would be the Tenori-On, designed by Toshio Iwai in collaboration with Yamaha. This 'musical instrument for the digital age' resembles a touchpad with a sixteen-by-sixteen grid of LED switches that can be used to manipulate sound and play the instrument in different manners.[100] 'Score' mode offers a reasonably traditional sequencer-style interface, while other modes allow similar loops and patterns to be programmed. The interface is analogous with the sound being produced by the instrument, and by offering sequencing and control of more than a single note at a time it can be seen to resemble a score that is being realised in real-time by the instrument. The wide range of expressive potential inherent in the Tenori-On, unlimited as it is to either a defined musical character or an unfolding structure in time, allows it to be classified as an instrument rather than an interactive composition.[101]

Toshio Iwai's various works provide an excellent overview of different classifications: the Tenori-On, a mass-produced instrument, was in part developed from *Composition on the Table* (1999), an interactive installation by the same artist.[102] This installation offered the user four table-top surfaces with which to interact, each provided a different, simple form of interaction with the musical material and projected images. These interfaces could not be classed as instruments, due to the continuous, recognisable musical material heard

[100] Toshio Iwai and Yu Nishibori, 'Tenori-On', *Proceedings of the 2006 International Conference on New Interfaces for Musical Expression (NIME06)* (Paris: 2006): 172–175.
[101] Videos can easily be found online of people performing cover versions of both popular songs and classical pieces with the Tenori-On, demonstrating its capability to play multiple compositions across different styles; one example is the established artist Little Boots covering Hot Chip, 'Ready for the Floor' (http://www.youtube.com/watch?v=N6tLRCDqJ2c, 22 September 2014).
[102] Toshio Iwai, 'Composition on the Table', *ACM SIGGRAPH 99 Electronic Art and Animation Catalog* (ACM, 1999): 10.

without any user involvement; users could only interact with and alter the existing music, in the nature of a liquid composition. Iwai has also developed similar principles of interaction with sound into works that can be classed as games, the next genre to be discussed.

2.1.3 Game

Arguably, the largest number of existing procedural audio works fall into the classification of *games*, due primarily to the existence of the enormous video games industry. Though rarely the primary focus of video games, the implementation of procedural audio—and, indeed, liquid music—is regularly viewed as a key part of these multimedia works. There is also a growing number of games and game-like works focused on musical expression.

Defining what constitutes a *game* of any kind can be difficult, and the question has naturally generated much discussion within the field of game studies. Although researchers such as Huizinga, Salen and Zimmerman have made valuable contributions to this discussion,[103] I propose to work with a more recent definition of what constitutes a game by Juul,[104] a respected academic with numerous publications in the field of ludology and video game studies. His book *Half-Real: Video Games Between Real Rules and Fictional Worlds* (2005), though focused primarily on video games, includes an excellent review of literature from the broader field of ludology, and examines

[103] John Huizinga, *Homo Ludens: A Study of the Play-Element in Culture* (London: Routledge & Kegan Paul Ltd., 1949); Katie Salen and Eric Zimmerman, *Rules of Play: Game Design Fundamentals* (Massachusetts: MIT Press, 2004).
[104] Jesper Juul, *Half-Real: Video Games Between Real Rules and Fictional Worlds* (Cambridge: MIT Press, 2005), 36.

established definitions for the term 'game'. Drawn from these sources, Juul's own definition of the category is both comprehensive and clear, and is frequently cited in more recent academic works on the topic. For the purposes of this chapter, this definition perfectly delineates the category under discussion.

Juul proposes six features, the most salient of which is that games are 'a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values'.[105] In other words, success or failure can be measured and expressed (often as a score) in a game, on the basis of a system of defined rules and objectives: what might be termed 'ludic goals', that is, objectives to be achieved by playing the game. Chess is a game, with universally recognised rules and goals leading to an outcome. Similarly, the game *Wii Music* (2008) includes within it a number of sub-games, such as 'Mii Maestro', in which the user follows rules (the Wiimote is used to conduct the orchestra's performance) in an effort to achieve goals (the performance of the music as accurately as possible) and achieve a quantified outcome (expressed as a score at the end of the game).

According to these criteria, the Tenori-On could not be called a game, as the user's interaction with it is not limited or guided by a specific set of rules (other than the capabilities of the programming and construction). There are no objectives beyond music-making when playing with the Tenori-On, and doing so has no quantifiable outcome. An instrument, therefore, can also be defined in part by what it is *not*: unlike a game, an instrument is not a rule-based system.

[105] *Ibid*., 36.

Rovithis states: 'it is clear that there is a contrast between the existence of rules and the compositional freedom',[106] indicating that once there are rules to limit the interaction—and thereby the musical output—a work becomes less an instrument and more a game or toy. A noteworthy similarity between games and instruments is that both require the user to dedicate a considerable amount of time to the activity of playing: any instrument requires practice for the user to become adept at creating music with it; similarly, any game requires practice for the user to become adept at navigating its rules in order to achieve the defined goals. The time invested in a composition comes instead from the composer (rather than the listener), and any user of an interactive composition can expect an almost immediate accessibility with little or no learning or practice involved.

Numerous sources cite Atari's *Touch Me* as the earliest example of an electronic game focused on audio.[107] Released as an arcade game in 1974, *Touch Me* simply required the user to repeat lengthening sequences of pitches for as long as possible, by pressing four buttons with a distinct pitch assigned to each. Subsequently, the field of electronic—and later digital—audio games has grown enormously, and a number of classification systems have been proposed by researchers such as Pichlmair and Kayali (2007) and Rovithis (2012).[108][109] The various categories of audio game will be examined in greater detail in a later section of this thesis; for the current discussion, it is sufficient to say that in

[106] Emmanouel Rovithis, 'A Classification of Audio-Based Games in terms of Sonic Gameplay and the introduction of the Audio-Role-Playing-Game: Kronos', A*udio Mostly 2012 Conference Proceedings* (Corfu: September 2012): 160–164 (162).
[107] *Ibid.*, 160.
[108] *Ibid.*
[109] Pichlmair and Kayali, 'Levels of Sound'.

order to be classed as an audio game, a work should function as a rule-based system, with goals or objectives and a quantifiable outcome. Some video games may cross the boundaries with other genres, or contain elements and sections which do not meet these criteria, such as the 'free-form' mode offered in *Electroplankton*—a game which is also a prime example of 'Active Score Music'. Generally, however, it is true that 'no sound game can be played as freely as a traditional instrument', and that creating unpleasant, discordant or musically poor arrangements of sound within these games is considerably more difficult than creating pleasant arrangements.[110]

2.1.4 Sound-toy

The final interactive media genre which will be addressed here is that of the *toy*. This term may carry with it connotations of triviality, of juvenile or perhaps pointless play. It appears to lack the element of seriousness desired by creative media or multimedia artists, and may imply that a work is too simple, or even lacking in worth. This is highly questionable, as numerous interesting, innovative and worthwhile musical works have been created in recent years which seem to fall under the description of toy, rendering it something of a misnomer. Another popular term, however, is *sound-toy*,[111] which I propose to use when discussing electronic or software toys specifically designed as musical or audio works. Sound-toy may be a more appropriate term, adding a sense of more serious creative work.

[110] *Ibid.*, 428.
[111] Crawford, 'SuperConductors', correctly states that this term is used in several online sources, not least for the extremely good archive of works at www.soundtoys.net, though it is not universal or standardized in any fashion.

Crawford (2011) makes a special study of sound-toys, using the term in a specific manner to relate to a number of software works available on the Internet and accessible through web browsers.[112] He points out that, although sound-toys can vary widely in both appearance and function, their defining properties are that they have a primary focus on the production of musical sound, use some form of interactivity, and are of a relatively small size, both in terms of the memory used to program and run them, and the sonic material which they contain. Since Crawford's study, sound-toys have begun to migrate from their predominant location on the Internet to mobile platforms: iOS, Android and other platforms all host a number of sound-toys which retain the same essential characteristics as their web-based predecessors, of which there are still just as many available.

Andrew Dolphin has dedicated a chapter to 'Defining Sound Toys,' in which he describes them as 'interactive, sonic-centric systems in which the end user may trigger, generate, modify or transform sound'.[113] Dismissing the characteristics of games as not present in sound-toys, Dolphin classes them as a middle ground between compositions, compositional tools, and instruments, based mainly on the level of musical control inherent to a given work.[114] In the current context, I would argue that anything which could be classed as a composition or instrument, should be so; while those remaining works that match Dolphin's rather broad description may be called *sound-toys*.

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[112] *Ibid.*
[113] Andrew Dolphin, 'Defining Sound Toys: Play as Composition' in *The Oxford Handbook of Interactive Audio*, Collins, Kapralos & Tessler (eds.) (Oxford: Oxford University Press, 2014): 45-61 (45).
[114] *Ibid.*, 53.

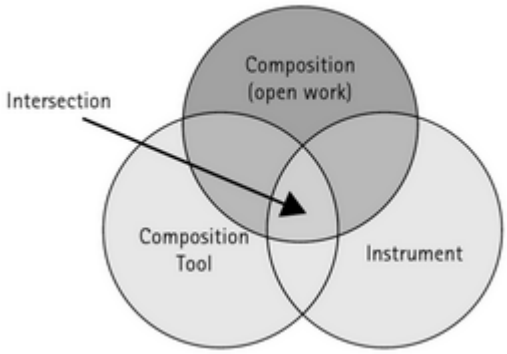

FIGURE 2.1—'Intersection of terms of classification' (Dolphin, 2014, p.53)

Sound-toys are perhaps most closely related to audio games, in that the expressive potential of their audio output is often quite strictly limited. However, the rules governing a user's interaction with a game are not so strongly present (if present at all) with a sound-toy: there is no "wrong" way to interact with a toy.[115] Equally, a toy has no clearly defined objective or goals for the user to complete, simply offering a free-form play experience.

Toshio Iwai's *SimTunes* (1996) offers an example of a sound-toy released in a similar format to a game: published by a game development company as a Windows CD-ROM, it contains no clear ludic goals but only a type of creative musical interaction. Different "bugs" representing instruments or timbres are released onto a user-created "picture", in which each colour represents a different note. The interaction of "bugs" with this environment drives the musical output. Though clearly not a game, *SimTunes* offers a more complex and expressive interaction than most sound-toys, resembling perhaps a sort of generative music sequencer or environment.

[115] Rovithis, 'A Classification of Audio-based Games', 162.

A sound-toy's limited expressive potential differs it from an instrument. Unlike either instrument or game, a sound-toy does not require any great investment of time from the user in order to "master" or improve their interaction with it. Instead, a sound-toy is an immediate experience for any user, linked to the relative simplicity of its sonic material. Despite these facts, the sound-toy is potentially a more flexible type of work than any of those discussed previously, and it appears that they are crossing and pushing the boundaries of the classifications more than any other current works.

Crawford (2011) suggests that sound-toys 'may represent the first stage of an emerging genre of participatory popular music',[116] an observation which seems to have some merit. Sound-toys are certainly part of a wider technological and creative movement towards interactive art forms, and while such artefacts cannot be termed liquid music compositions, these relatively simple audio-based interactions may be laying the groundwork for later development of more complex liquid musical works.

2.1.5 Installation

The final classification to mention is that of the *installation*, a definition based upon the context in which a work is presented rather than the precise nature of its content or procedural elements. Sound installations are largely a product of music technology that emerged during the mid-twentieth-century, with roots in art movements such as Dadaism and Futurism which called 'for the merging of

[116] Crawford, 'SuperConductors', 77.

art and science, as well as the integration of media', thereby providing 'the building blocks of digital installation art'.[117] A work displayed in a gallery, or any space which has been appropriated for the display of art works, may be called an installation; artists like Edgard Varèse (1883–1965) and Iannis Xenakis (1922–2001) were early exponents of the genre.[118] More recently, digital technology has made a significant impact on the creative possibilities and features which audio installations may exhibit. Most pertinently, installations may these days be in some fashion interactive, designed for users to engage with in a particular manner, as 'participatory and interactive art is becoming an important component of contemporary art'.[119] Installations may be constructed with dedicated hardware, a variety of software, and often some combination of both.[120]

Installations can be separated from the other classifications under discussion in this chapter precisely because of their open nature. An installation may take almost any form, its description as an "installation" being a signifier not of the work's content, but of the manner in which the work is presented to its potential users. Rather than being distributed as a physical product, or digitally over the Internet, it is an individual work which is housed in a specific location, requiring the user to actively approach and participate. Installations may also be classified as *composition*, *instrument*, *game* or *toy*: the term is not mutually exclusive.

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[117] Bruce Wands, *Art of the Digital Age* (London: Thames & Hudson, 2006), 98.
[118] See for example Xenakis' *Polytope de Cluny*, a work for music and lights installed in the Roman Baths of Cluny in Paris (1972); or the earlier *Poeme Electronique* by Edgard Varése, installed at the World's Fair in Brussels (1958).
[119] Wands, *Art of the Digital Age*, 16.
[120] *Ibid.*, 124.

An installation for the Milan Museum of Musical Instruments (as a contribution to the European Commission 'DREAM' project) which takes the form of an interactive touch-screen exhibit was created by Fencott and Dack in 2011:[121] a sequencer-style interface is displayed upon a touch-screen, mounted within a bespoke table-like piece of hardware. The installation is a digital realization of the composition *Scambi* by Henri Pousseur, composed in 1957; the original work consisted of thirty-two sound segments on individual pieces of magnetic tape, which could be re-arranged as desired by the user. Fencott and Dack created a visualization of these pieces of tape within an interface which allows for easy arrangement of the segments, each of which is tied to digital audio files of the material originally recorded onto tape, enabling multiple versions of the composition to be created with relative ease. This installation, therefore, can be viewed as an interactive composition, programmed with a touch-screen interface and housed within a bespoke piece of hardware.

Raffaseder (2007) also created hardware specifically designed for an interactive installation: in this case, a ping-pong table with six contact microphones mounted on the underside.[122] These contact microphones feed signals to a PC running *Reaktor* (an audio programming environment) which is used to extract and determine information about the gameplay occurring atop the table, such as the ball hitting the table, the area where it hits, and how frequently these hits are occurring. This game information is used to trigger percussive samples, set them into looping patterns and alter the tempo and

[121] Robin Fencott and John Dack, 'An Interactive Surface Realization of Henri Pousseur's "Scambi"', *International Sound and Music Computing Conference 2011*, Padova, Italy (July 2011).
[122] Hannes Raffaseder, 'SoundTableTennis—an interactive sound installation', *Proceedings of the Audio Mostly* C*onference,* 27–28 September 2007 (Rontgenbau: Fraunhofer IDMT, 2007): 37–39.

other elements of the audio. Exhibiting this functionality, *Sound Table Tennis* could perhaps be considered an interactive composition: more accurately, I would suggest that it, just like regular table tennis, is a game, albeit one that in this case has a strong adaptive audio element to go with it. While the game can be played according to the normal rules of table tennis and soundtracked by Raffaseder's musical programming, users could also choose to ignore those rules and simply interact with the table for the purposes of exploring its musical potential—perhaps thereby re-classifying it as a toy. This raises the interesting observation that a single work may *in potentia* exhibit the features of two different categories, depending on the intentions of the user(s) and the manner in which they interact with the work.

As is made evident by these examples (and the many others which could be chosen), an interactive installation can take many forms, though often relying on bespoke hardware of some kind working in tandem with software programming. An *installation* is not a classification of the nature of a procedural audio work itself, but any installation may exhibit the properties of compositions, instruments, games or toys.

2.1.6 Drawing Boundaries

With such a multiplicity of musical media, making use of an assortment of advances in digital audio technology and interaction design, it has become increasingly difficult to categorise different works. The blurring, breaking and crossing of boundaries between the classifications of composition, game and so

on is however a positive process, freeing artists, musicians and developers to create in whatever way they see fit without feeling limited or restrained by clearly delineated functions or purposes. Interactive audio works can take almost any form imaginable: compositions may feature interactive elements, adding a toy-like approach; games may offer a freedom of expression within their system of rules that can bear resemblance to an instrument. This blurring does, of course, render accurate classification more difficult, a problem which this chapter has attempted to address. While it is probably best to approach classification on a case-by-case basis, with the intention of the artist or developer also taken into consideration, and while it should be recognised that within any given work two or more of these genres may be represented, a broad system of classification does seem possible.

A *composition*, with or without liquid elements, must always retain a recognisable musical character: procedural material offers only greater possibilities, within authored and defined parameters, for musical choice or content than a fixed composition. Little or no practice or expertise is required of the user when engaging. An *instrument*, meanwhile, as something that rewards a level of skill, does require effort or practice from the user in order for successful engagement. It is not limited to the production of recognisable musical material with every engagement, like a composition, but offers freedom of musical expression. A *game* is a system with clearly defined and enforced rules, with an objective (or *ludic goal*) to the gameplay, and a quantifiable outcome for the user; some effort is usually expected for the user to be able to play "well." Finally, a *toy* (or *sound-toy*), has no ludic goals or quantifiable outcome, offering

free-form play or interaction and requiring no effort or expertise. The expressive musical potential may be less than an instrument, nor is it structured over time in the style of a composition.

For the purposes of this thesis, classification of these works is important so that existing works which make use of procedural audio in any fashion can be accurately reviewed and related to the proposed interactive systems or frameworks. It is also important when developing demonstrations of liquid music compositions that these works do not take on the characteristics of another media classification, functioning not as composition but as sound-toys, games or digital instruments.

2.2 Musical Mutability

Prior to the late nineteenth century, music publication consisted of written notation, scores through which the composer's intentions could be disseminated. The consumer bought this score and played it at home upon their own instruments, and aside from public performance, this was the established paradigm. While the score may have been intended to allow faithful replication and appreication of the composer's work, a consumer may also have chosen to play *with* this music: deliberately improvising around it, altering, changing or re-appropriating elements for the purpose of personal entertainment. Today, though music publishing still includes printed scores, the field of business is also concerned with the development and release of music recordings, protected under separate 'mechanical' copyright.

Recorded music, often in digital formats, represent a different paradigm for the dissemination of music. Consumers purchase and play this music at home through specific hardware and software—it is only more recently, though, that they can again play *with* the music in the same way as realizing a score. Though many playback formats offered a degree of interaction, most notably DJs who could scratch and mix with vinyl records to generate unique performances from recorded material, it is the proliferation of cheap or free digital audio editors that have opened this ability to a much wider amateur field. Consumers might be referred to as "users", as they have become participants in the creation of the music, by altering or re-appropriating elements of it as they see fit, for the purpose of personal entertainment, in a fashion commensurate with that of music consumers in the days before commercial music recording.

> Technology makes new forms of music possible—or perhaps the new music is created as a result of the technology being available.[123]

Investigating the possibilities for a new paradigm of liquid music involves addressing the nature of the musical work itself. A liquid pop song will not— indeed cannot—exist as a single recorded artefact, an unchageable version which has been created by the artist. Instead it will be a malleable, changeable entity, a song which can exist in multiple forms. Rather than constituting an enormous or untenable departure from previous consumer engagement with published music, it can be argued that liquid music is in some ways a natural progression from existing practices of audience engagement, and

[123] Virgil Moorefield, 'Modes of Appreciation: Covers, Re-mixes and Mash-ups in Contemporary Popular Music', in *Recorded Music: Performance, Culture and Technology,* Amanda Bayley (ed.) (Cambridge: Cambridge University Press, 2010), 291–306 (301).

that the idea of a musical work as a malleable and changable entity is widely accepted.

2.2.1 Early Precedents for Liquid Music

A brief look at earlier centuries allows for the concepts underpinning liquid music to be traced back centuries. Music was rarely conceived of by composers as fixed and immutable. Classical operas, such as those by Vincenzo Bellini (1801–1835) and Gioachino Rossini (1792–1868), were exemplary in their use—or reuse—of previously written musical material. The melody of Rossini's 'Questo cor ti giura amore' from *La pietra del paragone* (1812), for example, re-appears in no fewer than five of his later operas.[124] Indeed, when faced with the prospect of a publication of his collected works, Rossini wrote to the publisher to say that 'it will lead to much (justified) criticism, for the same pieces of music will be found in several different operas'.[125] Despite any anxiety about potential criticism, these opera composers were well aware of the malleable nature of music and the fact that a single work may have multiple variants—that a single melody may exist in a variety of settings, each as valid and worthwhile as the next.

Standing in one way diametrically opposed to Rossini's style, Ludwig van Beethoven (1770–1827) exemplified an alternative approach to musical aesthetics at the start of the nineteenth century, as the latter 'claimed for music

[124] Christopher Headington, Roy Westbrook and Terry Barfoot, *Opera: A History* (London: The Bodley Head, 1987), 158.
[125] *Ibid.*, 156.

the strong concept of art'.[126] A combination of broader factors, including the establishment of a musical canon, the rise of German Romanticism, absolute music, and as Einstein (1947) points out, the sociological shift from composers with patrons and employers to please (everyone up to Haydn, and even Mozart) towards freer 'creative artists' with a freedom of expression,[127] led to a similar shift in perception of the work of a composer from the work of a skilled craftsman to the inspiration of a genius:

> ...the Romantic notion of 'Art,' with its image of the composer as the solitary genius imagining an autonomous, self-contained musical structure [...] that most idealized of all Romantic art forms, the work of 'absolute music.'[128]

Understandably, such a view of musical aesthetics did not sit comfortably with the notion of music as a malleable, functional art form; while Beethoven's scores represented 'inviolable musical "texts"',[129] Rossini's were always subject to change:

> …a score could be adapted to the changing conditions governing various theatres without violating its meaning. (Strictly speaking, there is no 'authentic,' 'first-hand' or 'final' version of a Rossini opera […] instead, all we have is a series of instances standing side by side as equivalent realizations of a mutable conception.)[130]

The emergence of sound recording technology managed the impressive feat of both reinforcing and simultaneously breaking down the Romantic idea of the "masterwork". This dichotomy is evident by the manner in which the non-

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[126] Carl Dahlhaus, *Nineteenth-Century Music*, 9.
[127] Alfred Einstein, *Music in the Romantic Era* (W.W. Norton Inc., 1947), 14–15.
[128] Philip Alperson (ed.), *What Is Music?: An Introduction to the Philosophy of Music* (Haven Publications, 1987), 27.
[129] Dahlhaus, *Nineteenth-Century Music,* 9.
[130] *Ibid.*, 9–10. Note the term 'adapted,' indicating a score would be changed in response to indirect conditions not of the composer's making—in a way very similar to the definition given for 'adaptive' audio.

linear nature of recording formats (especially magnetic tape) began to highlight the possibilities for the re-ordering and juxtaposition of music or sound, while at the same time, the widespread dissemination of specific, individual recordings with extrememly limited potetnial for disruption or interaction led to those recordings taking on an "authentic" status of their own.

2.2.2 Non-Linear Music

There is a long tradition of musical works that might also by commonly described as *non-linear*, a term implying that there is no fixed path, or linear progression, through the work. This is another term that is worthy of definition within the context of this thesis, as a variety on the idea of changeable and unfixed works which has precedent in Western music. Non-linear music exhibits fluid aspects, and *will always by definition be included under the heading of liquid music*, though liquid music in turn need not be exclusively non-linear, as linear works of liquid music can have been created). This section examines the terms *linearity* and *non-linearity*, of which two slightly different readings can be taken, whether in regards to music or other narrative (multi)media.

It is important to identify and distinguish between the two separate meanings that can be understood from the term *non-linear*; they can be referred to respectively as *causal non-linearity* and *structural non-linearity*. The former relates to an intra-musical, phenomenological analysis of musical works, while the latter relates to form and structure, or the ordering of musical material; it is this second meaning that is of greater importance with regard to liquid music,

as causal non-linearity may be present as a feature of either liquid or fixed, static music.

Music is, of course, a time-based medium: it exists within and unfolds through time, unlike many other art forms (such as painting, or sculpture), whilst also differing from other time-based arts such as film and theatre, in that the latter are primarily narrative genres. Music—despite elements of narrative in song-writing, opera, or potential programmatic associations with instrumental music—is broadly speaking not narrative. Yet, 'as a time-based medium, music incontestably unfolds moment by moment upon a linear canvas'.[131] The reception of music by a listener who hears a succession of musical events over a period of time is therefore an inevitably linear experience. Despite this there are not one, but two distinct ways in which music can be referred to as non-linear. Theorists and researchers from a number of disciplines have approached the subject and discussed these views, with most writers usually choosing to focus on one to the exclusion of the other. Kaae (2007) presents an exception, highlighting the dichotomy to some extent and differentiating between 'phenomenological' and 'structural' views of musical linearity and the progression of time; these equate to the two approaches as defined here.[132]

The phenomenological approach, or *causal non-linearity*, relates entirely to intra-musical processes and events from which a sense of linearity can be constructed or disrupted. For centuries, Western music has been guided by

[131] Lindsay Vickery, 'The Evaluation of Nonlinear Musical Structures', *Sound Scripts: Proceedings of the 2009 Totally Huge New Music Conference* 3 (2011): 74–84.
[132] Jesper Kaae, 'Theoretical Approaches to Composing Dynamic Music for Video Games', in *From Pac-Man to Pop Music*, Karen Collins (ed.) (Aldershot: Ashgate, 2008), 75–92 (76).

certain rules of cause and effect, goal-oriented progression, and large or small-scale formal structure, of which the tonal system can be seen as the highest achievement.[133] The disruption, relaxation or abandonment of these rules (as seen throughout twentieth century art music) allows for music to be described as causally non-linear. In *The Time of Music* (1988), Kramer lays out five distinct classifications of linearity in music, related to the causal approach of how one musical section might lead from the previous; these classifications can be arranged as points along a scale (or *continuum of linearity* as it is referred to by other researchers)[134] from 'goal-directed linear time' to 'vertical time', the latter with no discernible musical movement or progression.[135] Non-linearity in this fashion allows musical works to remain identical upon each playing; researchers such as Parker have further discussed this definition of linearity, treating the term as a function of musical language, organization, and goal-orientation.[136] This approach has yielded much musicological research and writing, yet it cannot be seen as the only definition of linearity in music.

The second approach that can be taken views linearity as an aspect of structural progression through a work, irrespective of the musical material being played; linearity is dealt with in a strictly formal sense, without any reference to the inherent connections (or lack thereof) in the content. This approach can be termed *structural non-linearity*, and is of greater relevance to this thesis, as works exhibiting this form of non-linearity fall invariably under

[133] Jonathan Kramer, 'New Temporalities in Music', C*ritical Inquiry* 7/3 (Spring 1981): 539–556 (539).
[134] Vickery, 'The Evaluation of Nonlinear Musical Structures', 74.
[135] Kramer offers Steve Reich's *Come Out* (1966) as one example of this 'vertical time': Kramer, 'New Temporalities in Music', 551.
[136] Imogen Parker, 'The Time of Music: the Music of Time', *Critical Quarterly* 50/3 (October 2008): 43–76.

the heading of liquid music. Structural non-linearity rejects the notion of progression from one point to another along a fixed and pre-defined route (beginning, to middle, to end), instead making it possible for different routes to be taken, for the musical material to unfold in a different manner or through different sections. Collins uses the metaphor of an urban metro system to describe structural non-linearity: while traditional linear music resembles a single train on a track, non-linearity is just such a system of different, inter-connected routes, within which a passenger can jump from train to train and travel in any direction they desire.[137] In a similar vein, Kaae writes about non-linear audio and games using a system of 'nodes' and 'links' in a method of construction similar to that of hypertext.[138]

The key feature of structurally non-linear works—that there is no fixed path through the musical material, however progression may be guided or implemented—means that any possible ordering should be equally as valid as any other. It should be noted that a structurally non-linear work will always *appear* linear after only one playing, due to the nature of music, presenting the listener with an isolated linear experience over time. Unlike causal non-linearity, structural non-linearity cannot be immediately identified in a composition by the listener, but will reveal itself over the course of multiple listenings or experiences. The case could also be made that, while both

[137] Karen Collins, 'An Introduction to the Participatory and Non-Linear Aspects of Video Games Audio', in *Essays on Sound and Vision* (Stan Hawkins and John Richardson, eds.) (Helsinki: Helsinki University Press, 2007): 263–298 (263).
[138] Jepser Kaae, 'Theoretical Approaches to Composing Dynamic Music', 77.

approaches to non-linearity may exist exclusively or simultaneously, causal non-linearity encourages structural non-linearity.[139]

The differences between *causal* (or, alternately, *narrative*) and *structural* linearity can be readily likened to those between 'story' and 'plot' as defined by Bordwell.[140] Primarily a film theorist, he defines 'story' as a causal, chronological series of events, while 'plot' refers to the order and duration of events as they are presented to the viewer (or listener). Though structurally non-linear video is not something which has appeared to any extent in popular culture to date, these two concepts are made apparent in films such as Christopher Nolan's *Memento* (2000),[141] which follows two alternating sequences of events in successive sections, one moving backwards and one forwards through a chronological period (the 'story'), until they converge on the same point in time and thus provide the climax of the 'plot'. *Memento* is causally or narratively non-linear, disrupting the order of events presented to the viewer and negating the rules of cause and effect from one scene to the next. It is however structurally linear, as it has been arranged (or composed) in a particular, fixed sequence for the artistic purpose of revealing the story to the viewer in an unusual way.[142]

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[139] One pertinent example of this would be the nineteen sections of Stockhausen's *Klavierstück XI* (1957), discussed further in the next chapter; by detaching the sections causally, the composer was enabled to more easily detached them structurally, rendering each sequential choice as valid as any other, and encouraging the development of alternate means to link sections—in this case, the placement of tempo and dynamic markings at the end of each section, pertaining to whichever is chosen to follow.

[140] David Bordwell and Kristin Thompson, *Film Art: an Introduction* (7th ed.) (New York: McGraw-Hill, 2004).

[141] Christopher Nolan and Jonathan Nolan, *Memento,* Christopher Nolan (dir.), (I Remember Productions: 2000).

[142] It should be noted, in a later special DVD release, there was a hidden option to play a version of the movie re-arranged into chronological order, making it narratively as well as structurally linear—or structurally non-linear, if it can exist in two forms. Yet the theatrical release would

2.2.3 Mutability in Popular Music

Moore (2010) identifies 'the primacy of the recording as the carrier of identity for the popular song',[143] and indicates that, in the current age, a recorded version of a song will usually define what the song "is", so to speak. The recording has *become* the song after a fashion, replacing the older idea of the score as "the music". Turino (2008) also identifies this shift from performance to recording in the cultural conception of music.[144] This is reinforced by the fact that 'what we might define musicologically as categories like texture and timbre signify much more strongly than they do in music normally encoded in scores'.[145] A recording of a piano piece, in other words, will contain far more definite information on the sound of the piece than would be contained in the written score. Despite this, recent decades have also seen the systematic undermining of this aspect of the recording as identity-carrier for the musical work.

This dichotomy addressed in the previous section, and the aspects of recorded music which give rise to it, can be seen as a specific manifestation, or evolution, of the age-old practices of musical borrowing and quotation. The recording as artefact, along with more recently developed practices such as *sampling, remixes* and *mash-ups*, have both enhanced and undermined the essentially Romantic notions of authenticity and definitiveness in a musical work. This is due to the facilitation, through digital technology, of regular recontextualization of short, often instantly recogniseable pieces of music. Yet if

arguably be the definitive version, as the film was not initially designed to be altered structurally.

[143] Moore, 'The Track', 258.

[144] Turino, *Music as Social Life* (2008), 25.

[145] Moore, 'The Track', 258.

the principles behind these practices are separated from the technological methods that facilitate them, they can indeed be seen as manifestations of a long-existing musical approach. For example, the emergence of recorded *cover versions* from the early twentieth century onwards is a technologically implemented evolution of practices that Katz (2010) has traced back as far as Medieval music.[146] Other practices can be examined in more detail, with the aim of highlighting how musical mutability is at the forefront of today's popular music—so much so that fixed, unchanging music is almost redundant.

The term *sampling* may have any of three related meanings within the field of popular music:[147] it might refer to 'the digital incorporation of any pre-recorded sound into a new recorded work',[148] which in its broadest sense incorporates multisampled instruments designed for MIDI playback or use in audio recordings, such as the Vienna Symphonic Library orchestral sample packs.[149] *Sampling* is also used to refer to the practice of reusing recorded material from other artists' work as an element of one's own work, or in Hoskins' words, 'the "borrowing" of a segment of musical material as found in genres such as hip-hop.'[150] This latter practice takes pieces of audio directly from existing songs (often short phrases, drum beats or vocal hooks, rarely more than a few seconds in length) and uses them as the building blocks for creation of entirely new songs.

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[146] Mark Katz, *Capturing Sound: How Technology has Changed Music* (revised edition) (Los Angeles: University of California Press, 2010), 148.
[147] The first of which is the 'sample rate' of digital audio files, the others outlined in the main text. Dan Hosken, *An Introduction to Music Technology* (New York: Routledge, 2011), 233.
[148] Katz, *Capturing Sound,* 147.
[149] *Vienna Symphonic Library* (vsl.co.at, 13 January 2014).
[150] Hosken, *An Introduction to Music Technology*, 233.

Sampling undermines the notion of musical works as unchangable artefacts, allowing and encouraging the recontextualization of previously recorded music. To give one instance, a considerable number of songs have been built around the same four-bar sample of Isaac Hayes' 'Ike's Rap II': some of the more famous include Portishead's 'Glory Box' and Tricky's 'Hell is Round the Corner' (both released in 1995).[151] Some samples have attained a classic status, such as the two-second drum break from James Brown's 'Funky Drummer' (1970) which has seen continual reuse since it was first recorded.[152] Entire genres have even been built upon specific samples: the "Amen Break", a sample from The Winstons' 'Amen, Brother' (1960) is at the very core of Drum'n'Bass music, helping to define the entire style of the genre.[153] The purposes behind such sampling may be entirely aesthetic, or they may be representative, samples used to convey extra-musical associations. For example, Mark Katz provides a deconstruction of the signification and political issues present in the track 'Fight the Power' (1990) by Public Enemy.[154]

Sampling is accepted as a significant part of contemporary popular music, a widespread evocation of musical mutability. Music written and recorded previously is reappropriated—often (though not necessarily) in its original form—by another artist, and used (possibly in a collage style with other samples, or in an isolated fashion for either reference or aesthetic effect) to create a new piece of music. In this fashion, popular music is recycling its own

[151] Portishead, 'Glory Box', *Dummy,* compact disc Go!Discs 828 553-2, 1994; Tricky, 'Hell is Round the Corner', *Maxinquaye*, compact disc Island Records 524 089-2, 1995: both sample Issac Hayes, 'Ike's Rap II', *Black Moses*, LP Enterprise ENS-5003, 1971.
[152] Katz, *Capturing Sound,* 146.
[153] Oliver Bown, Alice Eldridge and Jon McCormack, 'Understanding Interaction in Contemporary Digital Music: From Instruments to Behavioural Objects', *Organized Sound* 14/2 (August 2009): 188–196 (192).
[154] Katz, 160.

past in a most direct fashion, reusing existing material in new contexts. It cannot be said that any of the music in question exists in only one, unchangeable form, as placing samples of musical recordings into a new context will indelibly alter them: 'a sample changes the moment it is relocated. Any sound, placed into a new musical context, will take on some of the character of its new sonic environment'.[155]

Another relatively new musical practice, the development of which has been made possible through the continuing advancements in music technology, is the *remix*. Remixing is the practice of using audio recordings of completed songs, either in the officially released stereo format or divided into multiple tracks as recorded by the artist(s), to create a new version or "mix" of the song. This will often constitute a re-arrangement of the musical material within the song, alterations to the structure of the song, and possibly the addition of new musical layers or elements. The practice started with the "dub" records made in Jamaica during the 1960s,[156] and found more mainstream adoption in the late 1970s, when 'American DJs started dissecting the 3-minute song and reassembling it into an artefact suitable for dance club use',[157] bringing remixing to the attention of popular musicians.

Remixes constitute a different form of reworking to cover versions or sampling: while cover versions are re-recordings (or performances) of an existing work by another artist, a remix is undertaken using the same sonic material, or elements thereof, as the original work. It uses what Katz refers to as

[155] *Ibid.*, 174.
[156] Moorefield, 'Modes of Appreciation', 297.
[157] *Ibid.*, 297.

performative, rather than musical, quotation and re-working.[158] The alterations, additions and extensions made during the process of remixing frequently result in a piece of music less similar to the original work than a cover version might be; however, just as some cover versions can achieve heightened popularity, it has at times been the case that 'a remix could supplant the original producer's work'.[159] 'Brimful of Asha' (1998) provides one perfect example of this: the original song by Cornershop achieved only middling success when released in 1997, before a remix by Fatboy Slim was released the following year and brought the song to a whole new level of success, quickly reaching number one in the UK charts and garnering an enormous amount of radio play.[160] Remixing has become so ubiquitous that it has cast serious doubt upon the relevance of "definitive" versions of songs within contemporary popular culture: it has simultaenously laid the groundwork for further exploration of the mutability of pop songs, their potential for alteration and re-working, and their capacity to exist as multiple versions of a single work.

If the remix is perhaps the greatest espousal of musical mutability in contemporary pop music, then the more recent phenomenon of the *mash-up* is just one of many possible directions for such practices to develop and evolve within popular music. Inspired by the culture of remixing, a mash-up is, at its simplest, an amalgamation of two different songs to form a new musical work. Usually the vocal track from one song is arranged over the instrumental parts of another, though more complicated amalgamations can and do occur quite

[158] Katz, 77.
[159] Moorefield, 'Modes of Appreciation', 298.
[160] *150 Best Tracks of the Past 15 Years: #105 Cornershop – Brimful of Asha (Fatboy Slim Remix)* (http://www.nme.com/list/150-best-tracks-of-the-past-15-years/248648/article/248712#article, 5 December 2012).

frequently, sometimes including elements from more than two songs. The artist Gregg Gillis, better known as Girl Talk, specializes in mash-ups and has released several albums to date, each track generally using a multitude of elements from a variety of artists.[161]

Unlike sampling, wherein only small chunks of recorded music are taken and reused, mash-ups retain entire melodies, vocal, and instrumental parts (making them far more difficult to justify from a legal and copyright perspective). Yet this openness of practice has helped to make the creation of mash-ups a popular amateur pursuit. Whether or not the creation of a mash-up can be called composition is an interesting question: the consensus, especially amongst mash-up artists themselves, seems to be that it cannot or should not be.[162] What it would instead appear to represent is a practical and popular example of listeners and music fans attempting to *interact* with popular music, to engage with it and create a more personal experience, with popular songs used as raw materials for individual creations. As Moorfield writes:

> ...the mash-up is inherently the most radical contextualization of previously recorded tracks, and points to the larger phenomenon of cultural recombination, most generally expressed as the trend to remix absolutely everything.[163]

Though these practices represent the trend *towards* liquid music, they are not liquid music. No finished product of remixing, sampling or mashing-up has the

[161] Lists and diagrams of the various songs used in each mash-up by Girl Talk can be found online; one deconstruction of the album *All Day* identified twenty-four different songs which were used in the construction of the opening track 'Oh No': Tyler Gray, 'Infographic: Girl Talk's Latest Mash-up Masterpiece Deconstructed' (http://www.fastcompany.com/1707948/infographic-girl-talks-latest-mashup-masterpiece-deconstructed#self, 25 October 2013).
[162] Katz, *Capturing Sound*, 172.
[163] Moorefield, 'Modes of Appreciation', 303.

inherent capacity to change from one iteration ot the next. Related performative acts of playing with music, most notably DJing, can also not be termed as liquid music: a DJ set is a performance, within the potential for improvisation and alteration inherent to any musical performance. A DJ set uses pre-existing audio assets, but does not arrange these into a defined composition, with composed potential for change.

The widespread availability and use of digital audio editing and recording technology today has brought popular music to a point where no song is "untouchable" or unavailable for recontextualization or reuse in some fashion. A culture of musical mutability, of re-appropriating musical works and songs at will, is firmly established within and around modern popular music. When combined with the increased desire for user-driven content and interactivity throughout modern media,[164] the development of inherently procedural musical works and systems seems to be a natural progression from current practices and modes of dissemination. To an audience already familiar with existing methods of digital music distribution, editing and recontextualization, liquid music may be seen as an exciting and viable new paradigm.

2.3 Existing Liquid Popular Music

Methods and approaches to liquid music have already been implemented by a number of popular musicians, espousing the conception of music as a mutable medium, holding its place in modern participatory cultural practices. The extent

[164] As Moorfield stated in 2010, it is undeniable that with regards to music '...it does seem as though there is a more participatory culture afoot.' *Ibid.*, 292.

to which truly liquid music has been created remains limited, yet definite advances have been made over the last decade in both the number of releases, and the complexity of their material. This section provides a look at some of the works released, and suggests loose categorization so as to highlight three of the most common approaches taken by composers.

Possibly the earliest examples of liquid popular music—which not only provided additional content alongside audio files, within a specially designed interface, but also utilized a form of procedural music programming—were produced by Peter Gabriel. The CD-ROM *Xplora1: Peter Gabriel's Secret World* (1993) was intended as a companion piece to the album *Us*, which had been released the previous year.[165] *Xplora1* offers game-like elements through which the user can progress, such as locating and collecting items, solving puzzles, and unlocking audio-visual content. Pertinently, one section of the program also presents the user with a four-channel mixing desk interface enabling the remixing, in a limited fashion, of one of the songs included on the CD-ROM.[166]

Gabriel went on to release a similar project named *EVE* in 1996.[167] *EVE* is a considerable step forward from the previous release, offering much higher graphical and audio quality than *Xplora1*, as well a more engaging and easily navigable interface in the form of an abstract gameworld which develops as the user progresses through the work. The four distinct stages within *EVE* are each soundtracked by a different song. Elements of the songs are taken and reused as background music or ambiences, while individual samples and loops are

[165] Peter Gabriel, *Xplora1: Peter Gabriel's Secret World* (Real World Media, 1993).
[166] The four channels offered are in the interface are labelled 'Drums,' 'Bass,' 'Guitar' and 'Peter' (referring to vocals), and offer simple level control over the relevant components of the song.
[167] Peter Gabriel, *EVE* (Real World Multimedia, 1996).

associated with game objects and elements, so that exploration of a given stage results in a sort of musical "collage" created from the related song: a form of adaptive music derived from puzzle-solving (or interactive music, made possible by the user identifying specific actions with specific musical results). Three of the four songs are also accessible through *interactive mixing rooms* within the gameworld: a selection of loops and background sounds from which to build the foundation of the song are available, as are shorter samples and musical elements to be triggered over the top of these layers. Remixes made in such a fashion can be saved and replayed at a later time.[168]

The similarities between the design of *Xplora1*, *EVE* and the design of contemporary video games are highly noticeable; indeed, both of Gabriel's works are frequently categorized as games.[169] *EVE* is largely free of any enemies or threats, any means of counting a score, quantifying the outcome, or any clearly defined goals, yet does present the user with an abstract gameworld through which they are expected to advance from beginning to end, unlocking new content along the way. As such, it could be more accurately described as an interactive artwork or composition. Whatever the classification, in order to create a form of liquid music, Gabriel employs game-like programming and interface design, as well as interfaces that resemble standard music production tools (namely the mixer interfaces found in both *Xplora1* and *EVE*).

This 'remix' approach to interactive music remains a common trope and can be found in a number of guises and releases. In 2012, some twenty-seven

[168] Steve Ramsey, 'Peter Gabriel's EVE: Review' (http://metzomagic.com/showArticle.php?index=448, 24 June 2014).
[169] This is perhaps also due to the CD-ROM release format: 'adventureclassicgaming.com', 'mobygames.com', and 'amazon.com' all list *EVE* and *Xplora1* as games.

years after the original release of his song 'Golden Years', David Bowie released a new EP in the form of an application based upon this song.[170] The *Golden Years EP* app not only contains a number of remixes of the song, but retroactively renders the song in an interactive form and allows the user to create their own remix. A digital mixing environment places control over the levels of the various recorded instruments into the hands of the user, enabling them to alter and remix the song in real-time, saving, loading and sharing their versions as they so desire. A similar app-based release was made of Bowie's classic *Space Oddity*, celebrating forty years since its original release.[171]

A second approach to liquid music composition taken up by some commercial musicians involves site-specific or 'location-aware' music.[172] Though site-specific installations and performances in art music are not uncommon, the band Bluebrain has taken a similar approach with a focus on distributable recorded music: site-specific ideas have been applied to the recording of a series of albums, the first of which, entitled *The National Mall*, was released as an iOS app in 2011. The album is directly linked to the park of the same name in Washington DC: the listener's geographical position is tracked by the app via the iPhone's GPS locator, and their location within the Mall drives the delivery of the music. Bluebrain (brothers Hays and Ryan Holladay) divided the park into 264 different zones, each with its own musical triggers, so that as the listener moves through the Mall a continuous musical soundtrack is created,

[170] David Bowie, *Golden Years App* (EMI Records Ltd., 2011).
[171] David Bowie, *Remix David Bowie—Space Oddity App* (iKlax Media, 2010).
[172] This approach has seen considerable scholarship and research in a more academic context, and has further application in the fields of gaming, tourism, education and so on. See for example Fionnuala Conway and Natasa Paterson, 'Engagement, Immersion and Presence: the Role of Audio Interactivity in Location-Aware Sound Design,' in *The Oxford Handbook of Interactive Audio*, Collins, Kapralos and Tessler (eds.) (Oxford: Oxford University Press, 2014), 263–279.

intentionally related to the locations, museums and monuments of the surroundings.[173] In a talk delivered in 2011, Ryan Holladay states how initial inspiration for the album came from video games (navigating a virtual landscape and hearing the music and audio change), while also likening the experience to a 'choose-your-own-adventure' book.[174] At the same time, the band are keen to state in the press release that this project 'is not a toy or game that allows users to input or experiment with limitless possibilities to alter what they're hearing'.[175] Rather, it is a specifically composed, liquid music work which has the same permanence as a static LP.

The National Mall can, unfortunately, only be heard while the listener is physically located in the correct part of Washington DC, so a proper analysis of the music has not been possible for this thesis. Ryan Holladay makes mention of piano, cello, strings, choir and drums with regards to orchestration around the Washington Monument,[176] while in the *Washington Post* it is described as both 'electro-pop' and 'electronic soundscapes'.[177] Snippets of audio available online seem to confirm that this work is primarily instrumental, electronic music with elements both of popular genres and a more artistic sound design.

[173] Musical material will also loop if the listener remains in the same spot. Chris Richards, 'Bluebrain's "The National Mall": The First Location-Aware Album', *The Washington Post*, 28 May 2011 (http://www.washingtonpost.com/lifestyle/style/bluebrains-the-national-mall-the-first-location-aware-album/2011/05/25/AGtTVsCH_story.html, 7 May 2014).
[174] Ryan Holladay, 'Reinventing the Album' at TEDxPennQuarter 2011 (https://www.youtube.com/watch?v=fDcqvbkNAO0, 7 May 2014).
[175] *The National Mall* (http://bluebrainmusic.blogspot.ie/2011/03/national-mall.html, 7 May 2014).
[176] Holladay, 'Reinventing the Album'.
[177] Richards, 'Bluebrain's "The National Mall": The First Location-Aware Album'.

FIGURE 2.2—Radiohead's *Polyfauna* (screen capture by author).

Radiohead, well-known for their musical experimentation since the 1990s, are another group to have experimented with interactive musical programming in recent years. In collaboration with their producer Nigel Godrich, and art and design studio Universal Everything, they created an application for iOS and Android, released in 2014 as *PolyFauna* (see FIGURE 2.2).

This app presents the user with abstract generative environments created from elements such as terrain styles, weather, moon phase and so on, through which they can move at a fixed pace.[178] By locating and following a red dot which appears in these environments, the app can be reset and a new terrain state generated. Musically, *PolyFauna* was intended to 'explore variations of the track "Bloom"',[179] and each environment is accompanied by a remix or variation of musical material from either this track or elsewhere in the album *The King of Limbs* (2011). The band produced thirty-one audio mixes

[178] Filip Visnjic, 'Radiohead: PolyFauna – An Immersive, Expansive World of Primitve Life', *Creative Applications Network*, 11 February 2014 (http://www.creativeapplications.net/featured/radiohead-polyfauna-an-immersive-expansive-world-of-primitive-life/, 5 May 2014).
[179] *Ibid*.

from this material, and any given environment uses an audio mix broken into four separate stems or channels.[180] These stems are physically located within the gameworld, enabling the user to navigate "through" the mix of the song and to position themselves relative to different musical sources within the three-dimensional environment. *PolyFauna* is therefore a liquid musical work which will sound different every time the user engages with it, based on which audio mix is called and how the four stems are placed within the generated environment. It also exhibits adaptive functionality, as the user's movement through these environments alters the stereo positioning, levels and so forth of the music's constituent parts. Rather than being focused on popular music, however, the work is perhaps a multimedia art piece, with as much emphasis on visuals and interaction as music, the latter being distinctly ambient or abstract rather than popular in aesthetic.

A third approach which has been undertaken by popular musicians is the creation of generative musical works. In 1996 Brian Eno, formerly of Roxy Music and the foremost pioneer of generative music, released *Generative 1*, a computer-based set of generative compositions. More recently, he has released a series of apps for iOS which offer users musical experiences by applying generative techniques.[181] Arguably the most successful of these, *Bloom* (2008), resembles a simple sound-toy as defined earlier in this chapter, with which users can create repeating patterns of notes by touching points on the screen. The more recent *Scape* (2012) occupies a boundary space between composition

[180] Rachael Steven, 'Universal Everything Creates Immersive App for Radiohead', *Creative Review*, 12 February 2014 (http://www.creativereview.co.uk/cr-blog/2014/february/radioheadapp, 5 May 2014).
[181] These apps have been co-created with Peter Chilvers, who previously developed generative music for video games. (www.generativemusic.com, 18 November 2015).

and instrument—described as 'more an act of curation rather than composition' by the creators[182]—allowing users to build 'soundscapes' with backgrounds and foreground objects, each of which exhibit different generative and adaptive behaviours.[183] Objects respond differently based on the presence of other objects, on the user-defined 'mood' represented by colours, and on system information such as the time of day.[184] These releases are particularly noteworthy, as they mark a clear shift in generative music: whereas previously, due to the limitations of distribution channels, Eno would create fixed recordings of processes for release, he has latterly released *the processes themselves*. This allows users to engage with a liquid composition, rather than simply hearing a single iteration of that procedural work.

In 2011, Welsh songwriter and musician Gwilym Gold, whose prior work can largely be classed as electronic pop music, released an album entitled *Tender Metal* for iOS. While *Tender Metal* initially appears to be a standard electro-pop album, the nature of the programming behind the release belies this: entitled 'BRONZE format', this is as described on the project's dedicated website, a 'new non-interactive format'[185] through which any song played is subject to change in an unspecified manner upon each iteration of playback,

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[182] Stuart Dredge, 'Brian Eno and Peter Chilvers talk Scape, iPad apps and generative music' (http://www.theguardian.com/music/appsblog/2012/sep/26/brian-eno-scape-ipad-apps, 18 November 2015).
[183] *Scape by Brian Eno and Peter Chilvers – Available for iPad* (https://www.youtube.com/watch?v=8zNLlKRrUVk, 12 December 2015).
[184] Though based on 'generative music' principles, these works can be seen as interactive, as the music is driven primarily by deliberate action taken by the user to create a continuing, unstructured musical output based on the programming rules. It should also be noted that the musical output of these two works does not, strictly speaking, adhere to a popular music aesthetic.
[185] *BRONZE* (bronzeformat.com, 5 October 2012). BRONZE was developed in collaboration with Dr. Mick Grierson and others from Goldsmith University in London—however, the work seems to have been primarily commercial in nature, and no published research has been forthcoming from those involved. Furthermore, direct inquiries for information were turned down for reasons of intellectual property.

thereby 'generating a unique and constantly evolving interpretation of a song on each listen.'[186] The music is *not reactive*: the user has no method of directly altering, controlling or affecting the elements of the music in any way, beyond the master volume control of the player. Nor does it appear to be reacting indirectly to any user input or other system information external to itself: 'nothing you do affects how it works', stated Gwilym Gold in an interview with *The Guardian*.[187] It is therefore entirely *generative* in nature: musical elements within a given song will alter from one iteration to the next based on procedural and randomized choices made within the programming of the format in real-time, as the song plays back.

It is immediately apparent upon analytical listening that the basic structure of each song on *Tender Metal* remains intact throughout, exhibiting a recognisable and fixed structure, with the main sections (verses, choruses) always retaining the exact same length, and occurring in the exact same sequence. That these sections are tied to the lead vocals of the songs is obviously of paramount importance, as the vocals also remain unchanged throughout the album. Less structurally important sections which occur without vocals (introductions and codas, bridges between sections) are predominantly of a variable length, though some seem to exhibit a weighted tendency towards a given number of bars. Each song is composed with a number of different timbres, sets of samples or electronic sounds which could be defined as "instruments," which appear to have considerable freedom, though prominent

[186] *Ibid.*
[187] Alexis Petridis, *Music Weekly* (podcast), Scott Cawley (ed.), 3 June 2011 (http://www.theguardian.com/music/musicblog/audio/2011/jun/03/music-weekly-battles-gwilym-gold-audio, 14 October 2013).

parts (such as the piano, marimba and bass in 'Flesh Freeze') are more commonly tied to specific sections. Some of the more textural sounds, and a number of individual samples which may be anything from a number of beats to several bars in length, seem to appear in each song with greater randomisation, entering almost anywhere throughout.

The musical coherence which each iteration of each song exhibits to a greater or lesser degree is extremely noteworthy, suggesting a complex procedural approach: it is highly possible that within the programming there are chains of decisions to be made, the higher-level ones deciding initially upon the tone and overall sound of the song being played, while lower-level decisions concern aspects such as section lengths, when to add or remove specific instruments for a few measures, or triggering one-off "spot effects" during the song. An iteration of 'Limbless' which begins without percussion or piano, for example, will not suddenly erupt into a full texture comprised of all the available instruments for the song, but will retain a stripped-back feel throughout, adding and removing elements in an always musically coherent manner relative to what has come before. 'Tender Metal' (the title song), as another example, will not include the definitive rhythms of its piano-led middle-eight if the iteration being played has not had its rhythmic elements in place from the beginning—almost certainly a higher-level decision to preserve the nature of an individual iteration, rather than something left to real-time randomized choice.

Tender Metal can, therefore, be viewed as a popular music application of Whitelaw's theory of metacreation.[188] Unlike works with reactive elements,

[188] Whitelaw, *Metacreation: Art and Artificial Life*.

Gold's music is constructed as an entirely self-contained process or emergent system. This inherent difference helps to highlight how the construction of artificially intelligent creative systems— 'metacreation' and generative music— can be implemented as one potential approach to popular liquid music.

Elements such as the alternative ending for 'Lust For Sale', which was only encountered once in ten iterations, suggest that there could be numerous choices for versions of songs which are not common or frequent. Weighted randomization may mean that some sections, instruments or other musical elements may appear only once in ten, twenty or even a hundred realizations of a song. This exciting possibility means that there may be "hidden" pieces or arrangements of music present which the user cannot access at will, but must continue listening to the album in the hopes of encountering. This ephemeral nature of BRONZE has the potential to be both very pleasing (removing complete control over every aspect of the song from the users' hands, as they have with digital music files, and offering inaccessible, self-controlled content instead) and infuriating (the inability to create or recapture any such "hidden" elements, or pleasing versions of the songs, may be anathema for some users). Gold has stated that the ability to save or record versions of a given track may be a future addition to the format.[189]

[189] Petridis, *Music Weekly* (podcast), 3 June 2011.

2.3.1 Biophilia

In 2011 well-known Icelandic musician, songwriter and artist Björk released the album *Biophilia*, and in keeping with her reputation for creating new and innovative musical works—'an artist who continues to push the boundaries of the pop song'[190]—*Biophilia* represents the exploration of a different paradigm to her previous static albums.

Released for iOS mobile platforms,[191] *Biophilia* is presented as an app within which ten songs are bundled. These songs can be individually accessed through a navigable main interface (which doubles as the album's first track, 'Cosmogony'), each song comprised of various versions and realizations of the music. Interactive media artist Scott Snibbe was commissioned by Björk to create the varied apps in consultation with her own desires for the work. Formerly working in animation, Snibbe was one of the first artists to create interactive art works for iOS, releasing his first three in May 2010. One of these, entitled *Bubble Harp*, was a music-based app closely related to the sound-toys discussed above: by drawing upon a blank screen, the user creates patterns of strings with varying lengths which are automatically played in a sequence with user-variable tempo. The strings, dependent on their length, relate to and trigger different notes of a scale (a number of which are available for the user to

[190] David Robson, 'Björk: I was always a bit of a nerd', *CultureLab* 21 September 2011 (http://www.newscientist.com/blogs/culturelab/2011/09/Björk-i-was-always-a-bit-of-a-nerd.html, 11 October 2013).
[191] A Kickstarter campaign which aimed to raise the funds to port *Biophilia* for Android or Windows systems was abandoned in February 2013, as the programmers felt it was too difficult a task to achieve with the resources available. *Björk: Biophilia App for Android and Windows 8 (Cancelled)* (http://www.kickstarter.com/projects/501402653/Björk-biophilia-app-for-android-and-windows-8, 11 October 2013).

select).[192] For *Biophilia*, Snibbe used the audio middleware system FMOD to sequence and control the musical content.[193]

The interface design and methods for interaction within *Biophilia* vary widely across the album. Each individual song has a main menu over which some section or fragment of the music will play in a looped or sustained manner: the options provided in each case are 'play', 'score', 'animation' and 'credits'.[194] The 'animation' option is the closest thing offered to traditional playback of any song. Much of the recorded material is heard in a fixed, linear style, and accompanied by a scrolling, sequencer-like visual representation of the music (vocal and instrumental parts layered atop each other, with pitch represented in the y axis and time in the x axis, not unlike a MIDI piano roll), while the lyrics are displayed along the bottom of the screen. In a number of the songs, however, the instrumentation contained within this 'animation' section is not that of the full song, but rather a stripped-back version missing some parts. 'Mutual Core', as just one example, with its up-tempo chorus and driving electronic rhythms, finds itself quite radically altered in the 'animation' section by the reduction of the chorus to only a lead vocal and slow glissandi from the backing vocals. The 'score' option similarly provides a scrolling visual to accompany the song, in this case a representation of the sheet music. The simultaneous playback of the song is not the recorded product, but rather a MIDI or simple synthesized rendering such as one might find within a score

[192] *Snibbe Studio: Bubble Harp* (http://www.snibbestudio.com/bubbleharp/, 11 October 2013).
[193] Scott Snibbe, email to the author, March 3 2016.
[194] The only song that varies from this template is the opening 'Cosmogony', which has no 'play' option, instead offering 'intro' and 'song' options. The former initiates a spoken introduction to the album by renowned documentary-maker and naturalist David Attenborough played over a visual demonstrating navigation through the master interface. Over a similar visual, the latter option plays through the recorded song—uniquely throughout the album, this is the only time the user is presented with a definitive playback of any song.

editor. Each of these options, 'animation' and 'score', also include a scroll bar at the bottom of the page which shows the current position in the track, allows play/pause functionality, and enables the user to scroll freely to any position within the song.

The 'play' option within the nine relevant songs offers unique interfaces and functionality in each case—yet the differences from song to song mean that the nature of this interactivity is never the same, each of the nine offering something individual to the user. Some are engaging and complex interfaces, while others are simpler in their approach. A number of the individual apps offer both 'instrument' and 'song' modes within this 'play' section, while others do not. Each app is worthy of detailed analysis, though for the purposes of this review I will focus on a selected few.

Three of the nine songs offer 'play' sections which are essentially simple sound-toys with differing functionalities. 'Sacrifice' and 'Moon' are constructed as a limited sample player and step sequencer respectively, while 'Hollow' plays organ music in different time signatures and at a variable tempo in response to the user queuing differently coloured 'enzyme' sound agents onscreen.

FIGURE 2.3—'Solstice' from Björk's *Biophilia* (screen capture by author).

'Solstice' presents the user with a more complex and variable sound-toy than any of the three mentioned so far. The interface of this song is made to resemble a central sun, with rays extending from it and planets orbiting it: each of the rays represents a different pitch, directly proportional to its length, taken from a hexatonic scale (c–d–e–g–a–b flat) and anywhere within the range of C2—d5; these pitches are triggered by the passing planets, and sound as plucked string samples. Each planet, meanwhile, can be set in orbit around the sun at any distance at either a slow, medium or fast speed, thereby increasing or decreasing the time taken for a complete revolution, and in turn the tempo at which it triggers the notes it passes. Rays and planets can be created in any of four different colours, and planets will only trigger the notes indicated by rays of the same colour as themselves, allowing for several sequences to be run

simultaneously; coloured buttons at the bottom of the screen also enable a given colour to be muted or unmuted, while the elements remain in place. There appear to be no limits, beyond that of space upon the screen, to the number of rays or planets of a given colour which can be created. Once sequences have been set, the view can be switched to a "tree" rather than a "solar" layout, within which the user cannot manipulate the elements of the interface (see FIGURE 2.3). Further controls allow different configurations to be saved and loaded, or the audio to be recorded; there is also an option for a 'song' to be played. This sets an automatic configuration in motion, over which Björk's vocals can be heard. The high level of variation possible in 'Solstice' results in a much more complex system and potential range of outputs than those previously mentioned, perhaps classifiable on the border between sound-toy and instrument.

The fifth song app, 'Dark Matter', contains both a simple instrumental interface and a 'song mode', which functions as a simple ear-training and memory game. While the simple ludic repetition is engaging, the musical experience can be frustrating, as the song is divided into very small segments with no flow or continuity in their playback.

The remaining four songs all offer, in one way or another, properly reactive interpretations of their musical material: two with direct interactive controls, and two with ludic elements that drive adaptive musical elements.

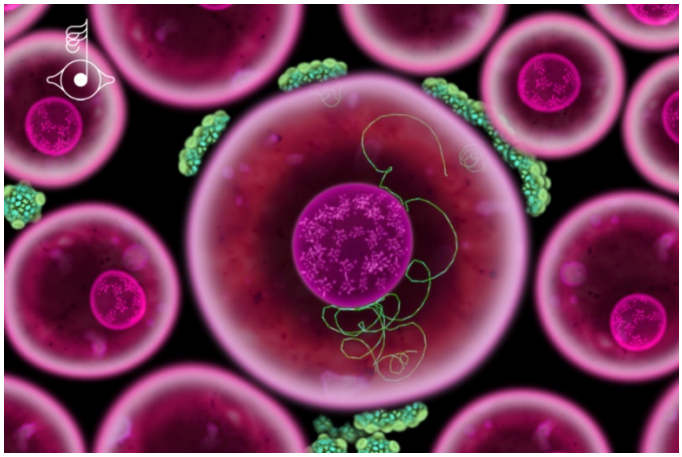

FIGURE 2.4—'Virus' from Björk's *Biophilia* (screen capture by author).

'Virus' is one of the latter, an app which takes the form of a simple game: the screen displays a number of cells, the largest of which occupies the centre. In 'instrument mode', the nucleus of each cell can be moved, activating a sample specific to that cell. Over time, a number of smaller virus cells also appear on screen, which can be dragged away from the central cell to which they are attempting to attach themselves, thereby triggering their more metallic gamelan samples. This 'instrument mode' simply creates a sort of large sound-toy, yet when the app is entered into 'song mode' it takes on rather different functionality. In that case, neither the large cells nor the virus cells trigger samples when the user interacts with them—instead, the recorded song begins to play, and over the basic instrumentation the higher-pitched metallic gamelan chimes associated with the virus cells play as the cells themselves appear on the screen and attack the largest cell. The density of these chimes is dictated by how many virus cells are present: the ludic element requires the user to remove these attacking cells by flicking them away, thereby protecting the large cell (see

FIGURE 2.4).[195] The progression of the song itself will be delayed while the cell remains healthy, yet, as the virus begins to successfully penetrate and destroy the cell, successive sections of the song will play.[196] This game of defending the cell from the attacking virus is in one way an exercise in futility; it is impossible to win, as the virus cells attack continuously, leading to the inevitable destruction of the large cell. Yet it is exactly this loss which allows the song to progress and reach its conclusion, in which the vocal and other instruments fade to nothing, leaving only the "viral" gamelan chimes. The goal therefore becomes an issue of how long the player can make the song last.[197] With such gameplay elements (density of attacking cells, progress of game) tied to musical elements (density of chimes, progression through song structure), the 'Virus' app constitutes an adaptive song in which user interaction with the game interface affects the nature of the music being played.

'Crystalline', in a similar fashion, offers the user a simple game interface. In this case, the user takes control of a floating crystal which progresses at a steady rate through a series of tunnels. By tilting the phone or tablet, this crystal can be directed towards the sides of the tunnels in order to collect other crystals of various colours. The object of the game is to collect specific sequences of coloured crystals that will unlock new tunnels at different points of the game. Progress through the game once again equates to progress through the 'Crystalline' song, which plays simultaneously. The tunnels of the game

[195] This element of programming was confirmed by the artist through personal correspondence. Scott Snibbe, e-mail to author, March 9, 2016.
[196] Björk and Scott Snibbe, 'Virus—App Tutorial' (http://biophiliaeducational.org/video/virus-app-tutorial/, 24 June 2014).
[197] This type of ultimately futile "survival" game is a common trope stretching back to arcade games such as *Tetris* (1984) or *Space Invaders* (1978).

represent different sections of the song, the order of which can be altered, extended and recombined by the player choosing to move along different routes. In this manner, the idea of a *branched* structure is given both a clear visual representation and a ludic element, allowing the user to re-structure the song as desired (within given limits). There is also an option to remove the interaction and simply play through the song with the tunnel visuals present.

The interface for 'Thunderbolt' resembles the sound-toys discussed previously, particularly Snibbe's *Bubble Harp*: by tapping upon a black screen with one finger, electrical sparks appear and fade out, triggering a short "spark" audio sample. Drawing with two fingers creates a lightning bolt which plays through the range of notes that it spans along the x-axis, at a tempo dictated by the y-axis position; the notes played change pitch, but remain in the form of an arpeggiated 7/4/3 chord (for example, a–c–d–g). Drawing with three or four fingers creates a shape from the lightning bolts, which triggers a three- or four-note arpeggio with notes dictated by the points of the shape. This functionality can be explored in 'instrument mode', but once the user enters 'song mode' the first interactive song available on *Biophilia* is accessed. The song plays through as recorded, with the exception of the idiosyncratic arpeggio line recognisable from its other versions—the instrument which plays this line is instead offered to the user to control as described, creating arpeggios of their own design at will throughout the song. The pitches of the notes alter in order to fit with the harmony of the song, while the tempo values are quantized to values relative to the beat of the song, thereby ensuring that nothing the user does will sound 'wrong'. One minor issue that arguably detracts from the work is the relative

volume of the user's arpeggio instrument, which sits too loudly in the foreground of the mix for an entirely pleasant musical experience.

The tenth and final song on the album is also the second to exhibit interactive functionality. 'Mutual Core' offers an 'instrument mode' in which the interface consists of two symmetrical images of blocks of earth, thirteen differently coloured layers deep on each side. These two blocks can be dragged together by the user to initiate an organ sound, sustaining a chord the notes of which can be changed by pressing or sliding across the different coloured layers of earth (offering a rough keyboard-style interface). Just as with 'Thunderbolt', the 'song mode' here allows the user to play this interface as an instrument while the song plays back. In this case, however, the original part for the instrument is still included, and its playing is visualized by the shifting of colours on the user interface. 'Mutual Core' features a chorus that provides quite a contrast to the slow, quiet verses, breaking into a loud dynamic with driving electronic percussion; this chorus also features a different interface, unique amongst the apps reviewed here, in which a series of hollow hemispheres rotate around each other (blue, brown, orange and yellow in colour) to reveal a red core. Functioning as a game rather than sound-toy, the user is able to alter the rotation of the hemispheres in order to access the core. Once the core has been uncovered, the game finishes and the song resets, bringing the organ interface back and playing from the first verse again. By leaving the core alone, the song will progress as written. Unlike 'Virus', where inevitable defeat led to completion of the song, in this case the successful completion of the ludic aim causes the song to reset and feels almost like a failure of some kind, as it

disrupts the musical flow and seems counter-intuitive. Nonetheless, 'Mutual Core' is a liquid composition, featuring both interactive and adaptive elements.

Throughout *Biophilia* Björk's over-arching themes of cosmology, biology, and science are linked quite deliberately, through the songs and their methods of interaction, with a number of aspects of musical theory, technology and composition. There is a deliberate simplicity to the design, wherein one aspect of science is tied to one aspect of music: 'each of the ten songs within the *Biophilia* app reveals a different musicology [*sic*] theme and a corresponding natural element, which you can explore'.[198] The educational potential of the apps in *Biophilia* and other related projects is a priority for Björk, readily apparent by the launch of the Biophilia Educational Program which offers a freely accessible curriculum for teachers and parents to use in conjunction with the apps to teach children about science and music. [199]

The ten songs of the album are never presented in a regular, unified manner. Each exists in numerous forms through the various sections of their apps: stripped-back in some fashion for the 'animation' section: looping or presenting different sections in the background of the app's menu; as a MIDI-type file alongside the score; or in any number of forms within the different 'play' functionalities. This speaks well of the unfocused, liquid nature of the music in *Biophilia*. Simultaneously, however, the simplicity of the interactive interfaces helps to preserve the nature of the songs as the artist has composed them, by limiting the user's control. It is highly significant that the album was

[198] As written on the Kickstarter page; the elements are not related to musicology at all, but rather, as I have said, to basic aspects of music technology, theory and composition. 'Björk: Biophilia App for Android and Windows 8 (Cancelled)'.
[199] *Ibid*.

released in physical form, on CD, as well as being made available for download in traditional formats. There does exist, therefore, a single "definitive" version of the album, from which any form of interaction can only detract. While the listener may enjoy altering aspects of the music when the control is offered to them, never varying from an experience which is compositionally and musically valid, any step they take is nonetheless a step away from the "true" form of the album as conceived by the artist. This arguably marginalizes the artistic merit of the liquid elements within *Biophilia*, indicating to the user that nothing which they do is as "correct" as the static version.

2.4 Liquid Music in Video Games

As highlighted earlier in the chapter, a large number of works that utilize procedural audio programming can be classified as *games*. Naturally, many of these are found in the form of video games, and exhibit some form of meaningful and interesting interaction with musical elements. In a review of existing liquid music, this inherently interactive medium is worthy of particular attention. Different game elements—states, triggers, or continually changing parameters—can be used to alter, affect and drive musical content in a host of different and often innovative reactive manners. Detailed analysis of these compositional approaches will follow in the next chapter, but this section provides an overview of the field.

The current section begins by examining the loose genre of *music games*, or games in which music is a primary focus. Methods of interaction can be used as a classifying factor to highlight some frequently taken approaches to creating

such a musical focus within a game setting. Following this, the use of licensed popular music in video games will be discussed, to determine if and how popular music has been programmed with procedural behaviours in an interactive multimedia setting.

2.4.1 Music Games

Throughout the literature on game audio a number of titles reappear frequently due to their innovative or well-made musical interactions. These, along with other notable examples, chosen for their influence in the field, their widespread appearance in the game audio literature, and for their diversity, form the basis of a concise review. Partial reviews can be found in Pichlmair and Kayali,[200] Liebe,[201] and others. Further to this, every researcher will offer different examples of games fulfilling different functions or espousing different properties. Numerous further examples for each category could, of course, be given.[202]

Games which use music or sound as their focus have variously been termed *music games* and *audio games*: Pichlmair and Kayali offer the term 'music game', for which they define three categories: rhythm games, games as instruments, and musical puzzles within other game contexts.[203] The first two of these constitute games clearly designed with musical interaction as their

[200] Pichlmair and Kayali, 'Levels of Sound'.
[201] Liebe, 'Interactivity and Music in Computer Games', in *Music and Game: Perspectives on a Popular Alliance*, Peter Moormann (ed.) (Wiesbaden: Springer VS, 2013), 41–62.
[202] Discussions of 'canon' within video game music and the field of research relating to it have arisen in recent years; this is not a topic with which I seek to engage here. The games referenced within this section are chosen purely for (i) prevalence within the literature, and (ii) espousal of the ideas under discussion.
[203] Pichlmair and Kayali, 'Levels of Sound'.

primary focus, while the third can be placed to one side as an interesting sub-set of musical interactions occupying a secondary role within other game genres (for example, the long-running use of instruments in the *Legend of Zelda* series, or the piano melody used in *Final Fantasy VII* to discover Tifa's ultimate weapon). Without offering a concrete definition of the term 'music games', Pichlmair and Kayali nonetheless derive a set of features which music games may possess (though none seem to possess all features): these include the use of quantisation; synaesthetic qualities; the ability for play to take on a performative quality; the ability for free-form play (in the manner of a sound-toy rather than a game, as defined here in Chapter Two); and the presence of in-game sound-producing visual agents. Rovithis, meanwhile, offers the term 'audio-based games', and defines it as video games of any genre or platform which, in comparison to other genres, emphasise a 'much more important role of sound in many or all aspects of the gameplay'.[204] He further differentiates between 'music video games' and 'audio games', stating that the former 'use certain properties of sound to enhance gameplay and/or affect sonic outcome', while the latter 'feature complete auditory interfaces and mechanics, so they can be accessed and played without any use of graphics'.[205] This description ties into the concept that 'audio games' are usually developed for blind or partially sighted users, and is congruent with Cordeiro *et al*'s discussion of 'audiogames', or games which rely primarily, or entirely, on aural rather than visual feedback to guide the player's interaction: 'There are… [video games] … that put the focus on the sound dimension, mainly by exploring music as the driving force for the

[204] Rovithis, 'A Classification of Audio-Based Games', 160.
[205] *Ibid.*, 162.

game experience'.[206] Again, these are cited as games traditionally geared towards blind or visually impaired users, though evidence can be offered to support the claim that such games are appealing to fully sighted users too, for whom there may still be a challenging dimension to the gameplay and who may appreciate new interfaces and new forms of interaction in games.[207] The term 'music game' is also used by Liebe, who believes it to be a 'very specific and yet very diverse genre'.[208] He defines the term essentially as 'games in which music is a main factor of the way the game is experienced or played'.[209]

The latter definition of 'music games' by Liebe is a good starting point to work from, yet as used within that author's work it remains somewhat broad for the purposes of this chapter. While Rovithis' description of 'music video games' is also slightly too broad to be of use within this thesis, the latter researcher's definition of 'audio-based games' is one that could be applied more widely than he intended, and be worked into a definition for *music game*. For the purposes of this thesis, therefore, I would like to define a *music game* as one in which music (rather than non-musical sound), plays the primary role in guiding the interaction with the player. *Music games*, therefore, represent a subset of *audio games*, a broader term covering any game in which audio (musical or otherwise) plays the primary role in guiding the interaction with the player. These games will most often include a visual element, though any games using predominantly or exclusively audio as a means of interaction (for which I will use the term

[206] Joao Cordeiro, Andre Baltazar and Alvaro Barbosa, 'Murky Shooting: The Use of Auditory (Non-Speech) Feedback on Mobile Audiogames', *Audio Mostly Conference 2012* (September 2012): 40–43 (40).
[207] *Ibid.*, 41.
[208] Liebe, 'Interactivity and Music in Computer Games', 41.
[209] *Ibid.*, 42.

audio-based games, or *ABGs*) would also be included under the broader headings of audio games, or potentially music games.

The question of genre in video games is an important one, especially given the attention paid to it by the wider gaming community. Detailed work has been undertaken in the broader field of game studies to deal with questions of genre, notably by researchers such as Wolf (2002) and Apperley (2009).[210] A discussion of game genre with specific focus on musicological approaches to game music has been undertaken by Summers (2012), dealing with musical aesthetics, form and function within pre-existing (if fluid) game genres.[211] Summers' stance that there are two genres for a given game, one based on the narrative setting and one on the form of interactivity or ludic style,[212] can be compared with Wolf's discussion of 'iconography versus interactivity' as the 'central determinant in describing and classifying video games'.[213] However, such topics will not be engaged with in any depth here, as re-classifying or altering any of the existing approaches to genre in video game studies falls outside of the current discussion. Nevertheless, I will set out a number of categories into which 'music games' might be organised—these are based, similarly to Wolf's categories in his chapter on 'Genre and the Video Game',[214] on the nature of the interaction in question rather than the narrative or stylistic setting (the 'iconography').

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[210] Mark J. P. Wolf (ed.), *The Medium of the Video Game* (University of Texas Press: 2002); and Thomas H. Apperley, 'Genre Studies', in Bernard Perron and Mark J. P. Wolf (eds.), *The Video Game Theory Reader 2* (New York and Abingdon: Routledge, 2009), 353–354.
[211] Timothy Summers, 'Video Game Music: History, Form and Genre' (PhD thesis, University of Bristol, August 2012).
[212] *Ibid.*, 15.
[213] Wolf, *The Medium of the Video Game*, 114.
[214] *Ibid.*, 114.

Pichlmair and Kayali's three categories of 'music games' are a succinct yet accurate delineation of the genre (and are praised elsewhere by Liebe); I draw on these as a starting point for the categories outlined here.[215] Rovithis, in his 'Classification of Audio-Based Games', sets out eleven separate categories covering every kind of audio interaction found in video games:[216] though some are redundant, and others can be conflated, these are also a valuable point of reference. Liebe, being more concerned with forms of interaction with music in the broader video game field, makes mention in passing of 'rhythm-action games' and 'music-generating games'; his own delineation of music games is, however, between those that constitute 'computer performance' and those that allow for 'player performance'. The former relates to games in which sounds are produced by the actions of the player's avatar 'provoking musical sounds and hearing the […] results of the actions',[217] for example, in *Otocky* or *Loom*: while the latter relates to games which encourage the player to interact in a more physical manner than simply pressing buttons on a controller—*Dance Dance Revolution* or *Rock Band*, for example. These categories are of less use for the approach taken here to classifying music games by forms of interaction.

The widest category for music games to fall into is that of *rhythm-action* (this is comparable to Pichlmair and Kayali's 'rhythm games' and Rovithis' 'music synchronization'). The basic principle for interaction in a rhythm-action game is that the player must provide input (be it by pressing buttons, tapping screens, or via any other method) in time to cues provided by the game, usually as a series of visual symbols displayed or scrolled across the screen. The aim for

[215] Liebe, 'Interactivity and Music in Computer Games', 50.
[216] Rovithis, 'A Classification of Audio-Based Games', 161–162.
[217] Liebe, 'Interactivity and Music in Computer Games', 54.

the player is always to synchronize the rhythm of their input with the music, sound and/or visual cues presented by the game. One excellent example of a rhythm-action game would be the Nintendo DS title *Elite Beat Agents* (2006) (released as an updated version of the Japanese title *Osu! Tatakae! Ouendan* (2005)). In this game, a series of levels are available, each focused on a popular music hit (though the versions included within the game are cover versions)[218] and requiring the player (nominally taking the role of the eponymous Agents) to provide input in time to the music. This input is made by using a stylus controller upon the DS's touch-screen interface, and may take one of three forms: tapping points on the screen, drawing lines across the screen, or drawing circles on the screen. The input required is made apparent by the visual cues which appear onscreen during the level.

A wide variety of narrative structures and ludic purposes have been overlaid on this fairly simple premise for interaction, covering games from a host of traditional genres. Further examples which might be discussed would include *Vib Ribbon*; *Frequency* and its sequel *Amplitude*; the *Guitar Hero* and *Dance Dance Revolution* series; *Rhythm Tengoku, Patapon* and a proliferation of recent mobile games such as *Beat Sneak Bandit*.

The second category for music games correlates to Rovithis' 'generative music' category or Pichlmair and Kayali's term 'electronic instrument games', and can also be linked with the idea of Active Score Music (discussed earlier in this chapter). Within the category of *adaptive music games*, though, one should

[218] *Elite Beat Agents* (http://www.nintendo.co.uk/Games/Nintendo-DS/Elite-Beat-Agents-270660.html, 14 April 2014); note the phrase 'made popular by,' indicating that game versions are specially recorded cover versions.

be careful to exclude any form of musical instrument or sound-toy which cannot be classified as a game (for example, the Tenori-On). An adaptive music game is one in which the creation or realization of a musical soundscape, based on procedural principles within the game's programming, is a key part of the game's interaction. Parks (2012) refers to these games as 'Art Games',[219] and it is true that many such games may resemble contemporary music works, or sound-toys; yet there are numerous works which can clearly be defined as games within this field.

The most commonly referenced game in this category is certainly Nintendo's *Electroplankton* (2005), released for Nintendo DS. Though the game can be played in 'Audience Mode', rendering it more akin to a sound-toy in functionality, most of the levels also offer ludic goals when played in 'Performance Mode'. Each level displays a different environment, populated by a different from of 'plankton'. The movement, arrangement and behaviour of these creatures within their environment creates a musical work based on adaptive principles, with the musical features and timings being controlled and triggered by the behaviour of the game objects. In the 'Hanenbow' level, for example, the user launches 'plankton' towards a plant with several leaves, against which the creatures will bounce and ricochet when struck (see FIGURE 2.5). The user can manipulate the angle at which the 'plankton' are launched towards the tree, the rate of fire, and the angle of rotation for each leaf independently. As the leaves are struck, they change colour from green, through

[219] Eric Parks, 'Here There be Dragons: the Uncharted Areas and Opportunities in Modern Games', *Presentation at the AIT Gaming Forum 2012* (www.ait.gr/ait_web_site/conference/gaming/presentations.jsp, 8 April 2014), quoted in Rovithis, 'A Classification of Audio-Based Games', 162.

orange, to red; the ludic aim for the level is to turn all of the leaves red, thereby producing a flower atop the plant. The music is created by 'plankton' striking the leaves and bouncing against them—each leaf produces a metallic tone (similar to a struck bar, like a glockenspiel) when hit, the pitch of these tones rising as the colour changes. In this fashion an adaptive musical score is created and driven by the player's interaction with the game, which is simultaneously an attempt to "complete" the game and its ludic goals.

FIGURE 2.5—'Hanenbow' level, *Electroplankton* (Nintendo, 2005; screenshot from DeoGenZ Gaming, 'Let's Play Electroplankton – Hanenbow, https://www.youtube.com/watch?v=v4SxF4pV91E)

Sound Shapes (2012) can be examined as another type of adaptive music game, incorporating elements of Active Score Music and what Pichlmair and Kayali have called 'sound agents'.[220] Levels within this game are formed from individual screens in a side-scrolling fashion derived from the "platform" game genre; screens can also be created and edited by the player, offering insight into how the game and its music are programmed. A variety of game elements

[220] Sound agents are 'visual elements primarily existing for affecting, emitting, or accompanying sound': Pichlmair and Kayali, 'Levels of Sound', 428.

appearing in each level will emit specific musical or instrumental parts, their ludic functionality often in some way tied to or reflecting their musical attachment. For example, a vocal note held for a certain number of beats will come from a cloud-like platform. When the vocal rests for a few beats, this platform will disappear. The music of each level is therefore constructed from these parts, which simultaneously create the environment through which the player must navigate. The programming frequently combines cumulative musical forms with increasing ludic difficult as a given level progresses, in a fashion both innovative and rewarding. Toshio Iwai's *SimTunes*, though it can be properly classed as a sound-toy (see above), was released as a video game and could be included here as an adaptive music game, with a number of similarities to *Electroplankton*, *Sound Shapes* and other titles.

Other adaptive music games may operate in a different fashion, yet will all ultimately create a reactive soundtrack driven by the player's interaction with the game, while containing ludic goals. Another common approach is to build musical content as the player progresses through a level, reflecting the emotional as well as the ludic experience. This approach can be seen in the highly acclaimed *flOw* (2006) and *Flower* (2009) for Playstation devices. Games such as *Otocky* (1987), *Moondust* (1982) and *BeatBuddy: Tale of the Guardians* (2013) are also prominent adaptive music game titles.

A further subset of adaptive music games is that which can be described as *synaesthetic* in design, aiming to incorporate elements of sight, sound and touch into a gameplay model; *Moondust* being an early example of such an idea. These games may display similarities to rhythm-action games, in that input can

be synchronized to a beat, and may aid gameplay if done correctly, though this synchronization is not the main focus of interaction. They can be categorized as adaptive music games, as the player's actions may contribute to or alter musical elements as part of a developing soundtrack. An example of a synaesthetic game which is often quoted in the literature is *Rez* (2001). *Rez* occupies the game genre known as "rail-shooter", in which the player's movement through a level is set at a fixed speed along a fixed path. The player can look around from this "rail" and must shoot at targets. The soundtrack for the game is comprised of music in an electronic dance style, to which player actions are synchronized automatically so as to match the beat. Actions within the game (locking on, firing, and destroying targets) trigger musical sounds which add to the overall soundscape. A follow-up game entitled *Child of Eden* (2011) exhibits many of the same characteristics, and is compatible with gestural controllers such as Microsoft's Kinect, enabling a different method of user interaction to produce synaesthetic results.

Finally, games which include innovative procedural music soundtracks are also worthy of mention, especially *Spore* (2008); this game does not fit the definition of a *music game*, but is nonetheless noteworthy for the manner in which the music (programmed largely with Pure Data) is driven by and responds to the player's actions.

Pichlmair and Kayali's third category for 'music games' is included here as *musical puzzle games*, although as they clarify, game elements which can be viewed as musical puzzles—in other words, puzzles which make use of musical elements as their primary focus—are most often found as sub-sections of wider

games, and cannot be classed 'music games' in their own right. There are, however, a number of puzzle games which use music as a primary focus, especially a number of recent games created for mobile formats.

Loom (1990) from LucasArts (released before the development of the iMuse engine) provides one example of a *musical puzzle game*. Within the game, the player interacts with the gameworld by reproducing simple four-note melodies, or 'finding and remembering sound patterns and playing them',[221] each of which performs a different function (such as 'open', 'terror' and many others). The player can invoke further abilities by reversing certain melodies: playing the 'open' melody (e-c-e-d) backwards (to make d-e-c-e) invokes the effect 'close'. Other melodies are palindromic, and as such cannot be reversed. All puzzles in the game centre on the use of these musical fragments to affect the game world, avoiding the more familiar fantasy video game tropes such as weapons or an inventory of items.[222]

Positional audio games are a category of audio games which rely on aural feedback and cues to help the player locate and negotiate their way through the gameworld. Though I am not currently aware of any games which use music, rather than other audio, as the primary element in their interaction, music will often still play a part in such games.

One example of a positional audio game would be *Papa Sangre* (2010), released for iOS devices. This game presents the player with a visual interface of

[221] *Loom: A Computer Game Masterpiece From LucasArts* (http://www.salikon.dk/loom.html, 8 April 2014).
[222] An interesting side-note reflecting the musical focus of *Loom* is that the game's background music is derived almost entirely from Tchaikovsky's *Swan Lake* ballet, tying in strongly with the narrative of the game and its focus on swan imagery.

a compass, indicating the direction currently being faced and enabling them to turn, as well as two buttons used to walk forwards. The remainder of the game is presented aurally, with the player required to navigate levels and locate musical notes while avoiding monsters (all clearly audible as different sounds). *Papa Sangre* makes use of 'Head Related Transfer Functions' (HRTF) and binaural audio programming in order to create as realistic a listening environment as possible.[223] Other games in this category would include titles such as Nintendo's *bit Generations: SoundVoyager* (2006).

2.4.2 Popular Music in Video Games

The symbiotic relationship that has grown over the last two decades between popular music and video games is worthy of study for the potential approaches to implementing liquid music that may be found therein. Two chapters dedicated to popular music and games appear in *From Pac-Man to Pop Music* (2008). Tessler, in 'The New MTV? Electronic Arts and "Playing" Music', provides an excellent overview of the symbiotic relationship which has developed between the two industries; she feels that it has become a 'debatable question whether video games are reliant on popular music, or whether popular music is reliant on video games' with regards to promotion and generating income.[224] The music industry now sees video game soundtracks as a viable means of both promoting and selling their music; while in turn, the games

[223] Andrew Hugill, 'Towards an Analysis of *Papa Sangre*, an audio-only game for the iPhone/iPad', *The Online Repository for Electroacoustic Music Analysis,* January 2012 (http://www.orema.dmu.ac.uk/?q=content/andrew-hugills-papa-sangre-analysis, 26 May 2014).
[224] Holly Tessler, 'The New MTV? Electronic Arts and "Playing" Music' in *From Pac-Man to Pop Music*, Karen Collins (ed.) (Aldershot: Ashgate, 2008), 13–26 (16).

industry continues to see popular music licensing as a marketing tool for encouraging sales. Tessler focuses specifically on the business activity of Electronic Arts (EA), a major game developer particularly well-known for sports games, and provides an excellent perspective on the economics of the crossover between industries. In the following chapter, Kärjä presents a case-study of Poets of the Fall, a Finnish band who shot to prominence on the back of a tie-in with the video game *Max Payne 2* (2003). He then proceeds to examine issues of synergy, authorship, production and copyright with regards to popular musicians involved with video game scores.[225]

Collins addresses the issue of intellectual property and game audio in 'Grand Theft Audio? Video Games and Licensed IP', discussing a variety of ways in which games can make use of popular music.[226] Artists appearing in video games which contain their music, artists writing for video games, and the licensing of pre-existing popular music for use in-game are all addressed in detail, with a shared focus between issues of copyright and business, and how popular music has been featured and implemented in games. Strötgen touches on some similar issues in his chapter 'P(l)aying Music and Games',[227] which focuses the financial and business details of relations between the two industries. Further examination of the business of video game music has been undertaken elsewhere, yet this section focuses on the methods of interaction or procedural programming that have been implemented with licensed music in

[225] Antti-Ville Kärjä, 'Marketing Music Through Computer Games: the Case of Poets of the Fall and *Max Payne 2*' in *From Pac-Man to Pop Music*, Karen Collins (ed.) (Aldershot: Ashgate, 2008), 27–44.
[226] Karen Collins, 'Grand Theft Audio? Video Games and Licensed IP', *Music and the Moving Image* 1/1 (University of Illinois Press, Spring 2008): 35–48.
[227] Strötgen, 'P(l)aying Music and Games' in *Music and Game: Perspectives on a Popular Alliance*, Peter Moormann (ed.) (Wiesbaden: Springer VS, 2013), 191–214.

video games. For musicians working outside of the games industry, 'the use of well-known music in games raises many questions in terms of music's production and consumption';[228] it seems likely that the crossover between licensed popular music and procedural audio programming could provide a viable source of liquid music formats and approaches for a separate medium, distinct from multimedia or video games.

Collins identifies three reasons for game developers to include licensed music in their products: 'to appeal to specific markets, to reduce production costs and to open up new uses for music in games'.[229] Associations between video game music and licensed music can be broadly divided into games that are *focused* on, or make a feature of, licensed music, and more broadly, games that *include* licensed music. Collins offers an analysis of the former category in her article 'Grand Theft Audio? Video Games and Licensed IP',[230] classifying those games in which 'music is the primary driving motive or narrative element' under three headings: 'musician-themed games, creative games, and rhythm-action games'.[231]

A considerable number of games centred around a specific band or artists have been released, often with the purpose of functioning as a promotional tool for the musician(s) in question. This use of secondary media may create a greater awareness of their music and image, not dissimilar in function to the music video. Examples of such games are the 1982 title *Journey Escape*, released for Atari VCS and as an arcade game, cited by Collins as the first

[228] Collins, *Game Sound: An Introduction to the History, Theory and Practice of Video Game Music and Sound Design* (Cambridge: MIT Press, 2008), 117.
[229] Collins, *From Pac-Man to Pop Music* (Aldershot: Ashgate, 2006), 6.
[230] Collins, 'Grand Theft Audio?', 4–14.
[231] *Ibid.*, 5.

appearance of a band in a game;[232] or *Michael Jackson's Moonwalker* (1990), the motivation for which was to promote the artist rather than any particular musical release, as part of a continuous promotional campaign.[233] Popular music may also appears in instances where popular artists have been hired to write music for a game: one such example would be David Bowie's soundtrack for *Omikron: the Nomad Soul* (1999), a set of songs and short instrumental pieces that were later re-arranged and released as a stand-alone album entitled *Hours…*.[234] While Bowie's songs were used diegetically within the game, Xavier Despas was credited with the main sound design for the game, including ambiences, sound effects, ambient music and 'additional tracks'.[235] It seems fair to suggest that the vast majority of 'musician-themed games' do not add anything to the advancement of liquid music within the field of video games, nor do they attempt to bring significant procedural programming to bear on pre-existing music.

Many games that come under the heading of 'rhythm-action' games, as discussed above, make use of licensed popular music, though this is not exclusively the case. Nintendo's *Donkey Konga* (2004) uses a combination of licensed music with classic and original music from Nintendo games; while *PaRappa the Rapper* (1997) asked the player to strike button combinations in order to "rap" along to entirely original music. Foremost among rhythm-action games which *do* use licensed music are titles such as the *Rock Band* and *Guitar*

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[232] *Ibid.*, 5.
[233] *Ibid.*, 5.
[234] Matthew Belinkie, 'Video Game Music: Not Just Kid Stuff,' 1999 (http://www.vgmusic.com/vgpaper.shtml, 4 December 2011).
[235] *Omikron: The Nomad Soul: Credits* (http://www.allgame.com/game.php?id=11894&tab=credits, 29 October 2012).

Hero series, the first instalment of the latter released in 2005 to enormous popularity; for analysis here, I will take *Guitar Hero III* (2007) as a representative example. This game features an assortment of songs which fall within the broader genre of "rock", and which feature prominent guitar parts. The rhythmic element of the gameplay in *Guitar Hero III* is put into practice by holding down one or more of the coloured "frets" on the plastic guitar-shaped controller purchased alongside the game, then "strumming" it with the other hand: the player simulates the motions of playing the guitar, though in fact they are aiming to strike the right combinations of buttons in time to the requested and "correct" patterns which are presented scrolling along the screen. Successful completion of these combinations results in the smooth, continuous playback of the selected song; failure to correctly strike the buttons results in drop-out of the correct guitar part(s) from the song, replaced with a discordant noise—similar to an electric guitar mis-fretting or creating other "non-musical" sounds. These noises are not smoothly sequenced, but instead leap out of the audio mix to noticeably drown out other instruments which may be playing at the same time; they are not supposed to be realistic incorporations to, or alternate "versions" of, the song's original guitar track, but "error" messages with regards to the gameplay. Their primary function is of a ludic nature, signalling to the player that s/he has not successfully input the correct button combinations.

Such rendering of licensed songs into interactive iterations, with separately functioning instrumental parts, is accomplished by the use of

multitrack stems or *splits*.[236] Any game designers who seek to use popular music in games must obtain the licenses for use of the songs in their standard stereo release format. For *Guitar Hero*, the designers also obtain multi-track versions of the songs from the artists or labels in question, from which they are able to re-program songs within the game. The guitar tracks are isolated, and often, in a given song, grouped or arranged into easier or more difficult single-line parts (for example, playing a song on an easy difficulty setting may require the player to follow a sequence of chord changes in the style of a rhythm guitar track, while a more advanced difficulty setting will incorporate lead guitar melodies or riffs into the player's part). The remaining tracks of the song are then mixed into the game, and the guitar track sequenced to play alongside them *only* while they player is successfully striking the required combinations of buttons.

One further rhythm-action game worthy of mention here is *Amplitude* (2003) (and its similarly styled prequel, *Frequency* (2001)), in which the player controls a spaceship-like vehicle as it flies along a path divided into tracks or lanes. Each track corresponds to an element of the music (drums, vocals and so forth); the player is required to strike combinations of notes in a rhythmic sequence by firing at targets from their vehicle, thereby driving the audible playback of each element of the music and "completing" the song on which the level is based. *Amplitude* also features a 'remix' mode, allowing the player to re-order sections of a given song, add effects, change the tempo and so forth:[237] the functionality of this mode, however, no longer falls into the category of *rhythm-*

[236] Collins, *Game Sound*, 119.
[237] Collins, 'Grand Theft Audio?', 7.

action, or even *game*, but instead reflects that of 'music-making software titles' as discussed by Arrasvuori (2006).[238]

Similarities can be drawn between *Amplitude* and *Guitar Hero* regarding the method of input, the visual interface, the goal of successfully "playing through" a song and so on. Most importantly, both games make use of multitrack stems to add an interactive element to the licensed music in use. *Guitar Hero* removes the correct guitar parts from the audio mix when the player is unsuccessfully entering combinations, while *Amplitude* requires the player to "build" the song in cumulative fashion from its constituent tracks and keep them all playing. Though this addition and subtraction of pre-recorded layers (an example of the vertical approach to procedural composition) is a fairly simple method of interaction, both of these titles are nonetheless successfully merging popular music with interactive game music.

The third grouping of games focused on licensed music is 'creative games'. A number of titles have been released for console formats such as Playstation or Xbox which cannot be termed *games* in the functional sense, but instead represent a class of 'music-making software titles', of which further detailed discussion is made by Arrasvuori.[239] These titles, which can be classed as 'creative games', could be considered limited or simplified versions of professional music production software tools, though 'because of the limited set of features and their poor technical quality, it seems that the target audience …

[238] Arrasvuori, Juha, *Playing and Making Music: Exploring the Similarities between Video Games and Music-Making Software* (University of Tampere, 2006), 16.
[239] *Ibid.*

is video game players rather than amateur or professional musicians'.[240] Designed around paradigms of popular music production, some of these titles also include licensed music: *MTV Music Generator 2* (2001) included material by recognized artists (such as Gorillaz) as a basis for remixing or as examples for the player.[241] Despite this re-arrangement of existing popular music in a sample-based fashion, these titles offer no possibility for adaptive or interactive audio creation. They focus instead on re-creating the process of linear musical composition and arrangement. As such, they add nothing to the field of popular music implemented interactively within video games, or to liquid music outside the field of video games. Under the same heading can be included karaoke games, which also license popular music titles. *SingStar* (2007) is one popular example of such a game. Whilst earlier games relied on the acquisition of multitrack stems, vocal removal technology has recently been improved to such a stage where the developers can simply license stereo releases and sufficiently process the songs as karaoke versions.[242] Unlike *Guitar Hero* or *Amplitude*, unsuccessful adherence to the correct melody does not result in a drop-out of musical parts, or the addition of noisy "error" sounds, because rather than controlling playback of a recorded track, the players are performing themselves. This category adds no greater liquid potential to licensed music than the original karaoke format does: recorded tracks remain fixed and linear, offering only a performative form of interactivity with popular music, unvaried by its presentation in a video game format.

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[240] *Ibid.*, 20.
[241] *MTV Music Generator 2* (http://ie.ign.com/games/mtv-music-generator-2/ps2-15359, 9 July 2014).
[242] Dan Barry from the Dublin Institute of Technology developed the ADRes vocal suppression system now used for *SingStar*. *Heard About: SingStar PS3* (http://www.develop-online.net/features/164/Heard-About-SingStar-PS3, 2 November 2012).

A large number of other games including licensed music can be found, both *simulation games* (games with a "real-world" setting) and *ludic fiction games* (games with a "fictional" setting). The former category relates to games set in a simulacrum of the real world, including the bulk of genres such as sports games, driving games and so on. Rauscher points out that genres such as sports games will follow the aesthetic established in real sports, where they are accompanied by popular music. Meanwhile, 'game genres presenting ludic fictions'—RPGs, action/adventure and so on—have different ideas of realism, and often employ more cinematic scores.[243] Collins addresses the widespread use of licensed music in sports and racing games, noting that aside from the often linear nature of such games lending themselves well to linear licensed music, 'there is a well-established association' between the two in the real world: 'the use of popular songs in sports-themed games seems fairly "natural", then, in that it is a re-creation of these events'.[244] The function of licensed or popular music within the majority of sports, driving or other simulation video games genres is primarily a reinforcement of this "real-world" setting.[245] The music chosen for inclusion in these games usually has little or no relation to the gameplay. In a very broad sense, the game developers might select music of a certain style or styles (perhaps music of a perceived positive mood or high tempo) to encourage the player to be more engaged with the driving or sporting element of the gameplay. Yet this constitutes very minimal relations, and the

[243] Andreas Rauscher, 'Scoring Play—Soundtracks and Video Game Genres' Music' in *Music and Game: Perspectives on a Popular Alliance*, Peter Moormann (ed.) (Wiesbaden: Springer VS, 2013), 93–106 (97).
[244] Collins, *Game Sound*, 129.
[245] Game composer Garry Schyman notes: 'Licensed music makes sense […] In sports games and racing games it's an obvious choice.' Quoted in Rob Bridgett, *From the Shadows of Film Sound* (2010), 23.

substitution of any licensed music which meets the same basic criteria would produce the same effect, probably going unnoticed by the player and not affecting their gaming experience in any real manner.[246]

Beyond these games with strictly "real-world" settings, there are a number of other simulation games that include noteworthy use of licensed music. *The Sims* series (2000-present) includes songs by popular artists, many of whom re-recorded the vocal tracks for their songs in the fictional 'Simlish' language of the game's characters.[247] These songs appear diegetically within the game, being produced by visible sound sources inside the game-world, and proved an added selling point for the game: the juxtaposition of familiar artists and songs with the unfamiliar language provided cross-media interest, and enhanced the "simulated reality" setting of the game. Once again, however, it can be seen that advertising and promotion of the game, as well as creating an appropriate gameworld and setting for the gameplay, were the two main reasons for inclusion of licensed music within *The Sims*; reasons that are equally applicable in varying degrees to almost any game which makes use of licensed music.

Ludic fiction games may also feature licensed music, and include games from almost any genre including RPGs, survival horror, platform or the broad heading of action/adventure.[248] The *Grand Theft Auto (GTA)* series (1997–present) presents an unusual use of licensed music, again in a primarily diegetic

[246] This effect is noted by George Lucas in relation to film soundtracks: quoted in William Gibbons, 'Wrap Your Troubles in Your Dreams: Popular Music, Narrative, and Dystopia in *Bioshock*', *Game Studies* 11/3 (Dec 2011) (gamestudies.org/1103/articles/gibbons, 12 November 2012).
[247] Tessler, 'The New MTV?', 16.
[248] The term 'ludic fiction' is taken from Rauscher, 'Scoring Play'.

fashion. In the more recent editions of the video game series, starting with *GTA III* (2001), licensed music tracks are included on in-game radio stations, audible through the cars stolen by the player during gameplay. In the first two instalments of the series these radio stations played snippets of original songs, adverts and radio DJ dialogue written specifically as both a satire on modern radio and to reflect the lawless nature of the game's fictional urban setting. *GTA III* still showcased some such material, but also included licensed music accessible through the player's ability to "tune-in" any of the nine radio stations (eight music and one talk) available in the game at any time.[249] Whenever the player would take control of a car, the radio was there as an optional, interactive soundtrack to the game.

Later instalments of the series considerably increased the number of licensed tracks available in-game (*GTA: San Andreas* contains well over a hundred),[250] and continued to provide specialist in-game radio stations which play track-lists of a given genre of music. Simultaneously, the games have developed more specificity in their location and setting. *GTA: San Andreas* (2004) is set across a number of fictional cities which bear deliberate and striking resemblances to real cities (the starting location of 'Los Santos' is recognisable as a version of Los Angeles), while the narrative takes place during the year 1992:[251] the music licensed for use by the developers is relevant to the western US and dates from no later than that year, intended to situate the

[249] Collins, 'An Introduction to the Participatory and Non-Linear Aspects of Video Games Audio', 270.
[250] *GTA San Andreas: Soundtrack* (http://www.gtasanandreas.net/soundtrack/, 14 April 2014).
[251] Jeff Gerstmann, 'Grand Theft Auto: San Andreas Review', 7 June 2005 (http://uk.gamespot.com/grand-theft-auto-san-andreas/reviews/grand-theft-auto-san-andreas-review-6127083/?page=5, 8 November 2012).

gameplay and narrative in a certain place and time. It should however be mentioned that the Windows and Xbox versions of *San Andreas* also included an extra radio station, allowing the user to stream music files from their hard drive into the game in a diegetic fashion.[252]

The licensed music used in the *GTA* series is as stated largely diegetic, coming as it does from the radio stations within the game. By adding player control over the radio stations, as well as the enormous freedom which the player has in relation to their movement through the gameworld, this soundtrack can be considered interactive. Later games in the series improved the programming of the radio stations, and altered their nature. Rather than being comprised of one long audio file which would play through on an identical and predictable loop, the stations latterly exhibit an open form: songs, advertisements, DJ speech and all other elements of the radio station are randomly selected for playback in different combinations, delivering a less predictably linear experience. Even more interestingly, events within the narrative of the game can affect the playback content of the radio; commentaries on in-game events and situations can appear, making the audio design of the game functionally adaptive as well as interactive.[253]

Despite the extremely innovative and engaging audio design throughout the series, however, *Grand Theft Auto* still does little for the advancement of adaptive licensed music. While the "radio station" paradigm allows for player interactivity, switching between songs and stations deliberately and at will, the licensed music still remains as an audio "artefact"—that is, it exists as linear

[252] *Ibid.*
[253] *Ibid.*

audio files, identical to mp3 files on the user's hard drive (which, as seen, can be substituted into the game to perform the same function). Simply tuning in and out of songs during playback is interactive within the framework of the video game, but when examining the licensed music in isolation, the game does not provide a given track with any further interactive mechanism. Neither does a randomized track-listing within the game add any more to the interactivity of the music than any hi-fi equipment or media player with a "shuffle" function. This can be seen as the case in almost any diegetic use of licensed music.

There are many further examples of ludic fiction games which feature licensed music. The case of 'Late Goodbye' by Poets of the Fall used in *Max Payne 2* (2003) is noteworthy not just for promotional reasons, but for the variety of ways in which the song is incorporated into the game's sound design.[254] Those that have been discussed, however, serve as a good overview of how different games and game genres under this heading approach the use of licensed music.

> One of the most significant ramifications of choosing licensed music in games is that there is limited adaptability inherent in most popular music, whereas games require songs that may need to adapt to gameplay states or player interaction.[255]

The appearances of licensed music (mostly from popular genres) in video games, and the relationship between the two, are outlined within the three categories presented above. The primary purpose of this review is to find and explore instances of popular music being used successfully in liquid fashion within a game soundtrack. As highlighted by the above quote from Collins, there

[254] Kärjä, 'Marketing Music Through Computer Games'.
[255] Collins, 'Grand Theft Audio?', 16.

is an inherent problem to such an approach, due to the linear nature of popular music—nevertheless, it has been achieved in some instances.

In the majority of cases presented here, there has been little or no progress made in exploring the liquid potential of popular music. Some games have, however, demonstrated a form of interactive popular music made possible by the manipulation of multitrack splits or diegetically placed music. Rhythm-action games are the foremost exponents of interactive licensed music, with some games such as the *Guitar Hero* series focused entirely popular songs. These games often obtain multitrack stems for each song that they license, thereby having the capacity to break a licensed song into its constituent parts, before re-mixing and sequencing them in a liquid fashion. Problems with this approach can include the current difficulty of obtaining such multitrack stems,[256] and the input of the artists themselves, who often may not wish to relinquish control over their musical product. A song may be significantly altered to fit the non-linear aspects of game audio by being looped, having elements removed, being re-arranged or in other ways presented in a manner which the artist had not intended. While some artists may not have issue with this, others inevitably will, as it 'opens them up to the possibility of piracy and reduces their creative control over the ways in which their music is played back'.[257] Despite this, it seems that manipulation of multitrack stems is the most commonly found method of implementing interactive licensed music.

[256] *Ibid.*, 16 - Keith D'Arcy (Director of music resources for EMI Music Publishing) is quoted: 'If you're working with a specific record label on licensed audio for a game, you may be able to obtain splits of tracks for developing adaptive audio, but the actual process may prove quite difficult.'
[257] *Ibid.*, 16

The diegetic inclusion of licensed music in a game soundtrack also opens up potential for procedural functionality, as seen in the *Grand Theft Auto* series. Each time the player steals a car, they "unlock" the ability to listen to the radio, potentially changing stations to find different musical moods or styles: an example of interactive popular music within the context of the multimedia game. Yet as stated, the licensed tracks themselves remain linear throughout the game, and do not change inherently to reflect actions within the game. Without the use of multitrack splits, or some other function allowing songs to be separated into their constituent parts and manipulated individually, it would seem that properly procedural functionality cannot be readily applied to pre-existing music.

The "simulation" games for which popular music is most often licensed seem to reinforce the argument that such music is *not* really suitable for use in liquid game soundtracks. Though basic interactive elements may be added, the tracks still universally retain their linear playback. Yet the fact that game formats utilizing liquid music can and have been made with both licensed and original music (especially in the rhythm-action genre) lends weight to the opposite view that licensed music *can* be used successfully in liquid implementations, though the variety and scope of that procedural programming may not yet have reached the levels of games with original scores. Even working with multitrack splits of recorded songs, game designers are limited in implementing an adaptive playback system: if they were to alter, re-mix or re-arrange the songs in a fairly comprehensive manner, this could furthermore raise questions of authorship, copyright and so on. It seems plausible to say that

for popular music to be interactive, it should ideally be composed or developed in such a way *before* being rendered into a "finished" version or stereo mix; interactive potential must be included as a consideration during arrangement and production. As such, the potential for original music to be *designed* with a liquid nature is far greater than that for pre-existing licensed music, which is limited by the need to have any liquid functionality *imposed* upon it after it has been created.

Bridgett discusses the potential for an intelligent game system to analyse the tempo or identify sections of user-defined playlists, implementing transitions between tracks in order to build an adaptive soundtrack responsive to the game from the player's popular music library.[258] It is conceivable that artists might develop new approaches to song-writing, keeping in mind the required adaptability of a song written for inclusion in a video game. Certainly, there are other examples of popular songs being adapted to the playback media throughout history, such as the length of a record, and later the 45 RPM single and the LP. Might the production of popular music soon adjust to the needs of the gaming industry?[259]

2.5 Liquid Music in Classical and Contemporary Art Music

One further area in which precedents for liquid music can be found is that of art music. While this thesis does not engage directly with the aesthetics or creation of works in this field, it is worth providing a background review of some

[258] Bridgett, *From the Shadows of Film Sound*, 24.
[259] A question also asked in Collins, 'Grand Theft Audio?', 17; and Collins, *Game Sound*, 170.

approaches drawn from it, in order to influence the creation and development of a creation-model for liquid popular music. The oldest precedents for liquid works in Western music, observable as far back as the eighteenth century, can be largely grouped as structurally non-linear (following the definitions given in section 2.2.2). This leads to the highly relevant question: 'how can the music be structured if the order of events are uncertain?'[260] A variety of ways and means for ordering non-linear structures have been explored, some of which are discussed here.

One of the earliest and most regularly cited examples of a non-linear work in Western music is the infamous dice-game attributed to Mozart, the *Musikalisches Würfelspiel* of 1797.[261] Such games were not uncommon in eighteenth-century Europe, though Mozart's has remained the most well-known:[262] this *Würfelspiel* was a game in which a series of dice rolls dictated which from a selection of musical segments would be used, and where, resulting in the completion of a fully-formed and compositionally correct minuet and trio.[263]

In 1955, Karlheinz Stockhausen asked a friend: 'what if I wrote a piece where you could decide where you wanted to go on the page?'[264] What the composer was likely referring to was a piece he premiered in 1957, *Klavierstück*

[260] David Bessell, 'What's That Funny Noise? An Examination of the Role of Music in *Coolboarders 2*, *Alien Trilogy* and *Medievil 2*', in *Screenplay: Cinema/Videogames/Interfaces*, Geoff King and Tanya Krzywinska (eds.) (London: Wallflower, 2002), 136–144 (141).
[261] Zsofia Ruttkay, 'Composing Mozart Variations with Dice', *Teaching Statistics* 19/1 (March 1997): 18–19.
[262] This form of recombinatorial music enjoyed as a pastime was known as *Ars combinatoria:* Jesper Kaae, 'Theoretical Approaches to Composing Dynamic Music', 78.
[263] Returning to the definitions offered in Chapter Two, this "game" lacks a quantifiable outcome, and due to its instant engagement and retained musical character I would classify it rather as an "interactive composition"—perhaps also viewable as a forerunner to twentieth-century aleatoric music.
[264] David Tudor, interviewed by Victor Schonfield, 'From Piano to Electronics', *Music and Musicians* vol.20 (1972): 24–26.

XI. The premise of the piece is that the performer is presented with nineteen different sections (displayed on one large score sheet) which can be arranged and played in any order desired, ending when any given section is played for a third time. Unlike Mozart's dice game, the choices are made not by chance, but by the performer, either during or immediately before the performance. To add further interest to the piece while simultaneously increasing the permutations available for the work's performance to an outrageously high number,[265] Stockhausen placed tempo and performance directions at the end of each section, with instructions to apply them to the undefined following section. The composer termed this type of structure *polyvalent* or *mobile* form, and felt it offered many possibilities for future compositions.

Another composer, Earle Brown, spent much of his career developing two new practices: the first concerning systems of graphical notation, the second an exploration of mobile or open forms in which large-scale structural linearity is abandoned, often citing non-musical art works such as the mobiles of Alexander Calder or the paintings of Jackson Pollock as his primary inspirations.[266] *Twenty-Five Pages* (1953) was one of the earliest such works that Brown completed, asking the performer(s) to make choices regarding which lines or sections to play and the order in which to play them. Directions regarding dynamics, tempo and so forth are, unlike in Stockhausen's work, left to the performer's discretion rather than included upon the score. The score itself is presented upon twenty-five unbound pages which are to be divided

[265] The number of possible permutations has been calculated as greater than 10^{40}. R.C. Read and L. Yen, 'A Note on the Stockhausen Problem', *Journal of Combinatorial Theory, Series A* 76/1 (1995): 1–10.
[266] Herber, 'The Composition-Instrument', in *From Pac-man to Pop Music,* Karen Collins (ed.), 105.

between an unspecified number of performers (any number up to twenty-five, allowing for a minimum of one page each). Taking advantage of the possibilities inherent in his unmeasured notation—also a key part of the work—Brown indicated that to create further choice and variation any of these pages may also be played while turned upside-down (see FIGURE 2.6).[267]

An interesting development is observable in certain other works by Brown: rather than being left in the hands of individual performers, choices concerning structure and progression through pieces (as well as other concerns of orchestration, dynamics and so forth) are given to a conductor as an 'extension of the composer'.[268] This altered approach can be seen in *Available Forms I* and *II* (1961/62), both for larger ensembles, in which the conductor learns to communicate with the performers through a set of specific hand signals designed to control and order the performance.

Another composer from the mid-twentieth century who addressed similar ideas was Pierre Boulez. His third *Piano Sonata* was an ambitious work which remains largely unfinished, yet within two of the intended five sections—or 'formants' as Boulez named them—that have been published, innovative applications of non-linear structure can be found. The second formant is entitled *Trope* (1963), and according to the composer is intended to be bound in an unusual spiral fashion, further highlighting its non-linearity. Its four sections can be played in an interchangeable order, the only prerequisite being that a particular two of the four must be played in conjunction. Similarly to Earle

[267] Clemens Gresser, 'Earle Brown's "Creative Ambiguity" and Ideas of Co-Creatorship in Selected Works', *Contemporary Music Review* 26/3 (June 2007): 377–394 (388).
[268] *Ibid.*, 380.

Brown, Boulez cited modernist works from other arts as his primary inspirations, in this case the literature of Stéphane Mallarmé and James Joyce.[269] Many of the structural techniques used in Boulez's formants can be compared to similar devices used in such literature, the four movements and spiral binding of *Trope* reminiscent for example of Joyce's *Finnegan's Wake*.

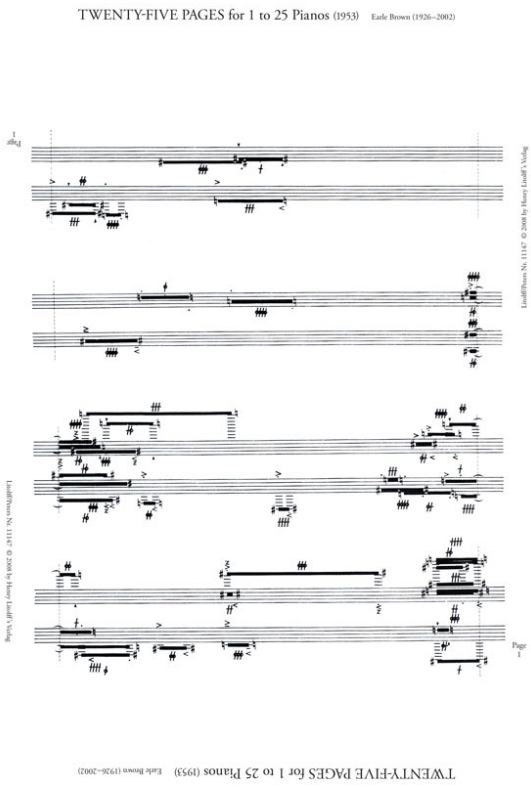

FIGURE 2.6—First page from the score of Earle Brown's *Twenty-Five Pages.* Headers helpfully produced in inversion at the bottom of the page.

[269] Pierre Boulez, *Orientations: Collected Writings*, Jean-Jacques Nattiez (ed.), Martin Cooper (trans.) (Faber and Faber, 1986), 143.

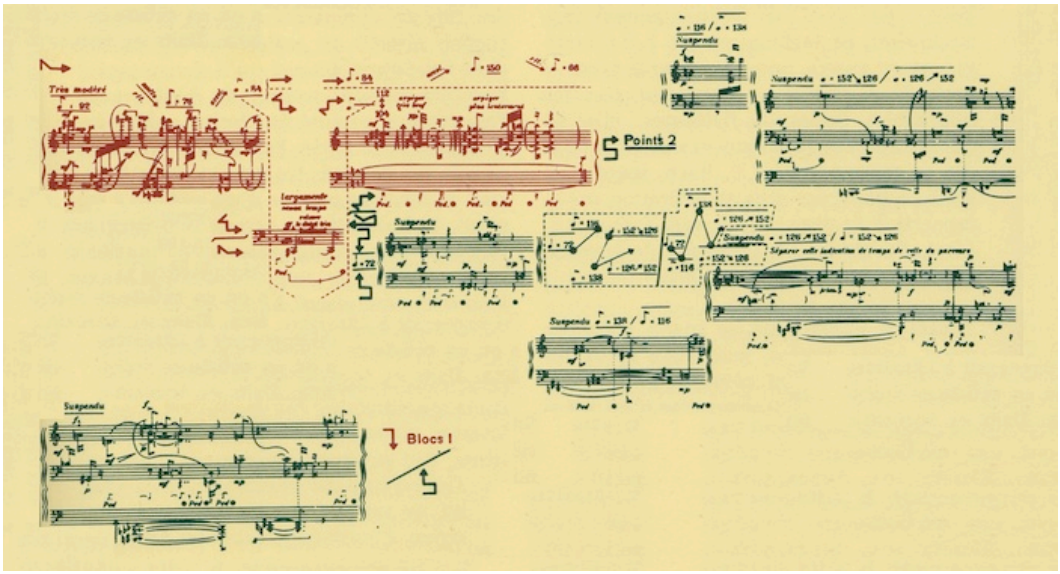

FIGURE 2.7—Pierre Boulez, score excerpt from *Constellation-miroir* (1963)

The third formant of Boulez's *Piano Sonata, Constellation* (1963) uses a different non-linear structural device, in this case a type of "branched" structure. Upon completion of one short musical section, the performer is guided to another or selection of others by arrows and symbols indicating possible continuations. Regular choices therefore must be made to determine which "route" will be taken through the piece, deciding which sections to play and which to omit in each performance (see FIGURE 2.7). Adding further choice to the formant there is, on the reverse of the score, a second score presented in perfect mirror image of the original. This second score, titled *Constellation-miroir*, can be substituted for the front pages at the performer's discretion. *Constellation* provides further ties to other non-linear artworks: the nature of the score can be seen as similar to a hypertext structure; it also exhibits a "locational" or map-like quality which could be compared to video game structures (driven by exploration of rendered locations and levels rather than a direct progression from point A to point B). Boulez himself made a similar comparison, stating that the structure of *Constellation* is 'like a town or

labyrinth' through which one must choose their route, though remaining subject at all times to certain 'traffic regulations'.[270]

A further key work in the development of structurally non-linear works is Henri Pousseur's *Scambi* (1957), a work by a composer who regularly experimented with non-linear structure, specifically with so-called *open forms*.[271] *Scambi* is an electronic work, composed not for live performance but as a number of sections recorded on magnetic tape that can be arranged by an editor into a realization of the piece. To encourage a sense of causal linearity, Pousseur identified four parameters within the recorded audio which could be used as links between different sections: 'relative pitch, speed, homogeneity and continuity'.[272] Connections between sections of tape can be made with these parameters, existing as possibilities for arranging a realization, though rather than being set in stone they are 'a guide to the making of a unified whole, it being left open to assemble a meaningful event without their help'.[273] Pousseur's work is important in the context of this thesis, as it brought the development of non-linear music from a performance-based to recording-based paradigm: his great innovation with *open* or *recombinatorial* form was to employ structural non-linearity as an element of a recorded work, in a pre-digital age.

Around the time of composition, several realizations of *Scambi* were made, including two by the composer. The major difficulty in doing so was the

[270] Peter Tannenbaum, 'Boulez's Structuralist Aesthetics of Music', *Open Access Dissertations and Theses,* Paper 5948 (1988) (http://digitalcommons.mcmaster.ca/opendissertations/5948, 16 March 2012), 104.
[271] John Dack, 'The "Open" Form—Literature and Music', presented at the Scambi Symposium (London: Goldsmiths College, 18 February 2005).
[272] Fencott and Dack, 'An Interactive Surface Realization of Henri Pousseur's *Scambi*', 2.
[273] *Ibid.*, 2.

problem of duplicating and distributing sections of magnetic tape to be recombined. With modern digital technology, this problem has become redundant. Many of the non-linear pieces discussed here may, in fact, be realized quite successfully in a digital medium. In 2006 the University of Bournemouth, funded by the AHRC, set up the '*Scambi* project' with the specific aim of creating new realizations of the composition, using digital media in order to make the process more accessible.[274] Two researchers, Fencott and Dack, constructed an interactive interface for realization of the work using a touch-screen table top, with physical and graphical representations of the audio sections.[275] This has the advantages of both quick and easy recombination of sections, as well as graphical cues representing potential links between sections.

Some of the pieces discussed here—Brown's *Available Forms*, for one—exhibit features comparable to interactive music interfaces which might be found today. In a liquid music release (such as *Biophilia*, discussed below), the user commences playback of the music, then engages with controls available through the hardware interface, programmed by the creators, to alter the musical playback as desired within the parameters given. The conductor of a relevant liquid piece by Brown (or another composer) causes playing of the music to commence, and uses the controls available through established or pre-defined hand signals to alter the musical playback as desired, within the inherently changeable parameters of the piece. A clear analogy can be drawn between the user in the first instance, perhaps guiding the structure of 'Crystalline' from *Biophilia*, and the conductor in the second, guiding *Available*

[274] The Scambi Project and all related information can be found at http://www.scambi.mdx.ac.uk/ (15 March 2012).
[275] Fencott and Dack, 'An Interactive Surface Realization of Henri Pousseur's *Scambi*'.

Forms. In theory, any "user" could learn the hand signals involved (analogous to a set of interface controls), and if placed in front of an ensemble could guide and interact with performances of compositions in much the same manner that they might interact with a recorded composition through a digital interface. *Available Forms* could in fact be compared to a video game soundtrack: taking the conductor as "player", the music which s/he hears will change with each performance, often remaining on a given segment (perhaps looping it, in a true video game aesthetic) until the correct cue is given. Each musician, in a way, becomes part of a procedural audio system, responsive to cues from the conductor or player's input. While exploring non-linear structures, composers like Brown and others were, by the necessity of guiding or controlling a linear path through a non-linear work, foreshadowing the potential interfaces for liquid music recordings.

2.6 Conclusions

This chapter reviews literature from a number of related fields, aimed at providing a solid foundation of background research from which to build and develop further discussion around liquid music.

Following on from the set of definitions given in Chapter One, a number of other terms are delineated here in order to accurately situate liquid music compositions within the fields of both music and procedural audio. Two widely accepted meanings for non-linearity in music, termed here *causal* and *structural*, are discussed, and the latter identified as having a greater

importance for liquid music. Causal non-linearity remains a compositional choice for both liquid and fixed works. All music will occupy a point on Kramer's 'continuum of linearity', depending on intra-musical processes, while composers may choose whether or not to implement non-linear structures.

A brief summary is made of each category of work in which liquid music and/or procedural audio programming may appear, to discern where the boundaries between these separate categories lie and how they might be seen as distinct. In proposing a creation-model for *liquid music compositions*, and discussing the elements thereof, it must be ensured that resulting works do not instead fall into another category. Concurrently, it is useful for creators of liquid music to see how procedural audio might be implemented and treated across all of the genres or categories discussed. The resulting definitions and classifications are summarized into a glossary, given below in FIGURE 2.8.

Later sections of this chapter have provided a review of existing works of liquid music drawn from a number of contexts. A survey of pertinent recent works by commercial artists shows that liquid music recordings are already being created. Many recent releases have taken the form of apps for mobile devices, allowing for novel interactions with music through a number of common approaches (remixing, location-aware adaption, or generative music systems, for example). Innovative steps were taken during the 1990s when Peter Gabriel released his multimedia CD-ROM projects *Xplora1* and *EVE*, in collaboration with visual artists. More recently, a number of popular artists and bands have begun to explore the interactive possibilities offered by advances in technology, particularly smartphones and tablets. Remixing of existing musical

material can be facilitated through customised software such as that created for David Bowie's *Golden Years EP*; location-aware music and albums, such as those by Bluebrain, offer excellent examples of adaptive musical works, albeit with potentially limited reach due to their site-specific nature; while artists like Radiohead, Gwilym Gold and Brian Eno have released apps with 2D and 3D interfaces allowing for user interaction with procedural music environments of greater or lesser expressive variety. Further relevant and innovative works are now being released every year.

Björk's multimedia quasi-educational work *Biophilia* presents the listener with multiple versions of each of its ten songs, and offers varying degrees of adaptive and interactive control over them. Interestingly, the audio content of the *Biophilia* apps was developed using the video game audio package FMOD, examined in Chapter Three, a fact which is significant with regards to potential production models for liquid music. By working closely with sound artist and computer programmer Scott Snibbe, the Icelandic artist has created something which resembles a number of pre-existing works (most obviously her own albums and Snibbe's sound-toys), and yet pushes the boundaries of what a liquid popular music work might be.

A broader historical context has also been given, through reference to pertinent Western art music of the twentieth century showing that precedents to liquid music can be drawn from the pre-digital age.

Glossary	
Term	**Definition**
Liquid Music	Music that includes a composed potential for alteration from one iteration to the next, within a single work.
Procedural	Any audio (including music) that plays as the result of a process, rather than a fixed or static piece of audio (also known as **dynamic**).
Reactive	Music that *reacts* to input stimuli from either a user, system state or environment (also known as **transformational**).
Generative	Music that is *generated* in real-time from an initial state.
Interactive	Music that reacts directly to user input.
Adaptive	Music that reacts to changes in system state or environment; may be an indirect consequence of user input.
Non-linear	*Causal*: music that does not espouse linear progression or goal-orientation within its musical language or content.
	Structural: music that does not follow a linear progression through a form, but may be reordered between iterations.
Composition	A repeatable and structured work with a definable character or 'aura'.
Instrument	An unstructured work with the expressive potential to play numerous compositions, requiring some level of skill or practice to master.
Game	A work with ludic goals or objectives and quantifiable outcomes, requiring some level of skill or practice to master.
Sound-Toy	Any sound-producing work without sufficient characteristics to be included in any the three previous categories.
Installation	A method of presenting audio or musical works, which may display attributes of any of the four previous categories.

FIGURE 2.8—Glossary of terms from Chapter Two

Despite the arguments supporting an observable cultural desire for interactivity or user participation across all forms of media,[276] there have been relatively few popular music works (or works by popular musicians) undertaken to date which can be recognized as liquid music. Issues of authorship and copyright (which have so publicly plagued the record industry in recent times), sociological or economic factors which may contribute to a lack of liquid music are all present, yet exploring such reasons why this may be the case falls outside the scope of this thesis.

The existence of liquid music within a subset of video games, classifiable as *music games*, is also highly relevant to this discussion, and offers examples of ways in which users of multimedia works can interact with music: in this case, usually with some kind of ludic goal driving the interaction. The licensing of popular music for use in video games has been examined, and conclusions drawn on the approaches taken to integrating *pre-existing* musical works or songs into a procedural multimedia program. Following on from existing research into the features of *audio games*, as well as game studies principles which derive genre classifications from interaction methods rather than narrative or iconographic content. *Audio games*—and its subset of *music games*—have been classified as any game in which audio (or music) plays the primary role in guiding the interaction with the player. This is a reasonably broad definition, as the role of auditory or musical interaction, whether it be cueing the player or a part of the player's actions, could subjectively be argued to be greater or lesser than other elements of the game. I am content that the

[276] See for example Henry Jenkins, *Fans, Bloggers, and Gamers: Exploring Participatory Culture*, (New York: New York University Press, 2006).

definition remain broad, however, so as to allow the admittance of as wide a range of games (and forms of interaction) as possible. The classification *music games* can be divided into *rhythm-action games, adaptive music games, musical puzzle games,* and *positional audio games*; these categories are not set in stone, however, and games may exist which use elements from more than one in their modes of play.

With the current state of the art for liquid music recordings established, the following chapter will proceed to develop a methodology for the creation of liquid music, both as a general creation-model and through the specifics of creating a portfolio of works.

Chapter Three Methodology

The practical aim of this thesis is to establish a creation-model for the paradigm of *liquid music*, the background to which has been discussed extensively in the foregoing chapter. Once such a model has been proposed, it will be tested through its application in the development of a number of liquid music works. As such, this chapter will begin by assessing the available technological processes and tools, and their merit for liquid music creation and distribution, as well as assessing compositional approaches that might be implemented. An analysis of popular music aesthetics will be conducted in order to provide an objective feature set to which the accompanying compositions should adhere. Finally, a full presentation of the created works will be given.

3.1 Existing Interactive Audio Standards

There have been several attempts made to design standardized technology and tools for 'interactive' (or liquid) music. These offer potential solutions for the creation and distribution of such works, and can collectively be taken as a step towards a unified set of requirements or features for liquid music—however, their relative lack of success may also provide inspiration for a more robust creation-model.

'Standards' have usually been developed with the interrelated aims of disseminating or distributing procedural audio more easily between users (whether as commercial releases, or during development of interactive media),

and simultaneously making the creation of dynamic audio easier or more accessible to users (who may or may not have experience working with existing technology and systems). While none has been widely adopted, a few may be identified as potential forms or genres of liquid music.[277] This could be compared to existing frameworks for fixed music: while not everyone wants to write, for example, with the twelve-bar blues, musicians across many decades have written an enormous variety of music utilizing that 'standard' framework.

3.1.1 Standard file formats

A number of attempts to develop a standard file format for disseminating liquid music have been made over the last twenty years. While varying somewhat in their aims and functions, each has sought to function as a platform-independent format that could be utilized by creators, developers and audiences. One relatively high-profile example is the Interactive eXtensible Music Format (IXMF), developed by the MIDI Manufacturer's Association (MMA). Work on this format began straight after the non-interactive XMF format was presented to the Interactive Audio Special Interest Group (IA-SIG) in 2001.[278] However, the group tasked to develop the format seems to have largely foundered and been on hiatus since 2010.[279]

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[277] These standards are valuable to the field, as while not everyone will wish to work within the same constraints for liquid music creation, some (perhaps amateur) users may enjoy working with pre-conceived styles or systems, help to make liquid music more accessible and more widely engaged with.

[278] Linda Law, 'Introducing the Interactive XMF Audio File Format' (http://www.gamasutra.com/view/feature/131262/introducing_the_interactive_xmf_.php, 8 November 2015).

[279] *IASIG Interactive XMF Workgroup (IXWG)* (http://www.iasig.org/wg/ixwg/index.shtml, 6 November 2015).

The IXMF format was to be aimed primarily at video game composers, offering the ability to create files which included scripts for dynamic audio behaviours alongside audio assets. These files could then be accessed by a game engine or other code, and the audio played as composed with dynamic functionality. A software tool called Soundtrack Manager was developed in order to create IXMF files with audio assets and scripts. It seems likely that the intended combination of this program and the IXMF file format would essentially resemble an audio middleware package, systems which are discussed below. 'Soundbanks' generated by the latter programs also contain audio assets and scripted audio behaviours, which can be hooked to a game engine or other interface. It may be the case that the prominence of audio middleware (which was not so prevalent in 2001) has rendered work on the IXMF format largely redundant, as the functions it was intended for have been successfully met by other tools.[280]

A second file format proposed is the MPEG Interactive Music Audio Format (IMAF), presented in 2011 with the supposition that 'a standardized file format is inevitably required to provide the interoperability between various interactive music players and interactive music albums'.[281] IMAF is essentially a multitrack stem playback format, one which—with a suitably designed player—would allow a user to adjust the levels of tracks (or groups of tracks) within a given piece of music, encoded as a file. The developers of the format cite

[280] This is supported by quotation from George Sanger in Law, 'Introducing the Interactive XMF Audio File Format', which describes exactly the sort of problems with proprietary game audio systems that third-party middleware is now effectively combating.
[281] A declaration this thesis argues against; Inseon Jang, Panos Kudumakis, Mark Sandler, and Kyeongok Kang, 'The MPEG Interactive Music Application Format Standard: Standards in a Nutshell,' *Signal Processing Magazine, IEEE* 28/1 (2011): 150–154, 150.

inherent possibilities and applications, including the production of karaoke tracks, instrumental tracks for highlighting and/or practicing a given instrumental part, and the creation of personalized mixes for sharing with friends or social networks. The format would also offer creators the capacity to impose 'rules' on user interaction with these multitrack files, making some stems irremovable, maintaining relative levels between others, or making some mutually exclusive. The IMAF file format remains quite limited in reactive functionality, offering only a basic ability for users to adjust the levels of multitrack stems.[282] Since the initial research proposal in 2011, the IMAF format does not appear to have been widely adopted, despite some further work by the developers.[283]

A third attempt at a standard format has been made with the IEEE 1599 file format, designed primarily for use with web applications and players.[284] IEEE 1599 files include symbolic information and metadata about a given piece of music; examples given in Baggi and Haus (2009) are focused on providing information for appreciation and/or education alongside music of all genres.[285] Video and image files can be incorporated and synchronised with audio playback. While it is stated that 'a single IEEE 1599 document can include and synchronize multiple audio and video tracks,' at no point in the presented research examples does this function appear to be used for multi-tracking

[282] The addition of EQ control is also suggested as a possible future development. *Ibid.*, 154.
[283] A more recent paper documents the development of a web player for IMAF files, using HTML5 and the Wed Audio API. Giacomo Herrero *et al*, 'An HTML5 Interactive (MPEG-A IM AF) Music Player,' in *Proceedings of the 10th International Symposium on Computer Music Multidisciplinary Research (CMMR), Marseille, France* (2013): 15–18.
[284] Denis L. Baggi and Goffredo M. Haus, *Music Navigation with Symbols and Layers: Toward Content Browsing with IEEE 1599 XML Encoding* (Hoboken: John Wiley & Sons, 2013).
[285] Denis Baggi and Goffredo Haus, 'IEEE 1599: Music encoding and interaction,' *Computer* 3/42 (2009): 84–87.

audio.[286] Numerous useful web-based applications are discussed, yet there appears to be no documented exploration of the possibilities of using IEEE 1599 for creating liquid music, rather than simply music with associated information (which may include alternate recordings or realizations of the piece of music in question).

These three standards are reviewed in *Exploring Musical Contents* (2010), yet none seems to have been adopted or taken up by either the music industry or the video games industry for purposes of music creation or dissemination.[287] The necessity for such a 'standard' file, which may be rendered redundant by other available software tools (as can be seen with IXMF) or be extremely limiting in terms of capacity for dynamic programming (as can be seen with IMAF) remains questionable. From this analysis, it is concluded that none of these formats best meet the requirements for liquid music creation as per this thesis.

3.1.2 Interactive Music Platforms

Aside from standardized file formats, efforts have also been made from a number of sources to develop a standard format or platform for interactive music. One notable attempt was made by UK company Reality Jockey Ltd., formed in 2008. The RjDj Sceneplayer app was released on iOS in the same year, and was available until 2012.

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[286] *Ibid.*, 87.
[287] Solvi Ystad, Mitsuko Aramaki, Richard Kronland-Martinet and Kristoffer Jensen (eds), *Exploring Musical Contents: 7th International Symposium, CMMR 2010, Málaga, Spain, June 21–24, 2010. Revised Papers* (Berlin: Springer-Verlag, 2011).

RjDj worked exclusively with the programming environment Pure Data (PD), and offered creators an application to host and serve as an interface for patches built in PD. These patches were called 'scenes', and referred to not as musical pieces or works, but rather as 'experiences'. RjDj was constructed with the libPD library, and as well as downloading released 'scenes', creators could develop and share their own to run within the RjDj Sceneplayer. A desktop authoring tool named RJC1000, allowing for the creation of scenes by users with no PD experience, enabled a wider community to more easily access and engage with the platform.[288] The stated aim for RjDj was the creation of *reactive* music, or music that reacts to the environment around the listener, without taking direct input.[289] This usage aligns more closely with *adaptive* as used in this thesis, as the music played by RjDj scenes would change based on indirect user input from microphones, light sensors, accelerometers and assorted other mobile hardware.

A number of commercially successful artists have worked with Reality Jockey, including Little Boots and most prominently Hans Zimmer, for the creation of *Inception: the App* (2010).[290] This app, distributed separately to the main RjDj Sceneplayer, can claim to be the most successful work developed with RjDj. Robert Thomas, who worked on the project, provides figures to support

[288] Jason Kincaid, 'RjDj Now Lets you Create Your Own Trippy, Reactive Music for iPhone and iPad,' (http://techcrunch.com/2010/03/30/rjdj-now-lets-you-create-your-own-trippy-reactive-music-for-iphone-and-ipad/, 5 November 2011).
[289] *Rjdj—PD Community Site* (https://puredata.info/downloads/rjdj, 5 November 2015).
[290] *Inception – the App* (Remote Control Productions, 2010).

this: *Inception* reached over six million downloads, with user interest remaining high, while the RjDj app only ever achieved roughly 400,000 downloads.[291]

Despite moderate levels of success, RjDj did not last longer than a few years in attempting to provide a 'standard' platform or format for liquid music: Reality Jockey Ltd. ceased trading in 2014. While a number of reasons may be posited for this, a lack of public interest in adaptive music is not necessarily evidenced as the sole cause. Engagement with *Inception* (albeit aided by a blockbuster film tie-in) suggests that users and listeners are open to new experiences, especially ones that are carefully authored with a clear 'use case', or a reason for the music to be interactive. Robert Thomas suggests that explicit functionality encourages interaction, and can make the required effort (of both creation and user interaction) more rewarding.[292] Similar work is now being undertaken by Thomas with the company BioBeats, focusing on biometrics and music therapy;[293] he has also recently developed the recent adaptive release *Fantom* (2016) with trip-hop group Massive Attack.[294]

RjDj serves as an example of creators and musicians exploring the potential inherent the liquid music paradigm, and contributed to expanding both the creative possibilities and broader awareness of liquid music. A number

[291] Robert Thomas, interview with the author, 28 September 2015. It should be noted that contradictory figures from the RjDj website (no longer accessible) quoted in Waldner *et al* state that 'by the end of 2010 RjDj counted about three million downloaded applications,' which may include standalone apps other than the main RjDj app; nonetheless, it indicates a higher user interest in reactive music than implied by Robert Thomas' figures. Florian Waldner *et al*, 'Cross-industry innovation: The transfer of a service-based business model from the video game industry to the music industry,' in *Emerging Intelligent Data and Web Technologies (EIDWT), 2011 International Conference on*, (IEEE, 2011): 143–147 (146).
[292] Robert Thomas, interview with the author, 28 September 2015: he suggests that apps designed with explicit functionality for exercise, relaxation and so on are more likely to be successful than those with a purely artistic or entertainment basis.
[293] *Biobeats* (biobeats.com, 1 March 2016).
[294] Massive Attack, *Fantom*, iOS app (Fantom & Sons Ltd., 2016)

of its features can be analysed to feed into a new creation model, though, not least as the format itself is no longer available, it would not be suitable for development.

A less successful example of a liquid music standard can be seen in Gwilym Gold's BRONZE format (discussed in Chapter Two). Touted as a new 'format' for music, BRONZE imposes greater limits for both user interfaces and musical styles than RjDj. Indeed, with no input beyond simple transport controls accepted, music created with BRONZE remains entirely generative, and as such could be described most accurately as a style or genre of generative music. BRONZE also imposes a set of stylistic traits, inherent to the nature of its generative programming, upon any music created for it, rendering any works or releases aesthetically similar.

While both the examples discussed have been described as 'formats', and may or may not have been conceived of by their creators as 'standards' for liquid music, it can be seen that the limitation of creative potential through specific software tools—whether that be the limitation of audio creation, of dynamic programming methods, or of interface design and creation—naturally narrows the compositional scope, from the entire paradigm of liquid music to a greater or lesser sub-section of the same. In a similar way, it could be declared that the imposition of limitations upon fixed music restricts the potential for composition from the entirety of 'music', to a style or genre ('classical', 'EDM', or another). In liquid music, just as in video games, genre may be identified

through methods of either iconography (established music genres) or interactivity.[295]

Limitations are often used as an aid to creativity, yet formats and standards for music release, such as records, CDs or MP3 files, impose no limitations (beyond, perhaps, a certain dynamic range or length, neither of which can be cited as definite stylistic characteristics). Any standardized distribution format for liquid music, therefore, should endeavour to be as neutral and transparent as fixed music formats.

This thesis, therefore, has established that a unified 'standard' for liquid music is *not* proposed as a form of development that would meet the research aims. Instead, a new conceptual creation-model, a process or framework to be applied independently of specific tools or software, will be drawn from analysis of existing works, and through assessment of the technology available.

3.2 Evaluation of Production Tools for Liquid Music

This section is intended to survey the potential audio production tools that are available for liquid music creation. An understanding of the capabilities and workflows of existing systems can help to shape the creation-model being developed; through evaluation of these tools it can also be decided which will be used in creation of the accompanying portfolio of works.

[295] A reprisal of Wolf's discussion on classification of video games. Wolf, *The Medium of the Video Game*, 114.

3.2.1 Establishing Likely Distribution Methods

Hunt and Kirk (1999) predicated that 'we will no longer buy tapes or CDs, but will download the tracks of our choice from on-line catalogues or even download them in *real-time* and pay for them each time we listen'.[296] Current statistics seem to have proved them right, as streaming and on-line purchase now dominate the distribution of recorded music.[297] Allied with this, many more people are listening to music on portable devices, a shift that has arguably intensified since digital audio files have been separated from the bespoke hardware of the CD and CD player. MP3 players first appeared in 1998 with the Rio PMP300 from Diamond Multimedia, offering listeners a means of transferring digital audio files—now being disseminated via the Internet—onto a portable system.[298] More recently still, the market for MP3 players has seen a sharp decline in sales and popularity due to the appearance of smartphones and tablets with audio-playing capabilities.[299]

With a focus on distribution methods and platforms for liquid music, all hardware release formats can safely be discarded for this thesis. While hardware liquid music releases are possible (through CD-ROM format, or even as recombinatorial section of audio tape as with the 1958 composition *Scambi*) these will always be the exception to the norm. Multimedia works such as video

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[296] Andy Hunt and Ross Kirk, *Digital Sound Processing for Music and Multimedia* (Oxford: Focal Press, 1999), 35.
[297] *Global Music Report 2017: Annual State of the Industry*, IFPI, 2017 (www.ifpi.org/downloads/GMR2017.pdf, 28 June 2018).
[298] Reebee Garofalo, 'Music Publishing to MP3: Music and Industry in the Twentieth Century', *American Music* 17/3 (Autumn 1999): 318–354 (350).
[299] At the end of 2012, sales of MP3 players had dropped 22% from the previous year, with further decreases expected, due directly to the rising sales of smartphones. James Hall, 'MP3 Players are Dead', *The Daily Telegraph*, 6 December 2012 (http://www.businessinsider.com/mp3-players-are-dead-2012-12, 11 October 2013).

games are also moving towards a fully digital, online distribution scheme, with services such as Steam capturing a large portion of the market.[300]

Within the software realm, there would seem to be no existing platform, as discussed above, that allows for standardized playback of liquid music. Traditional media players, such as iTunes, may offer simple audio enhancements to alter frequency content, play speed or other attributes, but this does not constitute an inherently composed difference between iterations of a musical work. These packages are focused largely on playlisting and organization of fixed music tracks, and the recommendation and purchase of new music. Aav discusses the possibility of such a liquid media player in his thesis of 2005, regarding 'the fairly new prospect of non-linear playback of commercial music' as a possibility, albeit one which 'would be a serious endeavour'.[301] However, from a review of existing music distribution, it would seem that a new interface for playing liquid music, one tied to available distribution methods, will need to be included in the creation model.

Smartphones, and the mobile OS platforms which they operate, are suggested as the most compatible hardware and software for liquid music development. Following the model of previous releases (notably *Biophilia* and *Tender Metal*), the sale of bespoke apps for music releases would allow for creators to package their liquid music content with a specific interface for engagement and playback. While this approach of 'music as software' is equally

[300] *UK Video Games Fact Sheet*, UKIE, June 2018 (ukie.org.uk/research#fact_sheet, 2 July 2018).
[301] Sebastian Aav, 'Adaptive Music System for DirectSound' (M.A. Thesis, Linkoping University, 2005), 22.

applicable on other software platforms such as Windows or MacOSX, the smartphone distribution model offers a couple of advantages.

Firstly, as a large number of music consumers are using smartphones to store, stream, and listen to digital music files already, there may be a natural progression to engagement with liquid music through the same hardware, in the same contexts. The rise of the casual gaming market, founded on smartphone technology and simple interactions, suggests an audience also willing to actively engage with media on their devices, rather than having a necessity for more 'passive' listening.[302] Secondly, the facility for interactive and adaptive engagement through the various hardware sensors and components of current smartphones offers liquid music creators a broad pallet for potential development, as discussed by Ballagas *et al* (2006),[303] and as highlighted in FIGURE 3.1. Creators designing interfaces and inputs for liquid music works will have to take into account the specific capabilities of the hardware that will be used to engage with the work.

[302] Mobile gaming currently makes up 43% of the global video games market, generating over US$50 billion. *UK Video Games Fact Sheet*, UKIE, June 2018 (ukie.org.uk/research#fact_sheet, 2 July 2018).
[303] Rafael Ballagas, Jan Borchers, Michael Rohs, and Jennifer G. Sheridan, 'The smart phone: a ubiquitous input device,' *IEEE Pervasive Computing* vol.5/1 (January–March 2006): 70-77.

Hardware Interaction Methods	
Movement	Accelerometer Gyroscope Gravity sensor
Time & date	System clock
Ambience	Light sensors Air Pressure sensor Humidity sensor Temperature sensor
Audio Input	Microphone
Location	Compass GPS Proximity sensor
Visual Input	Camera Webcam
HID	Keyboard Mouse Joystick Gamepad
Software Interaction Methods	
GUI elements	Buttons Sliders Knobs Toggle switches Touchpads Arrays LCD panels
System Messages	MIDI OSC
Haptic Feedback Methods	
Hardware	Vibration Light on/off
Software	Text Images Meters/values

FIGURE 3.1—Table of potential interface methods for mobile devices[304]

[304] Drawn primarily from *Sensors Overview* (http://developer.android.com/guide/topics/sensors/sensors_overview.html, 12 February 2016).

3.2.2 Popular Music Production Tools

A broad range of applications and tools exist for the purposes or recording, editing, mixing and mastering music. While professional studios will usually have expensive hardware and analogue processing, this evaluation will be limited to the software tools available for digital music production. Such an 'in-the-box' workflow is not uncommon for modern music production,[305] and as liquid music will be created and distributed through digital means, there is strong rationale for maintaining an entirely digital creation-model. Studio hardware is also not available to the author for the production of the accompanying portfolio, therefore will be excluded from discussion here.

The modern music studio is, with few exceptions, centered around a Digital Audio Workstation (DAW), 'full-featured recording and creation environments that can be used by engineers in a recording studio, pop or film producers in a project studio'.[306] All DAWs have broadly similar features, allowing for the recording, editing and balancing of audio, along with sequencing of electronic sounds, and the application of digital signal processing (DSP) to create a final production for release. The functionality offered is designed entirely to facilitate fixed, linear musical works, and no DAW offers the capacity to develop interactive, adaptive or generative behaviours with which to alter musical content or playback. As such, while DAWs are a ubiquitous part of music recording and must be accounted for in the creation-model, additional tools will be needed to develop liquid music.

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[305] Justin Paterson, 'Mixing in the Box' in *Mixing Music*, Hepworth-Sawyer and Hodgson (eds.) (Abingdon: Routledge, 2017), 77–93.
[306] Hosken, *An Introduction to Music Technology*, 86.

3.2.3 Performance/Production Hybrid Tools

A small number of existing DAWs, while not providing the capacity for liquid music production, do offer a closer approach based on real-time manipulation of audio. These DAWs have hybridized toolkits designed to be used for both production and performance of music,[307] the most popular of this kind being Ableton Live.

Live differs from the traditional linear sequencing approach of other DAWs through its *session view*, an arrangement approach whereby each track can contain a number of audio or MIDI *clips* in no fixed order. These clips can then be played back in real-time—started, stopped, and swapped for others in the same track, to deliver a real-time performance built from alteration of the various assets and layers within a session. Synchronization between clips is achieved by time-stretching all audio with the *warp* function, locking all clips to the master tempo and enabling precise rearrangement and transitions; the latter can be assigned to occur on bar or beat markers. Once the elements of a composition are in place, therefore, the user can commence playback and proceed to deliver a performance of the work, editing and altering various elements of it in real-time. This is noticeably different to the static, linear functionality of other DAWs. As stated within the Live tutorials, 'unlike a linearly arranged song, each section can play for as long as you like and in any order'.[308]

Live is not unique in this hybridized approach to production and performance. A second pertinent example is found is the program

[307] *Ibid.,* 86: Hosken refers to these tools as 'live audio sequencers'.
[308] *A Tour of Live* (https://www.ableton.com/en/articles/tour-live/, 26 July 2013).

Audiomulch,[309] which offers a modular audio arrangement through which users can construct a bespoke signal flow for their composition. Tied to this is a unique performative control interface, called the *metasurface*. Snapshots of settings can be assigned to this interface, meaning that values for any chosen DSP parameters will be mapped across the two axes (and represented by different colours in an arbitrary and abstract fashion). As performance of the work is undertaken, the user can move their cursor position across the metasurface, in turn changing the values for any assigned DSP parameters and altering the musical output. Similar two-dimensional controls, allowing alteration or randomization of defined parameters, are not uncommonly found on the interfaces of software synthesizers, such as Logic's Sculpture, or the Native Instruments FM8. The level of control offered by such an interface for real-time manipulation of production elements is impressive and may have considerable potential for liquid music engagement.

Despite the advantages of these hybrid software tools, and the benefits offered to performers, is remains questionable as to how useful they may be for liquid music production. For amateur users, the interfaces of these programmes are likely to be overly complex and difficult to operate—they are designed to be used by music *creators* rather than an audience. The software is quite expensive,[310] and offer complete control over music creation, rather than a curated engagement within specific boundaries. While the type of performance deliverable through Live or Audiomulch could in theory be abstracted for export

[309] AudioMulch was developed by Ross Bencina, and first released in 1998: Ross Bencina, 'About Us' (www.audiomulch.com/about-us, 24 October 2013).
[310] Ableton Live 9, standard version, was available for €349 at time of writing: *Ableton: Shop* (https://www.ableton.com/en/shop/, 10 October 2013).

as a distributable music release, perhaps with an interface resembling the latter's metasurface, or a stripped-down session view, such a possibility does not currently exist. Such hybrid tools, though they may be useful tools for composers, can therefore be concluded to be of limited use in the practical creation of distributable liquid music works.

3.2.4 Video Game Audio Technology

Video games have for decades implemented liquid music as an inherent part of their interactive medium. This field, therefore, has developed tools that may be just as useful to liquid music creators as popular music production software. Most game developers, as commercial bodies, do not publicly release details of their programming or audio systems—however, information can be gathered about the functionality and makeup of these systems through collation of information released, interviews with game audio professionals, primary analysis of video games and the study of freely available third-party game audio tools. These third-party tools, many of which are now regularly used by professionals within the games industry, are most likely to be of use for liquid music creation.

The broader history of video game music and its associated technology has been outlined and discussed in considerable detail elsewhere, most notably by Collins (2007) and Fritsch (2012), and there is little need to re-tread the same ground.[311] Early game music was programmed directly into the computer

[311] Collins, *Game Sound;* Melanie Fritsch, 'A History of Video Game Music' in *Music and Game: Perspectives on a Popular Alliance*, Peter Moormann (ed.) (Wiesbaden: Springer VS, 2010), 11–40.

code, or through early systems of MIDI which allowed for musical information to be played through hardware sound chips, such as LucasArts' highly influential *Interactive Music Streaming Engine* (iMuse).

Current industry practices, however, have largely seen a separation of roles between those responsible for composition, and those responsible for the implementation of sound and music within the game. As professional audio director Bradley Meyer highlights, 'it would be unfair to expect a sound designer to pick up scripting and suddenly be an audio programmer.[312] This balance between the artistic and technical aspects of implementing sound and music within an interactive multimedia format are highlighted by the emergence of freely available, third-party *audio middleware* packages: 'middleware game audio engines [...] are the key to understanding what makes game audio different.'[313]

Audio middleware packages are a particular type of software developed for ease of integrating audio assets into a game's programming; it could be viewed as the bridge between the composer and the programmer, the step between writing music for a game and implementing it within that game.[314] Audio middleware allows a composer to import the sounds and music that they have designed for a given game, and tie them to events or parameters within the game engine: for example, assigning a given level or location the correct

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[312] Bradley Meyer, 'AAA-Lite Audio: Design Challenges and Methodologies to Bring Console-Quality Audio to Browser and Mobile Games', *Gamasutra,* May 2011 (www.gamasutra.com/view/feature/134761/aaalite_audio_design_challenges_.php, 13 March 2014).

[313] Alexander Brandon, 'Audio Middleware: The Essential Link From Studio to Game Design', *MIX Magazine,* May 2007 (http://mixonline.com/basics/education/AudioNextMarch-June07.pdf, 5 March 2013).

[314] See Alexander Brandon, 'Audio Middleware,' for a good introductory discussion of the middleware packages available at the time of writing in 2007.

"background" music, or causing a "gunshot" sound to play every time the player presses the trigger button of their controller. Having started very much as computer coding tools, these packages are now being built to resemble audio production platforms, offering DAW-like interfaces in the hopes of being more user-friendly to musicians or audio engineers. ISACT was the first tool to use the familiar 'track' layout,[315] while Firelight Technologies recently built an entirely new package called FMOD Studio (replacing FMOD Designer), designed to closely resemble the structures of a DAW.[316]

Any large game development company will have a team of people hired to work on the audio elements of a game: composers, sound designers, audio engineers, audio programmers. The workload required to create a standard high-budget video game for PC, Xbox360, PS3 or any other platform is considerable, and realistically requires the varied skills of people fulfilling each of the roles mentioned. The challenge for smaller and/or independent game developers is to find people with the skill-sets to perform multiple roles (both in audio production and elsewhere) in order to create a successful product. The availability of low-cost, third-party audio middleware solutions is therefore invaluable to such developers. Music and audio assets can be manipulated, arranged, and fitted with dynamic programming within a more user-friendly and easily managed framework, rather than requiring composers to engage with more complex coding languages. Easy and immediate integration with game engines—proprietary or third-party—is also a feature of most middleware, helping to bring the entire development process, from concept and

[315] *Ibid.*
[316] *FMOD Studio* (http://www.fmod.org/fmod-studio/, 13 March 2014).

composition to actual gameplay, within the capabilities of a small audio team (potentially even a single person). As Meyer explains, these inexpensive and ready-made tools are very much to the advantage of the burgeoning independent and small-budget games development industry: 'most teams forgo costly proprietary game (and audio) engines in favour of a third-party engine'.[317]

On the other side of the industry, of course, many of the larger game development studios still use their own proprietary systems (or elements thereof). Bridgett writes of his work with Radical Entertainment on games between 2006 and 2009, for which he and his teams used a proprietary system named 'Audiobuilder';[318] the best-selling *Halo* series used Bungie's esoteric 'Guerrilla Toolset' to implement their award-winning audio. Electronic Arts (as well as having their proprietary AEMS system to call upon) rebuilt the free audio programming language Pure Data into a proprietary version labelled 'EAPD', which has been used to integrate audio programming in Pure Data with their own game engines.[319] As mentioned, there is typically not much information publicly available about these in-house systems, due of course to the commercial nature of the industry, and the desire of each developer to protect their own designs. Often only screenshots or the names of different systems are available: enough, alongside analysis of the games in question, to

[317] Meyer, 'AAA-Lite Audio'.
[318] Bridgett, 'The Game Audio Mixing Revolution,' *Gamasutra*, June 2009 (www.gamasutra.com/view/feature/132446/the_game_audio_mixing_revolution.php, 5 March 2013).
[319] Kent Jolly, 'Usage of PD in Spore and Darkspore' at *Pure Data Convention 2011* (Weimar, Berlin: 2011), 36–39.

enable basic overviews of the systems and processes being implemented.[320]

Bridgett predicts, however, that within the industry in the coming years:

> The more enhanced and developed that third-party tools become, the more pressure there is on in-house tools to compete with these solutions and to have the same, if not more features. This subsequent climate then puts pressure on in-house technology to be more agile and versatile, which in turn results in further innovation, eventually spreading out to the wider industry.[321]

It would appear likely that, as this quote suggests, a sort of low-key 'arms-race' has arisen between proprietary and third-party audio middleware systems, as each side attempts to gain the upper hand. The multitude of packages currently used will most likely all come to incorporate a similar set of standard features (similar to the homogeneity visible in modern DAW design), which will in turn enable the advancement of high-quality dynamic audio systems from a standard toolkit.

The concept of 'real-time mixing' has been a key recent area in the development of game sound. Bridgett (2009) and Taylor (2010),[322] for example, discuss a number of practices related to real-time mixing, which are not unrelated to established music production techniques like sidechain ducking, or multiband compression. The importance of flexible, real-time digital signal processing to the professional quality of the finished sound can be highlighted.

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[320] Lostchocolatelab, 'Audio Implementation Greats #2: Audio Toolsets'.
[321] Bridgett, 'The Game Audio Mixing Revolution'.
[322] Garry Taylor, 'All in the Mix: The Importance of Real-Time Mixing in Video Games', presented at *Develop Conference* (Brighton, 2010) (gameaudionoise.blogspot.ie/p/all-in-mix-importance-of-real-time.html, 8 April 2014); Rob Bridgett, 'The Future of Game Sound: Is Interactive Mixing the Key?', *Gamasutra,* May 2009 (www.gamasutra.com/view/feature/132416/the_future_of_game_audio__is_.php, 2 April 2014).

Of the numerous third-party middleware packages currently available, the most widely used have been comprehensively reviewed and compared in an excellent article by Brandon for *Mix* magazine.[323] Since this article was written in 2007, the field has developed somewhat, with some systems appearing to have decreased in popularity, while a handful of packages have improved rapidly to offer the state-of-the-art in dynamic audio implementation. Two of the foremost packages today are FMOD Studio and Wave Works Interactive Sound Engine (Wwise); both of these middleware systems are freely available for non-commercial or academic projects, and can export audio 'soundbanks' compiled of audio assets and dynamic behaviours, that will integrate with interface or game development systems.

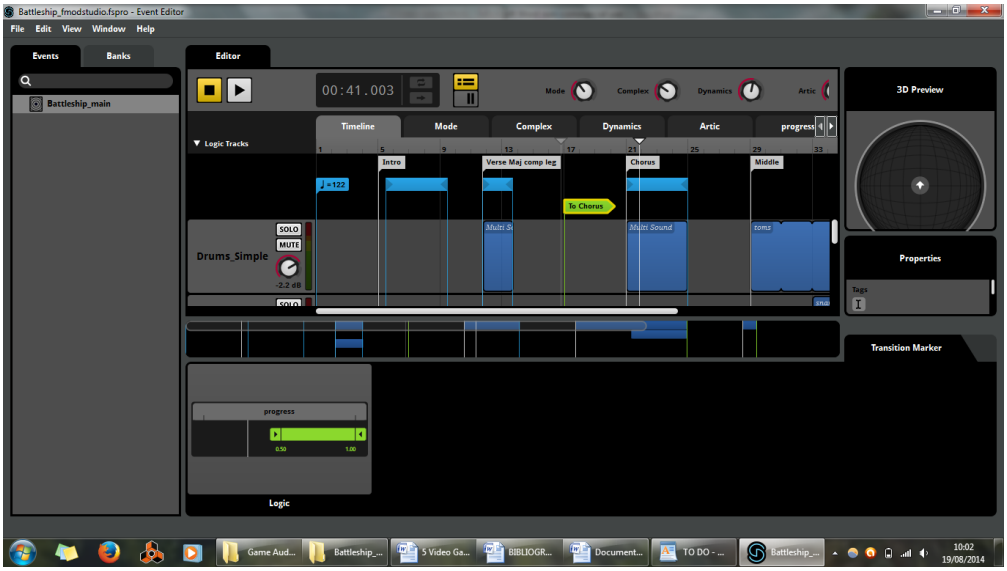

FIGURE 3.2—FMOD Studio (screenshot by author)

FMOD Studio is modelled upon traditional DAW structures and interfaces, in order to be more readily accessible and familiar to experienced music producers (FIGURE 3.2); FMOD systems have been used to implement

[323] Brandon, 'Audio Middleware'.

audio for best-selling big-budget games such as *World of Warcraft, Bioshock* and *LA Noire*.[324] The key difference to note between the FMOD track interface and that of a traditional DAW is that the horizontal axis of the interface does *not necessarily* relate to time; instead, it can represent any user-defined parameter, of which time is just one of many possibilities. Distance, threat level, or speed are just some common parameters which may be read from a game engine and used to control the behaviour of the audio in real-time. FMOD also supports the use of VST plug-ins on these tracks, thereby allowing music production plug-ins to be used for game audio events.

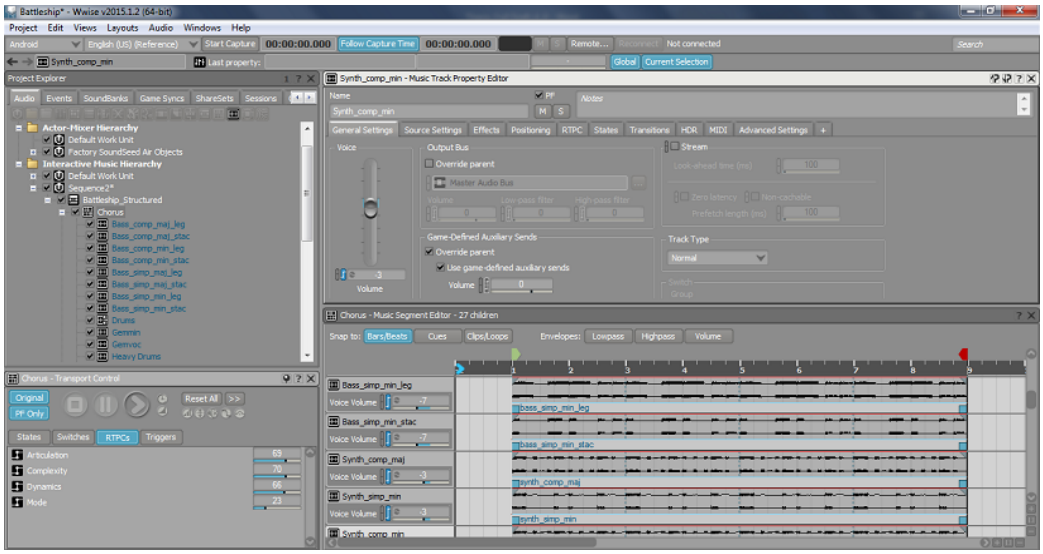

FIGURE 3.3—Wwise (screenshot by author)

Wwise operates with a more complicated hierarchical workflow and an interface built from multiple windows: it has been used for titles such as *Batman: Arkham Origins*, *Assassin's Creed IV* and *Halo 4*.[325] Brandon has praised

[324] *About Firelight Technologies* (www.fmod.org/fmod-aboutus.html, 13 March 2014).
[325] *Ibid.*, and *Microsoft Game Studios: Halo 4 credits* (https://www.microsoft.com/games/mgsgamecatalog/halo4_credits.aspx, 13 March 2014).

its interface as 'an ingenious design', and believed in 2007 that it was likely to become the leading audio tool for the industry.[326] Such a method of working with audio is entirely unrelated to traditional music production systems, resulting in the likelihood of a steep learning curve for anyone unused to game audio systems (see FIGURE 3.3). However, once a user becomes comfortable with Wwise, it is arguably both more powerful and more flexible than FMOD Studio or other similar middleware systems. A range of DSP effects are included in the package, while high-end professional audio plug-ins such as the iZotope range are also supported.

3.2.5 Audio Programming Environments

Besides professional software packages designed for audio production, a number of audio programming environments exist which are frequently used for assorted purposes of composition, research and development.[327] These programming environments may use a text-based interface, as with Csound and SuperCollider; or may employ a graphic interface for real-time editing of an 'interactive musical environment'[328] like Max/MSP (the modular interface of Audiomulch can be seen as a highly simplified and specialized version of this type of graphical programming environment). Irrespective of their interface, each of these systems offer the user a highly flexible and powerful audio engine with the capacity to construct various types of signal processing from very basic

[326] Brandon, 'Audio Middleware', 66.
[327] A good further discussion of this type of program, which he terms 'Interactive Music Systems' or 'Digital Audio Platforms for Interactive Music,' can be found in Rob Rowe, 'Split Levels: Symbolic to Sub-symbolic Interactive Music Systems', *Contemporary Music Review* 28/1 (February 2009): 31–42.
[328] Hunt and Kirk, *Digital Sound Processing*, 35.

components due to the low-level nature of the programming. While some, like Csound, are designed primarily for the sequencing and generation of electronic audio (highlighted by the program's two-part "orchestra and score" file structure),[329] graphical environments such as Max/MSP and Pure Data are often more open in their design as 'environment[s] in which you graphically place and connect objects to create synthesis algorithms',[330] rendering them suitable for audio processing, instrument design, algorithmic composition or other related purposes.

Max/MSP and Pure Data (PD) were both designed by Miller Puckette, the latter intended as a free and open-source version of the former: a strong resemblance therefore exists between the two.[331] Projects created in either are called *patches*, presenting the user with a blank canvas upon which various objects can be created, arranged and linked together in almost any combination. Using these objects, signal paths at both audio and control rates can be programmed and manipulated in real-time (that is, while audio processing is taking place), making these environments suitable for live performance as well as other functions. However, despite their versatility—or because of it—programming languages such as these do not have the same power or capacity for professional audio production as a high-end DAW. Recorded audio samples or tracks have to be streamed from disk or held within *arrays* in a patch, numerous simultaneous uses of either method often requiring a prohibitive amount of processing power. Synchronization and quantization of recorded audio in a multi-track arrangement is not generally regarded as a focus for these

[329] Hosken, *Introduction to Music Technology,* 230.
[330] *Ibid.*, 231.
[331] *Ibid.*, 231.

programming environments and can be difficult to achieve.[332] While work with audio samples or electronic music generation can be accomplished with great versatility, Max/MSP and Pure Data are not particularly suited for music production in the manner of a DAW or live audio sequencer, and as such see very little use in popular music production.

One potential advantage for audio programming environments is found in their flexibility for distribution. Pure Data can be built into the code of standalone applications, and disseminated as a part of a bespoke release.[333] This kind of integration allows for the use of Pure Data in creating a variety of audio and music-based apps, something beyond the capacity of any professional music production software. Third-party apps that allow for easy integration of Pure Data with mobile hardware and devices already exist: RjDj (discussed in section 3.1 above) was one such system, while current equivalents include Iglesia Multimedia's MobMuPlat.[334]

Pure Data is further able to be integrated into almost any audio production system or workflow, providing procedural audio programming within a more complex environment. One notable recent development has been the release of Heavy audio tools from Enzien Audio.[335] This is a framework that allows Pure Data patches to be compiled in several ways: as VST plug-ins for audio production in a DAW or similar software package; as plug-ins for Wwise, allowing for game audio middleware to incorporate the benefits of audio

[332] Literature and research often refers to them as "synthesis engines," rather than sequencers or anything similar, indicating that they have been designed for sound *creation* rather than *production*.
[333] For further discussion, see Peter Brinkmann, *Making Musical Apps* (Sebastopol: O'Reilly, 2012).
[334] *MobMuPlat* (www.mobmuplat.com, 18 February 2015).
[335] *Heavy Audio Tools* (enzienaudio.com, 12 September 2016).

programming; or as plug-ins for Unity, allowing Pure Data to be run as a part of video game development without the need for other middleware. The level of integration possible ensures that development of liquid music with this audio programming language is possible with almost any accompanying software or hardware.

3.2.6 Conclusions

Due to the existence of software packages with diverse functionalities and purposes, it seems unlikely that there is a need for one entirely new program or toolkit to be developed for liquid music creation. Instead, the creation-model being constructed from the research in this thesis should be a flexible framework that can incorporate the use of any existing software tools desired by the composer(s) for the ultimate aim of creating distributable liquid music recordings. While those familiar with traditional music composition may be skilled with audio production tools, the necessity to combine different software elements for the creation of a new work may be an area that could cause problems for those lacking in programming or IT skills.[336] This section has reviewed the current range of software that exists for the production of digital music, with a specific focus on tools that might be used or repurposed for liquid music development. While there are of course a multitude of tools and platforms that have been omitted, the most pertinent for the production, programming and distribution of liquid music are discussed.

[336] Teams of people can of course be utilized to create liquid music, though in this paradigm they may include programmers as well as musicians and/or producers. The terms 'comprogrammer' and 'programposer' are offered by Linda Law in describing the kind of joint position often held in earlier stages of the video games industry. Linda Law, 'Introducing the Interactive XMF Audio File Format'.

The most likely model for distribution of liquid music would appear to be in software format, with works packaged as bespoke apps (perhaps expandable with new releases as downloadable content). The advantages to distribution are clear, as a wide audience is already engaging with musical content through mobile devices. Furthermore, such devices offer many possible interactions through hardware devices and sensors, eliminating any need for specialist hardware to accompany liquid music releases.

Modern audio production software of the kind used for popular music is almost always designed specifically for fixed, static musical production. However, any liquid music creation will need to incorporate the composition and production of digital audio. As this will in many ways replicate the existing production, sequencing and mixing practices of popular music, traditional tools such as DAWs are perfectly suited to the task and could be used to great effect.

Certain packages that have been termed *hybrid production/performance* tools here offer a kind of potential for liquid music, due to their intended use in live performance rather than strictly for studio work. Their usability is restricted by the fact that the procedural functionality available for production is contained entirely within these programs, rather than being applicable or transferrable to any rendered output—recorded audio files produced from a live audio sequencer will be just as fixed and static as those produced by a DAW. In other words, the music may be interactive during production or performance, but can only be distributed in established, fixed forms. Elements of their functionality could, however, be abstracted and considered conceptually during liquid music creation.

Audio programming environments such as Max/MSP and Pure Data are likely not suitable for the major task of audio production, these highly specialized music production tasks better left to a professional DAW. These are, however, highly flexible tools that offer considerable control over playback and real-time manipulation of audio files, control which can be abstracted to simple interfaces for interactive or adaptive engagement—as well as allowing for complex generative behaviours to be programmed.

At the most professional level, computer programming languages may be used to design bespoke programs for liquid music, allowing for complete customization of interfaces and interactions. Video game development kits like Unreal or Unity, which offer free versions to non-commercial users, can also be used to develop standalone programs for multiple platforms. These offer the added advantage of ready integration with game audio middleware systems.

In the video game industry, large companies often use proprietary systems for audio and music programming, of which little is known publicly, though some understanding of their functions and features can be derived from studying the end product of the game. At the same time, other companies have been developing third-party audio middleware packages in an attempt to produce similar results and offer a ready-made set of tools for any game developer. It seems that a move towards a more standardized set of game audio tools is underway.[337] Middleware packages are *not* digital audio workstations, and as such do not contain all of the features that a music producer might expect; as such, they remain useful tools for programming dynamic audio

[337] Bridgett, 'The Game Audio Mixing Revolution'.

behaviours, but should remain separate from those used for music production (as discussed in the previous section).

Production values are usually a key factor in popular music, and one major issue to be addressed when attempting to create dynamic music is the need to retain professional-sounding production whilst incorporating interactive and adaptive potential. Real-time mixing, as it is being implemented in current game audio systems, is highly likely to provide a solution to this issue. The use of audio hierarchies, mixer snapshots and other techniques discussed by Bridgett, Taylor and others might enable musical works to be optimally mixed, regardless of what dynamic iteration of the music is currently being played.

In summary, for the portfolio of works accompanying this thesis, designed to test the flexibility of the proposed creation-model, a number of tools will be used based on the foregoing discussion.

- Works will be developed as bespoke software applications for both desktop and mobile platforms, with the focus predominantly on the latter. Desktop apps will be developed for Mac OSX, while mobile apps will be developed for Android, due primarily to the relative ease of developing for Android in comparison to iOS.

- An assortment of music production tools will be utilized, including Pro Tools 6, Reason 5 and Logic Pro 9.

- Pure Data will be used for some works, to assess the usefulness of such audio programming environments to the creation-model. PD will be used to develop for Android, through the use of the MobMuPlat app. This allows for integration of patches with the hardware sensors and input mechanisms, and for the creation of bespoke user interfaces. FIGURE 3.4 below shows the interaction methods supported by MobMuPlat.

- Wwise will be used, to assess the usefulness of game audio middleware. Wwise is chosen due to its position as a leading platform in the field, its sophisticated workflows enabling a wide range of interactive and adaptive elements to be programmed.

- Unity will be used as a means of developing unique interfaces that can be built as standalone apps for a variety of platforms. It is chosen over comparable game development engines due to its ease of integration with Wwise, and for the large amount of tutorial material available online to assist novice users in simple development tasks.

Interaction Methods		*Supported in MobMuPlat*
Movement	Accelerometer, gyroscope, gravity sensor	Yes
Time & date	System clock	Yes
Audio Input	Microphone	Yes
Location	Compass, GPS, proximity sensor	Yes
GUI elements	Buttons, sliders, knobs, toggle switches, touchpads, arrays, LCD panels	Yes
System Messages	MIDI, OSC	Yes
Feedback methods	Vibration, light, text, images, meters/values	Yes

FIGURE 3.4—Interaction methods available with MobMuPlat

3.3 A Creation-Model for Liquid Music

This section will present, based on the foregoing discussion, a full description of the proposed *creation-model* for liquid music as initially discussed in Chapter One, involving three distinct stages. The purpose of this model is to propose and establish an authoritative framework for the creation of *any* recorded liquid music work: one not limited by any considerations of style, genre, aesthetic, or indeed by tools and production systems used, but rather a software and hardware independent *creation-model* fully addressing the stages that must necessarily be followed when composing liquid music. As such, it represents an original contribution to the field: a clear framework by which both practitioners and researchers can create, and engage with, liquid music.[338]

This creation-model draws upon analysis of existing works of liquid music as reviewed in Chapter Two, and their methods of production. It also take influence from the available technologies and systems for the production and distribution of recorded liquid music as evaluated in the previous section, and from interviews with audio professionals involved in liquid music creation. The following sections will provide a discussion of practical demonstrations, intended both as a robust evaluation of the creation-model and as an exploration of some possibilities for developing new liquid music works. Before that, however, the three stages of the proposed model will be explicitly

[338] Though handbooks like Winifred Phillips, *A Composer's Guide to Game Music* (Cambridge: MIT Press, 2014) exist for interactive video game music, and research on interactive audio more generally (Collins, Kapralos and Tessler (eds.), *The Oxford Handbook of Interactive Audio*) there has to date been no definite work published on methodology and approaches for creating standalone, interactive, music.

delineated. While these three stages are presented sequentially, this is intended only as a rough order by which a creative artist may address them. They can be read more accurately as a holistic approach to liquid music creation, with decisions made during each of the stages affecting the completion of the other two.

As stated before, the aim of this thesis is not the development of a single interactive 'standard' file format or platform, but rather the provision of an over-arching approach to define a working method for full exploration of the liquid music paradigm. The idea of a three-stage process is echoed in Law's discussion of interactive audio standards: she identifies three aspects that are essential for game audio to work, namely 'the platform, the game (or audition application or editor), and audio content'.[339] This could be re-imagined as the arrangement and programming, the interface, and the audio assets respectively, as presented in the following sections. Thomas has also referred to his idea of a three-part approach to making liquid music that requires 'creation, distribution and experience'; 'creation' can be aligned with audio assets, arrangement and programming, while 'distribution and experience' align with interface (or user experience) design, and an awareness of how the final product may be disseminated.

It is equally important to consider that the linkages *between* the three stages—in other words, how audio assets are coupled to behaviours, or how behaviours are controlled by the interface—are as essential to the creation of liquid music as the stages in isolation.

[339] Law, 'Introducing the Interactive XMF Audio File Format'.

3.3.1 Outline of creation-model in three stages

The major contributions that this thesis has sought have been, firstly, to define and provide a foundation for the field of liquid music as a relatively new compositional paradigm; and secondly, to provide an over-arching creation-model for this paradigm. An element of 'reinventing the wheel' is apparent in contemporary practice, as many researchers will still feel a requirement to define terms in every publication, and creative artists exhibit a tendency to develop systems or working processes from the ground up. The recent *Oxford Handbook of Interactive Audio* (2014) highlights the former issue, evident through several contributors who feel a need to define or discuss core terminology.[340] The discussion of disparate platforms and standards presented earlier in Chapter Three, alongside the assortment of third-party and proprietary game audio systems in use, gives evidence to the latter.

The *creation-model* outlined here is not system or tool-specific; what it provides is a framework that must by necessity be followed when seeking to create liquid music. For any artist creating a work of liquid music, the three stages of the model must be followed and addressed. By providing a clear delineation of the necessary stages, discussing each in some depth, pointing towards the available possibilities for tools and approaches to be used within each stage, and consolidating existing practices into a clear overview, this thesis demystifies the creation of reactive and generative music, and seeks to provide a framework for any future creators in the field to follow. Provision of such a basis can enable artists to develop their ideas further, expanding or opening up

[340] *The Oxford Handbook of Interactive Audio* (2014); p.69, p.87, p.119, p.152.

new areas within the paradigm of liquid music, without the need to go through the groundwork covered here. Instead they are freed to focus on advancing their creative work.

3.3.2 Stage One—Audio Creation

The first stage concerns the creation of recorded music, or *audio assets*, very much in the model of traditional music production. This stage can be broadly aligned with existing popular music practices, though the resulting output will differ: rather than a mixed and mastered static stereo audio track, for liquid music a set of audio assets (unfixed in characteristics: they may be mono, stereo, wave files or another format) is required. Whether these files are long or short in length, comprised of individual samples, instruments or rendered mixes of several tracks, depends entirely on the requirements of the work in question with regards to composition and intended changes (the vertical or horizontal alterations discussed in the following section): different types of composition will require audio assets to be produced differently. Work to be undertaken in the other two stages, therefore, will have a significant impact on how the creation of audio assets should be approached.

Creators will, in the first stage, compose and write the music to be included in the work. This is the "song-writing" stage, as well as the music recording and production stage. Tools such as DAWs and standard audio production software will be used to create audio assets, whether by recording live sound, generating electronic sound, or collecting and processing samples. The audio files can be mixed as professional as possible at this stage, although

full mixing or mastering as completed for standard popular music production is unlikely to be possible, as the final orchestration, levels and so on may be varied in real-time. Advanced editing will need to be undertaken on the assets to ensure that they will fit seamlessly together. Looping, layering, transitions and any other form of implementation can be properly achieved in the following stage (a skill that may be more developed in practitioners of game audio production than music production).

At the end of this stage, the creator will have a collection of all necessary audio files: whatever sounds will be heard by the end user, ready to form the content of the work.

3.3.3 Stage Two—Audio Behaviours

The second stage concerns the implementation of procedural programming—that is, creating reactive and/or generative behaviours to apply to the audio assets produced in the previous stage—a process that will be familiar to creators of game audio, generative music or procedural audio of any kind. The potential tools available for this stage, as reviewed above, might include: audio programming environments such as Max/MSP or Pure Data (which could also be used in a contracted production model, wherein the production of audio might take place entirely through electronic means within these environments), game audio middleware such as FMOD and Wwise, which allow for liquid behaviours to be created in a more authored fashion, or the use of standard computer coding languages such as Java or C++ to create entirely original programs (thereby conflating the tools used for stages two and three of the

model, using the same system for creating both audio behaviours and user interfaces).

While the third option is available only to those with the necessary computer programming skills (perhaps encouraging the development of 'liquid song-writing teams,' wherein members with specialized skillsets take complementary creative roles), audio programming environments are widely used amongst electronic musicians. Game audio middleware, meanwhile, has been explicitly developed in recent years to bear greater resemblance (both visually and with regards to working processes) to traditional DAWs.[341] The professional interfaces of third-party middleware packages may be more engaging for musicians and composers unused to programming of any kind, and offer a more user-friendly method of designing liquid audio behaviours.

Upon completion of this stage, the creator will have all of their audio assets arranged and programmed with the desired dynamic behaviours, and will have as a result a file or files to be embedded, linked or accessed through an interface of some kind. These files may be audio patches from an audio programming environment, or soundbanks from an audio middleware system: either can be embedded into the programming of an application or interface created through another platform. For example, libPD allows PD patches to be embedded in standalone apps for mobile platforms built with Java, or through third-party apps such as RjDj or MobMuPlat, while Wwise soundbanks can be embedded and controlled through programming code, or integrated into a game engine such as Unity.

[341] *Products – FMOD* (http://www.fmod.org/products/, 4 March 2016).

3.3.4 Stage Three—Interface Design

The third stage concerns the design and creation of a user interface, or some form of distributable package that can then be accessed by the end users of the liquid music work. Numerous considerations must be taken into account for this design, as touched on in Chapter Three: liquid behaviours programmed in stage two will need to be controlled and made accessible through the interface, while simultaneously providing the user with feedback on how they are controlling these behaviours. Any form of user interaction requires an interface method; adaptive and generative changes might also be reflected and made explicit through visual feedback.

Max/MSP and Pure Data can act as their own interfaces, and patches from either can be built as stand-alone apps for OSX. However, this limits the scope of distribution to Mac users. It also, more importantly, limits the potential methods of interaction to those available through the audio environments (graphic user interface controls with mouse and keyboard input, or basic system state information, excluding the option for specialist controllers or hardware). By embedding patches from an audio programming language into an interface for mobile platforms, however, interfaces can take advantage of an expanded palette of hardware for user interaction methods.

Third-party game development engines are also freely available to the public, and provide a means of creating simple or more complex interfaces that can be tied to procedural audio programming (the integration of Wwise

soundbanks into Unity provides one excellent example).[342] Video games—especially music games—could be viewed in one way as elaborate interfaces for liquid music; by stripping away all ludic and narrative function from these games, a stand-alone interface (potentially cross-platform and fully compatible with many interaction methods), definable as a *composition* rather than a *game* (see Chapter Two) can be created.

Interface design can benefit from drawing upon further study into the field of interaction design, a distinct field that can be viewed as a creative discipline in which 'technical decisions influence the aesthetic qualities of the resulting interaction.'[343] Important steps such as design research and user modelling can draw largely upon the musical knowledge of the creator, while visual design or more advanced approaches may fall beyond the skillset of many musicians. For creators without further knowledge in this area, which moves beyond the scope of this thesis, it might be suggested that the user-centred design approach which has gained popularity in recent years is a good model for developing interaction and interfaces,[344] while keeping things as simple as possible, through use of the suggested tools and systems, and focusing on the musical content.

At the end of this third stage, the creator should have a completed liquid music work. Audio assets have been created, programmed with dynamic behaviours, and packaged with an interface that allows for user engagement. This work can then be made distributable through appropriate channels, ideally

[342] See Unity, Unreal Engine, or the newly launched Amazon Lumberyard.
[343] Mads Soegaard and Rikke Friis Dam, *Encyclopedia of Human-Computer Interaction* (Interaction Design Foundation, 2013).
[344] Dan Saffer, *Designing for Interaction: Creating Innovative Applications and Devices* (Berkeley: New Riders, 2010), 33.

as a standalone piece of software (or app) to ensure that users can access, listen to and engage with the music on any relevant platform, rather than requiring dedicated or specialist hardware or software.

3.3.5 Summary

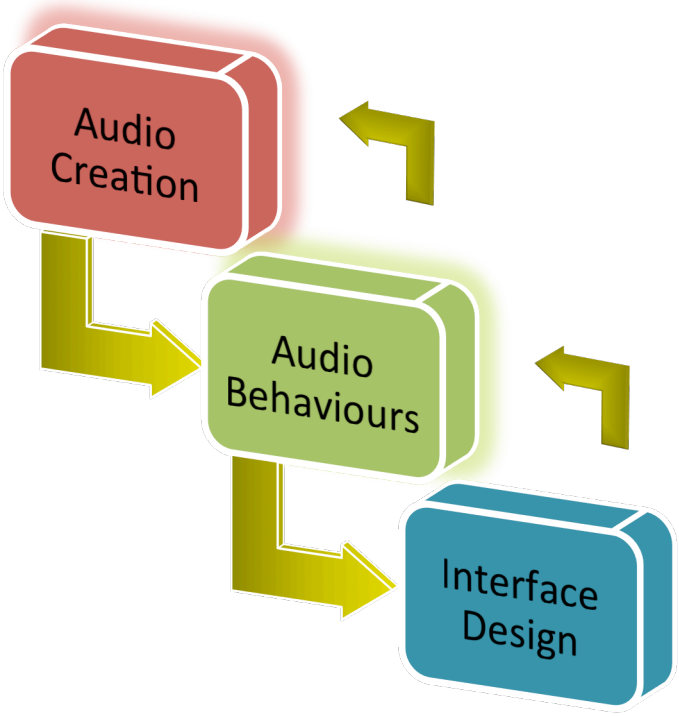

FIGURE 3.5—Flow diagram of liquid music creation-model

The proposed creation-model is comprised of three stages, illustrated in FIGURE 3.5. These stages form a loose progression from conception to completion, though ideally each of the three stages should be planned prior to the commencement of creative work, and approached holistically during development, as decisions made during each stage will impact the work necessary during the other two. The first stage is termed *audio creation*—this involves traditional song-writing or composition, music recording and production—resulting in a set of *audio assets* for use in the work. The second

involves the arrangement and programming of these audio assets with generative or reactive *audio behaviours*, thereby adding the liquid elements to the music. The third stage involves the design and creation of a suitable *user interface* in order to link the programmed behaviours to the necessary user input(s), and to drive the delivery and arrangement of the audio assets.

The creation-model is intended to reflect the common practice that has naturally emerged, as represented in discussions and interviews with both practitioners and academics, rather than imposing an entirely new framework or methodology upon the field. In doing so, it provides an authoritative framework for any future development of liquid music. This model will be applied to the creation of a portfolio of liquid popular music works, in order to rigorously test it through the use of a range of tools and techniques for each of the three stages.

3.4 Composing Liquid Music

Having evaluated existing technology for the production of liquid music, this section is aimed as assessing how compositional techniques that have been developed for 'interactive' audio, game audio and other media works, might be applied to the composition of liquid music. Drawing from game audio literature and praxis, as well as extrapolating compositional methods from the technical

capabilities of the tools evaluated, will allow for a set of musical approaches to be delineated and tested through the accompanying portfolio of works.[345]

While the existing implementations of liquid music to be found in popular music should be considered, the vast body of liquid music drawn from decades of video game releases—and the compositional systems developed alongside these—provide a valuable platform and models for composers. It should be borne in mind that the requirements of a composition intended for use in interactive media or multimedia such as video games are different to those for other multimedia (such as film or television) or for standalone liquid music (such as *Scape* or *Biophilia*). All video game music is inherently required to fulfil a number of ludic and narrative functions, being used to expand and colour the narrative setting, adhering to narrative devices, or offering ludic feedback on game events and game states.[346]

Whether game audio is implemented using audio programming environments such as Pure Data, or through audio middleware such as Wwise, the same compositional requirements must be addressed. The art of liquid composition need not be specific to a given tool or platform, but can, as a part of the creation-model, be discussed conceptually. The same compositional

[345] Karen Collins has previously pointed the finger at music education systems which do not encourage or prepare composers to write for dynamic or non-linear media in *An Introduction...* (2007); however, by 2016, a number of excellent practical texts for game audio and liquid composition—reviewed herein—have been published; while subjects or courses in music composition for interactive media are now run by a large number institutions, including Berklee, University of Melbourne and Leeds Beckett University.

[346] For a thorough discussion of these functions see Michiel Kamp, 'Ludic Music in Video Games' (MA Thesis, Utrecht University, 2009). Many of them are acknowledged throughout the literature, for example Zach Whalen, 'Play Along: An Approach to Video Game Music' in *Game Studies* 4/1 (November 2004) (http://www.gamestudies.org/0401/whalen/, 20 December 2012), or Axel Berndt and Knut Hartmann, 'Strategies for Narrative and Adaptive Game Scoring' in *Audio Mostly: 2nd Conference on Interaction With Sound*, Fraunhofer IDMT, (Germany, September 2007): 141–147.

principles that hold in game music are also largely relevant to the broader field of liquid music. The methods used to compose interactive or adaptive music, irrespective of their context within the game, can be examined and potentially applied to liquid music *sans* game.

Some literature is worthy of mention in this context. Bajakian (2010) has clearly defined the boundaries between the roles involved in game music creation: composition, editing, production and implementation are all separate roles, requiring separate skills.[347] Other industry professionals such as Paul have concurred, believing that maintaining this separation rather than integrating the roles too much, and potentially "overloading" one person, leads to a more effective process (though a knowledge of the workings of each role can assist everybody involved in better completing their own task).[348] Naturally, reactive and generative composition involve and have a relation to programming, and an artist may have complementary skills in a number of fields. The remainder of this chapter will focus, however, on the specific musical composition skillset required for an artist to write liquid music.

A Composer's Guide to Game Music (2014) by Philips provides one of the first dedicated handbooks for aspiring video game music composers, addressing a broad range of game music topics.[349] Chapters 10–13 of the book offer the most relevant information with regards to the practicalities of composing non-linear and dynamic music, separating the treatment of 'rendered music', or pre-

[347] Clint Bajakian, 'Adaptive Music: The Secret Lies within Music Itself', presentation at *Game Developers' Conference 2010* (San Francisco, 2010) (http://www.gdcvault.com/play/1012601/%20Adaptive-Music-The%20-Secret_Lies, 19 March 2014).
[348] Leonard Paul, 'Droppin' Science', in *Music and Game: Perspectives on a Popular Alliance*, Peter Moormann (ed.), (Wiesbaden: Springer VS, 2013), 63–80 (70).
[349] Winifred Phillips, *A Composer's Guide to Game Music* (Cambridge: MIT Press, 2014).

recorded audio files, from 'music data,' or approaches based on control information such as MIDI systems or implementation of procedural music (as in *Spore*). Phillips' work functions as an excellent practical handbook for nascent composers, frequently providing anecdotes from within the industry to illustrate various compositional approaches. Other recent handbooks for interactive composition, albeit highly centred on the video game medium, include Thomas's *Composing Music for Games* (2015) and Sweet's *Writing Interactive Music for Video Games* (2014).[350]

3.4.1 The Vertical and Horizontal Approaches

Approaches to the dynamic, or real-time, alteration of music can be broadly grouped into two categories: those that alter the music *vertically*—that is, changing the musical content in terms of orchestration, layers, mix levels, or expressive performative characteristics such as tempo—or *horizontally*—that is, changing the structure of the piece, the order of sections or the movement from one section to the next. These twin approaches to reactive or generative musical changes form the foundation of liquid music composition, re-appearing time and time again throughout the literature and appreciable through analysis of a vast array of works; the terms, and an understanding of them, are critical to the theory and practice of liquid music.

What is most pertinent to note is that these approaches are not limiting, instead offering a wide array of potential musical changes, which can be

[350] Chance Thomas, *Composing Music for Games: The Art, Technology and Business of Video Game Scoring* (Boca Raton: CRCPress, 2015); Michael Sweet, *Writing Interactive Music for Video Games: A Composer's Guide* (Crawfordsville: Addison-Wesley, 2014).

designed in any interactive, adaptive or generative manner, and aligned with any number of interface mechanisms or user inputs,

Liljedahl, in *Game Sound Technology and Player Interaction* (2011), affirms that in the field of game audio numerous 'techniques and systems have been developed' for the creation of non-linear, liquid music, and furthermore, that the majority of these systems have been developed as proprietary tools by commercial developers.[351] Liljedahl succinctly sums up the *vertical* and *horizontal* techniques in question: the former referring to the manipulation of musical layers in order to control 'musical intensity and emotion', the latter manipulating structure to control 'aspects of time and form'.[352] Other writers explicitly referring to these techniques include Van Geelen (2008), who discusses the practicalities of creating liquid music, while acknowledging the difficulties created by the bias of recording and production technology towards linear music.[353] He offers five potential methods for liquid composition, which are easily equated with vertical and horizontal approaches: branching, or enabling a piece to follow different paths, layering, or the addition and removal of instruments, lines or parts, transitioning, or the writing of transitions for each possible progression of musical sections, generating, equivalent to *generative* music; and parallel composing, or writing entirely pre-composed tracks that can be synchronized and then segued between in real-time. While Van Geelen's five categories offer somewhat limited methodologies within the two approaches to

[351] Mats Liljedahl, 'Sound for Fantasy and Freedom' in *Game Sound Technology and Player Interaction: Concepts and Developments*, Mark Grimshaw (ed.) (IGI Global, 2011), 22–43 (33).
[352] *Ibid.*, 33.
[353] Tim van Geelen, 'Realizing Groundbreaking Adaptive Music' in *From Pac-Man to Pop Music*, Karen Collins (ed.) (Aldershot: Ashgate, 2008), 93–102 (95).

liquid composition, he also provides an excellent practical case study using a famous drum break.[354]

The vertical approach can be further loosely divided between orchestration—simple addition, subtraction or volume adjustment of instrumental layers; or what has been termed *expressive performance manipulation*, referring to the manipulation of expressive musical features such as tempo, articulation, pitch transposition, or dynamic adjustment of DSP effects and other types of audio processing.[355]

These terms appear to be broadly understood within the fields of procedural audio and game music. They are not universal, as commentators will still suggest alternate nomenclature such as 're-sequencing,' 'branching' or 'layering', however these terms have more specific meaning within the context of liquid composition, and seem unlikely to reduce confusion.[356] What is clear is that the underlying concepts are sound, and represent a general blueprint for liquid music composition.

3.4.2 Examples of Vertical Alterations

Vertical alterations of varied kinds can be found in many of the existing liquid music works reviewed in Chapter Two. These exist in interactive, adaptive and generative implementations.

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[354] *Ibid.*
[355] Berndt and Hartmann, 'Strategies for Narrative and Adaptive Game Scoring', 143.
[356] Such is the stated aim of proposing new terms in Paul, 'Droppin' Science', 64.

Scape and *Bloom* both grant the user explicit, interactive control of audible instruments and layers. In the latter work, as well as certain songs from *Biophilia* (such as 'Thunderbolt') vertical changes can be made to performative elements such as mode, and DSP effect parameters such as delay time. Radiohead's *Polyfauna* allows the user to adjust the relative levels of the audio layers playing back at any time. This is accomplished through the simple engagement of the users' movement through the virtual environment—their distance to any of the invisible sound sources places within the environment dictates the control of amplitude levels in an adaptive fashion. Gwilym Gold's *Tender Metal* uses generative programming to make considerable vertical alterations to audible layers, mix levels, melodic construction, drum patterns and so on.

Prevalent throughout video game music, examples of vertical alteration offered in the literature include one from *Grim Fandango* (1998): Collins describes the character Manny standing on the docks, at which point the player may cause him to look up at the moon, causing a high sustained string track to be added to the existing musical cue.[357] Research on the ludic functions of game music points to a considerable number of games (*Super Mario Bros.* (1985), or *Space Invaders* (1978)), in which tempo changes are used to signal an approaching time limit, or proximity to the end of a level.[358]

Paul, meanwhile, quotes from Gustaf Grefberg, composer for *The Chronicles of Riddick: Escape from Butcher Bay* (2004) to provide a slightly

[357] Collins, 'An Introduction to the Participatory and Non-Linear Aspects of Video Games Audio', 267.
[358] Whalen, 'Play Along: An Approach to Video Game Music'.

different approach: each action cue within the game is composed of two versions, a 'battle' track and a 'sneak' track, which play simultaneously (though only one is audible at a given time). Based on the player's actions, the tracks will cross-fade back and forth in relation to the game state, providing appropriate music for fighting or sneaking.[359] Further complexity might be added to this model by increasing the number of potential tracks from just two pre-rendered audio mixes: separate stems for each instrument could be faded in and out, or alternate versions of instrument tracks provided, which could be cross-faded in order to adjust the intensity or feel of the music in an adaptive fashion driven by gameplay.

God of War (2005) provides a similar implementation of this technique, with separate layers of the orchestral track having multiple interchangeable parts of greater or lesser intensity that can be layered and substituted to create more or less intense versions of the musical cue.[360] *Fallout: New Vegas* (2010) adds and removes layers of orchestration to build or soften musical cues based on players' proximity to urban areas of the game, thereby using vertical alterations to create an adaptive, location-driven score (see FIGURE 3.6).[361] A theoretical basis for these kinds of approach is presented in the paper 'A Survey of Variation Techniques' by Berndt *et al*. The collage-like layering of musical parts, referred to as 'building set principles' derived from Baroque music theory,[362] allows a composition to be realized in a variety of forms by omitting

[359] An implementation of van Geelen's 'parallel composing'. Paul, 'Droppin' Science', 65.
[360] *Ibid.*, 65.
[361] Lawlor, 'The Music of the Mojave Wasteland', *Gamasutra* (http://www.gamasutra.com/view/feature/134544/the_music_of_the_mojave_wasteland.php, 29 December 2010).
[362] Axel Berndt, *et al*, 'A Survey of Variation Techniques for Repetitive Games Music', *Audio Mostly Conference* (September 2012): 61–67 (63).

or including different instrumental layers, each written in such a way that the piece 'sounds complete even in the absence of several (optional) parts'.[363]

Guy Whitmore provides a very useful case study of his work on the spoof-spy game *The Operative: No One Lives Forever* (2000). Within each 'music state' in the game, instruments have several variations that they could potentially play. Every time the state is called to play, one of these variations will be randomly selected. For example, there may be three guitar parts composed for a given cue, each of which will work when combined with the other instrumental layers. Only one of these is selected to play each time, while other layers remain the same, thereby offering three possible variations on the same piece of music. In this fashion, interest is maintained while the musical content changes continuously and unpredictably, without requiring excessive amounts of music to be composed. Whitmore explains: 'I found that four or five variations on two or three instrument parts was enough variety for most music states'.[364] *No One Lives Forever* utilizes a system of *downloadable sound banks* (DLS banks), including licensed sampled instruments and some original instruments and samples created for the game, all programmed through MIDI sequencing in the game engine.[365]

[363] *Ibid.*, 63.
[364] Guy Whitmore, 'A Spy's Score: A Case Study for *No One Lives Forever*', July 2003 (http://www.iasig.org/aan/NoOneLivesForever.shtml, 19 March 2014).
[365] *Ibid*.

FIGURE 3.6—Audio layering zones in *Fallout: New Vegas* (Lawlor, 2010)

Vertical alterations, therefore, can encompass a wide range of musical changes, including arrangement, mix levels, and expression performance manipulation.

3.4.3 Meaningful Vertical Alterations: Music and Emotion

Through performance manipulation and vertical alteration, there is the capacity for musical change within a liquid music composition to apply findings from other, related fields of research in a meaningful way. The common thread throughout many interrelated fields of 'music and emotion' is a specific regard to how musical features, gestures and attributes such as tempo, loudness, or

pitch relations might be abstracted and linked to distinct affective states.[366] These studies, and the approaches and methods used therein, may therefore offer a means of designing an emotionally responsive liquid music work, with real-time changes. This is one approach intended to add a purposeful structure to user engagement, and will be implemented through two of the accompanying works. This section details the theory and background necessary for using vertical alterations to develop an affect-based piece of music.

Psychologist Russell was among the first researchers to lay out a form of emotional representation that appears to have become widely accepted.[367] Building on this, Thayer (1989) sets out further evidence for the two-dimensional space as a model for the categorization of emotional states, delineated by mapping *arousal* along the x-axis and *valence* along the y-axis (FIGURE 3.7), terms which have since been taken up by many researchers.[368] Thayer also delineated the difference, as he determined it, between the previously interchangeable terms 'mood' and 'emotion': whereas emotions can change rapidly over a short period of time (often focused on or affected by individual events) a person's mood will often stay the same for a much longer period of time. Russell's proposal of the circumplex model, followed by Thayer's adjusted model of the two-dimensional arousal/valence plane, has been used extensively by researchers in the field due to its practicality as a tool for gathering and representing data. For those involved in liquid music

[366] See Patrik Juslin and John Sloboda (eds.), *Handbook of Music and Emotion: Theory, Research, Applications* (Oxford: Oxford University Press, 2011), for one example of the breadth of research into music and affect.
[367] James A. Russell, 'A Circumplex Model of Affect', *Journal of Personality and Social Psychology* 39/6 (December 1980): 1161–1178 (1162).
[368] Robert E. Thayer, *The Biopsychology of Mood and Arousal* (Oxford: Oxford University Press, 1989).

composition, another advantage of this '2DES' is apparent in its potential as an *interface*.

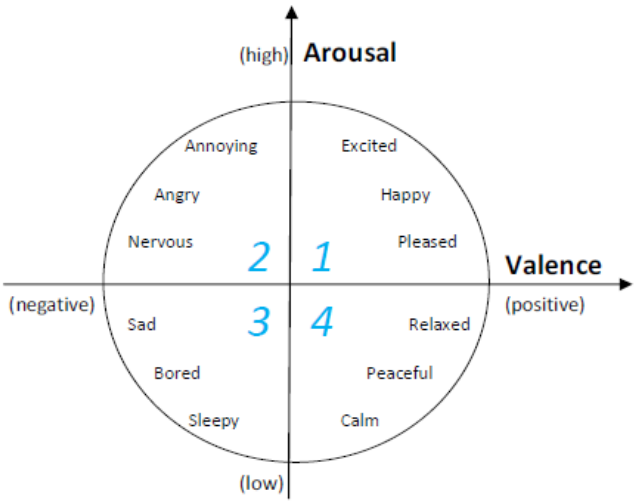

FIGURE 3.7—Thayer's arousal/valence two-dimensional emotion plane.[369]

Other studies have focused on isolating and quantifying the correlations between specific musical parameters (tempo, articulation, and so on) and the perception of emotion, as 'many researchers acknowledge that it is often an ensemble of interacting musical features that induce emotional expression.'[370] Schubert (1999) conducts a survey with four pieces of classical music: conclusions include increased arousal levels from higher tempos, though Schubert claims that 'loudness is a sufficient predictor of arousal' and the tempo adds little information.[371] Valence remains largely unaffected by tempo, other than where variation within the framework of other parameters allowed it to change. Dynamics are unequivocally mapped to arousal, while also displaying a trend to affect valence when allied with a faster baseline tempo and shorter

[369] Image taken from Pieter Kanters, 'Automatic Mood Classification for Music,' (M.A. thesis, Tilburg University, 2009), 12.
[370] Emery Schubert, 'Measurement and Time Series Analysis of Emotion in Music' (Ph.D. Diss., University of New South Wales, 1999), 177.
[371] *Ibid.*, 378.

articulations, while melodic contour can be seen to affect the measurement of valence.

Livingstone and Brown (2005) make the use of the 2DES, further subdividing their two-dimensional grid into octants.[372] A number of primary musical elements are mapped to this grid, namely are the musical mode, loudness, articulation, pitch and harmony, each of which is variable along a scale of degrees.[373]

Eladhari *et al* build upon similar principles, altering the musical parameters of musical mode or scale, tied to valence values (here referred to as 'inner mood') and the time signature of the music, tied to arousal values (here referred to as 'outer mood').[374] Their model also takes into account the fact that a given piece of music is not confined to one strict emotion throughout, but can instead jump from one *emotion* to the next on a surface level, while maintaining a more continuous *mood*. Their assignment of 'inner' and 'outer' moods highlights links between longer moods which derive more from the valence plane, and shorter emotions which derive from the arousal plane: a distinction not directly addressed, but which might be supported by evidence from a number of studies.[375]

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[372] Steven Livingstone and Andrew Brown, 'Dynamic Response: Real-Time Adaptation for Music Emotion,' *The Second Australasian Conference on Interactive Entertainment*, Yusuf Pisan (ed.) (Sydney: Creativity & Cognition Studios Press: November 2005): 105–113 (107).
[373] *Ibid.*, 108.
[374] Mirjam Eladhari, Rik Nieuwdorp and Mikael Fridenfalk, 'The Soundtrack of Your Mind: Mind Music—Adaptive Audio for Game Characters,' *ACE 2006*, June 2006 (New York: ACM, 2006), 4.
[375] This is directly quoted from Annabel Cohen's idea of 'emotional polyphony,' while echoing Thayer's differentiation between mood and emotion. Annabel Cohen, 'Music as a source of emotion in film,' *Music and Emotion: Theory and Research,* P. Juslin and J. Sloboda (eds.) (Oxford: Oxford University Press, 2001), 249–72.

Each of the studies mentioned seeks to measure or implement a system of vertical alterations to music with the expressed aim of changing the perceived mood of the piece. This is achieved primarily through the adjustment of discrete musical parameters, or expressive performance manipulation. The affective qualities of melodic and harmonic construction, or of orchestration, are infrequently touched upon. Throughout the literature, a number of musical elements have been found to have a consistent correlation with the two dimensions of valence and arousal. The musical dynamics of a song or work will map universally and directly to arousal values, while certain studies have also found that they can also evoke small changes in valence at a higher tempo or with shorter articulation. Tempo offers a similar mapping, meaning that the more beats per minute contained in a piece of music, the more it represents an aroused affective state;[376] though Schubert (1999) posits that tempo adds little information regarding arousal beyond that derived from musical dynamics. Articulation may be mapped vaguely along the valence dimension, also affecting arousal when at higher valence states. The mode of a given piece has a direct correlation to valence, but has considerably less affect when arousal is low. More or less complex harmonic content also maps to the valence dimension, though at lower valence this will serve to increase arousal. Therefore, a piece of music with alterable dynamics, tempo, articulation, mode and harmonic complexity should in theory be able to alter its perceived mood quite effectively.

An issue which does not appear to have been subject to published study is how alterations to DSP effects—equalization, reverb, delay, distortion and so

[376] The most obvious explanation for this is that musical tempo or b.p.m. reflects the human heart rate—therefore, a faster tempo evokes a faster pulse, a physiological trait present when humans are in a higher state of arousal.

forth—may impact upon the perceived emotional content of a piece. It would be surprising if such factors did not have an effect, and when dealing with the alteration of pre-recorded music they should certainly be taken into account alongside other compositional factors.

Changes to musical parameters such as those highlighted are usually implemented at a note-level, whether in research or commercial applications, through MIDI or synthesis systems. For composers of liquid music, vertical alterations could be composed in an objective, research-based fashion, intended to create a form of meaningful change through affect. The field of music and emotion psychology also provides a readily adaptable interface design in the form of a two-dimensional emotion space, capable of accurately representing, or potentially controlling, affective states.[377]

3.4.4 Approaches to Horizontal Re-structuring

As discussed in Chapter Two, structural (as distinct from causal) non-linearity can be viewed as a spectrum, from entirely linear works to entirely non-linear works. This results in four broad approaches that can be taken to structuring non-linear musical works (which by definition must also be liquid works).

Liquid works that make use of vertical alterations may of course be entirely linear. Others may be predominantly linear, yet include 'loop points' at

[377] This is an approach which may be undertaken in an intuitive or subjective fashion by composers for video game, or other multimedia; see Inger Eckman, 'Psychologically Motivated Techniques for Emotional Sound in Computer Games,' *Proceedings of the Audio Mostly Conference 2008* (Pitea: October 2008): 20–27. This also ties with Robert Thomas's view that for musical interaction to be engaging it should have an explicit function or meaning.

which the musical progression will stall until a particular input is received or condition met— 'Virus' from *Biophilia* is a prime example of this. Once a work is divided into interchangeable sections, it can be said to be in *branched form*. Branched form music will offer choices for progression at structural junctures, limiting the possible combinations within a given work and enabling the composer to retain a sense of large-scale form or even narrative (choose-your-own adventure books such as the *Fighting Fantasy* series are an excellent non-musical illustration of this concept).[378] As the inherently authored guidance of a branched form is reduced, by opening up a much greater number of choices for possible progression and structural recombination, it can be said to be in *open form*. The line between branched and open forms is unfixed, yet dependent on the level of control retained over structural progression: the majority of non-linear works can be seen to fall between these two approaches.

At the other end of the spectrum, works exist in which only one section of music is composed, exhibiting no progression, causal or structural linearity at all. This relates to Kramer's description of 'vertical time',[379] a moniker that serves well in this context as horizontal alterations are not present. Instead, the music is built from a radically free construction of vertical elements. Much generative music, including *Scape* and *Bloom*, displays this type of linearity within a liquid music context. It can also be found in reactive works such as *Inception*. These four approaches—linear with loops, branched from, open form and vertical time—can be proposed to encompass the breadth of horizontal alterations in liquid music works.

[378] Jackson, Steve and Ian Livingstone, *Fighting Fantasy* series (Puffin, 1982–1995).
[379] Jonathan Kramer, *The Time of Music: New Meanings, New Temporalities, New Listening Strategies* (New York: Schirmer Books, 1988).

3.4.5 Examples of Horizontal Alterations

Horizontal alterations, like their vertical counterparts, can be found throughout all styles of existing liquid music works. Bluebrain's *The National Mall* organises sections of music in a branched form, allowing progression from one section to the next in an adaptive fashion, based on the user's GPS location. 'Crystalline' from *Biophilia* presents an explicit visualisation of its branched form, with each musical section linked to the coloured tunnels of the interactive, game-like 3D interface. Composers of art music have notably experimented with open form works, such as Pousseur's *Scambi* or Brown's *Available Forms 2*. Boulez's *Constellation*, meanwhile, is structured with a branched form, guiding the performer through a series of choices in each iteration of the work.

In the field of video game music, horizontal alterations through branched forms are prevalent, due to the location-based nature of so many games. An early example of adaptive horizontal alterations can be seen in the game *Lazy Jones* (1984), in which the player moves between a succession of rooms, each containing a different challenge. The background music is essentially one continuous composition throughout, lasting for as long as the game is running, but providing change by transitioning to a different section of music for each room. These sections are all variations on the principle theme, and are programmed to transition from one to the next only when melodic phrases are completed, thereby ensuring a seamless musical work (which as a corollary result often lags behind the movement of the player).[380] Linear music with loop

[380] Certain variations also work as a sort of commentary on the game, such as a snippet of the melody for *Ninety-Nine Red Balloons* (written by Nena, released 1983) which is heard when the player enters the room with a game of the same title.

points to stall progression can be heard in *Sound Shapes* (2010), wherein each scene of the side-scrolling level forms a self-contained loop, repeating until the gameplay advances through to the following scene. Entirely non-linear music exhibiting 'vertical time' can be found in *Electroplankton* or *Spore* amongst many others. An interesting example of open form is highlighted by Collins in the 'Hyrule Field' location of *The Legend of Zelda: Ocarina of Time*:[381] preceded by an introductory section that does not reappear, a number of short music segments are recombined through randomized variations, possibly as a countermeasure to the propensity for players to become bored with a piece of music that would be heard many times during gameplay.

The first game audio system to explicitly utilize or facilitate the vertical and horizontal approaches, which have remained clearly defined to the present day, was the iMuse engine. This influential system was developed by LucasArts in the early 1990s in order to create a 'fully-composed soundtrack' for their games:[382] that is to say, one in which there is little or no silence, but continuous background music. In 'The Legacy of iMuse: Interactive Video Game Music in the 1990s', Strank devotes a special study to the workings and aesthetics of the iMuse system and several of the games for which it was employed. He identifies the two major features of the system as (i) musical continuity based on a cohesive system of transitions, and (ii) the introduction of variations in the form of 'horizontal re-sequencing' and 'vertical re-orchestration,' which he correctly states have 'had a great impact on the design of interactive video game

[381] Collins, 'An Introduction to Procedural Music in Video Games', 9.
[382] Willem Strank, 'The Legacy of iMuse: Interactive Video Game Music in the 1990s', in *Music and Game: Perspectives on a Popular Alliance*, Peter Moormann (ed.) (Wiesbaden: Springer VS, 2013), 81–91 (82).

music.'[383] Furthermore, transitioning between cues was identified by the developers as the most important factor for creating a soundtrack.[384]

3.4.6 Transitions

The methods and styles of transitioning between different musical cues will have a significant impact on the implementation of horizontal alterations to liquid music composition, and are key to maintaining the musical flow within a given work. Transitions have been identified by a number of writers, including Whitmore (2003) as one of the key areas for successful liquid music to address, as they are the "glue" which hold the piece together and make it appear seamless.[385]

Transitions from one cue or section to another must occur in a way that preserves musical coherence. Whether implemented through bespoke systems or audio middleware, these transitions will occur at particular times in the composition, with some kind of trigger event (whether interactively or adaptively triggered by the user or system). In terms of musical timing, this can happen immediately (with no reference to bars or beats), on the next beat, at the start of the next bar, or at the end of the current phrase or section. Each of these timings can present its own problems if implemented improperly, but defining which transition speed will work most effectively with the given material in the given situation is an important part of the composer's work.

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[383] *Ibid.*, 82.
[384] *Ibid.*, 82.
[385] Whitmore, 'Design With Music in Mind: A Guide to Adaptive Audio for Game Designers', *Gamasutra,* May 2003 (www.gamasutra.com/resource_guide/20030528/whitmore_pfv.htm, 5 December 2011).

In addition, the style of transition must be carefully chosen: sections may cut immediately from one to next (which can easily deliver rather frantic and musically incoherent results, as heard for example in the arcade game *Cavelon* (1983)): sections may cross-fade together, one section may fade out prior to the next fading in, transitions may happen in a layered fashion (with one instrument at a time dropping out, coming in or changing), or finally, unique or specific transitional music may be written to move from one given section to another. The composition of such extra musical material and/or the careful programming of transitions between each possible section is called a *transition matrix.* As Whitmore discusses in his case study of *No-One Lives Forever,* each thematic idea in the game is broken down and arranged into several 'music states', which can play for an indeterminate amount of time (allowing them to loop and continue for as long as required by the game engine).[386] Each state—the first of which in any level is simply silence—offers a different level of intensity, from ambient arrangements, to suspense, to action, reflecting the gameplay and player's actions as they move through a game level. As the music may be required to shift from one state to another at any point, a *transition matrix* is implemented in order to ensure seamless transitions at all times. Some cues can move directly from one to the other, yet some require extra musical material to be written, resulting in the composition of an assortment of brief transitional cues to complete the matrix. Whitmore elaborates further on transitions being set to occur at different points: for example, rhythmically ambiguous states could transition immediately to something with a beat, without breaking the musical flow or seeming unnatural. States with more of a

[386] Whitmore, 'A Spy's Score'.

beat or pulse, however, require transitions to occur only on strong downbeats; states with strong melodic phrases might require transitions to be held until the end of a given phrase, all so as to maintain the musical flow and give the impression that the end product which the user hears resembles a single piece of through-composed music.[387]

Transitions may also be aided by the use of *stingers*. These are short musical flourishes or fragments that can be triggered directly by a given game event and may play at any time. Paul (2013) adds a second similar category to the discussion, *overlays*, which he states are 'longer and less percussive musical phrases'[388] that function in much the same manner as stingers. The primary use for stingers (aside from the ludic function of highlighting a particular game event, for example locating a quest object as in *Tomb Raider* (2013)) is to help cover the change between musical segments. A loud fanfare or percussive strike, played over a cross-fade or other type of transition, can help to preserve the musical flow and distract from what might otherwise be a jarring movement from one piece of music to another.

3.4.7 Randomness and Variation

In *From Pac-Man to Pop Music*, Kaae discusses 'Theoretical Approaches to Composing Dynamic Music for Video Games', in which both the concepts and practical elements of liquid music composition are addressed. While the non-linear nature of liquid music is a key element for Kaae, he also writes of its

[387] *Ibid.*
[388] Paul, 'Droppin' Science', 66.

'variability', referring to either weighted or random variation made by the computer, as distinct from 'adaptive' audio driven by game engine states and events.

One of the most high-profile games to implement a procedural (or liquid) music system to date has been *Spore* (2008). *Spore* was designed as an exploration of emergent systems, with a form of generative character creation at the core of the gameplay. The accompanying game music reflected this approach, and benefitted from the input of Brian Eno.[389] Spore's music was created and implemented with a bespoke version of Pure Data, called EAPD, designed to integrate with the EA game engine, and comes to the foreground during the 'editor' sections of the game. As players are expected to spend a lot of time within these sections, the use of ever-changing background music will prevent aural fatigue or irritation as might be caused by fixed, looping music. Also, with little actual "gameplay" going on, more CPU power becomes available to drive the music engine. In reaction to every action taken by the player, instrumental layers drop in and out, short themes are played, and the very scales and modes used in the composition will shift and change, all intended to 'respond to the user, but in a way which makes musical sense'.[390] This indirect response to the user's actions classifies the music of *Spore* as adaptive, rather than generative, yet it also makes use of many techniques drawn from generative composition, namely the use of algorithms, markov chains, weighted randomization and so on. Audio developer Aaron McLaren describes this form

[389] An excellent discussion on generative systems given by Eno and *Spore* creator Will Wright can be found online: *Wright and Eno Transform Generative Systems into Art,* (http://fora.tv/2006/06/26/Will_Wright_and_Brian_Eno, 19 August 2014).
[390] Kent Jolly and Aaron McLaren, 'Procedural Music in *Spore*'.

of composition as 'composing in probabilities'—a different approach to composition, using external events (in this case, player interaction with a game interface) to trigger musical development and variation: 'it's still composition, but in a different paradigm'.[391]

3.4.8 Conclusions

A large ranges of approaches to altering music in liquid fashion can be grouped under the heading of either vertical or horizontal change. This is loosely relatable to two-dimensional representations of music, such as in a score: the horizontal flow of the staves shows the unfolding structure of the music over time, while the vertical stacking of notes and staves shows harmonic content, pitch, and orchestration. It can also be seen from some of the examples given that the line between horizontal re-structuring (changing musical sections) and vertical re-orchestration (adding or removing layers) may be blurred in a given piece of music, as the addition or removal of layers can be equated with a change of musical section, or vice versa (especially within a popular music paradigm). This is left open to individual analysis and interpretation.

3.5 Popular Music Compositional Aesthetics

It has been stated in Chapter One that the focus of this thesis will be on popular music, defined broadly as any musical work for which the primary artefact is the

[391] *Ibid.*

recording, disseminated for broadly commercial reasons through the mass media. When developing a practical portfolio of compositions, with the aim of evaluating the creation-model proposed, it is important to ensure that these compositions musically adhere to the expected aesthetics of popular music in order to benchmark the finished portfolio against existing works. However, the given definition does not make any provision for aesthetics, focusing instead on format, distribution and commercialism. This section, therefore, seeks to establish a broad aesthetic or style that is appropriate to Western popular music, which can be used to influence or guide the composition of liquid music works as a part of this methodology. This will also help to establish the applicability of the creation-model to existing musical styles, in the expectation that liquid music should not need to differ in any aesthetic fashion from fixed, solid music.

The outcome of this section should not be taken as any comprehensive overview of popular music aesthetics, but rather represent a theoretical conceptualization of certain styles of 'popular music'. A rough set, or sets, of musical traits should be derived which can be used to identify given genres of popular music. The primary method of establishing this will be through analysis of key compositional features that can be identified as common to the majority of musical works within a given genre. This will be then be supported by analysis of a small number of important works.

As Gracyk (2007) states, 'popular music embraces a staggering range of sounds and practices.'[392] The majority of those involved in popular music studies—whether they see themselves primarily as musicologists, sociologists, or another—seem to agree that it is very difficult to establish a set of solely musical characteristics, based on rhythm, harmony, melody, structure, or instrumentation, by which popular music or genres therein can be identified. However, various efforts at doing so have been made, and there is acceptance from a certain section of academics that such a musicological approach is possible, and provides a necessary element of a broader approach to popular music studies. Frith (2004) identifies the absorption of Afro-American forms and conventions as the key factor that separates Western popular music from other musical traditions in the twentieth century.[393] Moore (2017) meanwhile suggests that 'there do seem to be ways of articulating musical sounds that are common to many of these songs which listeners call 'rock.'[394] It is these ways that will be identified below, not just for rock but for other branches of popular music.

3.5.1 Identifying Three Meta-Genres

Shuker (2016) discusses the issue of genre in music, agreeing that there are stylistic traits or characteristics present, in terms of compositional elements, instrumentation and so on, that can 'produce an identifiable sound.'[395] While it

[392] Theodore Gracyk, *Listening to Popular Music, Or, How I Learned to Stop Worrying and Love Led Zeppelin* (Ann Arbor: University of Michigan Press, 2007), 1.
[393] Simon Frith, 'Towards an Aesthetic of Popular Music,' in *Taking Popular Music Seriously: Selected Essays* (London: Routledge, 2007), 145.
[394] Allan Moore, *Rock: The Primary Text*, 2nd ed. (Abingdon: Routledge, 2017), 2.
[395] Shuker, *Understanding Popular Music Culture*, 5th ed. (Abingdon: Routledge, 2016), 113.

is unlikely that a listener, given no extra-musical context, would always be able to correctly identify musical works as one genre or another, it can be argued that a common set of characteristics exist that would allow the bulk of works to be correctly identified purely through musical means. A Beethoven sonata is unlikely to be labelled 'pop,' nor a heavy metal song as 'house,' by any even reasonably educated listener.

Shuker points towards *pop* and *rock* as 'the dominant meta-genres in popular music,' utilizing the term meta-genre to refer to a broad branch of popular music with many sub-genres, which will likely exhibit a considerable amount of stylistic variation around a basic set of common features.[396] From a list of twelve proposed by Shuker, while acknowledging the fluidity and potential for debate around these dozen meta-genres, I have chosen three on which to focus: the aforementioned *pop* and *rock*, along with *electronic dance music (EDM)*. These three have also been selected as they are the styles in which the bulk of my own professional practice, as composer and producer, has been undertaken. Sets of common musicological features proposed here are drawn from my own observations and experience, as well as implicit reference to commentators and music journalists. As these represent styles in which I have considerable experience, this should allow the focus during creation to remain on the application of the creation-model and liquid music approaches.

As quoted above, Moore suggests in *Rock: The Primary Text* that rock music has a common set of musical features, including common instrumentation

[396] *Ibid.*, 83.

and harmonic organization.[397] Instrumentation can be seen as key to establishing music as rock: the core of guitar (usually electric), bass guitar and drum kit is a common theme of almost all rock songs, with regular focused on vocals and lead guitar in melodic and virtuosic roles. Distorted electric guitars are a key timbre which dominate certain styles of rock. Many songs follow a roughly standardized verse and chorus structure, though it is not unusual to find exceptions to this. Harmonically, rock songs are often relatively uncomplicated, making use of frequent repetitions of short progressions.

The meta-genre *EDM* offers two observations within its name on how it might be identified, one cultural and one production-based. Many definitions of the term will mention that the intended purpose of the music is often for dancing to, while the methods of production employed are largely based upon the electronic manipulation and generation of sound. Shuker (2016) also suggests that EDM has 'a reliance on technology and beat,' with a major focus on sampling also highlighted.[398] These encapsulate the key elements of the meta-genre, foremost amongst which is the predominance of repetitive beats and rhythms, almost without exception using a 4/4 time signature. This is perhaps best highlighted by the 'four-to-the-floor' element of house music, in which the kick drum is played on every quarter-note. Instrumentation tends to be created from a combination of electronically generated timbres, from synthesizers, and electronically manipulated pieces of audio in the form of samples (refer to section 2.2.3 for a discussion of this practice). Harmonically, like rock music, EDM is usually built from regular repetition of short, straightforward

[397] Moore, *Rock: The Primary Text*.
[398] Roy Shuker, *Popular Music: The Key Concepts*, 4th ed. (Abingdon: Routledge, 2017), 112.

progressions. Structurally, it is less likely to adopt a verse and chorus structure, more regularly having lengthy sections broken up by 'builds' and 'drops'.

Finally, *pop* music is most difficult to identify in isolation, as this meta-genre tends to be stylistically flexible, drawing on elements from other popular music genres to follow commercial trends. However, pop is uniquely focused on the artist's voice, with vocals at the forefront of nearly every song. Time signatures are often 4/4, though some exceptions to this can be found. Structurally, a narrative verse-chorus approach is to be expected more frequently than any other. As identified by Burgess (2014) amongst others, many characteristics of EDM have come to underpin pop hits in the early 21st-century.[399]

3.5.2 Analysis of Songs

Following the methodology used by Stephenson in *What to Listen for in Rock* (2002), the establishment of a broad set of musical features common to each of the three meta-genres of popular music given above can be reinforced by an analysis of individual works.[400]

Establishing criteria for deciding which works to analyse in this case is problematic. Firstly, a recent timeframe should be set, so that the aesthetics discussed are relevant to contemporary trends. As the primary purpose is to provide a stylistic benchmark for the composition of the accompanying portfolio, it is decided that modern aesthetics, rather than those of 'classic'

[399] Richard James Burgess, *The History of Music Production* (Oxford: Oxford University Press, 2014).
[400] Ken Stephenson, *What to Listen for in Rock* (New Haven: Yale University Press, 2002).

tracks, should be referenced. For that reason, all the works selected for analysis here will be drawn from specific and recent time periods.

If popular music is produced and disseminated for commercial reasons, then commerce may be one deciding factor in selecting works: total sales figures provide one means of deriving key works, while time spent in the sales charts offers another. Radio airplay and streaming figures could be used to suggest popularity or commercial success. More critical evaluation of works may be drawn from commentators and journalists, either through their direct suggestion of particular works as important to a given genre, or through the kind of 'best of' lists regularly compiled for a variety of topics. The Rock & Roll Hall of Fame, for example, set their criteria for entry as artists who: made their first release at least twenty-five years previously; demonstrate 'unquestionable musical excellence and talent'; and who have had 'a significant impact on […] rock & roll'.[401]

A combination of these approaches is used herein. For *pop*, arguably the most commercially focused of the three meta-genres, a survey was conducted in January 2013 of time spent in the UK singles charts over a five-year period from 2007–2012. The songs ultimately chosen were those which attained a No.1 status in the UK charts, within the given timeframe, for a period of at least five weeks: this provided a set of nine songs, as detailed in FIGURE 3.8.[402] These songs were then evaluated for their adherence to the criteria given above.

[401] *Induction Process* (www.rockhall.com/inductees/induction-process, 4 July 2018).
[402] All sales records used to derive the lists were taken from the Official Charts Company website (http://www.officialcharts.com/archive, 4 Feb 2013).

Song Title	Artist	No. of weeks at #1	Tempo	Key	Time
We Found Love	Rihanna/Calvin Harris	6	128	F#	4/4
Someone Like You	Adele	5	67	A	4/4
Somebody I Used to Know	Gotye/Kimbra	5	130	Dm	4/4
Just Dance	Lady Gaga	10	124	C#m	4/4
Umbrella	Rihanna	10	88	Bbm	4/4
Mercy	Duffy	5	130	G	4/4
Bleeding Love	Leona Lewis	7	104	F	4/4
Grace Kelly	Mika	5	124	G	12/8
I Kissed a Girl	Katy Perry	5	132	Am	4/4

FIGURE 3.8—Table of chart-topping pop songs in the UK, 2007-2012

The primacy of the vocal track is readily apparent throughout this sample of works. Without exception, the vocal is at the forefront of these songs, often being a vehicle for virtuosic expression and musicality. Harmonically, few of the songs offer anything complex. Most are built upon regular and prolonged repetition of two- and four-chord progressions, including the I—V that opens 'We Found Love', or the i—VII that underpins most of 'Somebody That I Used To Know'. Only 'Grace Kelly' has significantly more complex harmonic content, which can be ascribed to the clear influence of jazz or musical theatre on the work.

Structurally, all are without exception based around the interpolation of verses and choruses, in variations on the established 'song structure.' All but one of the songs are in 4/4, and the one exception in 'Grace Kelly' still exhibits a strong rhythm of four pulses to a bar, only with a compound division into 12/8.

Tempo changes within the songs, either sudden or gradual, are almost non-existent. 'Someone Like You' has a brief *ritenuto* before a softly-sung chorus which instantly restores the original tempo; 'Bleeding Love', the other ballad present, decreases its tempo after the percussion has dropped out during the coda. Both the latter song and 'Grace Kelly' make use of half or double-time sections, though the same pulse continues through these songs. The majority of songs are grouped around a tempo range of between 120 and 130 b.p.m., though several slower ballad-type songs are also present. The construction of songs from pre-existing samples and loops lends itself naturally to the establishment of a *tempo grid* set to a master tempo, ensuring that every layer added to the song's arrangement can be kept perfectly in time and easily re-arranged. Production software like Pro Tools has aided this style of composition, and enshrined the tendency for popular music to retain a single tempo throughout a given song, rarely using either sudden switches of pace or passages of gradual *accelerando* and *ritardando* (despite the capacity for such changes to be programmed within most modern DAWs).

For *EDM*, different criteria are used to establish a sample of works. *Billboard* magazine, a leading publication of music sales and journalism, regularly publish 'best of' lists for given genres and time periods. For this section, the '50 Best Dance/Electronic Songs of 2017: Critics' Picks' was taken as

a source, as it claims to rank songs from the year in question by both their commercial sales and influence on the genre as a whole.'[403] Such influence is arguably hard to accurately gauge for a list published at the end of the year in question, however the compilers of the list are professional music critics, and can therefore support their subjective choices with a level of knowledge and experience. The top ten songs from this list are taken and summarized in FIGURE 3.9.

Song Title	Artist	Position in Chart	Tempo	Time
Slide	Calvin Harris	1	104	4/4
Stay	Zedd	2	101	4/4
It Ain't Me	Kygo	3	100	4/4
Silence	Marshmello	4	142	4/4
Scared to be Lonely	Martin Garrix	5	138	4/4
Love$ick	Mura Masa	6	89	4/4
Line of Sight	ODESZA	7	90	4/4
Know no Better	Major Lazer	8	119	4/4
More Than You Know	Axwell Ingrosso	9	123	4/4
Without You	Avicii	10	134	4/4

FIGURE 3.9—Table of top ten EDM songs of 2017 according to *Billboard* critics

[403] *Billboard's 50 Best Dance/Electronic Songs of 2017: Critics' Picks*, December 2017 (www.billboard.com/articles/news/dance/807060, 9 July 2018).

Each of the ten tracks listed gives prominence to rhythmic elements, with strong beats and rhythmic patterns emphasized, especially on the choruses. Vocals are also important, with featured vocalists appearing on almost all of the tracks—however, the chorus sections of the tracks are more likely to push the rhythm and electronic elements to the forefront of the acoustic space. All ten songs are in 4/4, though there is a clear divide between slower songs in and around 100b.p.m., and faster songs from 120b.p.m. and upwards.

Instrumentation is dominated by synthesizers and manipulated samples. Several tracks use loops of acoustic instruments—guitars or pianos—but these are audibly manipulated and looped. Harmonic progressions are, almost without fail, short repetitive loops. 'It Ain't Me' shows more complexity than any other songs on the list, with an eight-bar progression for the bulk of the song and variation at the pre-chorus section. The structures of the sample selected show, along with prominent vocals, an unexpectedly regular use of verse and chorus sections to build song structures.

Finally, for *rock* music, a slightly more arbitrary approach utilizing Google's online search engine will be taken. By entering a search for 'rock songs 2010s,' a list of songs is automatically populated. No explanation is provided for how or why these songs are selected, though it is noted that while repeatedly searching the same term does not alter the results, searches for 'best rock songs,' or 'top rock songs,' provide slightly different results. This list is taken, despite the esoteric reasoning for its creation, potentially drawn from sales, commercial activity, advertising, user searches or other search engine data.

Limiting the list to one entry per artist, and selecting eight from the top sixteen, gives the following set of songs for analysis.

Song Title	Artist	Tempo	Time
Tighten Up	The Black Keys	109	4/4
The Catalyst	Linkin Park	135	4/4
Another Way To Die	Disturbed	112	4/4
Dark Necessities	Red Hot Chili Peppers	92	4/4
Radioactive	Imagine Dragons	136	4/4
Say You'll Haunt Me	Stone Sour	140	4/4
Do I Wanna Know?	Arctic Monkeys	85	4/4
Still Breathing	Green Day	75	4/4

FIGURE 3.10—Table of first eight song returns on Google search for 'rock songs 2010s'.

Each of these songs exhibits the clear instrumentation common to rock music, built around the core of bass, drums and guitars supporting a lead vocal. Distorted electric guitars are present somewhere in the texture on all but one of the tracks ('Dark Necessities'). Again, as seems to be the case for each of the meta-genres analysed, the established 'song structure' with interpolated verses and choruses is traceable through each of the songs listed. Harmonically, the songs are based around regularly repeated progressions, often suggested within the song textures by prominent motives or 'riffs' played on guitar or bass guitar.

Songs are again dominated by the 4/4 time signature, though without any real pattern to the distribution of tempos. It is also worth noting the gender divide in vocalists between different meta-genres. While the sample of rock songs taken is entirely dominated by male singers, the samples from pop in contrast almost all feature female vocalists. The EDM sample falls somewhere in the middle, with both genders reasonably represented in vocalist roles.

3.5.3 Summary

The aim of this examination of popular music meta-genres is to establish aesthetics, or musical feature sets, that can be broadly said to be representative of the genres. Identifying features are proposed for *pop, rock* and *EDM*, which are then tested through analysis of songs from within given timeframes, selected by largely arbitrary commercial and critical measures. As a result of this process, loose compositional aesthetics for the accompanying portfolio of works are established. By composing within these aesthetics, the works developed can be shown to fall within the three meta-genres, and therefore broadly representative of contemporary popular music styles. This will ensure that liquid music creation is evaluated within the context of existing compositional practices, and does not require specific musical aesthetics to be valid—rather, it is a paradigm for composition that should be applicable to any genre, meta-genre or sub-genre.

3.6 Practical Demonstrations

Following directly from the creation-model proposed earlier in this chapter, a portfolio of demonstration works has been created, intended to rigorously test different applications of the creation-model using assorted hardware and software combinations. The demonstrations also aim to explore as wide range as possible of the compositional techniques discussed, in order to ensure that none of these musical possibilities necessitate variation or departure from the three stages outlined. These liquid music works have all been designed deliberately, using approaches and techniques drawn from the research undertaken herein, to cover a range of different possible approaches to the paradigm of liquid music—including some original ideas—showcasing both the necessity of the three-stage creation-model, and its flexibility.

The portfolio consists of four short demonstration works, presented as initial and relatively straightforward explorations of the concepts underlying their composition. A fifth and final large-scale major work draws together many of these ideas and develops them further, providing an original and comprehensive example of liquid music creation.

While the creation-model is focused primarily on the technical and practical requirements for liquid composition, and is intended to be equally applicable to all genres and styles of music, it is important to demonstrate that liquid music is not an aesthetic of its own—rather, it is a compositional paradigm. For this reason, it was decided that the various works in the portfolio should be designed to broadly adhere to a pre-existing aesthetic, in this case

that of popular music. The compositions will refer back to the analysis of popular music aesthetics delivered in the previous section in order to show that nothing in the creation-model inherently or unavoidably imposes any stylistic or musical features. Furthermore, it ensures that the works created meet the professional standards of published music in this field, in terms of both their composition and production, and that liquid music works can be developed on a par with existing popular music.

The portfolio is not, however, intended as a presentation or espousal of particular programming approaches, or design elements. As stated in the introduction, this thesis is intended as a musicological work concerning the paradigm of liquid music from a primarily compositional and theoretical standpoint: being written for musicians, there is no concern given to providing original contributions in the fields of computer programming or interaction and interface design. These field are engaged with as a necessary part of the three-stage creation-model, and a range of options are explored in a basic fashion to test both the applicability and the flexibility of the model. Further work may be done by more skilled practitioners in these fields, who have a lot to offer as part of any liquid music production team.

Considerable time is spent in the previous chapter analysing and discussing existing liquid music works in a variety of fields—primarily popular music, but also video game music and art music. Each of these exhibits some kind of inherent mutability expressible as either vertical or horizontal alteration, if not both. As a first step in developing a portfolio of works, these compositional approaches were collated and summarised in order to establish a

list that should be addressed within the portfolio, and to highlight any particular trends or connections that might be present. These are shown in FIGURE 3.11 below.

Art music, as a primarily performative genre rather than a recorded one, is in some ways less applicable to the stated aims of this thesis: issues of progression relate more to performer or conductor choices and activities, and require a control method rather than any form of designed interface. While composed and performed works like Boulez's *Constellation* or Lutoslawski's *Symphony No.3* (which uses a technique labelled 'controlled aleatory' to, in effect, create a liquid music performance guided by the conductor)[404] include fascinating compositional approaches that may provide inspiration for future liquid music works, they do not directly offer examples of approaches to *recorded* music. However, they are included here so that any potential influence or ideas may be drawn for the purposes of the accompanying portfolio.

VIDEO GAME MUSIC		
	Horizontal	*Vertical*
Wii Music (Mii Maestro)	Linear	Tempo, Dynamics [Responds to user action]
Guitar Hero III	Linear	Layering [Responds to user action]
Sound Shapes	Linear progression of loops [Responds to game progress]	Layering [Responds to game progress, Active Score Agents]
God of War	Branched form [Responds to game state]	Layering [responds to game state]

[404] Charles Bodman Rae, *The Music of Lutoslawski* (3rd ed.) (Omnibus Press: 1999), 77.

The Operative: No One Lives Forever	Branched form	Layering, Variation [Responds to game state and randomization]
Fallout: New Vegas	Open form [Responds to location]	Layering [Responds to location]
Electroplankton	Non-linear ['vertical time']	Musical material [Responds to user action, Active Score Agents]
POPULAR MUSIC		
	Horizontal	*Vertical*
Tender Metal	Linear	Musical material [Generative]
Golden Years EP	Linear	Layering [Responds to user action]
Biophilia, 'Virus'	Linear progression of loops [Responds to game progress]	Gamelan chime layer [Responds to game state, Active Sound Agents]
Biophilia, 'Mutual Core'	Linear, with one adaptive change [Responds to game progress]	Musical material [Interactive]
Biophilia, 'Crystalline'	Branched [Responds to accelerometer]	n/a
The National Mall	Branched [Responds to GPS location]	Layering [Responds to GPS location]
Polyfauna	Non-linear ['vertical time']	Layering [Responds to location]
Scape	Non-linear ['vertical time']	Musical Material [Responds to user action, Generative, Active Score Agents]
Inception: the App	Non-linear ['vertical time']	Musical Material [Audio input, Responds to hardware sensors]
ART MUSIC		
	Horizontal	*Vertical*
Musikalisches Würfelspiel	Linear	Musical material [Based on dice rolls]

Scambi	Open Form [Based on user arrangement]	n/a
Klavierstück XI	Open form [Performer controlled]	Tempo, Dynamics [Based on horizontal progression]
Twenty-Five Pages	Open Form [Based on user arrangement]	Tempo, Musical material [Performer controlled]
Third Piano Sonata, 'Constellation'	Branched [Performer controlled]	n/a
4'33	Non-linear ['vertical time']	Musical Material [Audience/ambience]

FIGURE 3.11—Table of compositional implementations of liquid music

A number of observations and conclusions can be drawn from this table, to serve both as general guidelines that may be useful for composers of liquid music, and as a set of principles or approaches that have informed the portfolio of demonstration works accompanying this thesis.

Firstly, there would appear to be a loose correlation between the types of structure, or horizontal alterations, and the vertical changes found within any single work. Works which retain a linear structure often use orchestration changes, through the addition or subtraction of layers, as a method of vertical change, and may also use loop points to add a reactive element to the progression of the work. Works that are entirely non-linear, exhibiting 'vertical time', may include generative sound sources, perhaps allowing for the manipulation of 'active score agents' or on-screen sound generators, add or remove layers adaptively through reaction to location, or make use of audio input through a hardware microphone to encourage reactive music relevant to a given environment (as in *Inception: the App*, for example).

Open form appears to be more prevalent in the sphere of art music than any more commercial genres, perhaps suggesting that it is inherently unsuited to the traditional linearity of the song forms central to a popular music aesthetic (as discussed in the previous section). Open form, liked branched form, is built from segments of fixed musical material which may be longer or shorter. How these segments are treated, and transitions between them, are highly important. Between the open form and branched form works listed above, various options for such treatment are offered. Segments may be looping, or exhibit a contained vertical time, allowing them to run indefinitely before any progression must be made. Some works may be programmed to make a randomized choice if no input is received ('Crystalline'); progression may also be guided adaptively, negating the need for indefinite playback of a given section, by responding to location (*The National Mall*) or another parameter. Engagement through a graphic user interface (GUI) might be used to adjust mix levels (*Golden Years EP*); to manipulate active score agents (*Scape*); or progress a stalled linear form through user activity (*Sound Shapes*).

Works exhibiting a branched form face many of the same issues as those in open form, with regards to progression and transitions between sections. The greater control that the composer retains over large-scale form, however, through careful design of the structural progression, suggests that branched form may more easily be utilized for recognisable song structures as often found in popular music. This seems to be borne out by its use in the popular liquid music works reviewed. Branched form may be implemented in either an adaptive fashion, as seen in *The National Mall*; or in an interactive fashion, as

seen in 'Crystalline' from *Biophilia*. There also appears to be a regular link between branched from and a 'layering' approach to vertical alteration, wherein instruments in each section may be added or removed to reflect some other parameter or engagement option.

3.6.1 Conception and Aims for Portfolio

Whitmore feels that the compositional approaches specific to game music are different to those required for other musical genres, and he states that working on video games 'freed [his] thinking about how music is put together'.[405] While approaches to liquid music composition might consist of a handful of relatively simple concepts—outlined in the table above as four approaches to non-linear structure, and the vertical approaches of layering or performance manipulation—many existing liquid music works, particularly in the field of video games, exhibit innovative and complex scores built upon these concepts. This indicates that liquid music is not simple or limited, but in fact quite the opposite: within these basic concepts lies the potential for an enormous amount of variation and experimentation with different approaches: a huge creative palette in a new paradigm for composers to explore and develop.

The aims for the accompanying portfolio do not include attempting to comprehensively explore liquid music composition, a task which would be nearly impossible. Rather, the principle aim of rigorously testing the creation-model proposed for liquid music creation will be approached by designing a

[405] Whitmore, 'A Spy's Score'.

number of works, each of which tests and explores a different combination of possible tools and techniques. Different technologies will be used—different horizontal alterations and non-linear structures—and different vertical alterations, while within these, different solutions will be tested to some of the inherent and common problems faced by liquid music composers. Through this, the creation-model will be examined for its flexibility to different approaches, and its strength in facilitating these differences.

Based on the findings and discussion above, the first four minor works in the portfolio were planned to test the following. Two works should provide implementations of *only* horizontal and vertical alterations respectively, to ensure the coherence of such approaches in isolation; the same two works should test user engagement in only interactive, or only adaptive fashion. Building upon these, two further works should be designed to integrate horizontal and vertical alterations, exploring some of the linkages between these compositional ideas. The same two works should also seek to integrate interactive and adaptive engagement, exploring how multiple input mechanisms can be used within a single piece of music. Three of the four possible approaches to structuring will be employed through these works. As one work will be only focused on vertical alterations, it must be fully linear, while the remaining three will explore implementations of branched and open form.

In terms of production tools, all works will utilize a combination of professional DAW and music production software for stage one—there is less need for examination of the efficacy of different tools at this stage, as the use of a variety of platforms for music production is already established by

practitioners. Two of the works should be designed using Pure Data for both stage two, audio behaviours—one of these can then be built as a desktop application, with PD providing an interface (stage three), while the second should be built for the Android platform, using MobMuPlat as an interface designer. The two remaining works should be designed using Wwise for audio behaviours, and incorporating the resulting soundbanks into interfaces and programmes built in Unity. These latter works will remain as desktop applications for MacOSX, due to the higher level of programming skills required to build Unity apps for mobile platforms—arguably beyond the ability of most musicians or composers at the time of writing, including those of the author.

Following these four minor works, a brief evaluation will be carried out. This will then inform the creation of a final, major portfolio work, which will again aim to include and explore a broad range of compositional ideas in order to test the creation-model through a larger-scale compositional work.

3.6.2 Ash Player

The first and simplest of the demonstrations documented here is entitled the *Ash Player*, a work developed for the Android platform. This work focuses entirely on *horizontal* rather than *vertical* change, and offers a preliminary exploration of branched non-linear structures, in order to address some of their inherent compositional difficulties. The *Ash Player* is composed with a guided non-linear structure, or *branched form*, similar to those used in liquid popular music works such as Björk's 'Crystalline', as well as art music works such as

Boulez's *Constellation* and non-musical media like hypertext fiction. The work also focuses exclusively on *interactive* user engagement, with the intention of explicitly linking the user input to the desired musical change.

Aesthetically, the music follows the characteristics discussed in section 3.5, and exhibits an EDM style. This is accomplished through a consistent 'four-to-the-floor' kick drum beat which runs through much of the song, the foregrounding of drums and percussion in the mix, use of sampled bass and guitar loops, and a female lead vocalist whose lyrics are also sampled and used as melodic 'hooks' at different points of the song.

The first stage (audio creation) was undertaken using a range of music software packages including Pro Tools LE, Reason 4 and Logic Pro X. The work is designed in such a way that the user holds interactive control over the progression of the song, from one song 'segment' to the next, [406] following a structural skeleton planned out during this composition phase. To implement the branched form, the song was initially recorded, mixed and produced as twelve individual segments, comparable to the verse, chorus, break of a standard song structure. Each segment was then rendered as an audio file, containing all of the vertical musical information in a finished form, something made possible by the exclusive use of horizontal change in this work. The twelve segments are composed to be self-contained with no over-lapping phrases, in order to enable the programming of simple cue-to-cue transitions during the second stage on the creation-model, without jarring or unmusical results.

[406] I will refer hereafter to the fragmented parts of liquid music works as 'segments,' in order to avoid confusion with 'sections' of this written thesis.

For successful implementation of a guided non-linear structure, it is critical to decide both what will guide the progression, and how this will be controlled. Progression may be generative (or randomized), adaptive to external states, or may be made interactive, requiring a direct user input—in the latter case, as is used for the *Ash Player*, the composer must also account for the possibility of *no* input being provided by the user, and consider how the music will respond in these circumstances.

The first option is to ensure that playback continues despite a lack of user engagement in an interactive system. This might be achieved by including a generative element in the audio behaviours, which would automatically make choices in the absence of interaction.[407] This has the advantage of allowing a song to continue through its structure in a timely fashion, not disrupting musical progression, yet also has the disadvantage that user input is not necessitated, which may potentially devalue user interaction and discourage engagement.[408]A second option would be to link the structural progression to some kind of adaptive input (position, rotation, time, or anything else), ensuring that there is always a state to be read and used to guide progression, again making sure that musical flow is not broken. As mentioned earlier in section 3.6, a further option, which leaves the user with interactive control, is to create self-

[407] This is the solution provided in 'Crystalline' from *Biophilia*, wherein the constant forward movement of the user-controlled avatar guides it to a new tunnel at each intersection even when the user does not interact to provide direction.
[408] This follows the opinions of composers and audio programmers Robert Thomas and Michael Friendebaucher, who see functional interaction as the best method of encouraging user engagement, such as RjDj's jogging app: Eliot Van Buskirk, 'Video: RjDj Jogging App Customizes Music as You Run' (http://evolver.fm/2013/02/07/video-rjdj-jogging-app-customizes-music-as-you-run/, 4 March 2016).

contained, looping sections, which will continue to play on repeat until input of some kind is received.

In order to retain a reactive element, rather than allowing iterations of the work to be entirely generative in practice, a variation on this latter solution is implemented for the *Ash Player*. As there are no vertical alterations programmed in this work, the potential for horizontal changes to be entirely generative would negate the intended interactive nature of the user engagement. Therefore, if user input is not received, the song will move to one of two instrumental sections, with the overall dynamic of the music lowered—achieved in practice by a simple lowering of the output volume. These two instrumental sections with remain playing interchangeably until user input is received, at which point progression resumes from the last structural juncture reached.

The second stage of the creation-model was completed using PD. Audio behaviours were programmed by cueing and playing the twelve audio assets through alternate [readsf~] objects, a design made straightforward by the cue-to-cue transitions composed between each segment. In order to help smooth these transitions, two production techniques were used. Firstly, the audio assets were rendered with appropriate note tails included at the start of each segment: notes which play at the very end of a segment would naturally have audible sustain that would carry across the bar, and this sustained part of the note was included in the mix at the start of each segment. As a result, the notes in question do not cut off unnaturally when a new segment in started. In cases where the notes in question are not present at the end of one segment, and the

sustain sections are present at the beginning of the next, these sustained note tails are not highly noticeable to the listener: due to the lack of a note attack, and the relatively low level of the sustained note tail, there is almost no jarring at the transition point (considerably less than would be felt if the notes cut off unnaturally when present). Second to this, a mastering reverb effect was implemented in PD—by effecting the entire track, this reverb helps to smooth the transition points by sustaining audio across the abrupt cut between segments.

The third stage, interface creation, was undertaken using the third-party app MobMuPlat, allowing for the hosting of PD patches on Android devices with bespoke interface design. A basic interface screen was created with "play" and "stop" buttons for playback functionality, along with a slider to provide visual feedback and guidance to the user on the nature of the desired interaction (see FIGURE 3.12). Progression through the song is controlled interactively by input from the gyroscope contained in the Android device. When progression options are available to the user at particular points of the song, the red boxes situated at the left and right extremes of the slider will be highlighted: by tilting the device to the left or right at these junctures, the user can see the slider move in response to the tilt of the device. When tilted fully left or right, the red box is reached by the slider, and will deactivate. At the same time, the device will vibrate, providing haptic feedback to the user to indicate that they have completed a successful interaction. Compositionally, this interaction will guide the song structure down one or other of the possible 'branches' available at that given point.

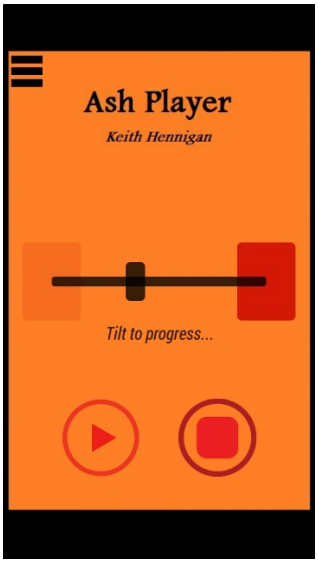

FIGURE 3.12—*Ash Player* screenshot.

As a finished liquid music work for Android devices, the *Ash Player* functions as an initial exploration of an *interactive branched structure*, using only a *horizontal* approach to liquid functionality. The segmented approach to its composition mirrors the prevalent "blocky" or "cut-and-paste" nature of much popular music production through use of repeated loops and self-contained musical sections, enabling potentially easy and effective re-ordering of broadly interchangeable material in an EDM aesthetic.

3.6.3 Commoveo

The second demonstration, created alongside the *Ash Player*, focuses entirely on potential *vertical* alterations to a song within a fixed, linear structure. To frame a meaningful method for vertical alteration, the previous discussion of music and affect is used to dictate a somewhat predictable and authored system of

adjustment to a defined set of musical parameters. This allows the user to change the perceived mood of the music, through a real-time interaction with the work. Rather than utilizing generative or interactive control, the work is thereby designed for adaptive engagement, wherein the user adjusts a controller signalling affective states, which in turn causes meaningful adjustment to the music. This is an implementation of expressive performance manipulation, rather than layering or other vertical approaches to liquid music composition.

The existing research on broad connections between specific musical parameters and their impact on the perceived mood of the musical piece provides an excellent model for vertical alterations, offering both a compositional framework and an established two-dimensional interface, using arousal and valence in the x and y axes. Rather than arbitrary assignment of musical parameters to an equally arbitrary interface, *Commoveo* should enable any user, whether musically educated or not, to find the interface engaging and intuitive to use. The adaptive design links hidden musical changes to explicit affective states, rather than (a) allowing direct *interaction* with multiple musical parameters, which the average user may not understand or find intuitive, or (b) linking two or more dimensions to musical parameters in an arbitrary, individual manner, which may seem subjectively appropriate to one user but not at all so to the next.

This is not something that has been explored in existing liquid music releases, though it can be related to adaptive video game music, such as that found in *Spore*. As such, it represents a novel approach to liquid music being

explored in this portfolio, in order to test the creation-model with new ideas as well as new implementations of exiting ideas. Based on the previous discussion, four parameters can be established that should combine to offer clear changes of affect across the two given dimensions of arousal and valence. These are the dynamics, mode, articulation and complexity of the music. Three of these parameters (mode, articulation and complexity) are implemented as binary states: major or minor for the mode, legato or staccato for articulation, and simple or busy for the complexity. Dynamics are implemented to change gradually over a fixed range.

The first stage (audio creation) was again undertaken with the use of DAWs and standard music production software. The music exhibits a pop aesthetic, in this case identifiable through a prominent vocal with vocoder processing applied (a regular feature of much pop music); an identifiable song structure, and a texture built from primarily electronic sounds.

As discrete changes to individual layers are required with this implementation, each instrumental layer is rendered separately from the others, in the form of phrases or loops. This serves to both minimize the total number of audio assets required, and to keep the file size reduced by allowing each loop or phrase to play multiple times rather than being rendered multiple times as lengthy audio files. The drums, taking this approach further, are constructed from individual samples, which can be constructed into four different patterns that are randomly sequenced during playback. This, technically, introduces a minor generative element into the work, whereby the programming dictates in

a random fashion, without either direct or indirect input, how the drums will play in a given iteration of the work.

The second stage (audio behaviours) for *Commoveo* was completed using the game audio middleware Wwise. As it exhibits a fixed, linear structure, the song was constructed within a single playlist container, enabling a clear and consistent structure to be sequenced. To enact the required vertical changes, four real-time parameter controls (RTPCs) were created and linked to the four musical parameters being altered. Separate audio assets are in place for each instrument and each combination of binary parameters—for example, the bass will have one set of assets for staccato, simple and major, another for staccato, complex and minor, and so on. These assets are played or muted in a system of exclusivity, whereby only one part per instrument will be audible at any given time, based on the current combination of the four musical parameters.

For the third stage, a suitable interface was created using the game engine Unity (see FIGURE 3.13). A two-dimensional grid with a moveable avatar that can be positioned anywhere onscreen is used to represent the attributes derived from research on music and affect, on which the y-axis represents arousal and the x-axis represents valence. Audio assets with programmed behaviours were exported from Wwise as a soundbank and integrated with Unity, from which a standalone Mac OS program was built. On-screen transport controls and the arrow keys on a standard QWERTY keyboard are used to engage with the program, and the colour of the interface changes based on the position of the avatar in order to provide visual, as well as audio, feedback.

Drawing inspiration from Crayonroom's Moody software,[409] these colours are roughly associated with the relevant affective states.

Commoveo implements the three-stage creation-model by using tools designed primarily for video games to program interactive audio behaviours and build a distributable user interface. It explores potential for *vertical* change to alter the perceived mood of a song—within composed parameters—by adjusting the dynamics, mode, articulation and complexity of individual instruments, based on the user's manipulation of a 2D interface. The liquid nature of a song such as this engages musical interest by shifting from one mood to another. However, manipulation of musical parameters should likely only be used to make an individual song feel slightly *more* angry, *more* sad, or so on, within the composed range of affective states—the actual emotional range of a given song, mapped at its extremes to the 2D grid, would likely never cover more than a relatively small array of human moods.[410] This demonstration is created to explore the hypothesis that there is considerable potential for development of liquid music with affect-based interaction.

[409] *Moody FAQ* (mjelle.com/moody/moodyfaq.php, 15 October 2014).
[410] Speaking from a compositional viewpoint, it would be both naïve, and likely counter-productive to the quality of a musical work, to assume that every emotion felt by a user, and representable by a full 2DES, could be represented by procedural manipulation of a single song or work.

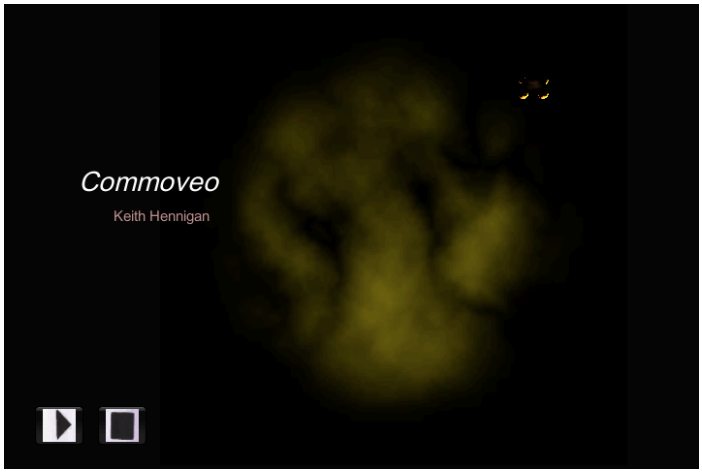

FIGURE 3.13—*Commoveo* screenshot.

3.6.4 Minos

Following from the previous works, in particular the *Ash Player*, a third demonstration entitled *Minos* was created to incorporate both vertical and horizontal alterations, as well as both interactive and adaptive programming. The name is intended to reference the labyrinth of Minos, a metaphor for the type of branched structure again being employed—this also echoes the visual interface of 'Crystalline'. Aesthetically, the piece is a pop/rock song, built upon recorded guitar, bass and vocals, with sampled drums, intended as a representation of a standard four-piece band recording. Horizontal changes will be controlled interactively, while vertical changes will react adaptively, changing dependent on the time of day at which the song is being played.

Compositionally, *Minos* is divided into nine discrete segments which may appear at different points during one iteration of the song; this is achieved through implementation of a similar branched structure to the *Ash Player*, in which segments roughly resemble the verse, chorus and other structural parts of a linear song structure. For the first stage, all necessary audio assets were

recorded with Pro Tools 6 or built from samples in Reason 4. To facilitate both horizontal and vertical alteration, each instrument's parts were rendered separately to each other as loops and phrases, or in the case of the drums, as individual samples.

An important issue when implementing non-linear structures with a pop song aesthetic is how composers might deal with the inevitable disruption of the ubiquitous 'song form,' identified as a key signifier of pop songs in the previous section. The development of original responses to this problem may be interesting to observe in future liquid music development. One option, exhibited through the composition of *Minos*, is to compose segments resembling the traditional verse, chorus, middle eight and so on, then implement a branched form to ensure a semi-authored progression through the work, retaining for the composer an ability to broadly design dynamics, pacing and narrative through any potential structural arrangement.

For the second stage, audio behaviours were programmed using PD. *Minos* is composed with an interactive non-linear structure—in other words, the user guides the progression, as with the *Ash Player*. Similarly to the approach taken in the latter, generative choices will not be made in the absence of user interaction, but instead segments in *Minos* will loop repeatedly until input is received, necessitating activity from the user to continue the song. If no action is taken, a 'boredom switch' will be triggered after a set time and the music will fade to a conclusion.[411] While encouraging greater user engagement, the nature of this programming adds the compositional requirement for each segment to

[411] A technique mentioned in Collins, 'Participatory and Non-Linear Aspects of Video Games Audio', 271.

not only transition smoothly to all possible proceeding segments, but also to function as a self-contained loop, clearly highlighting the aforementioned need for the three stages of the creation-model to be undertaken holistically, as requirements for each stage will inevitably affect the other two.

Adaptive engagement is also designed as a part of this work, being used to control vertical alterations to instrument selection, performative dynamics, mix levels, and DSP effects. All of these elements respond to the time of day, read from the system upon playback of the song. Individual instruments are sequenced to play through [readsf~] or [tabread4~] as appropriate, with the first two elements (instrument selection and performative dynamics) altered through selection of different audio files (the guitar being either strummed or plucked, for example) and the second two (mix levels and DSP effects) altered based on pre-set value ranges, stored as tables within PD. Reverb and delay effects aid the cohesion between segments by allowing effect tails to carry across transition points, all of which are implemented as cue-to-cue cuts. Drum patterns are built from samples stored in tables, and play in a generative manner driven by weighted randomization. All of these programming elements combine to create a different vertical iteration of the song for each hour of a twenty-four-hour cycle, while the user retains direct interactive control over horizontal structural progression.

The intention of the time-based adaptive engagement is to provide a unique listening experience, composed to be suitable for different time of the day and night. For example, an iteration of the song played in the morning or early afternoon will exhibit loud dynamics, and stronger performative styles

(strummed rather than picked guitar). An iteration in the early hours of the morning will exhibit softer dynamics, simpler drum patterns, and a greater amount of reverb in the mix. These changes are derived, in this case, from an entirely subjective compositional standpoint, meant to reflect the different phases of the day and the types of music that a listener may want to engage with at those times.

The interface for *Minos* is built entirely in PD, and makes use of the GEM visual environment (included as an extended library) in order to explore the potential of this environment for user interface creation. The functionality of GEM for receiving input is limited, capable of little beyond registering mouse clicks and positioning. As such, it does not appear suitable for future development, being most suitable for providing visual feedback on programming elements rather than facilitating interaction as an interface. In this case, the GEM environment is used as a means of communicating visual feedback absent from the *Ash Player*. A structural map, outlining the possibilities of the work's branched structure, is highlighted based on the route chosen during an iteration of the song with different colours (always located at the same points in the structural map) representing the nine segments of the piece. UI buttons allow the user to guide the structural progression through point-and-click interaction.

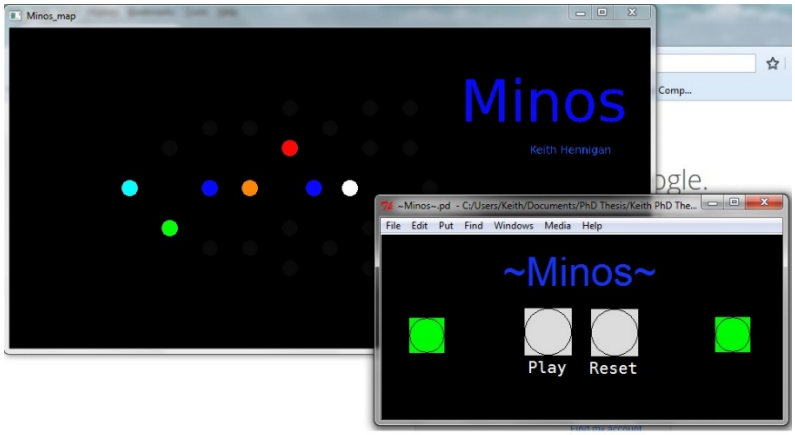

FIGURE 3.14—*Minos* screenshot

Using a combination of vertical and horizontal alterations, *Minos* incorporates interactive, adaptive and generative programming in a work that builds upon the two previous demonstrations. A branched structure, represented visually through the GEM interface, requires user interaction to progress, while performative and mix elements adapt to the time of day in a composed manner.

3.6.5 Hydra

The fourth minor work presented here, created in a similar fashion to *Minos*, is intended as a development upon the initial two works. This work again integrates both vertical and horizontal alterations, and makes use of software tools from the field of video game audio in order to highlight the adaptability of the creation-process to any suitable toolset. *Hydra* is an alternative rock song in aesthetics, with primarily electronic timbres supporting a lead vocal.

For the first stage, audio assets created largely with Reason 4 were mixed and rendered in Pro Tools LE. *Hydra* is composed with an unguided

linear structure, or *open form*: an introductory segment plays when an iteration of the song is started, following which any of the other five segments of the song can play, and will repeat as self-contained loops until the user interactively triggers progression to a new segment. As with *Minos*, if a certain time elapses without user input a 'boredom switch' will be triggered, transitioning to a concluding segment of music and ending the iteration of the song. As *Hydra* is in open form, the five main segments are completely interchangeable. In order to maintain musical coherence and flow with such an unguided structure, *Hydra* explores the implementation of a *transition matrix* which enables bespoke transition types, including additional short musical segments, for each possible progression between segments (as discussed in section 3.4.6, and illustrated below in FIGURE 3.15). Structural epithets such as verse, chorus and so on may become less meaningful in an open form, despite the retention of a popular music aesthetic—as such, the segments in *Hydra* are referred to by roman numerals.

The second stage, audio behaviours, was completed with Wwise. Audio assets are arranged into sections, with a combination of switches and RTPCs programmed to control progression through the open form, as well as vertical alterations to mix levels, complexity of individual lines, and DSP effects including reverb, delay and filtering. Vertical alterations are programmed to occur in five discrete steps, along a spectrum of "lighter" to "darker", in order to provide more explicit feedback to the user on how their interaction affects the musical output. A greater element of generative programming is included than in previous demonstrations, through randomized arrangements of different

instruments and parts within each segment. Transitions between segments occur at specific points, according to the transition matrix, and as such it may take anywhere up to twenty or thirty seconds for the music to reach a point where it will react to user input in a horizontal manner; vertical changes, on the other hand, are enacted upon user input with brief fades.

From \ To	I	II	III	IV	V	VI
I	**X**	Cue-to-cue	Cue-to-cue	To IV Transition	Cross-fade	*Unique Transition*
II	Cue-to-cue	**X**	Cue-to-cue	To IV Transition	Cross-fade	Cue-to-cue
III	Cue-to-cue	Cue-to-cue	**X**	To IV Transition	Cross-fade	*Unique Transition*
IV	Post-Bridge Transition	Post-Bridge Transition	Post-Bridge Transition	**X**	Post-Bridge Transition	Post-Bridge Transition
V	Post-V Transition	Post-V Transition	Post-V Transition	To IV Transition	**X**	Post-V Transition
VI	Pre-climax cue-to-cue	Pre-climax cue-to-cue	Pre-climax cue-to-cue	To IV Transition	Pre-climax cue-to-cue	**X**

FIGURE 3.15—Transition matrix for *Hydra*

The interface was designed with Unity, again built as a standalone program for Mac OS with an integrated audio soundbank exported from Wwise. A single interface window displays five coloured spheres, representing the five major segments, which light up or fade to indicate progression through the open form. Meanwhile, a single spotlight on the textual information provides direct

visual feedback on the interactive vertical alterations, becoming "lighter" or "darker" in sympathy with the musical change.[412]

Hydra combines interactive control of horizontal and vertical alterations with generative compositional elements. Its primary focus as a demonstration of liquid music is the implementation of an open form work with a transition matrix, and exploration of how such a work might be developed with the proposed creation-model. A composed matrix such as this must be taken into account by the creator during design of both the first and second stages, whether for an open or branched form. *Hydra* also progresses from the simple cue-to-cue transitions of previous demonstrations to achieve a greater musical flow and coherence, reinforcing the idea discussed in Chapter Three of strong and effective transitions forming a key part of liquid composition. Though this demonstration was created with comparatively longer audio assets than previous ones, some instruments—such as the bass—were built from individual samples.

While the programming stage remains reasonably simple in construction and development of expressive performance control (due to the nature of the audio assets), the addition of MIDI note-level control to Wwise from version 2014.1 has created the potential for more effective implementation of note-level changes to musical parameters such as tempo, articulation and so on—a development that will be advantageous for future works that make use of this particular middleware tool.

[412] This is a deliberate visual representation of the terms lighter and darker, often used descriptively in discussions of musical works, and indicative of the intended effect of vertical changes present in *Hydra*.

3.6.6 Testing and Review of Initial Demonstrations

Four minor works have been presented above, intended as both proof-of-concept, or as demonstrations of how the technical and compositional requirements for liquid music, researched throughout this thesis, can be successfully negotiated by application of the creation-model proposed. Each of the four demonstrations explicitly follows this three-stage framework, while focusing on different compositional approaches and employing different software options for production. Interactive, adaptive and generative user engagement is facilitated across the four works, different non-linear structures are employed, and a range of vertical alterations are implemented. Whether a given work is designed as an exploration of horizontal or vertical alterations, and is programmed with interactive, adaptive or generative behaviours, it is the marriage of these broad possibilities—covered by the first two stages of the creation-model—with the capacity for unique interfaces and a range of hardware inputs that offer enormous creative potential for the emerging paradigm of liquid music. The three stages of the creation-model codify this potential and shape it into a solid framework with which any musician(s) might approach the creation of liquid music.

Informal testing of the preceding works was undertaken on three separate occasions during 2014—15. Works were presented, either with or without verbal explanation or instruction, to nine individual testers (ranging from those with no formal music training to postgraduate music students). This follows the method of user-centred interaction design, by asking a sample of

potential end users to evaluate and provide feedback on prototypes.[413] Some results and feedback from this informal testing are worthy of note.

As discussed in section 2.2.2, liquid music works may remain structurally linear, or exhibit some form of *non-linearity*. The four initial demonstrations approach the issue of structural non-linearity in different ways: *Commoveo* retains a fully linear structure, while the *Ash Player* was composed with a reasonably simple branched form, guiding the user from a beginning to an end. One problem identified during testing of the works was how to develop a suitable means of progression through an interactive non-linear structure. By programming a song to make random choices at structural junctures, user control is rendered unnecessary, yet when user input is received, the immediate effect may be somewhat difficult for the user to discern, especially when transitions are delayed in order to retain musical flow. While inclusion of visual or haptic feedback can remove the otherwise esoteric nature of the interaction by displaying an immediate response, as demonstrated in the *Ash Player*, works may still suffer from what Robert Thomas identifies as a key problem: a lack of clear relation (or functionality) between user action and musical reaction.[414] *Minos* offers one solution to this issue by implementing a branched structure that *cannot* progress without user interaction. While testing proved that this serves to increase user engagement, it adds the compositional requirement for each segment to be musically self-contained as well as linking to all possible successive segment.

[413] Saffer, *Designing for Interaction*, 34.
[414] If the user cannot comprehend how the music is *reacting*, their further action will not be based on the new musical state, and therefore the process cannot be said to be truly *interactive*.

It would appear that the more guided the structure, the more conducive it is to presentation of a traditional or narrative popular song style, while less guided forms, including the potential for lengthy loops in *Minos*, cannot be expected to exhibit the same musical form or development, instead lending themselves more to *causally* non-linear works, perhaps such as those found in popular EDM or electronic styles.

Potential for a research-led non-linear structure is also feasible, following the example of the 'Mind Module' discussed by Eladhari *et al* (2006).[415] Failure to make a choice could constitute a choice in itself, leading a song towards softer or sparser arrangements or sections, while choices made by the user (indicating a higher level of user activity) might lead towards louder or denser sections.[416] In this fashion, a liquid music work could adaptively follow a user's level of engagement. This can be directly associated with ideas drawn from the research on music and affect (discussed earlier in the chapter), whereby higher or lower arousal levels might alter the perceived mood of a piece in a similar fashion to that described.

Hydra explores further possibilities for user interaction with musical structure: while composed in a largely unguided open form, the work includes a dedicated transition matrix, enabling different types of progression between segments. Though open form works will inherently tend towards a lack of narrative or development, testing suggests that use of a transition matrix within a more guided structure may allow for a level of narrative or large-scale form,

[415] See Eladhari *et al*, 'Soundtrack of Your Mind: Mind Music—Adaptive Audio for Game Characters.'
[416] Something similar is achieved with the programming of generative music in *Spore* (2008), which reacts adaptively to the level of user activity; Kent Jolly and Aaron McLaren, 'Procedural Music in *Spore*'.

retaining musical cohesion while enabling explicit links between user action and musical reaction.

Testing of *Commoveo* indicates that immediately audible vertical changes to the music, responding clearly and directly to user interaction, prompted greater engagement and interest than many of more esoteric interactions with horizontal, structural alterations present in the other works—further supporting Thomas's statement regarding clear functionality. The application of existing research from another field (namely music and affect) in a liquid music context engendered a notably higher level of interest in both the compositional mechanisms and the music itself. The user perceives changes through both the visual feedback of colours, and auditory feedback, which in practice seems to support the foregoing research by altering the perceived musical mood in a predictable fashion. While any form of interaction risks becoming a "gimmick", easily dismissed when not allied to an enjoyable foregrounded musical experience, it might be suggested that this kind of intuitive and immediate interaction represents a strong future direction for liquid music development.[417]

Further development and complexity could of course be explored through the potential combination of vertical and horizontal alterations within a single work. *Minos* and *Hydra* both implement vertical alteration alongside

[417] Future works using an affect-based approach might further explore the links between different musical parameters and moods, as discussed in Chapter Three; a certain amount of fine-tuning and experience, at both the compositional and programming stages, would likely improve the accuracy of the alterations to perceived moods within a given work. Manipulation of DSP effects, and the implementation of faster or slower alterations to reflect the difference between 'mood' and 'emotion'—both features implemented in *the Liquid EP* below—could also likely be developed further.

branched and open forms respectively—the latter through discrete levels of interactive adjustment to instrumental layers and DSP effects, the former utilizing adaptive programming to drive selection of musical parts, mix levels and DSP effects in reference to the time of day. Though this feature remains obscured to users without any explicit reference to time on the *Minos* user interface, once explained or demonstrated this feature again elicited a higher level of interest than others being tested. The potential for change over a given time period—be it hours, days or even longer—would seem to heighten the chance of user engagement over a sustained period of time, though once more it was stated by a number of testers that a sufficient level of musical quality, irrespective of the liquid programming and nature of the work, should be maintained during all possible iterations.

The advantage of being able to undertake a comprehensive and professional mix for 'Ash Player' cannot be understated in terms of delivering a finished work which retains the production quality expected from distributed musical releases. In the case of this work, such a mix was possible due to the lack of vertical alterations within the work, ensuring that the instrumentation, arrangement and dynamics were fixed from the first creation stage. While such mixing will therefore only be possible in works with exclusively horizontal alterations, it is worth noting the enthusiastic response to the production quality of the *Ash Player* in comparison to the other three minor works.

Interface design was approached in all four works with an adherence to both simplicity and universality. No more controls than necessary are present, which allows for quick and intuitive user interactions. For the sake of

distribution and accessibility, interfaces do not require any specialist software or hardware. While simplicity in regard to user input appears to be effective, it is observed that clear visual feedback, aimed at making explicit user or system input and relations to the breadth of potential musical change, is always desirable. Obscuring the links between user actions, the resultant changes in programmed audio behaviours, and in turn the broader scope of the liquid composition, can be observed to lead to confusion and a loss of interest from the user: a clearly discernible cause-and-effect relationship aids engagement.

Three of the initial four demonstrations were built to run on Mac OSX desktop systems, offering broad possibilities for dissemination. However, the process of creating and testing these works, as well as continuing research into the rapidly developing field, suggests that mobile devices—smartphones or tablets—probably represent a better platform for liquid music. These devices are, by 2016, ubiquitous enough to not constitute 'specialist' hardware, and offer easy distribution methods for apps. For this reason, the *Ash Player* was developed for Android, and testing has shown a stronger user interest in works on mobile devices. Meanwhile, the selection of hardware interfaces and sensors available through these devices offer considerably expanded possibilities for liquid programming and musical alterations.

The importance of the compositional approach, and abilities required by any prospective composer of liquid music, cannot be overstated. The three-stage model proposed here offers the composer the capacity to build non-linear structures and to define expressive musical parameters that might be dynamically altered, to define how these parameters and structures might

change, individually and in relation to each other; and to design bespoke interfaces and methods of interactive or adaptive control, resulting in an enormous creative palette. Composing with non-linear structures in mind requires that dynamics, phrasing, harmonic and melodic progressions, and so on, will all retain a sense of unbroken musical flow from one segment to all others that might potentially follow, irrespective of choices made by the user. Equally, composing with musical variation in mind requires that all iterations of the work—irrespective of the combination of values or states in mode, tempo, articulation, dynamics and so forth—will retain musical coherence and balance at all times. A composer with a good grasp of the traditional linear arts of instrumentation and composition, music production in fixed as well as the liquid paradigm, capable of writing disparate sections to precede and follow each other without jarring or sounding unmusical, and capable of altering musical characteristics within a work without compromising the balance and quality of the music, is very much to be desired. Greater prevalence of courses teaching composition for interactive media, and similar topics, will help to develop practitioners with these requisite skills.

3.7 Major Portfolio Work: *The Liquid EP*

Proceeding from the initial demonstration works discussed above, a final large-scale work was created. It represents an exploration of how the proposed creation-model might be applied to a larger musical work. It is also intended to develop selected findings from the previous demonstrations, and to provide

comprehensive summary and demonstration of the research undertaken and framework proposed in this thesis. This major work or magnum opus is entitled *The Liquid EP*.

The table in FIGURE 3.16 below outlines the desired characteristics drawn up for this demonstration prior to its development. This is a working brief to be realised through successful application of the creation-model. Working holistically towards this end product, the desire to develop for mobile platforms with greater capacity for user interaction through use of hardware sensors led to the choice of *MobMuPlat* (a third-party implementation of *libpd* that allows for hosting of patches with non-native interfaces on Android systems) as the tool for interface design, with Pure Data therefore necessarily used to program audio behaviours. Along with a range of hardware sensors and inputs to demonstrate, it was proposed that this work should exhibit a range of compositional approaches showcasing both vertical and horizontal alterations. Sections of the work can be structured linearly, in branched form, open form, or as an entirely static and causally non-linear work. Meanwhile vertical changes can be controlled in reactive fashion, or rendered generatively, and composed with scaffolds for meaningful change such as perceived affective change or suitability for time of day.

Due to the required scale of the demonstration, and the desire to retain a broadly popular music aesthetic, it was decided to create a liquid music equivalent of an EP-style release, rather than a single song (as very few popular songs, in any genre, are liable to last for upwards of ten minutes). Individual 'song' segments could be composed, interspersed with additional material, and

the entire work tied together with an appropriate transition matrix in order to create a unified musical experience.

Aim:	Compose a large-scale liquid music work, building on previous demonstrations; exhibiting research findings from throughout this thesis; and successfully applying the three-stage creation-model to a large-scale work.
Composition & Programming:	This work should: • Provide musical material that will last for c.25-30mins in any given iteration, in line with its function as a major research work; • Exhibit a broadly popular music aesthetic, to serve as a benchmark for the viability of the creation-model for existing genres and styles; • Incorporate a variety of both vertical and horizontal alterations to musical material; • Incorporate both *reactive* and *generative* musical programming, showcasing different techniques for each; • Include appropriate transitions; • Allow for some element(s) of user customization, e.g. the ability to input a sample or play an instrumental voice.
User Interface & Experience:	This work should: • Run on a mobile platform, and take advantage of a variety of options for hardware and sensor input as a part of the interface design;

- Exhibit considerable inherent potential for different iterations through reactive and generative programming and composed alterations, ensuring that the user experience is highly variable;
- Provide explicit information about the links between audio assets, programmed behaviours, and user action.

FIGURE 3.16—Design brief for *The Liquid EP*

3.7.1 Presentation of The Liquid EP

The Liquid EP is a liquid music work comprised of four main 'song' sections, and four 'interlude' musical sections, experienced together as a continuous musical work of unfixed length. The eight sections are structured in a cyclic arrangement, within which songs and interludes are interleaved while maintaining a general clockwise progression so as to create a sense of musical flow (FIGURE 3.17). Any given section may transition randomly to either of two further sections. Transitions between sections are composed in a simple matrix using fades, cue-to-cue and layered transitions. Users may either let individual sections play to completion before the work automatically progresses, or advance through the work at will (though it should be noted that some sections will play *ad infinitum* until the user chooses to move on). There is no 'end' to the work as such, as users can simply exit the app when desired—however, an average iteration of the work, playing through the eight sections with little or no repetition, lasts for approximately twenty-six minutes. It is composed, like previous demonstrations, in a broadly popular music style, and is intended to be

illustrative of the kind of work a commercial artist or band might release (not dissimilar in this way to *Biophilia* or *Listen to the Light*). A video demonstrating one full iteration of *The Liquid EP*, with commentary, is included as a part of the portfolio.

Each of the eight sections within the work is composed to showcase one particular type of interactive or adaptive programming, and to take one primary input from a given hardware sensor or user interface component—though secondary programming elements and input or interaction methods, as well as some generative elements, are also present throughout. Sections are composed to systematically explore different approaches and solutions to some of the inherent problems of liquid composition—these have been collated and drawn from the approaches to liquid music in existing works, discussed previously.

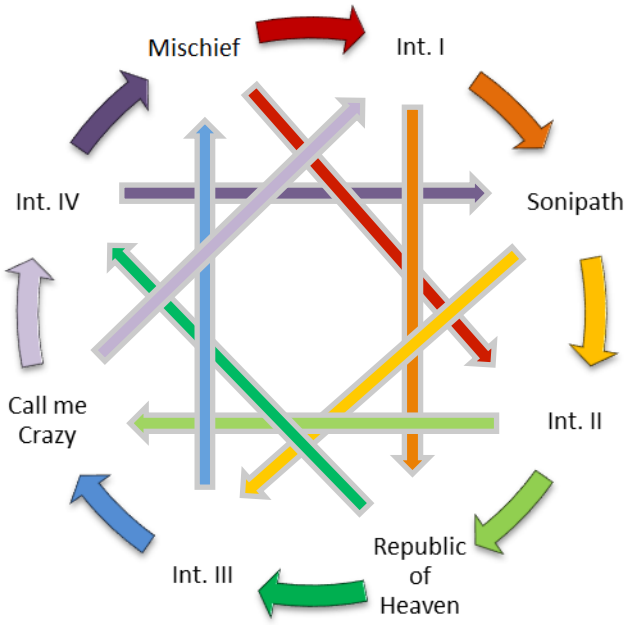

FIGURE 3.17—*The Liquid EP* structure

Structural linearity, as stated, can be broadly divided into four approaches: pieces may be causally non-linear, with complete freedom of

material over time without any sense of progression or development (what Kramer refers to as 'vertical time');[418] they may be in recombinatorial, or open form, in which any segment can follow any other. By limiting the latter and imposing guidance on the progression between segments, a work can exhibit 'branched' form (essentially a more directed or limited version of open form). Finally, pieces may be linear, but potentially of variable duration—as in the case of Bjork's 'Virus', which will loop at certain points until a particular condition is met. The eight sections of *The Liquid EP* approach horizontal change in a systematic manner: divided into pairs, each type of non-linearity is explored by two discrete sections—in the case of *Sonipath* alone, a fully linear structure is used (see FIGURE 3.18).

The vertical alterations explored in *The Liquid EP* include generative implementations of musical parts or material—especially effective in the two interlude sections with entirely non-linear form, the lack of development enabling a focus on texture, as espoused by generative or adaptive music releases such as Eno and Chilvers' *Scape*.[419] 'Call Me Crazy' incorporates a generative element while the song is held at any of four separate 'loop points'—snippets of mandolin or vocal lines from elsewhere in the song are randomly triggered, processed through reverb, delay and filters, in order to add unpredictable colour to an otherwise repetitive loop which may run for some time.

[418] Kramer, *The Time of Music* – though Kramer's discussion concerns causal non-linearity, it is relatable to discussion of structures, with complete non-linearity of either kind enabling the other. The moniker 'vertical time' is not to be confused with vertical alterations as an element of liquid music composition.

[419] While the user interaction in *Scape* means it cannot be classed as generative, the musical style derived from fully non-linear music bears a certain identifiable character which has often come to be associated with 'generative' music, despite the two descriptors applying to discrete characteristics.

Song	*Structure (Horizontal)*	*Alterations (Vertical)*	*Input(s)*
Mischief	Open form [5 segments]	- Performative DSP actions; delay, filtering	- Gyroscope
Interlude I: Before	Non-linear [Four-chord loop]	- Synth timbre - Melodic contour - Panning - Layering	- GUI Sliders
Sonipath	Linear	- Dynamics - Complexity - Mode - Pitch - DSP effects	- GUI Touchpad
Interlude II: Meanwhile	Non-linear	- Generative texture - Interactive instrumental voices - Stingers	- Accelerometer - GUI Grid - GUI Multi-touch
Republic of Heaven	Branched form	- Instrumental voices - Dynamics - User creation of instrumental part through microphone	- Time - Date - Microphone
Interlude III: Black	Branched form	- *n/a*	- Compass
Call me Crazy	Linear [with loop points]	- Layers (generative)	- GPS (Distance)
Interlude IV: After	Open form [5 segments]	- User creation of audio content through microphone	- Microphone - GPS (Location)

FIGURE 3.18—Table of characteristics for *The Liquid EP*

'Sonipath' builds on the research into music and affect, explored initially by *Commoveo*, and alters both expressive performance parameters and DSP effects to achieve a designed and predictable affective shift. 'Republic of Heaven' builds from the initial work of *Minos* in adaptively altering instrumental voices, mix levels and DSP effects based on the time of day. 'Mischief', meanwhile, uses input from the gyroscope to offer performative DSP changes such as might be heard in EDM works, and are readily available in programs such as Ableton Live: the addition of a long delay to certain layers, or a low-pass filter being applied to the entire track—in this case, they have been re-contextualized as composed elements within a distributable liquid music work for users with no experience of music production techniques to engage with. 'Interlude IV: After' is based around the processing of audio input through a microphone, the different segments of its open form offering slightly different processing styles and musical settings; this is designed to exhibit an ambient musical aesthetic, and a similar (though simplified) experience to *Inception: the App*. Two segments of 'Republic of Heaven' also make use of processed audio input from the device's microphone as an instrumental layer for musical bridges.

With regards to reactive inputs for various sections, *The Liquid EP* again systematically explores eight different options from the potential input mechanisms discussed in section 3.2.1. The choice of these inputs, and much of the interface design as stage three of the creation-model, were naturally influenced by the choices of Pure Data and MobMuPlat as a toolkit for programming and distribution, and further by the use of a Huawei Honor 4C as the testing device (therefore limiting feasible testing to those hardware

elements present in the device). The work is compatible with any mobile device running Android 4.0 or higher, assuming the presence of the required hardware for each section, as detailed in FIGURE 3.18.

3.7.2 Discussion

FIGURE 3.19—*The Liquid EP* start screen

The Liquid EP is a large-scale demonstration work (with an approximate length of c.26 minutes), which draws together the research undertaken into the paradigm of liquid music and showcases possible implementations of various approaches and elements discussed. The work was created by following the three stages of the creation-model proposed in section 3.3, utilizing a combination of established music production software to create audio assets, Pure Data to program audio behaviours, and MobMuPlat as a tool for interface design and integration with an Android system.

While *The Liquid EP* fulfils its creation brief, and in doing so offers an exploration of possibilities for liquid music development, it also suggests some of the various potential avenues through which further development and

composition in the paradigm might take place. A range of different hardware sensors and GUI elements could be utilized for reactive programming, while generative music programming offers enormous further potential for variation. Vertical and horizontal alterations could be applied in many ways, the former to any mix level, effects, instrumentation, or expressive performance parameters—right down to note-level variations with MIDI or other systems—and the latter with any amount of authorship and guidance from fully linear to fully non-linear. Aside from variations within each of the three stages of creation—audio assets, audio behaviours, interface design—further variation in the manner of linkage and integration between the three stages ensures that there is an almost limitless potential for new liquid music to be composed, with *The Liquid EP* serving only as a systematic demonstration of an appropriate number of possibilities, and as a broad exploration of the three-stage model necessary for the creation of any liquid music works.

Chapter Four Evaluation and Conclusion

This thesis documents research into the field of *liquid music*, defined in Chapter One as any musical work written with the deliberate and inherent potential to differ from one playback or iteration to the next. While this definition might cover music written for performance, it is primarily related within this thesis to recorded music, and stylistically to popular music, in which the primary artefact is the recording, disseminated for broadly commercial reasons through the mass media. Music recordings might no longer considered as largely immutable objects, as was the case during much of the twentieth century, but can be integrated as digital audio files into a *procedural* system, within which the playback behaviours of recorded (or electronically generated) audio can be controlled and influenced by external factors, rendering it *reactive*.

Popular music that can be described as 'liquid' and placed within this emerging paradigm has been discussed in Chapter Two; similar works continue to be released, and these constitute the predominant artistic field with which this thesis engages and seeks to progress.[420] A number of aims with regards to the new field of liquid music have been addressed, as detailed below.

[420] Noteworthy works reviewed include *EVE* (1996), *The National Mall* (2011) and *Biophilia* (2011), while further new works such as Massive Attack's *Fantom* (2016) continue to appear with each passing year.

4.1 Research Outcomes

4.1.1 Proposal and Definition of Liquid Music

The first step towards achieving the stated aims has been to debate the usefulness of existing terms and definitions, applied in the literature surrounding different media and multimedia, and to isolate the prevailing observations and research before determining a workable glossary for liquid music (provided in Chapter Two). This builds on established definitions from key researchers such as Collins (2008), and earlier discussion of terminology such as Nieuwdorp (2007). Alongside this, a cogent examination of the qualities and discernible characteristics of different media and multimedia categories allow for liquid music compositions to be more clearly codified in relation to the potentially similar attributes of electronic instruments, games or toys. A full glossary has been provided which clearly establishes important terms and concepts that then reappear throughout the thesis: most notably, how *liquid music* fits into the broader field of procedural (or dynamic) audio.

The umbrella term of *liquid music* has been proposed for disparate composition, research and development by others—key works of which are documented herein—which has usually focused solely on individual aspects of multimedia, art music, video games, or particular works of popular music. A broad scope is provided here that, for the first time, allows *all* musical works irrespective of genre, style or function, to be encompassed and addressed in

relation to liquid music as a field, while also incorporating discussion of technological and compositional elements. [421]

Work has been explicitly undertaken to provide a comprehensive theoretical framework for this emerging paradigm, focused on the creation and distribution of standalone musical works. The need for such a framework can be justified by, and contextualized within, current practices: namely existing musical works,[422] and research drawn from a number of fields concerning procedural, interactive, adaptive or reactive music.[423] This framework may serve as a platform for further work by both academic researchers and practitioners within the creative industries.

4.1.2 Contextualization

Examples of liquid music can be found in the fields of contemporary art music, and music for interactive multimedia (especially video games). From a cultural perspective, however, it might be argued that the emergence and growth of interactive popular music deserves more attention than it has to date received. With every passing year, artists are developing and releasing new forms of

[421] Noteworthy work on interactive composition within the context of video games has been produced in Phillips, *A Composer's Guide to Game Music* (2014), Sweet, *Writing Interactive Music for Video Games* (2014) and others; while the broader field of interactive audio engages with a wide array of media and multimedia, as exemplified by Collins, Kapralos and Tessler, *The Oxford Handbook of Interactive Audio* (2014). This thesis, however, provides an original insight into composition and creation of liquid music as a standalone field or paradigm.

[422] Primarily liquid popular music such as *Biophilia* (2011), but also drawing on art music such as *Constellation* (1963) and video game music such as *Sound Shapes* (2012), as detailed in Chapter Two.

[423] This includes the scholarly fields of interactive audio and game music, represented through key texts such as Moormann (ed.), *Music and Game: Perspectives on a Popular Alliance* (2013) and Collins, Kapralos and Tessler (eds.), *The Oxford Handbook of Interactive Audio* (2014); professional audio commentators such as Winnifred Phillips or Alexander Brandon; and technological advances in interactive music through middleware like Wwise, or platforms such as RjDj.

interactive, adaptive and generative popular music, often drawing on ideas derived from video games, sound-toys, and other media. Key examples cited in Chapter Two include Björk's *Biophilia* (2011) and Radiohead's *Polyfauna* (2014). This thesis posits that new technologies for the creation, dissemination and playback of music may, once again, introduce a paradigm shift in the forms and content of popular music being produced.

An important question to be answered in regard to this thesis concerns the existing state of work that could be classed as *liquid music*, and the contextualization of this paradigm within past, current, and potential future practices. It can be reasonably concluded from the provision of precedents in both contemporary art music (see quoted examples from Boulez, Stockhausen *et al*), and more recently popular music, that liquid music is already an established creative field. Interactive multimedia such as video games and sound-toys serve to both provide and develop new approaches to liquid music, and to familiarize users with these musical ideas. The development of interactive media as a part of a broader participatory culture can tentatively be linked with professional and amateur musical practices such as remixing, sampling and mash-ups, and this in turn allows for a cultural conception of recorded music as a more malleable artefact than has been true since the early twentieth century.[424] With the emergence of a technological literate audience of 'prosumers' that seeks to actively engage with musical works—disregarding the

[424] These observations are drawn from key works including Katz, *Capturing Sound* (2010) and Jenkins, *Convergence Culture* (2006): for broader perspectives on participatory culture, specifically with regards to music, these—alongside Turino, *Music as Social Life* (2008)—provide an excellent starting point.

Romantic notion of music as an untouchable work of art,[425] and the passive consumer role previously occupied by many listeners—and conversant with modern interactive multimedia, it could be suggested that liquid music will be a significant future direction for both artistic and commercial music. As such, considerable future research on various aspects of the field, only touched on within this thesis, will likely be needed.

4.1.3 Development of Creation-model

Building upon the initial research covered in Chapters Two, as well as the evaluation of tools, techniques and processes undertaken in Chapter Three, a comprehensive creation-model for liquid music has been described, encompassing the three main stages necessary for development of any liquid music work. This creation-model is intended not as a prescriptive 'standard' for interactive audio, but rather as a constant for all liquid music creation, appropriate for use with any applicable or desired tools or software. It is borne out by comparison to existing works, which may demonstrate results that have or may have been achieved through application of a similar process. It has also been tested thoroughly by its use in the creation of a portfolio of practical works which accompanies the thesis.

Liquid music, whatever tools may be used for its creation, can also be discussed from a more abstracted compositional perspective. The approaches, broadly recognized by researchers and practitioners as divisible into *horizontal*

[425] Typified by Dahlhaus's description of Beethoven's scores as 'inviolable musical "texts"': Dahlhaus, *Nineteenth–Century Music* (1989), 9.

and *vertical*, have been discussed at length and will likely continue to be engaged with by many commentators, especially with a focus on commercial video game audio.[426] Expanded research could be done in this area on more informed reactive changes, perhaps utilizing a combination of objective and subjective affective states within musical works, refining existing approaches further in other ways, or perhaps including more timbral or spectral alterations. The evaluation held in Chapter Three is intended as a guide towards existing and potential techniques and strategies for the composition stage of the creation-model, and points towards the wealth of work already being undertaken in this specific area.[427]

The focus of most music production tools and means of distribution on fixed, linear music has likely hindered the growth of liquid music. It is no coincidence, therefore, that the fairly recent emergence of new mobile hardware in the form of smartphones and tablets has been paralleled by a growth in liquid music releases. With the widespread availability of these digital devices, alongside a variety of options for creation of generative or reactive music—programming environments, video game audio packages, and popular commercial products like Ableton *Live*, all available to amateur and independent practitioners—natural pathways for developing and distributing liquid music have appeared. Previous attempts down this line have included standardizing 'interactive' audio file formats, or the provision of specific tools for creation and

[426] This division of liquid music approaches is detailed, with broadly similar terminology, by numerous writers such as Liljedahl, 'Sound for Fantasy and Freedom' (2011).
[427] Compositional guides for game music, such as Phillips, *A Composer's Guide to Game Music* (2014), are of considerable worth for liquid music development, though this thesis differs by providing a compositional approach to liquid music shorn of any other multimedia context.

distribution;[428] though these may achieve limited success, it can be concluded that as liquid music recordings move forward, more universal models and approaches need to be developed. These should allow for individuals to use any of the available technologies, while still following a clear process. Creation of music in any paradigm should not be limited by the tools used—the wealth of potential methods to create liquid music is a positive thing, and should be left largely unprescribed in order for the focus to remain on the final product.

To that end, an over-arching creation-model has been proposed within this thesis, drawn from the various research elements involved, supported by discussion with practitioners, analysis of existing works, and the application of the model to the creation of demonstration works. This model is intended to be both broad enough to allow for individual artists to utilize any tools or approaches they desire during the creation of liquid music, while also being prescriptive enough to ensure that the major elements necessary for a liquid music work must be considered and developed properly, in a holistic and thorough manner.

4.1.4 Portfolio of Practical Works

The accompanying demonstrations can be viewed as an espousal of the three-stage creation-model developed and proposed. They make use of a number of different software and hardware tools and platforms to show that the same basic principles can (and indeed should) be universally applied for liquid music.

[428] Noteworthy amongst these are the RjDj platform, or the iXMF file format, documented in Chapter Three.

A large-scale work, *The Liquid EP*, stands as a successful application of much of the foregoing research, showcasing and contrasting different approaches to horizontal and vertical alterations, interactive, adaptive and generative programming, and user interface methods. A video files included with the demonstrations in the accompanying software package serves to document the various elements present in a single iteration of *The Liquid EP*, which can be expected to last for approximately 26 minutes without excessive repetition.

A reflective evaluation of the portfolio works leads me to believe, first and foremost, that the production quality (with regards to the same recording and mixing processes necessary in fixed, solid music) is still a primary factor in the subjective success of a given liquid music composition. Those works that have met with the best reception from users are noticeably those with higher quality production values (including *Ash Player* and 'Call Me Crazy' from *The Liquid EP*). It is regrettable that more time was not spent on the first stage of the creation-model to ensure a more uniform quality of the finished recorded works, and this is certainly an area that will be focused on more closely in future work.

While *The Liquid EP* represents an engaging and comprehensive exploration of reactive and generative approaches, horizontal and vertical alterations, and user interface mechanisms, I believe that such a variety of ideas incorporated into one work actually detracts from the product as a whole. Future large-scale works might be focused more concretely on a smaller range of techniques: for example, an album exploring different implementations of music and affect, utilizing a single interface. This removes the need for a user to

engage with and learn a different mechanism for each part of the work (something which may potentially cause confusion or irritation), instead allowing for one powerful 'theme' to encompass a full musical work, while also allowing for greater compositional exploration of the theme in question. This seems to be the case in many works reviewed in Chapter Two, such as *The National Mall*, which focuses solely on the integration of GPS location with an adaptive branched form, allowing for coherent and straightforward user engagement.

4.2 Directions for Future Research

The scope necessary for a sufficiently broad overview of the liquid music paradigm, as given in this thesis, has naturally resulted in the exclusion of, or a limited focus on, a number of areas that might add further to the work. Some of these areas can be identified as potential directions for future research, either through continuation of the work undertaken here, or by others working in the same field. Areas that have been identified throughout the work as falling outside of the scope of the current research and praxis are discussed below.

Music psychology/psychoacoustics

The understanding of how people both respond to and engage with music in a variety of contexts could feed into the development of liquid music, ascertaining

both how and why certain approaches to its creation achieve different results to others, and helping to guide future creation within the paradigm.[429]

Interface design

Excluded as it does not fall under the more musicological focus of this thesis, an expanded examination of not just the potential tools for interface creation, but the aesthetic, psychological and functional design behind successful interfaces for multimedia would greatly benefit liquid music creation.[430]

Specific compositional approaches for reactive music

A number of common approaches to liquid music creation within the popular music sphere—mixing desk interfaces, location-based works, active sound agents—have been identified here (see Chapter Three). Each of these approaches may benefit from further research and exploration to ascertain their greater potential as compositional methods within the paradigm of liquid music. Meanwhile, further approaches that perhaps have not seen much work yet could be investigated and developed further. Two particular areas that this thesis touches upon with strong potential for future work are the use of two-dimensional interfaces depicting emotional spaces to allow interactive adjustment of musical affective states, and the use of time-of-day states to drive

[429] See continuing work in the field of musical affect such as Sloboda and Juslin (eds.), *Handbook of Music and Emotion: Theory, Research, Applications* (2011); and applications of affect-based interaction such as Livingstone and Brown, 'Dynamic Response' (2005).
[430] See as a starting point Janet Murray, *Inventing the Medium: Principles of Interaction Design as a Cultural Practice* (MIT Press, 2011).

adaptive musical works. The latter could draw further from examination of video games with in-game time states that are reflected by musical change.[431]

Cultural context

The cultural impetus behind the emergence of liquid music works could be explored in much greater detail, with regards to broader developments in participatory culture and DIY media. Perhaps more importantly, issues of copyright, authorship and economics will be important to liquid music as it moves forward, and will benefit from strong research.[432]

4.3 Conclusion

This thesis has defined and provided a framework for liquid music, highlighting how developments and works across a variety of media, platforms and genres that have included music with designed mutability can be drawn together under one heading. Contemporary practices in popular music, interactive audio, app development and a number of related fields provide context and precedent for this work, which specifically advances the field of 'liquid' music as a distinct paradigm for musical creation. The theories and concepts discussed within the thesis are highlighted and demonstrated through accompanying original practical works, which serve as a both a support for the theoretical work achieved and a validation of their relevance to the professional fields outlined.

[431] Neither of these approaches have solid precedent in released works, the nearest benchmarks being works such *Scape* (2015) or *Fantomas* (2016), each of which may alter musical behaviours based on the time of day, amongst a large number of other factors.
[432] Further research might start with Katz (2010), or Turino (2008).

The original contributions made herein are (i) an over-arching theoretical framework for liquid music, and (ii) a practical creation-model which functions as a guide for any liquid music composition. Intended primarily for musicologists and composers, the framework and creation-model provided here can serve as a platform or basis for considerable potential future work in the field, and as such will provide a valuable addition to research in this and related areas.

Appendix A DVD of Dynamic Music Programs

A DVD containing the programs described within Chapter Three of this thesis, as well as all relevant files and assets, is included as part of the submission. Below is a duplication of the instructions contained on the disc describing the programs.

Programs

Ash Player

This program was built with Pure Data 0.47.1, and runs through the MobMuPlat interface. To run it, download the MobMuPlat app from the Google Play Store; on your device, replace the folder labelled 'MobMuPlat' with the unzipped folder of the same name, included here. Run the app, and the *Ash Player* will be selectable from the drop-down menu.

Tapping the play button begins the song; progression is controlled by tilting the device along the x-axis. Visual and haptic feedback is provided by the interface.

Commoveo

This program was built with Unity Pro v.4.2.0f4, and uses audio soundbanks generated with Wwise v.2013.2.4. It runs on Mac OS.

After commencing playback by clicking the play button, the on-screen avatar is controlled by the <arrow keys>. The affective state of the music is altered based on the position of the avatar.

Hydra

This program was built with Unity Pro v.4.2.0f4, and uses audio soundbanks generated with Wwise v.2013.2.4. It runs on Mac OS.

After commencing playback by clicking the play button, progression between segments of the song is controlled by pressing the number keys <1> through <5>. The 'brightness' of the song is controlled with the <up> and <down> arrows keys. The affective state of the music is altered based on the position of the avatar.

Minos

This program was built with Pure Data extended v.0.43.4. It runs on Mac OS. Playback commencing by clicking on the interface's 'Play' button; progression through segments is controlled by clicking two smaller buttons on either side of the interface. A second GEM window displays a visual representation of progression through the work.

The Liquid EP

This final work was built with Pure Data v.0.47.1, and runs through the MobMuPlat interface. To run it, download the MobMuPlat app from the Google Play Store; on your device, replace the folder labelled 'MobMuPlat' with the

unzipped folder of the same name, included here. Run the app, and *The Liquid EP* will be selectable from the drop-down menu.

Tapping the 'play' button starts playback of the work. Each segment requires different interface controls, which are made explicit through clues on the visual display and/or through the discussion of the work in Chapter Three. The work continues until the user exits the application.

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