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Virtual Orchestration: A Film Composer's Creative Practice

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Declaration

I certify that the research presented in this thesis is original work carried out by the author. The work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university other James Cook University and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

The research presented in this thesis was approved by JAMES COOK UNIVERSITY Human Research Ethics Committee, Ethics Approval Number H6731, on 27/10/2016.

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Abstract

The advent of digital technologies has led to a major change in the process of film music composition; consequent developments in music technology have forced film composers to adapt to this change. Technological innovations such as digital audio workstations (DAWs) and virtual musical instruments have made possible the creation of virtual orchestras that are technologically capable of simulating the sound and behaviour of a traditional acoustic orchestra. This has had an effect on film music production and on the creative process of the professional film composer in a way that today, creating orchestral simulations or 'mock-ups' that imitate live orchestras (or smaller ensembles) has become a requirement in the film industry and thus an essential part of the film-scoring process. In the context of contemporary film music production, this thesis investigates how orchestral simulations are composed and created using computer music technology and virtual sample-based instruments. In asking 'how', the focus is on the film composer's activities and thought processes during this creative cycle, along with the nature of the interactive relationship between composer and music materials. This study aims to show the complexity of the film composer's creative practice and to advance understanding of how the use of computer music technology and orchestral sample libraries is influencing the compositional process and compositional outcome.

To address these questions, a qualitative multiple case study methodology approach was chosen that included examination of the practice of seven professional film composers working in the field of feature film as the primary valid source of data. The exploration involved semi-structured interviews with composers, observations and analysis of their studio practice and inspection of their compositional tools.

Taken as a whole, the evidence provided by this study is that the process of creating orchestral simulations is a process of film music composition during which professional film composers are creating orchestral sounds through the use of computers, digital sequencing, samplers and sample-based virtual acoustic instruments for the realisation of musical works. It is a process of using and manipulating recorded samples of real acoustic instruments to generate an expressive and convincing musical performance through sample-based orchestral simulation. A characteristic of this compositional practice is that it is a continuous process that proceeds in stages over time where all procedures can be applied repeatedly between stages. The process of creating orchestral simulations for the purpose of the film score is a multifaceted compositional activity involving a complex set of relationships among different compositional states of mind and compositional activities in which film composers experience music and interact with musical materials and media in various ways. This creative activity is a process involving a single person and a mixture of various compositional tools, the composer's skills and abilities brought into existence through a creative process that requires a thorough blend of art and craft to be demonstrated at all times.

Keywords: virtual acoustic instruments, orchestral sample libraries, orchestral simulation, film music, film composer.

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Chapter 1: Introduction

The effect of computer technology is all around us; from education to health care, communication, transport and entertainment. It is therefore not surprising that it has had a resounding effect on the art of music in the late twentieth and early twenty-first centuries. It has transformed how music is practised, transmitted, preserved and heard. Less and less frequently do we hear musical sound that has not at some level been shaped by technology. For most people computers are an everyday tool used for everyday tasks; at the same time, they are a central part of exciting new technologies for artists, including film composers. As they improve and become more powerful and faster, computers are becoming as integral to a film composer's work as any other instrument. In recent years, both the philosophy behind and technique of film music production has undergone a major transformation. As a consequence, the context surrounding film composition has shifted rapidly, leading to the complete disappearance of a long-established division of labour in the film-scoring process (Borum, 2015).

New requirements in the film industry caused by continual developments in computer music technology have led to major changes in the way film scores are being made. Not so long ago, composers were one part of an enormous music machine; they wrote scores and attended recording sessions while performers and orchestras performed. As technology became a necessary part of the film-scoring process, film composer duties steadily increased; delivering a film score in today's commercial environment requires that composers take on multiple roles (Ellis-Geiger, 2007, Karlin and Wright, 2013, Wierzbicki et al., 2012). Today's film composer is responsible for each step of the music team's process, and more often than not the composer is the entire team (Morgan, 2016, Borum, 2015, Karlin and Wright, 2013, Brown, 2001).

Technological innovations such as digital audio workstations (DAWS) and virtual musical instruments have made possible the creation of virtual orchestras that are technologically capable of simulating the sound and behaviour of a traditional acoustic orchestra. Hence, film composers increasingly are utilising computer technology to enhance or even entirely replace physical orchestras, with often brilliant results. This has had an effect on film music production and the creative process of professional film composition in a way that today, with very few exceptions, film producers and directors expect a composer to present their score cue by cue in the form of well-executed orchestral simulations or mock-ups (mostly containing orchestral sample libraries), and to work with composers to refine (or revise) their music to suit the filmmaker’s expectations and wishes (Karlin and Wright, 2013, p.101). This enables film directors and producers to audition a number of pieces of music from different composers and make informed decisions about which composer and music to use for particular projects. Further, today, when previewing a composer’s film score, the majority of film directors expect the mock-up orchestra to provide an accurate simulation of a real orchestral performance (Ellis-Geiger, 2007, p.136), and demonstrating the entire score is almost always done by the composer through the creation of orchestral simulations.

Because of that, creating computer-generated orchestras or ‘mock-ups’ that imitate live orchestras (or smaller ensembles) has become a requirement in the film industry and thus an essential part of the film-scoring process—a process that requires creating expressive and convincing simulations of real orchestras using computer music technology. However, a thorough understanding of this creative practice, and the theory behind it, is largely unavailable. The available literature focuses almost entirely on traditional compositional methods, computer musical software and computer interface design. Very little academic literature addresses how the creative process of film composers is affected when computers and orchestral sample libraries are the primary tools for film music production. The same is true for the effect of computer music technology on compositional and decision-making processes in film-scoring practice.

The goal of this project is to investigate, through primary and secondary research, the film-scoring process of creating orchestral simulations during which composers utilise computer music technology as a primary tool for music composition. The main research question that underpins and drives this research is, **how are orchestral simulations (mock-ups) created using computer music technology and virtual sample-based instruments**? In asking 'how', the focus is on film composers' activities and thought processes that take place during this creative cycle, along with the nature of the interactive relationship between composer and music materials. This study aims to highlight the complexity of this compositional practice and advance understanding of what experienced film composers do, why they do it and how they utilise computer music technology throughout the process of creating orchestral simulations for the purpose of the film score. This research provides a conceptual model of creative practice that encompasses and describes most actions and thought processes that take place during this creative cycle and how the use of computer music technology and orchestral sample libraries is affecting the compositional process and outcome.

During this research the compositional practices of seven experienced composers were examined in detail. These composers utilised computer music technology in various ways during the process of creating orchestral simulations. This thesis presents my examination of the composers' tools, methods, working environments, motivations and creative thoughts so that a detailed picture of this important compositional practice can be developed. Throughout this thesis, a number of new theories about this creative practice are proposed; most significantly the theory of virtual orchestration presented in Chapter 8, which I use for categorising the compositional activities common to all composers during the process of creating orchestral simulations for the purpose of the film score.

The significance of this study is that it will lead to a better understanding of this new and established film-scoring practice as the expressive organisation of sound, and how professional film composers utilise computer music technology during that practice. To fully appreciate the film composer, we have to understand why and what composers do, the complexity of film scoring and the role of the film composer today. This research attempts to reveal the diversity of film-scoring compositional practice and how professional film composers perceive their practice, composers' creative thoughts, what is the role of the film composer throughout this practice and how computer music technology is used to enable and enhance the film-scoring process of creating orchestral simulations. As the music-making process is constantly shifting and changing, morphing into a continuous stream of computer enhanced activities that no longer have the distinctions of the past, we must ensure that academic research continues to keep up.

In general, the evidence from these case studies demonstrates that the process of creating orchestral simulations is a multifaceted compositional activity that involves a complex set of relationships among different compositional states of mind and compositional activities, in which film composers experience music and interact with musical materials and media in various ways. This entire compositional practice is a creative activity that can be suppressed or amplified using computer tools and scenarios. A prevailing consideration is that this production process involves a complex mixture of different perspectives and relationships between a composer and the musical materials. These relationships are predominantly influenced by particular project requirements, a composer's previous experiences, their thoughts and feelings, and their skills in using the computer music technology as a compositional tool to interact with musical materials as a means of personal expression.

An overview of the thesis structure

The thesis is divided into nine chapters. Chapter 2 provides a review of the key academic sources relevant to a study of film music and computer-assisted film music composition. In particular, I examine the definition and function of film music, the role of technology in film music making, specifically examining creative processes, sample-based orchestral simulation and literature that encapsulates research on this topic.

Chapter 3 describes the research design of the study, explaining the research methods employed; the rationale for the selection of the case study composers; and the data collection and analysis procedures employed. Data were collected from composer via interviews, site visits, audio and video footage, examination of compositional tools and by observing the composer in action utilising these tools. The composers are introduced briefly below.

In Chapter 4 I describe the concept of orchestral simulation and present it as the creative product film composers are required to produce. The purpose of Chapter 4 is to inform the reader about the complexity of processes involved and to briefly explain them before going into more detail in later chapters about what orchestral simulation as the required outcome of a composer's work is supposed to represent.

Chapter 5 examines the composer–computer interface used in this study and its effects on compositional approaches to film scoring. The objective is to understand the nature of the computer interface composers utilise and how they interact with this technology, specifically referring to the use of input–output devices with supporting software. This issue is considered form three perspectives—physical, visual and audible interfaces—and the actions of composers interacting with them.

In Chapter 6 I explore how composers organise their compositional processes from initiation to completion according to their individual circumstances. Each of the composers worked in a particular way and their stories are presented throughout Chapter 6 to describe how their workflow was managed towards compositional ends and how they proceeded through various steps during the process of creating orchestral simulations for the purpose of a film score. The creative process here is viewed as a staged process where each stage reveals particular aspects of creative practice and shows if and how this practice is influenced by the use of computer music technology.

Chapter 7 examines in more detail some specific tools and techniques composers are using to modulate the variety of expressive detail in their virtual orchestral performance. In particular, I examine how composers coordinate their actions to manipulate and alter the expressive character of their virtual orchestral ensembles to create orchestral simulations that simulate both the behaviour and character of a real orchestral performance.

In Chapter 8 I introduce my model of creative practice that I term 'virtual orchestration'. I outline and introduce a taxonomy of compositional activities that encompass and describe most actions and thought processes that take place during the process of creating orchestral simulations. This discussion is based on the activities that are common to all case study composers, regardless of the project requirements, composer's musical and compositional styles, musical outcomes and equipment utilised. Finally, in Chapter 9, I summarise the major research findings; outline some implications for creative work and music education; and suggest directions for further research.

The appendices contain evidentiary documentation supporting the research methodology processes. These include interview questions, a summary of the researcher journal and data coding categories.

Introducing the case studies

This section presents a brief outline of each of the case study composers. These composers were chosen because as a group they utilised a variety of computer hardware and music software in a variety of ways and created music in a range of musical styles. Only composers who were experienced and well respected by their peers were considered so that the group could be regarded as representative of experienced film-scoring compositional practice.

Key terminology

To avoid any ambiguities throughout this thesis about the meaning of my comments relating to the case study composers, film-scoring process or film music in general, I adopt the following descriptive practice.

- Film refers to storytelling through a motion picture, movie, television show or video, which most people value as a source of entertainment.

- Creative practice or creative process refers only to the process of creating orchestral mock-ups for the purpose of the film score during which the composer is composing music using computers and orchestral sample libraries. Unless stated otherwise, this does not refer to the entire film-scoring process, which also includes spotting sessions, film composer–film director/producer relationships or recording sessions with live orchestras.

- Throughout the thesis I use the term ‘the composer(s)’ when referring to the seven case studies.

- I use the term ‘professional film composer’ when referring to composers who, like the composers chosen for this study, are skilful and have a prolonged or intense experience through film-scoring practice. When referring to all composers in general I purely write 'composers'.

- Throughout the thesis the word 'audience' refers to the general cinema audience as well as the movie director/producer as an audience of one.

Case study composers

Holkenborg

Tom Holkenborg, aka Junkie XL, is a Hollywood composer whose versatility puts him at the cutting edge of contemporary music, as well in the vanguard of exciting new film composers. His film-scoring credits include *Mad Max: Fury Road (2015)*, *Superman Man of Steel (2013)*, *Deadpool (2016)*, *Black Mass (2015)*, *Divergent (2014)*, *Brimstone (2017)* and the forthcoming *Dark Tower (2017)* and *Tomb Raider (2018)*.

Partos

Antony Partos is one of Australia's most awarded film composers. His feature film credits include *99 Homes* (2014) (Australian Guild of Screen Composers Award for Feature Film Score of the Year), *Animal Kingdom*

(2010) (Australian Film Industry [AFI] Award for Best Feature Score) *The Rover (2014)*, *Disgrace (2018)*, *The Home Song Stories* (2007) (AFI Award for Best Feature Score) and *Unfinished Sky* (2007) (AFI Award for Best Feature Score).

Rona

Jeff Rona is a Los Angeles-based contemporary film composer and recording artist. He has worked on numerous film and television projects with directors such as Ridley Scott, Steven Spielberg, Robert Altman, Steven Soderbergh, Frank Darabont and many others. Many of Rona's projects have received awards such as Oscar and Emmy awards, and numerous film festival awards around the globe. He is a two-time recipient of the American Society of Composers, Authors and Publishers (ASCAP) film and television music award. He also composed for the 2008 Beijing Olympics.

Yeo

Caitlin Yeo is a highly acclaimed, multi-award winning Australian film, documentary and television composer. Her compositional style emerges from a fascination with music from different cultures, twentieth century composition and a deep love of telling stories with music. In

2011, Caitlin was awarded the Australasian Performing Right Association (APRA) Professional Development Award, which garnered her a place at the prestigious ASCAP Film and TV Scoring Workshop in Los Angeles. Caitlin is the current president of the Australian Guild of Screen Composers and a lecturer in film music, composition and production at the Australian Institute of Music.

Mann

Two-time Emmy-award-winning Canadian composer/arranger Hummie Mann has collaborated with some of Hollywood's most celebrated directors including Mel Brooks, Peter Yates, Leszek Burzynski and many others in both theatrical and television films. Mann holds a Doctor of Music Arts degree in Film Composition from the University of Salford in Manchester and he is the creator and lead instructor of the Pacific Northwest Film Scoring Program, which 5 years ago became the music department of the Seattle Film Institute.

Rowland

Bruce Rowland is a well-known Australian composer who wrote scores for some of Australia's most successful films. Rowland has written the scores for over 40 films in Australia and the United States. Along with film, Rowland has been involved in a variety of special projects. In 1988 he was commissioned to write the *Royal Fanfare* for the opening of Expo 88. In 1996, he was commissioned to write the music for the Prime Minister's Olympic Dinner and then in 2000, Rowland wrote and conducted the music for the opening ceremony of the Sydney 2000 Olympic Games.

Simjanovic

Zoran Simjaniovic, a member of the European Film Academy, is a professor at the Faculty of Music Art in Belgrade, Serbia (former Yugoslavia). He is an internationally awarded film composer whose career spans over 40 years, during which he composed and orchestrated music for over 160 feature films and television shows.

Glossary of terms

Arpeggiator—a feature available on various hardware and software musical instruments capable of automatically performing a sequence of notes or chords based on player's input.

Click—a digital version of a metronome

Compressor—a hardware or software device used to reduce dynamic range of an audio signal (the span between the softest and loudest sounds).

Cue—a single piece of music.

Cubase—a DAW and musical instrument digital interface (MIDI) sequencer software application for the Microsoft Windows and Mac OSX platforms.

DAW—a virtual recording studio system designed for recording, editing and playback of audio materials.

Digital Performer—a DAW and MIDI sequencer software application for the Microsoft Windows and Mac OSX platforms.

Envelope—In music and sound, a term "envelope" represents the varying level of a sound wave over time broken down into four stages: attack, decay, sustain and release (ADSR). Attack is the initial onset of the soundwave when it begins to vibrate; decay refers to how long the fundamental frequency and harmonics of the soundwave(s) remain at their peak volumes before they start to become less and less audible; sustain presents the period of time during which the amplitude of the soundwave remains before the soundwave becomes silent; and release presents the time it takes for the amplitude of the soundwave to drop from the sustain level to silence.

Equaliser—a hardware or software device with a set of frequency-specific volume control knobs used to adjust the amplitude of audio signals at particular frequencies.

Logic Pro—a DAW and MIDI sequencer software application for the Mac OSX platform.

Legato—the style of playing notes in a phrase without a significant silence between them. This indicates that musical notes are played or sung smoothly and connected. By playing legato, a player creates a smooth and flowing melodic line.

MIDI—a communication protocol that allows electronic musical instruments to synchronise and communicate.

Mid-field monitor—a generally larger studio monitor optimised for positioning between 2 and 4 m away from the listener.

Mock-up—a demo of a musical material created using electronic (samples) and/or acoustic instruments.

Plugin—a software component that supplements larger software applications.

Near field monitor—usually a small studio monitor designed to be positioned approximately 1–2 m away from the listener, making it ideal for smaller studios.

Portamento—a continuous pitch sliding from one note to the next note in the musical phrase.

Post-production—deliberate manipulation of the recorded musical and/or video materials.

Pro Tools—a DAW and MIDI sequencer software application for the Microsoft Windows and Mac OSX platforms.

Round-robin—a method of sample playback that allows playing of different sampled versions of the same sound each time a performer hits the same key; this method produces natural variations in otherwise static patterns.

Sampler—a digital or electronic musical instrument that uses and plays back sound recordings (or "samples") with the use of electronic keyboard or other MIDI triggering device (e.g. a sequencer).

Sample—a digitally recorded sound.

Sequencer—an electronic device, or application software that can record, edit and play back musical material in the form of digital audio or MIDI data.

Spotting session—a meeting during which the director/producer and composer get together to decide where in film the music will be used and what is music going to do in the film.

Time stretching—a procedure that changes the speed or duration of the audio signal without changing its pitch.

Chapter 2: Context and Literature Review

This literature review aims to identify and describe the key academic sources relevant to a study of film music composition utilising computer music technology. The first section, the context review, traces the history of ideas that surround acoustic musical instrument simulation and maps the major thoughts and debates that have emerged from both practice and technological developments. In the second section, the definition and function of film music is investigated. By synthesising a broad range of research, the third section centres on the role of technology in music making, specifically examining the creative process, compositional engagement and musical computer user interfaces. Finally, the fourth section focuses on sample-based orchestral simulation and reviews the literature that encapsulates research on this topic.

The purpose of this literature review is to help to determine what is the main role of music in a film, how film scores are created using computer music technology, and to identify the problems and challenges associated with the production of film scores utilising technology. As will be seen, the review of the academic literature reveals a distinct lack of research that delves into the intricacies of creating orchestral simulations for the purpose of film scores using computers, sample-based orchestral instruments and computer music software and hardware. As a consequence, this chapter draws upon academic studies and professional sources as a way of establishing current views on how film scores are created using computer music technology.

Context review

The phenomenon of simulating sounds, musical instruments or human performers is not new. During Roman times, one of the oldest instruments, the hydraulis, was an early pneumatically powered pipe organ. Modifications of this organ replicated birdsongs and in the early nineteenth century, mechanical organs called orchestrions imitated all the instruments of the symphony orchestra (Davies, 1996, p.4). Similarly, instruments that can replicate voice and song have been around for centuries. In ancient China, a myth exists of a bamboo spike fixed below a sliding temple door running in a groove in the floor, which produced the sounds 'please close the door' and, in reverse, 'thank you for closing the door' (Davies, 1996, p.5). In the late nineteenth century, Thomas Edison invented the cylinder phonograph, which was the first system devised for both storing and replaying sound, and as such, an important landmark technology in the effort to simulate or reproduce human musical performances. Of course, one of the most widely utilised forms of simulating another instrument was developed during the second half of the twentieth century, when imitations of earlier instruments became widely available on electronic keyboard instruments.

Technological advancements are not reserved for popular music forms, such as techno, dance music, house or hip hop. There is a long history of technological innovation in the classical music tradition stretching back to the mid-twentieth century when developments such as *musique concrete* and *elektronische musik* changed the music landscape irreversibly. Pierre Schaeffer is considered a pioneer of sample-based music composition and one of the most influential experimental, electroacoustic and electronic musicians. In 1948 he coined the term *musique concrete*, meaning music produced from recordings of instrumental and field-recorded sounds that are then altered using tape techniques (Russ, 2004, p.9). Schaeffer was the first composer to make use of a number of editing techniques that gave birth to the idea of constructing musical works and 'performances' from a library of pre-recorded materials. He was also one of the first musicians to use recorded sound combined with other sounds to create a musical piece. Tape-splicing and tape-looping techniques were used consistently in his approach, which was often referred to as sound collage. Karlheinz Stockhausen and Luciano Berio are also considered early innovators of tape music composition. They used recorded sound sources to produce *electronische musik*. This repertoire of works from the 1940s and '50s established the idea that studio techniques could be used to create unique listening experiences that extended beyond the confines of a singular musical performance. According to McGuire and Pritts, 'early electronic composers found that manipulation of recorded sound materials opened a whole new palette of sound sources for musical expression' (McGuire and Pritts, 2013, p.193). These studio compositions created imaginary sound worlds that did not exist in the physical realm.

Glenn Herbert Gould, a celebrated Canadian classical pianist, was one of the first musicians to explore the idea of studio-based performance. For Gould, recording and broadcasting were not supplementary to the concert hall, but rather distinct art forms that 'represented the future of music' (Breckbill, 2013). In the 1960s and '70s he produced scores of albums, steadily expanding his repertoire and developing a professional engineer's command of recording techniques. One of his motivations for abandoning live performance at a relatively young age was to pursue the potential of the recording studio to construct performances that extended beyond the limits of any one recorded take and were constructed from many different takes. He was empowered to control every aspect of the final musical piece by selecting different parts from various takes to produce a 'perfect' performance. Gould likened his method to that of a film director, arguing that just as a viewer does not perceive that a 2-hour film was made in 2 hours, the act of listening to music should be no different (Kingwell, 2009, p.151).

Gould conducted a series of listening experiments whereby musicians, sound engineers and non-experts were asked to listen to recordings and determine if and where splicing had taken place. Based on their relationship with music, different groups of people gave different answers, but no group gave accurate answers. Although his conclusions were by no means scientific, Gould made an observation: 'The tape does lie, and nearly always gets away with it' (Kingwell, 2009, p.158). This is an important historical precedent in the field of acoustic instrument simulation in that although the instrument itself was real (in that Gould performed on a real piano) the performance was not. It was constructed from many different source recordings or takes, yet the audience believed it was one coherent performance. Gould's work in the area demonstrated that audiences could perceive highly constructed and edited materials as a 'real' performance.

The next historical step towards virtual instruments was the idea of the virtual acoustic instrument, which had its genesis in the sampler—a device that allowed the recording and replaying of real acoustic instrument sounds and gestures. This concept can be seen to have originated in an early analogue tape-based device known as the Mellotron. In his book, *Guide to MIDI Orchestration*, Gilreath explains that the Mellotron, which generated orchestral sounds using pre-recorded strips of analogue tape, was the first 'sampler' available to the public (Gilreath et al., 2004, p.521). The Mellotron was designed to operate so that when a key is pressed, a connected tape is pushed against a playback head, similar to a tape recorder. As long as the key stays depressed, 'the tape is drawn over the head, and a sound is played. When the key is released, a spring pulls the tape back to its original position' (Awde et al., 2008, p.17). The Mellotron set an important technological precedent and was used in the 1970s by bands such as Genesis, the Moody Blues and Yes. It was only after The Beatles used the technology, however, that the Mellotron became popular and widely used by commercial studios (Goodwin, 1988).

By the late 1970s, digital technology was starting to emerge in the context of music production. This allowed the concept of the sampler to be further developed. The Fairlight computer musical instrument (CMI), a digital sampling synthesiser, was designed by Peter Vogel and Kim Ryrie in 1979. The Fairlight CMI introduced sampling to the world of commercial music production in the 1980s and was used on numerous hit singles and albums (Harkins, 2015). Composer Jan Hammer was an early adopter of the technology, using the Fairlight CMI to compose the soundtrack for the television drama series Miami Vice. Arguably, it was during this period that the concept of believability emerged; the notion that it should not be possible for the audience to tell the difference between acoustic instruments and digitally created sounds. The Fairlight CMI was originally marketed as a device that could replicate the sound of real instruments. Kim Ryrie, Fairlight founder, once said, ‘we wanted to digitally create sounds that were very similar to acoustic musical instruments, and that had the same amount of control as a player of an acoustic instrument has over his or her instrument’ (Tingen, 1996). While the quality of the Fairlight CMI’s samples was unrefined by today’s standards, it was nonetheless praised for its ability to mirror real instruments ‘perfectly’; as Ryrie describes it, ‘the orchestra-in-a-box syndrome’ (Tingen, 1996).

The success of the Fairlight CMI inspired other developments in sampling, most concerned with the goal of emulating or replacing real acoustic instruments. For example, New England Digital modified their digital synthesiser, the Synclavier, to perform sampling and E-mu introduced a sampling keyboard called the Emulator, a device whose name spoke loudly about the commercial motivations and aims for the development of digital sampling technology. Ensoniq introduced the affordable Ensoniq Mirage in 1985, which made sampling available to the average musician for the first time.

Another important precedent work was the hyperinstrument project. Started in 1986, its goal was to design expanded musical instruments using technology to give extra power and finesse to professional performers (Tanaka, 2009). Guitars, keyboards, percussion, strings, even the conductor, were augmented using the project. Such hyperinstruments have since been used by some of the world's foremost performers, such as the Los Angeles Philharmonic, Peter Gabriel and Yo-Yo Ma. Since 1992, the focus of the hyperinstrument group has morphed and the emphasis is now on building interactive musical instruments for non-professional musicians, students and the general public. In the late 1980s, sampling became a standard feature of the electronic keyboard, not only as customised instruments but also as an additional method of generating more complex sounds (Davies, 1996). Since 1988, synthesisers, electronic organs and pianos have increasingly featured both synthesised and sampled sounds. These are sometimes kept as separate groups of waveforms and sometimes fused together. By 1991, 80% of synthesisers were based on sampling synthesis combinations and as computing power increased while costs decreased, the difference between the two was obscured.

Electronic sound synthesis incorporates many forms of sound production and sound-processing methods, including subtractive synthesis, additive synthesis, wavetable synthesis, sample replay, granular synthesis, frequency modulation (FM) synthesis and physical modelling. Developing the capability to electronically reproduce the sounds of acoustic instruments such as drums or pianos in real time so that they cannot be distinguished from real instruments was a difficult task. In 1967 John Chowning, a PhD student from the Center for Computer Research in Music and Acoustics at Stamford University, discovered that complex sounds could be created using only two waveforms if the output of one waveform was connected to the frequency input of a second waveform. He named this 'frequency modulation synthesis' or FM synthesis. At that time, this method produced sounds that were entirely foreign:

> I was aware that I was probably the first person to ever hear these sounds, that what I was hearing was something musical that had probably never been heard by anyone before—at least, not by anyone on this planet (Crockett, 2015).

Chowning took his discovery to the Office of Technology Licensing (OTL) because he realised that this approach could possibly be useful to the music industry. As a result, Stanford University received a patent in 1977. After approaching all of the major organ companies including Hammond, Wurlitzer and Lowry who understood the abstract, but had no knowledge of the digital domain, the OTL contacted Yamaha, who believed that digital technology was an important part of the future of electrical instruments. Yamaha decided that FM synthesis coincided with their ideas and thus applied for an exclusive license, which Stanford University granted.

Since FM synthesis was very difficult to achieve for real-time instruments and because Yamaha had to wait for the next generation in digital chip technology when chips would have enough power to handle the process, it was not until 1983 that they released their first highly popular product, the DX-7 synthesiser, which quickly became the preferred instrument of a number of artists worldwide. The DX-7's sound character was praised by a number of famous musicians who used the DX-7 on their recordings, artist such as Elton John, Stevie Wonder, Queen, U2, Phil Collins, Kraftwerk, Talking Heads, Brian Eno, Yes, Depeche Mode, Toto and Chick Corea. Since its implementation, FM technology has provided the sound for many Yamaha electronic keyboards. With the development of computers and DAWs, Yamaha FM synthesis chips found their way into a large number of the sound boards that provided personal computers with the ability to reproduce voices and music.

The next important step in the advancement of sound production and methods for replicating the sounds of actual instruments was the development of physical modelling synthesis in the late 1980s. Physical modelling synthesis was developed to model the tonal characteristics produced by acoustic instruments, including all of their performance gestures. It was specifically targeted towards acoustic instrument simulation (Smith, 2004). According to Smith, physical modelling synthesis can be regarded as modelling sound at its source, thereby enabling parsimonious representations and sonic manipulations that closely follow the physics of sound production. Consequently, physical modelling synthesis provides a complete playability range for virtual acoustic instruments (Smith, 2004, p.285). The first commercially available physical modelling synthesiser that modelled the sound of acoustic instruments through mathematical means was the Yamaha VL1, developed in 1994 by Yamaha in collaboration with Stanford University's Professor Julius O Smith III. It was the first synthesiser that modelled physical strings, wind and reed sounds. Many felt the VL1 produced sounds that so accurately reflected real instruments that it was hard to think of them as being electronically generated (Russ, 2004).

Another major advance in computer sample playback technology came when computer software company NemeSyS developed its computer software GigaSampler, in 1998. GigaSampler was noteworthy because it did not require a sample memory, instead directly streaming audio from the hard disk as required. Prior to GigaSampler, hardware and software samplers required samples to be loaded in a random-access memory (RAM) device, which directly restricted the number and size of the samples they could use. The innovation of GigaSampler meant loading times were greatly reduced, since rather than having to load sounds completely into RAM, they were always available and RAM was only used for the buffers when running the software. It was this product, according to Gilreath, that 'included the streaming technology necessary to move sampling to the next level' (Gilreath et al., 2004, p.521). Streaming from hard disks enabled large sample collections to be ready for playback in real time.

In 1996, Steinberg GmbH, a German musical software and equipment company, released its Virtual Studio Technology (VST) software interface, which integrates software audio synthesiser and effect plugins with audio editors and recording systems to enable users to use virtual instruments and produce or play sounds on a computer. Because of that, virtual instruments could be used on a computer as plugins hosted by DAW software (e.g. Steinberg's Cubase; Logic or GarageBand by Apple; Pro Tools) or as stand-alone applications (Pejrolo and DeRosa, 2009).

There exist two types of virtual instruments. The first type makes sounds by creating and modulating waveforms, similar to traditional analogue and digital hardware-based synthesisers. The second kind of virtual instruments are sample based virtual instruments; such instruments trigger recorded audio materials performed by live musicians. Recorded 'samples' are later edited, organised and assembled for use in a sample library. In the context of orchestral sample libraries, musical elements such as single notes and tone sequences (phrases) are recorded with different kinds of expressions, tempos and articulations (Pejrolo and DeRosa, 2009). Such variations cover the capabilities of each individual instrument and instrument sections in ensemble. Finally, to make them usable in a sample library or virtual instrument, the recordings are edited and processed in the studio.

The need for closer integration between software musical instruments and samples for increased realism and performability led to the development of proprietary sample playback computer programs. This allowed composers and other musicians to effectively reproduce almost every nuance soloists or ensemble of performers were capable of playing with completely authentic results. Unlike virtual instruments, pure sample libraries depended on so-called software samplers (e.g. Vienna Instruments Player [VIPLAY]; Soundsonline's PLAY; and Native Instruments KONTAKT). The user had to load the sound libraries into the sample players for use (Sundstrup, 2009).

Different orchestral libraries have evolved over the years in such a way that they all exhibit different strengths and weaknesses for different applications; in practice, composers move around libraries to work to their strengths, or draw upon different libraries for different parts of a piece of music. No library is uniformly realistic; some patches and instruments are usually stronger than others and, in terms of realism, composers are utilising different libraries for different applications because they are more or less realistic for the kind of writing they are trying to do: for example, legato versus staccato, string quartet versus full orchestra or adagio versus allegro (Love, 2103, Sundstrup, 2009).

Different composers have different perceptions of different sample libraries being used for different genres. For example, Hans Zimmer is well known for having created his own private collection of sampled orchestral instruments, which gives him a signature sound because he is not hearing his samples used by anybody else, and his personal library allows him to use different articulations and simply provides him with more playability than commercial libraries (Hans Zimmer MasterClass, 2017).

The current industry leaders of compelling orchestral sample libraries include the Vienna Symphonic Library (VSL), LA Scoring Strings Collection and East–West

Quantum Leap Symphonic Orchestral Library. Since its introduction in 2005, VSL has been the most powerful virtual orchestral instrument on the market, consisting of a very large number of orchestral instruments and tens of thousands of articulations with a vast number of dynamic levels. The East–West Quantum Leap Symphonic Orchestral Library is an award-winning orchestral collection, and the only orchestral collection to be recorded in a 'state of the art' concert hall where orchestras mainly perform; while the LA Scoring Strings Collection brings a whole new set of tools and revised sonic profiles providing a new level of expressiveness, realism, real-time playability and programmability to sampled strings (Pejrolo and DeRosa, 2009, Russ, 2004, Sundstrup, 2009, Morgan, 2016).

Currently, many classically trained composers are utilising virtual acoustic instruments (VAI) in their everyday work. One of the first examples of virtual musicians was presented by the DIVA Group in the Electric Garden at Siggraph 97 (Schertenleib et al., 2004). Since then, computer simulations of full orchestral performances have developed to high levels of realism thanks to advances in technology, including powerful audio/MIDI sequencers, detailed instrument reproduction through sound synthesis, and performance modelling using data acquisition and expressive performance rules (Sundstrup, 2009). Today, many composers use VAI as an illustration for what will ultimately be performed by a live ensemble. Composer Jerry Gerber, for example, argues that the expressive potential of VAI makes it an artistic medium in its own right, capable of creating a sound worthy of being the final composition (Jones et al., 2012). Its precision, possibilities for new timbres and potential for automation make it a compelling platform for experimenting with and making music (Wang, 2007, p.55). Ultimately, with the expanding potential of computers, orchestral simulations can be accomplished in real time as realistic virtual performances without requiring live instrumentalists' support.

VAI does not depend on physical constraints faced by its acoustic counterparts, such as membranes, strings or the shape of an instrument. This feature permits a huge diversity of possibilities regarding sound production; however, strategies to design and perform these new instruments need to be devised to provide the same level of control subtlety available with acoustic instruments (Wanderley, 2001, Sundstrup 2009, Morgan, 2016).

The development of virtual orchestral instruments is not just about sample libraries; it is also about the corresponding technological development of MIDI and gestural controllers. When virtual instruments arrived on the scene they were integrated with DAW environments and input options were performance based or score/note entry based. Therefore, the question of how to design and create performances with new computer-based musical instruments such as gesturally controlled, real-time computer-generated sound needs to be considered to obtain similar levels of control subtlety as those available with acoustic instruments (Wanderley, 2001). For example, it is possible now to use gestural controllers such as a wind controller or an alternative note entry device to introduce an expressive flute or clarinet part, or to use pads to play the instruments for a percussion part.

Turning to cinema, the practice of using synthesised sounds in film production began in 1978 with the arrival of digital synthesisers and samplers (Palm, 2008). Many inherent issues with the analogue synthesiser, such as inadequate intonation and reliability, were resolved and new possibilities opened up for film composers (Burt, 1994, p.243). Entire studio orchestras were able to be replaced with this new technology. In 1982, Greek composer Vangelis, who used the synthesiser to replicate traditional instruments, became the first composer to win an Academy Award for an entirely digital soundtrack, *Chariots of Fire* (1981). According to Hickman, synthesisers were widely used in 1984, with the scores for two of that year's top grossing films, *Beverly Hills Cop* (1984) and *Ghostbusters* (1984), produced using this technology (Hickman, 2006, p.382). The trend to use synthesisers and samplers in film scoring has continued in recent years. Sampled instruments and orchestral sample libraries have become an important part of composer and record producer Danny Elfman's sonic template. He used piano and drum sample libraries extensively on the soundtrack of 2009 film *Terminator Salvation*. Jeff Beal, one of the most prolific and respected composers working in Hollywood today, has utilised orchestral sample libraries for many years both in the mock-up and final phase of production. According to Beal, 'these sounds offer absolute stunning quality, fidelity, and musicality' (Beal, 2014).

As this context review shows, the history of musical instrument and performance simulation has evolved significantly as a result of both practical and technological developments. Largely over the course of the twentieth century, successive refinements to key concepts and technology have enabled the evolution of an entirely new form of music production. In the realm of music performance, Glenn Gould demonstrated that performances could be convincingly simulated using editing techniques. These techniques became widely used in the analogue era and are now routine within the digital era. These developments highlighted that constructed/edited performances were readily accepted by audiences. At the instrument level, the concept of the ‘sampler’ emerged in the latter half of the twentieth century and established that a musical instrument could be imitated by recording a library of notes, articulations and gestures. These would be re-assembled first from analogue tape technologies (Mellotron) and later via digital samplers (Fairlight, Synclavier, Emulator, Mirage) whose capacity became greatly extended via the emergence of ‘streaming samplers’ such as GigaSampler in 1997.

For sound synthesis, the industry saw a series of developments from modular analogue systems; synthesis preset systems allowing the creation, storage and recall of ‘imitation acoustic instrument’ sounds; physical modelling synthesisers, which attempted to mathematically model the behaviour of real acoustic instruments; through to software synthesisers that allowed all synthesis approaches to be represented in software within a DAW system. While the invention of the synthesiser was not purely to imitate acoustic instruments, the uptake of synthesisers into commercial music production provided both the context and demand for them to be used to simulate acoustic instruments, thus offering a low cost, convenient way of using acoustic instrument sounds within orchestration without needing high budgets to pay for large numbers of musicians.

Music and film

This section of the literature review details the role music plays in film, and how music is used as a means of communication through interaction with visual imagery. In this chapter, the term 'film' refers to storytelling through a motion picture, movie, television show or video, which most people value as a source of entertainment.

The academic discourse on film music is comparatively brief, but despite its short history, the systematic approach to film music analysis stretches from musicology, media (communication) and philosophy (aesthetics) to psychology (cognitive studies), semiotics, psychoanalysis and neurological research (Buhler and Neumeyer, 2014). Classical film theory and the associated language theorists have used to describe the aural component of films, implies that the visual domain was assumed to be superior to the auditory domain of films (Kalinak, 1992, p.24). That is, seeing was more important than hearing. Historical views and cultural biases conditioned our perception of film sound as peripheral to the visual image and positioned hearing below vision, in terms of perceptual accuracy (Kalinak, 1992, Larsen and Irons, 2007).

Ancient theories of cognition clearly differentiated between the ways we see and hear. Greek philosophers such as Aristotle, Plato and Heraclitus considered visual perception as not only faster than aural perception, but also more reliable. To them, our eyes were responsible for processing sensory input—they facilitated the processing of knowledge about the outer world—while our ears were assumed to have direct access to our soul, the emotional side of man (Kalinak, 1992, p.21). Similarly, nineteenth century acoustic researchers, namely Georg Ohm, Edward Gurney and Hermann von Helmholtz, sustained a model of sensory perception that associated the eye more with the intellectual, and the ear with the emotional domains of human experience (Kalinak, 1992). Such scientific discourse of the nineteenth century, according to Kalinak, 'cast into relief the ideological subtext driving acoustical investigation: the value of objectivity over subjectivity' (Kalinak, 1992, p.24). It is not surprising that such theories and historical views influenced the scholarly discussion on film sound, which always suggested visual dominance over aural. Film sound was placed according to its function in relation to visuals: to run parallel or in counterpoint to the images. Such identification prompted the discussion of parallelism versus counterpoint, two different approaches to the use of sound and music in film. As classical theory's position on film music mirrored its discourse on film sound theories, the terms parallelism and counterpoint implied that film music could not produce meaning on its own, but rather 'meaning is contained in the visual image and that sound can only reinforce or alter what is already there' (Kalinak, 1992, pp.24–25). Despite its assumed inferiority to the visual, a closer examination of the aural realm revealed it to be far more complex in its constitution than it first appeared. In more recent years, researchers have deconstructed the theories of counterpoint and parallelism in an attempt to demonstrate that film music has been essential to the storytelling process.

When beginning to question the effect computer technology is having on the creation of film music, a useful starting point is to consider why film music is important in the first place. Graham (1995) argues that there is more to value in music than simply the pleasure we derive from it. He contends that the unique value of music lies in its ability to extend and explore aural experience. Graham suggests that music cannot simply be regarded as undifferentiated sound, which may or may not please. Rather, it has a structure, and 'great music', he argues, exploits structural possibilities to a degree that puts it far beyond the level of a simple melody so that it does not just have an effect on us, but 'provides material for our minds' (Graham, 1995, p.141). Even though music does not possess a narrative in itself, according to Kalinak music still has the ability to communicate meaning in the art form it accompanies (Kalinak, 1992, p.8).

Central to any study of film music composition is an understanding of all aspects of film music and its complexity. Once we realise how film music communicates when used with moving images, and how important the emotional effectiveness of film music is to enhance storytelling, we can then learn to appreciate the role of film composer in his vigorous attempt to express and convey a complex set of emotions and communicate with an immediacy and universality that often sits behind a common language.

Basic functions of music in film

Since ancient times, music has been integral to cultural events. It is therefore unsurprising that music has played a vital role in film. This section explores the numerous, and important, functions music plays in film, and reviews the literature on this topic.

At first, music was used simply as an accompaniment to the action or to enhance the film's mood, particularly in silent comedies and melodramas. Music was exploited to 'illustrate and explain the action' (Cohen, 2001, p.251); its purpose was to make up for the absence of speech, to fill the gaps of silence and to breathe life into the infant medium of film (Fischoff, 2005). In most cases musical accompaniment was a piano performed live, until later, when full orchestras carried the musical weight.

When silent films were introduced at the beginning of the twentieth century, the projector was anything but silent. Music also had a practical use, which was to keep the audience from talking and cover up the sound of the noisy projector (Buchanan, 1974); or, as Martin Williams writes, 'at the crudest level, one might say that the music is there simply to keep the audience from becoming distracted' (Williams, 1974, p.19). Despite the fact that the noisy film projector was a short-term problem (Kracauer, 1960, p.133), the significance of music remained. Besides its practical use, film music slowly became an important part of the film itself, 'to colour a scene, to suggest a general mood, to intensify a narrative or emotional tension' (Larsen and Irons, 2007, p.145).

To justify our pursuit of analysis of the process of film music composition, we must broaden our scope beyond music being merely informative or used to fill the gaps of silence. Today, when the majority of films are not silent, communication via the screen is not limited to visual means. Next to images, the audience is trying to make sense out of the complex interaction between dialogue, music and ambient sounds where each of these individual components bears meaning but, most importantly, meaning arrives from their interaction. In addition to other features in film practice, such as cinematography, film editing and film sound, music 'shapes our perception of the narrative, it sets the moods and tonalities in a film, it guides the spectator's vision both literarily and figuratively' (Gorbman, 1987, p.11).

When seeking to understand the role of music in film, according to Larsen, we must first distinguish three basic categories of film music: diegetic, non-diegetic and extra-fictional music (Larsen and Irons, 2007, p.211). Diegetic music is best understood as music that originates from a world or universe in the fictional narrative or ‘diegesis’[1] (Gorbman, 1987). This may include music coming from a car radio or playing in a nightclub. Whether or not the audience can see the actual source of music is not important. As long as the audience understands that the music is coming from the film itself and as long as the music can be heard, played or manipulated by the characters it qualifies as diegetic music. Conversely, for a piece of music to be considered non-diegetic it has to originate from outside the ‘narrative sphere’ of the story—outside of the world of characters where they cannot hear it. This type of music is only for the audience to hear and is far more common in film. Such music typically reflects the emotional state of the characters on screen and is used to influence and suggest the audience’s emotional reaction to what is happening in the film (Bordwell, 2013). The third category is extra-fictional music. Such music is heard not only outside the film's diegesis but also outside the fictional realm of the film. A typical example of extra-fictional music is the music played at the beginning and the end of a film during the titles or credits. Here, music functions as a musical guide, leading the audience into the narrative and fiction and then out again (Larsen and Irons, 2007, p.211).

American composer, composition teacher and writer Aaron Copeland was one of the first to propose the categorisation of music. He suggested six basic types according to function: creating atmosphere of time and place; underlining psychological refinements; functioning as a neutral background; building a sense of continuity; emphasising dramatic tension; and giving an impression of finality (Cooke, 2010,

[1] Diegesis is a style of fiction storytelling that presents an interior view of a world in which details about the world itself and the experiences of its characters are revealed explicitly through narrative.

pp.317–318). Copeland's approach was widely cited by later writers until a new generation of scholars (e.g. Cohen, 2001, Gorbman, 1987, Kalinak, 1992, Kassabian, 2001, Weis and Belton, 1985) began to reassess the medium in the 1980s and later.

To provide an understanding of how music works in conjunction with other channels of information on the screen, several researchers have suggested a categorisation of musical narrative functions in film. Cohen (2001) identifies eight functions of music in film: it i) masks unnecessary noise; ii) supports continuity between shots; iii) guides the viewer's attention to important elements on the screen; iv) induces mood;[2] v) gives meaning and supports storytelling; vi) becomes part of the film through association in memory (Boltz et al., 1991) and 'enables the symbolization of past and future events through technique of *leitmotiv'* (Cohen, 2001, p.259);[3] vii) enhances the sense of reality of the film; and viii) as a form of art, adds to the artistic impression of the film.

Similarly to Cohen, (Wingstedt, 2005) categorises music based on its function in the film as emotive, informative, descriptive, guiding, temporal and rhetorical. According to Wingstedt, the emotive function represents music's power to communicate to audience members emotive characteristics that belong to characters in the film. In contrast, the informative function refers to situations where music communicates information on a cognitive level. This can include representing characters through

[2] Several empirical studies explore and support the ability of music to induce mood (e.g. Konečni, 1982, North, 1996, Pignatielo et al., 1986). Music is also successfully used in music therapy (Frederick, 2011, Gaynor, 1999).

[3] In *leitmotiv,* movie characters or events are usually given their own theme music. Such themes guide the audience to respond to certain events and characters in specific ways even in their absence. A good example is *The Empire Strikes Back (1980)* when Darth Vader, the main villain, first appears. John Williams's *The Imperial March* concerto and vocal breathing pattern each helped make Darth Vader into one of the most recognisable villains to ever grace the screen.

leitmotivs, clarifying equivocal situations or evoking certain cultural settings or periods. The descriptive function refers to the informative function in specific situations where music is describing the physical world (physical setting, appearance or movement) instead of passively representing certain values. The guiding function directs the audience's attention; it foresees and indicates action. This function can be indicative or, if the aim is to have the audience perform a specific action, imperative, as in the case with computer games and advertising. The temporal function, according to Wingstedt et al. (2010, p.3), 'foregrounds the time dimension of music. Especially important is music's ability to provide continuity (immediate, longer or overall) as well as contribute and define structure and form'. The rhetorical function refers to how music explains events and situations by working against the visuals or pointing out familiar musical material.

These narrative functions of music in film clearly illustrate that music often has more than just one role in a scene: it works on different levels to influence the meaning of the story and, at a basic level, fulfils the role of conveying emotion. The ability of film music to convey emotions is of particular interest to this project because, ultimately, the source of this emotion is the composer (Cohen, 2001, p.263). The composer's fundamental compositional goal is to produce sound patterns that express emotion that is jointly recognised and experienced by the audience, binding the spectators to the screen (Kalinak, 1992, p.87).

Music as an emotive tool

Emotional expression is regarded as one of the most important criteria for the aesthetic value of music (Juslin, 2013, Adorno & Eisler, 1995). Cohen (2001) argues that emotion:

> contributes to the narrative's continuity; emotional meaning of events; induction of mood; creation and activation of memory (state dependence, heightening attention to particular events, providing cues in *leitmotiv*); maintenance of arousal, global attention and associated sense of reality; and finally, aesthetic experience (Cohen, 2001, p.263).

Some authors even describe music as a 'language of the emotions' (Cooke, 2001). According to George Mandler's theory of emotion, when something unpredicted takes place, it triggers a cognitive attempt to explain the discrepancy, which results in biological arousal of the autonomic nervous system and an associated emotional response (Mandler, 1990). It is the emotional response that filmmakers are attempting to evoke with every frame. The scenography, the actor's delivery energy, the atmosphere—all these choices are thoughtfully made with only one goal: to put the viewer in a specific mindset that is open to the creator's intent. According to Kalinak, 'the lush stringed passages accompanying a love scene are representation not only of the emotions of the diegetic characters but also of the spectator's own response which music prompts and reflects' (Kalinak, 1992, p.87)

Accompanying a scene, film music has a profound effect on meaning, significance and perceived emotion; it creates a rich, cohesive experience (Parke et al., 2007). According to Manvell and Huntley, 'Music allows the producer to suggest and express emotions and associations which would have been impossible to achieve by pictorial means alone' (Manvell and Huntley, 1957). Whether a specifically chosen soundtrack or a composed score, music brings out the emotional *landscape* of a scene. It places the viewer inside the brief reality on the screen.

There is some discrepancy between filmmakers in how they view the insertion of music into film. The theory that 'less is more' is favoured by some directors. According to Huntley, when used too much, music's dramatic power is weakened (Manvell and Huntley, 1957). Sometimes, the absence of music is a more effective approach. Some scenes remain the most intense without music because they live on their own. Composer Aaron Copland once said, 'sheer contrast is in itself dramatic' (Manvell and Huntley, 1957).

There is very little doubt that filmmakers can picture an emotional scene without music, but that 'the conditioned reflexes of the cinema audience have made music a vital ingredient in the production of a film' (Manvell and Huntley, 1957). The importance of the emotional impact of music to the development of the film is probably best described by Kay Dickinson. She suggests that we evaluate the importance of music in film by viewing the film *without music* and analysing our experience from there:

> The majority of filmgoers would not be able to tell you much about movie scores. Even if you were to catch a group leaving a movie theatre and ask them about the score they had just heard, many would admit to not really having noticed it. However, if the same ensemble had been asked to sit through that material minus the music, they would probably feel frustratedly disconnected from the

> film and its characters precisely because of the lack of musical prompts to guide them towards a set of expected responses (Dickinson, 2003, p.13).

Music as a means of communication in cinema

So far, this literature review supports the notion that film music fulfils the basic role of conveying emotion and that this emotion characterises the primary experience of both music (Sloboda, 1985) and film (Munsterberg, 1970, Tan, 2013). Nonetheless, musical film scores have come a long way, to actually shape the narrative through leitmotifs, themes and cues within a movie. With the ability to suspend reality and suggest connections within the film, and the power to create thematic transformations that describe characters, film music accomplishes the more intricate role of working together with what is happening on the screen to communicate and create meaning (Green, 2010).

The literature leaves no ambiguity about the effectiveness of music as a means of communication. A number of studies have investigated different aspects of musical communication as well as the perception and cognition of music. In his authoritative text *Film Language: A Semiotics of the Cinema*, Christian Metz defines film as being 'born of the fusion of several pre-existing forms of expression, which retain some of their own laws (image, speech, music, noise and written material)' (Metz, 1974, p.58). Stam et al. further elaborate on why it is important to analyse music as a channel through which viewers understand the meaning of a film:

> Metz's definition of the cinema's matter of expression as consisting of five tracks—image, dialogue, noise, music, written materials—served to call attention to the soundtrack and thus to undercut the formulaic view of the cinema as an

> 'essentially visual' medium which was 'seen' (not heard) by 'spectators' (not auditors) (Stam et al., 1992, p.59).

By separating out music, noise and speech as independent yet integral parts of a film, and once the audience and critics come to view music as integral, we can conclude that music is an essential part of the communication process of film. The interpretation of the ways in which film music communicates depends on the listener (Buhler and Neumeyer, 2014) and according to Donnelly (2011), there are two main areas of interpretation: the music itself and the way music interacts with the film. According to social semiotic theory 'an expression's contextual relationship is inseparably connected to how we make meaning' (Wingstedt et al., 2010, p.5). It can be argued that if the interaction between music and visuals occurs in a context that is well defined, this will provide conditions for music to clearly contribute to the narrative. Wingstedt et al. (2010, p.5) state that 'the typical filmic narrative relies to a large degree on socially and culturally established conventions, which contributes to making the musical narrative functions clear and "readable" to members of that culture'. Further, according to Fiske (1986), communication can only occur through a set of cultural conventions by which members of a society interact socially through messages with each other. This argument is also supported by Buhler and Nuyemeyer, who consider that to successfully communicate and transmit its meaning to the audience, music has to be transmitted through means of agreed cultural codes such as a minor key for sad, a major key for happy and fast for action, as well as style, timbre, leitmotif and musical and filmic form (Buhler and Neumeyer, 2014). The fact that since the beginning of cinema, music has been categorised according to topic and emotion supports Buhler and Nuyemeyer's argument. Music libraries are indexed by mood (romantic, light, eerie), geography (Western, oriental), time (futuristic, historical), action (crime, sport) and genre (rock, classical) (Kassabian, 2001).

By using various musical properties and cultural and historical associations connected to specific melodies, film composers have the ability to evoke these associations in the audience. In relation to film, Michel Chion refers to such connections as 'added value' (Chion and Murch, 1994). Chion's 'added value' hypothesis identifies film sound as a component that serves to complement not only as a sensual experience but as a component that enhances and adds value to the visual part of the film. He uses the term 'synchresis', 'the forging of an immediate and necessary relationship between something one hears and something one sees' to describe 'the audience's internal combustion effect when sound and image impact on each other' (Hillman, 2005, p.8).

Power to connect characters and themes

Besides reflecting the drama, music automatically communicates how viewers interpret what is happening on the screen. Larry Timm cites Copeland and writes:

> Music is used to create 'unspoken' thoughts of a character or unseen implications of a situation. Music can be used to transfer subliminal messages to the filmgoers where we can feel what the main character is feeling or where the music creates the conditions of the atmosphere on screen (Timm, 2003, p.5).

Another explanation for how music has the power to connect images and music into a whole and give them meaning from their integration is given by Claudia Gorbman, who argues that:

> The classical film score encourages identification: emotional proximity through the use of culturally familiar musical language and through a matching, an identity of sound and image which masks contradictions and posits a wholeness with which to identify unproblematically as subject (Gorbman, 1987, p.108).

Leitmotif

To communicate effectively, music must be understood immediately. To help build a sense of continuity, film music composers often use a leitmotif. The term is derived from the German *leitmotiv*, meaning 'leading motif'. It is a short, distinctive and consistent recurring musical idea that is associated with characters, action, story or other essential features in a dramatic piece. The leitmotif as a musical device can be traced back to the Renaissance opera, but it was the composer Richard Wagner (1813–83) who famously utilised it in the 1800s in his four operas, *Der Ring des Nibelungen*, where he employed leitmotifs associated with specific characters and situations. The way that leitmotifs create meaning in film is by making identifications that are clearly recognisable by the audience. According to Justin London, the introduction of leitmotifs is highly standardised and involves simultaneous presentation of the characters and their leitmotifs. He states that:

> Another constraint on the sound-shape of names and leitmotifs is that they must be reasonably stable so that every time they are uttered or performed they remain recognizable tokens of their name/leitmotif type(s). In musical contexts this means that while a leitmotif may be varied in a number of parameters such as orchestration, dynamics, accompanimental texture, and some small melodic or rhythmic variation (especially tempo), one cannot radically alter the basic shape

> of the musical leitmotif without risk of losing its designative function (London, 2000, p.88).

Leitmotif is an accepted and tested musical technique of film composers and was particularly popular in the classic Hollywood era in the 1930s and ‘40s, with composers like Erich Korngold and Max Steiner (Kassabian, 2001). Leitmotifs can be found in the film scores of many composers such as Ennio Morricone (*Once Upon a Time in the West*), Bernard Herrmann (*Psycho*) and Jerry Goldsmith (*Planet of the Apes*). Possibly the most recognisable leitmotif in film is John Williams's shark leitmotif from the movie *Jaws* (1975), directed by Steven Spielberg. A two-note motif of alternating notes F and F sharp, played on the low register of the violoncello, is used to represent the shark. This leitmotif is heard only when the shark is directly referred to; through regular recurrence and association between the motif and the creature it has gained a clear meaning, which by definition makes it a ‘true’ leitmotif.

As can be seen from this section of the literature review, film music interacts with visuals to help the audience experience the characters’ feelings and emotions and understand the film as a whole. Its purpose is to provide a recognisable function, support the action on the screen and serve the greater good of the film experience. By interacting with other aspects of the film (image, dialogue, text, sound) music progresses beyond simply filling silence to create meaning and truly have an effect on the film. Through the use of leitmotifs and different cues and themes, film composers help to build the narrative and control the way an audience interprets a film. To understand why and how people respond to film music enables us to engage with music as an audience, scholar or critic and is vitally important to the film-scoring composition process.

Technology and film music making

Over the past 20 years technological innovations have led to new means of producing music; developments in DAWs, virtual software and computers have been welcomed as a stimulus for future music. As computers improve and become faster and more powerful, they are becoming as integral to a musician's work as any other instrument. Musical performance with entirely new types of computer instruments is now commonplace as a result of the availability of inexpensive computing hardware and new software for real-time sound synthesis and manipulation (Cook, 2001).

These tools are now so refined we have reached a point where they are used by professionals to create, record and edit audio, to the extent that some even play and produce themselves (Ramshaw, 2006). Because of the obvious implications this has on the film music-making process, it is important to ascertain the effect of this new technology on the interaction that exists between film composer and computer technology in the process of musical creation.

One of the more prominent debates around modern music-making techniques relates to the access new technology affords to those who have not traditionally been afforded it. Whether because of the increased affordability or portability of music-making equipment, access is on the rise. Tomaz de Carvalho (2012) considers the effects of technologies and techniques, once reserved almost exclusively for professional studios but that can now be performed from just about any physical space, including the home (de Carvalho, 2012).

As we witness this changing nature of music production skills, it brings into question what level of technical mastery and understanding are or should be necessary for computer-assisted composition so that when synchronised with film the musical content enhances and supports the visual narrative. In seeking to uncover where music production is headed and the inter-related effects on film composition, music recording, sound engineering and music production as a whole, Ramshaw (2006) turns to the growing selection of digital tools now available that blur the distinctions between these four processes. Ramshaw's work is placed within a wider discourse that includes questions around what is and is not music, either in a commercial or academic sense—while noting that this interpretation is constructed by social and cultural forces operating within society—and questions whether self-taught digital music production is a valid enterprise to be considered in music production. While music production skills have, until recently, centred around a variety of people using analogue production systems, in the past two decades there has been a convergence towards integrated digital methods of production that can be managed and operated by a single individual. Ramshaw suggests that in this way composers are now using production tools and producers are becoming composers. We can go one step further to ask what role the technology itself is playing in the making of film music. Is technology merely a production tool, or is it actually the producer? Or even the composer? The concept of blurred boundaries and confused roles is an important point upon which this thesis further elaborates.

In line with the notion of blurred roles, Greene and Porcello (2005) suggest that music technology has brought about a blurring of the spheres of music production and consumption, in the sense that as soon as technologies are available (and affordable) they are put to service in local communities. They are then copied and loaded into the next generation of synthesisers and sample libraries to be distributed by music factories. Greene and Porcello argue that in the process, musicians are becoming both producers of music and significant consumers of technology (Greene and Porcello, 2005). Greene's and Porcello's work counters the usual criticisms of music technology (it is too carefully controlled; too inhuman; too pre-authored; too hegemonic; too fabricated; and even too independent of human labour) with the notion that technologically altered sound is an object of desire and pleasure. In a similar manner to Ramshaw's work, we can take this idea one step further to consider the role technology is playing in the process. How are we interacting with technology as film composers? How have the spheres blurred between film composers and computer technology?

Lippe (2002) has undertaken significant research into the function of computers in music compositions to better understand performer and machine interactions. He suggests that the term 'interaction', when discussed in the context of computers, is widely misused and loosely applied. Through his analysis of definitions of interactive music and systems, he suggests that much of what is considered interactive is actually just 'simple event triggering, which does not involve interaction except on the most primitive level' (Lippe, 2002). Lippe is quick to clarify that he is not interested in replacing instruments or performers with computers. Rather, he is interested in using the computer to model the relationship that exists among musicians during a performance, articulating the sonic design and compositional structures found in the interactive relationship between computers and live performers. Lippe's work is extremely valuable as it provides definitions of interactive music and interactive music systems, performance issues in interactive music, and performer–machine relationships that engender interaction (Lippe, 2002). As a composer himself, Lippe's work is somewhat rare in that it provides a first-hand account of how a composer is adopting advanced technology into the production of their music, which goes beyond a theoretical account of the 'pros and cons'.

What becomes apparent when reading the literature on this topic is that there is very little being written by scholars who either are, or at the very least once were, film composers. Academics and music philosophers are undertaking the majority of the research. This creates a significant gap in their writing; perhaps not necessarily a knowledge gap, but rather an experience gap. Just as the music-making process is breaking down barriers by making equipment and resources accessible, affordable and portable, the ability to write on any manner of things is greater than ever before thanks to the advent of computer technology; and while there is a plethora of content written on the topic of modern film music technology, it usually takes the form of an un-reviewed blog article or a magazine. While this content is often interesting and thought provoking, it is not based on research, nor has it been reviewed by anyone in particular before being published. As such, what this thesis is largely attempting to address is the lack of research and writing by academics who also have the knowledge and experience of working in music studios using computers and music software as compositional tools. There also appears to be a gap in the literature that considers all aspects of computer technology and its effect on the film music-making process, beyond the obvious. For example, little research has been done on virtual software and how it can emulate almost every instrument known to man. Because of these advances, film composers are interacting more and more with virtual instrument technologies as part of their writing process, and this has not been widely studied. How these factors affect the film music-making process needs to be better understood.

The findings from this research will lead to a better understanding of the role composers and computer music technology play in producing film scores; what the creative process of the professional film composer looks like when technology is the necessary part of their professional practice; and ultimately, what new skills music professionals in the film music-making industry will need in the future. As computers improve and become faster and more powerful, they are becoming as integral to a film composer's work as is any other instrument. New generations of composers are making music by interacting with computer music technology, meaning it is important we stop and consider the effect this has on making film music. More importantly, because of the implications of computer technology for the film music-making process, it is important to ascertain the effect this new technology has on film composers. We can then better understand how film scores are composed and created using computer music technology.

Computer-assisted film music composition

The advent of digital technology in the past 20 years has enabled computers to become the dominant tool assisting film composers in their compositional practice, and the diversity of software and hardware configurations means that the ways in which computers support the compositional process are numerous (Brown, 2001, p.1). Computer music and notation systems, often incorporating MIDI keyboards, have almost completely replaced the piano and manuscript paper in the composition studio, and computer-based recording systems now dominate recording studios (Brown, 2001, p.1). Nowadays many classically trained film composers are utilising computers and VAI in their everyday work; some composers, for example, use virtual orchestras as an illustration for what will ultimately be performed by a live ensemble. There are many others for whom the expressive potential of virtual orchestras makes it an artistic medium in its own right, capable of creating a sound worthy of being the final composition (Wierzbicki et al., 2012, Morgan, 2016).

A broad range of investigations has been carried out that are relevant to a study of computer-assisted film music composition. A great deal of attention has been devoted towards designing meaningful interfaces and software that provide accessible, yet complex control over abstracted musical behaviours. Studies on digital representation of music (Dannenberg, 1993, Gerzso, 1992, Wiggins et al., 1993), equipment design (Buxton and Owen, 1972, Oppenheim, 1986) and computer-assisted composition (Brown, 2003, Chen, 2006, Sundstrup, 2009, Love, 2013, Morgan, 2016) provide useful insights into composition with computers from theoretical perspectives and from each author's own compositional experiences. The traditional research in this area has mostly investigated the correlation between computer and musical representation, broader social and philosophical contexts of the composer, interface design, programmability and the algorithmic nature of the computer. The aim of this research, however, is to understand how film scores are composed and created using computer music technology. In asking 'how', the focus is on the film composer's activities and thought processes during this creative cycle, along with the nature of the interactive relationship between composer and music materials.

With the increased acceptance of the computer as a compositional instrument, the term 'computer-assisted composition' and what it constitutes has broadened. A computer is no longer used only to create experimental music, but as a creative tool that supports and extends composers' musicality through sound manipulation (Brown 2003). With the ability to store and recall sounds, make changes and revise previous decisions in real time, computer music technology is providing composers with a plethora of options beyond the limitations of traditional instruments (Brown 2003, Sundstrup 2009, Love, 2013, Morgan, 2016). Today, the use of computers and computer software in the film-scoring process is commonplace; therefore, the need to consider and understand the effect of computer music systems on film music composition is greater than ever.

Despite the criticism by early scholars that computers are intrinsically limited because the computational logic used by the computer is not an origin of intelligence but a consequence (Dreyfus, 1979, Weizenbaum, 1976), the growing belief that computers can play a significant role in our creative and intellectual activities continues to stimulate research. To understand the creative process and how digital technology affects film compositional practice, the relationship between the film composer and computer music system—whereby the computer acts as a tool that supports or extends human creativity—has to be appropriately explored. To adequately analyse the diversity of new techniques and approaches in the computer-assisted film-scoring process, the compositional procedure as a creative process can be reviewed from three perspectives:

I. The creative process: by exploring film composers' activities, particularly the various stages of the creative work.

II. Compositional engagement: by examining the range of ways in which film composers interact with computer system and musical materials.

III. The compositional user interface: by analysing how the interface presents musical ideas to, and receives compositional instructions from, the composer.

The next three sections explore these themes in more detail.

The creative process

Music composition as an example of human creativity has been examined in many psychological studies on creative procedures that result in a creative product (e.g. Brown, 2003, Csikszentmihalyi, 1996, Hickey, 2003, Sloboda, 1985, Webster, 2003). Such procedures often include multiple stages of creative work in which each step can be experienced many times and in no explicit order. A variety of theories, such as

Wallas's four-stage model (Wallas, 1926), Graf's psychology of the composing process (1947), Csikszentmihalyi's theory of flow (Csikszentmihalyi, 1996), Webster's model of creative thinking in music (Webster, 2002) and Sloboda's (1985) and Hickey's (2003) model of the creative process have been proposed, and highlight differences in the various stages of the creative process. Since these theories represent how creative thinking and creative ideas develop during the creative process, it is instructive to review in the following section some of their ideas, which can be used as theoretical background to effectively analyse the creative process of a professional film composer.

It should be noted that in the past some scholars have disregarded the idea that creativity should be expressed as a series of steps in a model and that creative thinking does not follow any particular model. For example, Wertheimer (1962) argues that creative thinking is a combined process of thought that does not fall within the segmentation indicated by the different phases of a model (Gruber et al., 1962). While such opposing views do exist, they are in the minority.

Wallas's four-stage model of the creative process

Theories on the music compositional process are mostly based on Wallas's four-stage model of creativity (Wallas, 1926). Graham Wallas, one of the earliest music philosophers to explore the creative process, identifies four stages of the creative process: preparation, incubation, illumination and verification. He suggests that the four stages overlap with each other continuously over a period of time when a creative person is exploring various issues associated with their work (Wallas, 1926). Figure 2.1 illustrates the important aspects of these four stages according to Wallas.

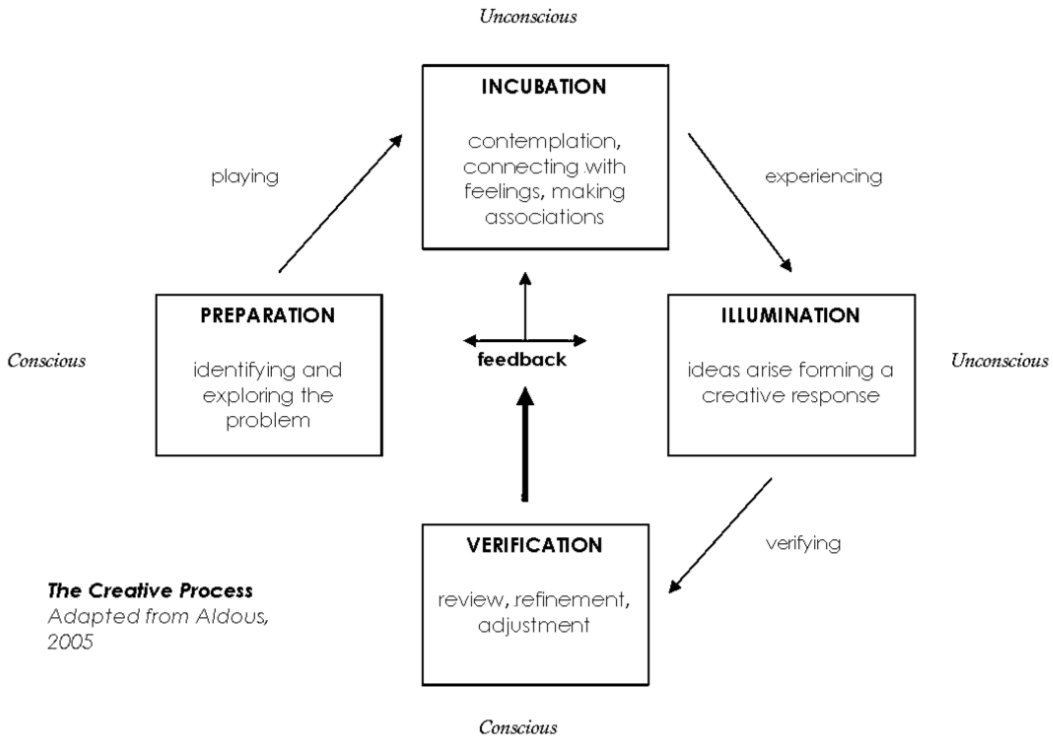

Figure 2.1: Wallas's four-stage model

Wallas's four-stage model can be applied to describe the creative process used by a computer-assisted film composer. For example, Wallas's first stage of preparation can be considered the 'conceptualising' step in the scoring process, where a film composer must make several crucial musical decisions. At this point, the composer might gain a sense of the tone of the movie scene and will begin to connect the ideas, environment and characters with music. At this stage the composer will employ conscious thought and begin to picture the types of instruments, arrangements and music styles that can be provided by suitable textures and so forth. It is during this stage that the composer establishes the foundational element of any good score: the score concept.

Wallas describes the preparation stage as the phase when a creative person discovers the problem; it is the process of seeking, collecting, analysing and examining data.

This stage involves conscious and logical thinking so that the creative person can test ideas and find the most suitable solutions.

The incubation phase is when unconscious processing occurs, during which the problem at hand is usually left unfinished. Wallas states that this stage has two conflicting elements: the 'negative fact' where a person is not consciously considering the problem, and the 'positive fact' where a sequence of unconscious intellectual events is taking place (Wallas, 1926). The illumination phase, according to Wallas, cannot be influenced. He writes:

> If we so define the illumination stage as to restrict it to this instantaneous 'flash', it is obvious that we cannot influence it by a direct effort of will because we can only bring our will to bear upon psychological events which last for an appreciable time (Wallas, 1926, p.53).

This stage can be the most important in the creative process, because it is the stage in which a solution to the problem can present itself. Unlike the incubation and illumination stages, which involve unconscious thinking, the last verification stage shares conscious and logical thinking with the preparation stage. In this last stage, the level of creativity is verified and the idea itself is reduced to an exact form (Wallas, 1926, p.53). Plsek argues that the idea that Wallas's model starts with conscious and meaningful preparation and ends with conscious and logical verification indicates that creative and logical thinking are complementing each other. He adds, 'creative thinkers study and analyse, but they have trained their perception mechanisms to notice things that others miss. Creative thinkers verify and judge, but they expect surprises and avoid judging prematurely' (Plsek, 1996, p.1).

Webster's model of creative thinking in music

Peter Webster (1988) proposes a model of creative thinking for music based on the idea that there exists a specific set of enabling skills and conditions that influence an individual's creative performance. Initially, he divided his model into three stages: product intention, thinking process and creative product. He states that the intention itself to produce something creates the goal for the creator (Webster, 1988). Both product intention and creative product follow the same stages: composition, performance, improvisation and analysis. He explains these stages as follows:

> **Composition**: the conception and recording of sound structures for presentation at a later time.
>
> **Performance/Improvisation**: the transmission of sound structures that are either composed previously or actually conceived by the performer at the time of performance.
>
> **Analysis:** the process of understanding and explaining sound structures in written, verbal or (in the case of active listening) mental form (Webster, 1988, p.163).

Between product intention and creative product lies the thinking stage of the model, where cognitive activity takes place. During this process a certain set of enabling skills (convergent thinking and divergent thinking skills) is required to successfully complete the creative task and to allow the thinking process to occur (Webster, 1988, p.163). Such skills are regarded as musical skills needed to complete musical creative tasks. Webster divides the set of enabling skills into four groups:

1. **Musical aptitude**: ability to recognise rhythmic and tonal patterns, musical syntax, flexibility and originality.

2. **Conceptual understanding**: single cognitive facts that comprise the substance of musical understanding.

3. **Craftsmanship**: the ability to apply factual knowledge in the service of a complex musical task.

4. **Aesthetic sensitivity**: the shaping of sound structures to capture the deepest levels of feelingful response; achieved over the full length of a musical work (Deliège and Wiggins, 2006, p.182).

A number of factors are involved in the creative thinking process that are not musical skills of the creative person and are grouped under the term 'enabling conditions'. These conditions include motivation, subconscious imagery, personality (risk taking, spontaneity) and environmental factors (financial support, musical instruments, acoustic or societal expectations) (Webster, 1988, p.163). When revising his model of creative thinking, Webster includes two additional variables—revision and extension—as important factors of the creative work. He also notes that by using technology it is possible to create textural diversity as well as a broad range of timbral and spatial effects (Webster, 2003).

Following predominantly Wallas's model, different writers express their own opinions on this issue. For example, Graf describes the creative process through stages of productive mood, musical conception, sketch and the composition process (Graf 1947). Csikszentmihalyi (1996) argues that the creative process consists of five stages:

preparation, incubation, insight, evaluation and elaboration. Hickey (2003), whose model also contains five stages, describes the creative process through task identification, preparation, response generation, response validation and outcome. Harvey (2006) identifies preparation, inspiration, perspiration and evaluation as steps in the creative process (as cited in Deliège, 2006).

Closer examination of each of these theories reveals differences among authors in how creative stages are perceived and defined. According to Newman (2008), 'the older authors see stages as consecutive and linear, whereas more current ones see them as intertwined and interspersed, where components of the process reoccur at various times' (Newman, 2008, p.84). For example, Wallas sees the preparation stage as a step in which the creative problem is defined and investigated in all directions, where the accumulation of intellectual resources occurs and new ideas are constructed (Wallas, 1926). Mihaly Csikszentmihalyi describes the preparation stage as becoming immersed in problematic issues that are interesting and arouse curiosity (Csikszentmihalyi, 1996, p.79). Hickey sees the preparation stage as a time when 'individuals can either build or recall information for exploring sounds in music and practicing musical ideas, much like the problem-finding activities' (Chen, 2006, p.71). Harvey describes the preparation stage entirely differently to Wallas, Csikszentmihalyi and Hickey: 'deliberately sitting down, or closing the eyes … going into an art gallery or visiting a Tibetan monastery' (Deliège and Wiggins, 2006, p.182). Similarly, when a composer's creative impulse is triggered by nature, Graf speaks of Beethoven and how he used to walk through the woods of Baden to free his mind from distractions and stimulate his creativity, or how 'the majesty of the Swiss Alps gave Wagner's musical descriptions of nature in *King des Nibelungen* their grand style' (Graf, 1947, p.298). The only difference is that Graf labels his initial stage as 'productive mood' instead of 'preparation'. He explains that this phase is a creative step during which a composer is in the 'condition of expectation' (Graf, 1947, p.273), and adds that in this phase 'the productive mood announces to composers that the moment is close at hand when the inner music accumulates before the gates of the subconscious and the gates are ready to open up under the pressure of the music bulk' (Graf, 1947, p.307).

Although Wallas and the aforementioned authors are not the only music philosophers to identify creative process models, they indicate a logical progression that a creative person follows during their creative process. This staged process focuses attention on skills and knowledge of the composer so that action or practice can be accomplished. While the creative process in computer-assisted film music composition practice is yet to receive systematic scholarly attention, by explaining the creative process as a staged process, creative researchers have made it possible to parallel the creative and computer-assisted film-scoring processes, and to examine if there is an identifiable set of trends in the field that can form a conceptual taxonomy of practices. Therefore, it is possible to use these creativity theories to make sense of the variables and complexity of a computer-assisted film music composition and gain insights into compositional practices by analysing the diversity of new techniques and approaches through composers' activities in the various stages of the creative process of creating orchestral simulations for the purpose of the film score.

Compositional engagement

The assumption that music making is essentially engaging is of great importance in this study. Even though the majority of people do not play musical instruments, music is still part of our everyday lives. The evidence that musical behaviour develops early in life (Radocy and Boyle, 2012, Welch, 1986) and is integrated into the child's play without adult supervision or demands (Weinberger, 1998) may explain our attraction to music and why we find music making extremely engaging. According to Custodero:

> musical engagement is initiated and maintained through skilled awareness of and responsiveness to opportunities for increased complexity implicit in musical materials. Such complexity informs an individual's perception, and therefore their psychological state. An activity considered highly challenging, coupled with confidence in one's abilities to meet that challenge, results in optimal experience, or 'flow' (Custodero, 2005, p.185).

Custodero is referring to 'flow', which is described by Csikszentmihalyi as a 'mental state of operation in which a person performing an activity is fully immersed in a feeling of energised focus, full involvement and enjoyment in the process of the activity. In essence, flow is characterised by complete absorption in what one does' (Csikszentmihalyi, 1996). Csikszentmihalyi also states that flow can arise from listening to music and 'even greater rewards are open to those who learn to make music' (Csikszentmihalyi, 2002, p.111). Reimer adds that what separates music making from music listening is self-reflection and the associated decision making when performing as a musician (Reimer, 2009, p.57).

In the process of music creation, a composer must be fully engaged with the compositional process to work effectively with their computer music systems (Brown, 2003, Hirche, 2011). Brown argues:

> While a computer can assist compositional practice, engagement seems not to be dependent upon any particular musical representation or computer music system. Nor does effective compositional practice with a computer depend directly upon the contexts in which the computer system is used. Rather, effective compositional practice with a computer relies upon the composer's engagement with the task and the system's ability to facilitate that engagement (Brown, 2003, chapter 7, p.1).

He adds that through an understanding of music materials, their basic relationships and their potential for expressive development, compositional engagement 'enables a composer to develop his or her "direct knowledge" of music' (Brown, 2003, chapter 7, p.1). What is common to all of the descriptions of compositional engagement presented here is the 'doing' or 'creating' an element.

In computer-assisted composition, compositional engagement, according to Brown, is 'the activity of a composer interacting with musical materials' (Brown, 2001, p.1). He points out that compositional engagement has many elements and that there are a number of ways that a composer can interact with musical materials and media. He refers to these as 'modes of compositional engagement' (Brown 2003, chapter 7, p.2). The modes of compositional engagement emerged during Brown's study of five experienced composers who used computers as part of their compositional process. Depending on the mode of compositional engagement, Brown identifies five modes that represent the composer:

i) **Audient mode** where a composer notices but has no influence on music;

ii) **Director mode** where a composer operates technologies to achieve their goals;

iii) **Player mode** where a composer acts as an instrumentalist with various musical instruments to create music;

iv) **Explorer mode** where a composer searches for relevant musical materials;

v) **Selector mode** where a composer chooses from computer-generated musical material.

He notes that:

> the order in which these modes are listed does not imply any particular hierarchy as composer can be constantly shifting between modes during creative activities and that each of the modes can be viewed from two perspectives: the composer's involvement, or from the computer system's design and operation (Brown, 2003, chapter 7, p.2).

Compositional engagement integrates these perspectives and indicates collaboration between the composer and computer system where a computer system can serve as a number of things, such as a musical instrument or a paper score or even an imagination. The composer's perspective exists in relation to the computer and thus the two perspectives are associated (Brown, 2001). Table 2.1 duplicates the table Brown developed during his study that represents the modes and their related computer functions.

Composer	Computer
Audient: The composer notices but has no influence on music	Container: Computer as holder, presenter or performer of a representation of the music
Director: The composer operates technologies to achieve his goals	Tool: Computer as a device for efficient operation
Player: The composer acts as an instrumentalist with various musical instruments to create music	Instrument: Computer as a resonator of action
Explorer: The composer searches for relevant musical materials	Model: Computer as a simulator of musical possibilities
Selector: The composer chooses from computer-generated musical material	Generator: Computer as artist or interpreter

Table 2.1: Computer functions and the modes of compositional engagement (Brown, 2001)

Figure 2.2: Descriptions of the modes of compositional engagement and related computer functions

To illustrate the relationship between composer and computer system, Figure 2.2 presents the modes as all being contained within one space. This diagram is helpful in clarifying that the modes share the same space, and that connections between modes are not fixed or defined by lines. It further illustrates Brown's argument that 'a composer might work predominantly in one particular mode of compositional engagement, change between modes quickly, or display features of different modes concurrently' (Brown, 2001, p.1).

Brown's research is relevant to this study because it shows that experienced composers can work effectively with their computer music systems when engaged with the compositional process. What Brown's research does not tell us is the way or ways in which computer and software-based technologies are used in a process of creating orchestral simulations for the purpose of creating a film score and how the use of computer technology is affecting this compositional process and the compositional outcome.

The compositional user interface

In computer-assisted composition, communication between composer and computer system is carried out via a human–computer interface. This method of communication enables an entry into composition through direct manipulation of the sound and at the same time provides instant feedback to the composer about their musical decisions (Brown, 2003). Designing interfaces to effectively translate a composer's ideas and to specifically capture expressive information is a challenging task (McPherson and Kim, 2011). A significant amount of attention and detail has been given to research and development of new software and hardware that simulates musical ideas and artistic performance (Canazza et al., 2004). Advances in computer interface technology have made it possible to separate the user interface from the sound-producing medium so that both the user interface and the sound-producing medium can be individually optimised for usability. For example, piano-style MIDI keyboards and a wide range of gestural controllers provide musicians with the ability to operate one user interface to control different types of software instruments, where an unlimited number of sounds can all be mapped to one user interface. However, despite all the obvious advantages, a price we pay for this separation is a loss of physicality (Mann, 2007, p.118). This issue is particularly present in the case of virtual instruments and DAWs that conceal the entire recording studios and symphonic orchestras inside a computer that neither the composer nor audience can feel, interact with or directly experience in traditional ways. To compensate for the lack of physicality, the question of how to design and perform software-based instruments and new computer-based musical interfaces needs to be considered to provide better communication between musician and computer and to obtain similar levels of control subtlety as those available with studio recording equipment and acoustic instruments (Wanderley, 2001).

Since new media usually begins by taking on the form of previous media (McLuhan, 1964), a good starting point for engineers is to design computer tools that imitate existing ones. In the early days of computer technology we had computer-based word processors that were analogically modelled on the typewriter (Linson, 2011, p.421). Today we have MIDI keyboards that resemble piano keyboards, DAWs that imitate entire recording studios and notation software that follows the conventions of a paper score. Brown describes this imitative process as a 'pragmatic desire for a new medium to prove itself useful in conventional terms, and the more deeply seeded desire for technological neutrality—for the computer to be invisible by working in familiar ways' (Brown, 2003, chapter 5, p.1).

Visual interface

The most easily perceived or understood form of communication between musician and computer system is via the system's visual interface, which uses a screen as a dominant mode of feedback. This visual presentation of computer-assisted composing has dominated the interface discussion in the computer literature since the late 1970s, when articles written by Curtis Roads (1996) and Buxton (1979) on this subject began to first appear. To provide an overview of process structure and an effective and logical means of manipulating the music representation, many computer visual systems employ graphical metaphors based on analogue, real-world predecessors (Balkema and Slager, 2000, Brown, 2003). When DAWs became available, they used metaphors that are familiar to people, such as mixing desks, multitrack tapes and printed scores. For composers, such graphical metaphors included virtual instruments, virtual mixing desks, notation scores and oscilloscope-like waveform displays (Brown, 2003).

According to Holtzman, the fact that many computer visual systems use graphical metaphors from the real world is of great significance:

> The goal is to get the computer interface to imitate the way people think, rather than to get people to think the way computers do. If the computer is to be a tool to facilitate tasks people are already performing, it is easier to use it if the interface is based on metaphors from the human world—in particular, metaphors that are familiar to people in the way they normally approach the task (Holtzman, 1995, pp.239-40)

Some older systems, such as Csound (Taube, 1991, Vercoe, 1986) and jMusic (Sorensen and Brown, 2000; see Figure 2.3) used text-based commands as a conversational metaphor, where the composer interacts with the computer by issuing commands to receive textual, audible or graphical responses (Brown, 2003).

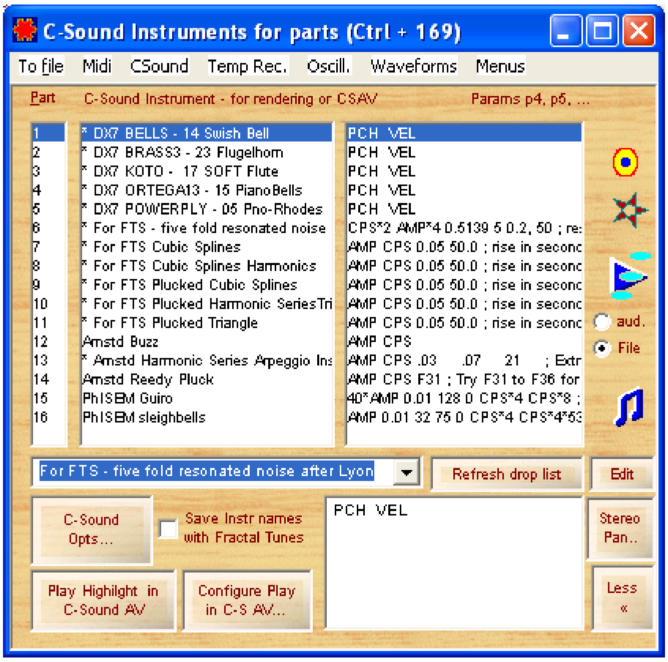

Figure 2.3: Csound command window

Other systems, such as MAX (Puckette, 1991, see Figure 2.4), utilised the flow chart metaphor portrayed as connected modules moving down the screen.

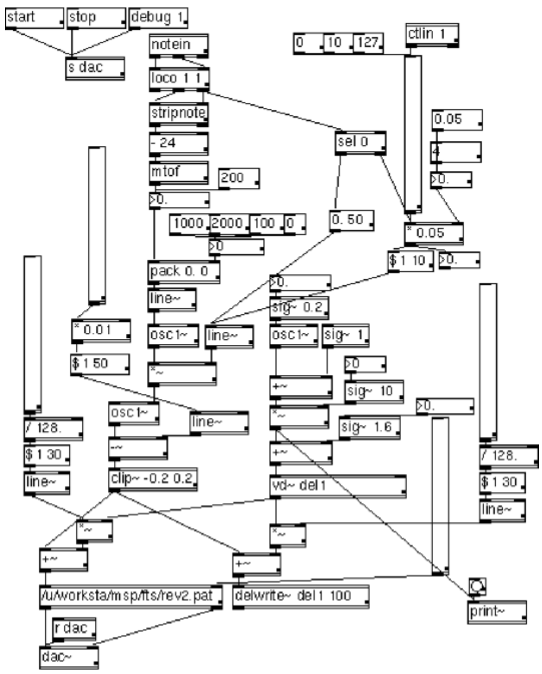

Figure 2.4: Signal processing in MAX

Graphically abstracted metaphors, such as the tape recorder that illustrates music linear timelines from left to right across the screen, are the most common metaphors used in modern DAWs such as Cubase (see Figure 2.5), Apple Logic and Pro Tools (Duignan et al., 2010). Today, the majority of audio editing software uses this temporal orientation to describe digital audio waveforms over time, where audio and MIDI clips behave like segments of tape.

Figure 2.5: Cubase interface

To make representation systems more flexible, today’s computer systems revolve around the arrange view and offer multiple views of data by providing multiple ‘windows’. While each DAW has its own presentational approach, each offers the highest level of sound editing and sound manipulation, where sections of music can be controlled and automated simultaneously. Different part editors offer different editing options for various audio and MIDI data formats. However, most of the available editing options are hidden, and to access them the user must go through layers of submenus. The use of diversified layers of abstraction in each DAW’s representation of music, according to Milward (2005), can lead to confusing program behaviour. Because of this relatively hidden nature, as a metaphor for the recording studio, Duignan sees DAWs not as an integrated editing environment but as a container of linked, but perceptually independent, musical tools (Duignan et al., 2010). That being said, DAWs integrate perfectly with conventional hardware-based recording studio practices, and more importantly they have proved an indispensable compositional tool used in smaller, more affordable home computer-based compositional environments (White, 2000).

Physical interface

The development of computer music systems is not confined to DAWs. It extends to the corresponding technological development of MIDI and gestural controllers. In practice, DAWs depend on the use of peripheral interfaces such as the computer keyboard and mouse, MIDI keyboards and various gestural controllers, which provide real-time entry of MIDI or audio data (Guerin, 2005). Compared with the visual representation of music, the use of physical interfaces enables a more direct mode of interaction between the user and the computer system (Leman, 2008).

When virtual instruments first appeared, they were integrated into DAW environments and the input options were either MIDI controller based (real-time performance entry) or score/note entry based (step time entry). According to Brown (2003), there is a difference in the relationship of physical interfaces to music representation in the computer. He argues that the difference is between 'the capture of input for mapping as a musical gesture and the use of actions to transform the digital representation directly' (Brown, 2003, chapter 5, p.20). MIDI keyboards, for example, can be used to capture data as a musical gesture to record a musical performance or to manipulate the instruments they are controlling. In the same manner, a computer mouse can be used in conjunction with the computer keyboard to control various synthesis parameters in real time and to 'navigate a graphical window-based interface, or more significantly to manipulate visualisations of the composing system' (Brown, 2003 chapter 5, p.16). Brown argues that:

> the majority of physical controllers can be used in either mode, however, the more limited the variability (for example, the on-off states of a computer key or mouse button) the less expressive the input and the less likely it is to be useful as gesture capture (Brown, 2003, chapter 5, p.20).

To provide users with tools specifically designed to accurately simulate musical ideas and artistic performances, most research into physical controllers has been directed towards real-time performance situations and how to make those devices more responsive to human input (Miranda and Wanderley, 2006, Holland et al., 2013, Stowell et al., 2008). While an overview of the literature in the area of physical controllers is beyond the scope of this chapter, some attention is given later to some of the concepts behind physical controllers' design and how they are used to capture the best possible interpretation of a musical performance.

The range of available interfaces, both visual and physical, provides film composers with a plethora of options for composing and working with music using the computer as a compositional assistant. It is therefore fair to assume that the observation of a film composer's studio practice, and inspection of their interfaces, will be quite revealing as to how they approach and realise their work when computer music technology is used as a necessary compositional tool during the film-scoring process.

Orchestral simulation (mock-ups)

Apart from becoming an integral part of the film composer's creative practice, computer music technology and its continual developments have led to major changes in the way film scores are being made and because of this, the context surrounding film composition has shifted rapidly over the past decade, leading to a complete disappearance of a long-established division of labour in the film-scoring process (Borum, 2015). Not so long ago, composers were one part of an enormous music machine; they wrote scores and attended recording sessions while performers and orchestras performed. As technology became an indispensable part of the film-scoring process, film composer duties have steadily increased and delivering a film score in today's commercial environment requires that composers take on multiple roles (Ellis-Geiger, 2007, Karlin and Wright, 2013, Wierzbicki et al., 2012). Today's film composer is responsible for each step of the music team's process and more often than not, is the entire team (Morgan, 2016, Borum, 2015, Brown, 2001,).

With very few exceptions today, film producers and directors expect composers to present their score to them cue by cue in the form of well-executed orchestral simulations or mock-ups (mostly containing orchestral sample libraries), and to work with them to refine (or revise) their music to suit the filmmakers' expectations and wishes (Karlin and Wright, 2013, p.101).

Today, most film directors, when previewing a composer's film score, expect the mock-up orchestra to give an accurate simulation of a real orchestral performance (Ellis-Geiger, 2007, p.136). Steven Scott-Smalley, arguably one of the most influential contemporary film orchestrators, explains that in his experience, once a track has been approved, most directors expect the real orchestra to sound like the mock-up orchestra (Ellis-Geiger, 2007, p.137). As a result, creating computer-generated orchestras or 'mock-ups' that imitate live orchestras (or smaller ensembles) has become a requirement in the film industry and consequently an essential part of the film-scoring process. It requires creating outstanding and convincing simulations of real orchestras inside the computer (Borum, 2015, Ellis-Geiger, 2007, Sundstrup, 2009, Karlin and Wright, 2013, Love, 2013, Morgan, 2016). Demonstrating the cues and themes, and in most cases the entire score, is always almost done by the composer through the creation of electronic mock-ups (Karlin and Wright, 2013).

When a director is auditioning a number of pieces of music from different composers and making decisions about which one to use, a poorly executed orchestral simulation will influence that decision. Hence, many composers believe that an orchestral simulation should be as perfect and convincing as possible when it is played for a filmmaker (Karlin and Wright, 2013). This has been a major influence in the creative process and skill profile of professional film composers, and ultimately on how and what they are required to produce.

In the quest to achieve the highest levels of authenticity, some sources have attempted to chart technological developments and their effect on a composer's ability to generate realistic simulations. Sundstrup (2009), for example, examined several software applications and the techniques used to quantify the composite process required to generate an impressive, convincing and realistic music performance through sample-based orchestral simulation. Similarly, a number of works document the process of creating computer-based music, the techniques required and factors that affect the quality of the final product (Love 2013, Pejrolo and DeRosa 2009, Russ 2004). However, the literature does not document the compositional process of creating an orchestral simulation for the purpose of the film score; nor does the literature analyse the composers' thought processes, their skills and the ways in which professional film composers create and experience music in the context of film scoring, which is the main focus of this study.

Idiomatic use of sample-based acoustic instruments

In industry settings, decisions made around the use of sample-based VAI are largely governed by budget, the composer's own technical skills and the wishes of the director (Ellis-Geiger, 2007). It can often be the case that a composer will imagine a cue that will sound effective when played using a real acoustic orchestra, but that may not, because of current technical limitations in virtual instrument technology, sound acceptable using currently available music software (e.g. sample-based musical instruments). Conversely, it is possible to produce music cues using virtual instruments that are beyond the ability of human performers alone. When crafting an orchestral arrangement, it is important to have a clear understanding of the kind of ensemble for which one is writing (Pejrolo and DeRosa, 2009). A string ensemble can be anything from a string quartet to a full-sized string orchestra of 40 or more players, and each instrument, and every player within the orchestra, has strengths and limitations. A composer must work within these parameters from the outset and the idiosyncrasies and particularities of each ensemble must be accounted for in the writing (Brown, 2003, Ellis-Geiger, 2007, Sundstrup, 2009, Love, 2013, Morgan, 2016). In a similar sense, virtual instruments come with different strengths and weaknesses across their solo instrument, small ensemble and large section libraries. The strengths and weaknesses arise not so much from the capability of the players as from the contents and arrangement of sampled materials in each library and the way in which each library patch has been made responsive to human input. Therefore, it is important to understand the limitations of all instrumental forces, as these might influence the composition of the cue or the arrangement. This is applicable to virtual instruments as much as it is to acoustic instruments. Additionally, when creating realistic performances with virtual instruments, it is important to understand not only the complexity of each instrument, but also how an ensemble of musical performers will behave in a live context (e.g. individual variations in timing articulation intonation and so on). If the goal is to create a realistic simulation of acoustic instrumentation from virtual instruments then the film score must be written specifically for the VAI that will be used (Karlin and Wright, 2013).

Besides the harmonic content that determines the unique sound character of the instrument, one of the most important aspects of any instrument that contributes to the personal character and character of the performance consists of the initial transients of an articulated tone. According to Sundstrup, 'the term articulation is used to describe the amount of legato/staccato with which a note is being played. It is defined as the ratio between the note duration (i.e. sounding duration) and the IOI [inter-onset interval]' (Sundstrup, 2009, p.29). The IOI as described by Friberg et al. refers to the time from one note's decay to the next note's attack (Friberg et al., 2006). Accordingly, articulation can be expressed as either the onset/offset of separate tones, or the onset/offset of one tone in relation to another (Sundstrup, 2009, p.29). Since playing music requires more than just playing the correct note at the right time, the way the notes are played is of equal importance as duration of the note or a pitch.

VAI tend to be sample based and therefore the attack characteristic of each note is the same. This can be mitigated to some extent if very large sample libraries are used that randomise the sample used for each event or draw on a large library of sample layers that are mapped against dynamic levels. Long before development of the latest detailed orchestral sample libraries, in which each instrument and articulations of that instrument are carefully recorded using envelope generators,[4] changing each note's ADSR was the only way of simulating articulations such as legato, staccato and pizzicato (Sundstrup, 2009). However, the ability of a computer system to now store and playback such detailed sample-based orchestral libraries provides additional options and gives composers the advantage of using sample-based sounds instead of synthesised ones. Pejrolo, and DeRosa explain why:

> The advantage of using sample-based sounds instead of synthesized ones lies in the fact that while a synthesizer tries to re-create complex acoustic waveforms artificially through the use of one or more oscillators and filters, a sampler uses random-access memory (RAM) to store the original recording (samples) of an acoustic set of waveforms that can be played (triggered) using a generic MIDI controller. This technique has the huge advantage that if you have enough RAM, and if the original samples were recorded and programmed accurately, the results can be astonishing (Pejrolo and DeRosa, 2009, p.120).

Different instruments in virtual orchestras will manifest different flaws. Virtual string instruments in particular typically exhibit some consistent weaknesses. Pizzicato sequences where the same note is plucked in quick sequence result in an identical or

[4] An envelope generator 'is a multi-stage controller that allows the synthesizer to control over time the amplitude of a waveform' (Pejrolo, and DeRosa, 2009, p.133).

very similar articulation to be presented in rapid succession, leading to the impression that a sample is being used and repeated for each note. Sundstrup describes this weakness as the 'machine gun effect' and states that:

> Many computer-generated simulations use the same sample patch for each repeated note that has the same pitch and dynamic. The result sounds artificial as the same sampled note is performed in sequence and does not contain the intricate deviations in tone, dynamics, and articulation that each repeated note performed by a live instrumentalist or instrument section would display (Sundstrup, 2009, p.31).

He adds that one way to increase the realism of repeated notes is 'to adjust each sampled note's dynamic level, timbre, and length by a very small amount' (Sundstrup, 2009, p.31). Some software sample players (e.g. Native Instruments KONTAKT, VIPLAY, East–West's PLAY) try to mitigate this problem by randomising different samples of the same pitch for each articulated note, but the limited variation in articulation is still often noticeable. These weaknesses in a sample library become most acute when attempting to perform a solo instrument line that is exposed in the musical texture with little or no other musical material present.

In human performances of acoustic instruments, there is a large amount of nuance and complexity in most aspects of the production of notes and phrases. Few, if any, articulations of the same note sound the same. This complexity is present in all human performances of acoustic instruments. However, it is this complexity that is most difficult to emulate or reproduce when using a virtual instrument. Beyond micro-detail a range of different articulations are associated with phrasing patterns.

In string instruments this might include bow direction, bow position and various articulations such as legato, vibrato, glissando and so on. When an acoustic instrument is heard in isolation, these details are clearly audible. Pejrolo and DeRosa further elaborate:

> The sound of a violin, for example, changes constantly even when repeating the same note over and over. Every time you play a particular note it will have a slightly different attack, release, harmonic con- tent, etc. Such variations mainly depend on the dynamic levels at which a note is played. Usually softer notes have a tendency to have a slightly longer attack while stronger notes feature a sharper attack (Pejrolo and DeRosa, 2009, p.122).

Different compositions or music cues emphasise or foreground these elements to different degrees. Some forms of music depend on a complex presentation of these articulations as a core feature of the genre. In other genres or compositions, the musical materials are very 'section based' and such individual details are less noticeable because of the effect of aggregating many players. More ambient styles often focus on a reduced range of articulations and foreground pitch duration and density, in preference to complex phrasing. In their book *Acoustic and MIDI Orchestration for the Contemporary Composer*, Pejrolo and DeRosa argue that the biggest issue with a virtual orchestra is that it is always perfectly in tune, particularly if sampled patches are used. They even suggest that a composer should make a virtual ensemble sound a bit 'worse' by subtly detuning each instrument in the orchestra (Pejrolo and DeRosa, 2009, p.142). According to Sundstrup, depending on the methods of detuning used, such a basic technique can have a profound effect on an orchestral simulation (Sundstrup, 2009).

If one goal of realistic and expressive music performance is to represent the properties of music to the listener (Walker, 2004), then the process of transferring musical expression to an audience using computer technology can be described as a communication of combined musical knowledge and technical skills from composer to listener. Every product of a composer's work, every film score, regardless of the genre, has the same basic goal: to communicate expressively to the audience (Gorbman, 1987). The essence of expressive performance is in nuance. Nuance is the 'subtle, sometimes almost imperceptible, manipulation of sound parameters, attack, timing, pitch, loudness and timbre that makes music sound alive and human rather than dead and mechanical' (Lehmann et al., 2007, p.85).

Orchestral simulations are no exception: starting from the music's structure, motifs, character themes and so on, the composer has to use the computer music tools at his disposal to communicate with the listener and this is achieved only through realistic and expressive performances. Artistic presentation requires both a clear overall conception and the coordination of all relevant details into that design in a meaningful way. As with real acoustic performances, realistic and expressive instrument simulations depend on many factors: the transitions between notes, individual timbres, slurs with varying amounts of portamento, lightly tongued or bowed note transitions, fast runs and detached hard attacks—these note transitions are the connective tissue of musical expression (Sundstrup, 2009). Whether composers play live from keyboard or edit directly in a sequencer, every section in the orchestra has to be transformed into a natural-sounding section to create an expressive sounding performance.

To produce a realistic orchestral sound using sample libraries it is important to realistically produce not only one note at a time but also how the notes are connected. Before large and highly detailed orchestral sampled libraries became available, simulating a realistic performance transition from one note to the next was a difficult task for sound designers. One method of simulating a legato phrase consisting of two notes was to reduce the decay of the first note and attack of the second note to connect the tones together, which would provide a close enough simulation of legato (Sundstrup, 2009, p.32). Another technique commonly used to blend different samples together and to change from one sample to another over time was a cross-fading technique (Pejrolo and DeRosa, 2009). With cross-fading:

> as the volume increases over time, a sample at a specific dynamic level will fade into another sample recorded at a greater dynamic level and so on. Consequently, the evolving dynamic changes over time to reproduce the natural timbral changes observed in a live performance (Sundstrup, 2009, p.34).

This effect can be used to simulate crescendos or, in reverse order, decrescendos.

The composer has to employ technology in creative ways to maximise the expressivity of the virtual orchestra to deliver a product that has all the elements of the real orchestra. Whether composers use samples of acoustic instruments, complex synthesised textures, voice, recordings of live instruments or sounds occurring in nature, there is an art and a craft to assembling them in a meaningful and expressive way; the principles are the same, whether the composer is dealing with a virtual orchestra or a real one (Wierzbicki et al., 2012, p.250). While there are many ways in which today's composers can learn how to get the most out of their digital orchestra, each mechanism requires a knowledge of traditional instruments and orchestration, combined with ‘a mastery of the technological resources available to you’ (Wierzbicki et al., 2012, p.250).

To create a product that simulates both the sound and behaviour of real instruments requires that through years of experience, a professional film composer has to acquire specific compositional techniques that allow them to work within the parameters of the film-scoring process. It also means that besides having a comprehensive knowledge and understanding of the intricacies of conventional arrangement and orchestration, today’s professional film composer must possess advanced computer-based sequencing skills (Love, 2103, Morgran, 2016). This underlines the importance of understanding what those skills are and what creative choices professional film composers have to make to create expressive virtual orchestral performances using computer music technology for the purpose of the film score.

Conclusion

This chapter demonstrates that the literature does not adequately consider the changing nature of film-scoring practice. The overall picture is one that does not fully take into account the changes in the way film scores are being made as a result of the continual developments in music technology over the past 20 years—changes that have had a major effect on film composers’ creative practice, namely approaches to creating orchestral simulations for the purpose of the film score and thought processes during the process of film music composition. What the academic literature does highlight, however, is that studies covering concepts from different, yet related, fields provide some useful concepts that may be used to commence an investigation in a musical context.

The review of film music and its function has revealed that music in films is an integral part of the cinematic experience and that film music arguably plays an essential role in setting the tone and contributing to the emotional effect a film has on an audience. The ability of film music to convey emotions is important to this project because the source of this emotion during the process of creating orchestral simulations is the composer who, by utilising computer music technology, creates an expressive virtual musical performance that expresses emotions that can be recognised and experienced by the film audience. What becomes apparent when reading the literature on this topic is that there is very little being written in regard to how—through the use and manipulation of recorded samples of live performances—film composers create an expressive virtual musical performance and convey musical properties of live orchestral performances to the movie director or producer, and ultimately to the audience. In other words, there is a gap in the academic literature that describes the artistic film-scoring process of creating orchestral simulations that simulate both the sound and behaviour of a real orchestra.

The literature reviewed in this chapter shows that the creative process of film music composition proceeds in stages over time, with evidence of procedures that can be applied repeatedly between these stages. What the literature does not cover is how composers organise their compositional processes from initiation to completion and how different circumstances influence the process of creating orchestral simulation when computer technology is used as a primary tool for music composition. In addition, there is a gap in the academic literature relating to particular aspects of this newly established film-scoring practice; specifically how professional film composers perceive this practice, composers' creative thoughts, what they learn and how computer music technology is used to enable and enhance compositional practice.

Further, the literature reviewed here shows that developments in music technology have had a tangible effect on filmmaking. From a purely economic standpoint, it is more affordable to compose film scores digitally. From an artistic standpoint, the literature shows that developments in music technology have made it possible for composers to make use of a much wider palette of sounds and instruments to create orchestral simulations when composing a scene. Composers have welcomed the opportunity to experiment and express with a plethora of sounds at their disposal. At the same time, the availability of this new technology has encouraged the next generation of musicians and filmmakers to compose and produce films, who might otherwise not have done so. Nonetheless, what the academic literature does not demonstrate is the diversity of skills, techniques and tools required to complete various tasks during the process of creating orchestral simulations and how professional film composers coordinate their actions and their creative thoughts to complete various tasks during this process of film music composition.

From a purely philosophical standpoint, the literature shows that by studying problems and challenges associated with the production of film scores using computer music technology, we might better understand not only specific technological systems used during this creative activity but also the intrinsic nature of composing itself. By exploring the technology-assisted film-scoring practice we are asking necessary questions about the relationship between artistry and technology that will potentially tell us something fundamental about the creative ability of human beings, when enhanced with present-day technology. The following chapters of this thesis aim to address the lacunae outlined above with a detailed examination of the creative process film composers use in the context of current technologies and standards in the film industry.

Chapter 3: Research Methodology

This chapter describes the research design of the study and explains the research methods employed, the rationale for the selection of participants, and the data collection and analysing procedures employed.

Research methodology

The goal of this project is to investigate how orchestral simulations (mock-ups) are composed and created using computer music technology and virtual sample-based instruments. In asking 'how', the focus is on film composers' activities and thought processes that take place during this creative cycle, along with the nature of the interactive relationship between composer and music materials. Related questions, many arising from the literature, include:

- In what ways do professional film composers utilise digital music technologies during the process of creating orchestral simulations for the purpose of the film score?
- How are technology and orchestral sample libraries affecting the compositional process and the compositional outcome?
- What problems and challenges are associated with the production of orchestral simulations utilising technology?
- Is there an identifiable set of trends in the field that can form a conceptual taxonomy of practices?

To address these questions, a multiple case study methodology approach was chosen as the most applicable method because it allows wider, in-depth exploring of research questions and achieving a deep understanding of a specific phenomenon by analysing the data both within each situation and across situations. By choosing a multiple case study methodology it is possible to create a more convincing theory when the suggestions are more intensely grounded in several empirical evidences (Gustafsson, 2017).

In this chapter I outline the processes of data collection and data analysis as well as the mechanisms for maintaining data trustworthiness and integrity. Further, I discuss the possible weaknesses and strengths of these processes.

Selecting a methodology

Film music composition using digital technology can be seen as a type of creative activity wherein computer music technology is used as the primary compositional tool. As such, an examination of the creative process of creating orchestral simulations for the purpose of the film score seems best achieved by observing the composer in action utilising these tools, seeking to understand the composer's creative practice and observing the relationships that exist between film composer and digital tools and music technologies.

To effectively address the research questions, one of the most important things is to select the most suitable sources of information for the project. According to Otto Laske, interviewing a working composer, provides a clear understanding of compositional practice (Laske, 1999, p.170). The ability to observe and document compositional practice is also acknowledged as important by John Sloboda in his studies on musical processes. He suggests several methods of examination including analysing what composers say about their own compositional process and 'live' observation of composers during a session of composition (Sloboda, 1985, pp.102–103).

Using the methods of examination suggested by Laske and Sloboda, this study employs a qualitative multiple case study methodology approach as the most suitable procedure 'due to its broad scope, situated focus, and suitability for comparative analysis' (Brown, 2003, p.55).

It was anticipated that insights into the research questions would be best gained through an investigation of computer-assisted film music composition, informed by an extensive discussion concerning the use of computers and virtual sample-based instruments in various stages of the creative process of the computer-assisted film composer, and exemplified by the actions of seven stylistically different professional composers working in the field of feature film as the primary valid source of data. The exploration included semi-structured interviews with composers (see Appendix B for interview questions), observations and analysis of their studio practice and inspection of their tools, the data from which are analysed and discussed within a theoretical framework influenced by the fields of film music, creativity theories, sound synthesis, expressive musical performance, gesture-driven computer music performance, human-computer interaction and computer interface design.

Several research methods focus on the examination and understanding of actions, human use of tools and compositional practice. One that examine actions is activity theory (Nardi, 1996). This method has been used previously in human–computer interaction studies; for example, researchers such as Andrew Brown have attempted to understand human use of tools in the computer-assisted compositional environment (Brown, 2003). According to Ellen Christiansen, to understand why composers utilise computer technologies in their film-scoring practice it is first necessary to understand what kinds of activity are involved in their practice (Christiansen, 1996, p.177).

Similarly, previous research into music composition utilising computers has considered the task environment to be an important factor (Di Scipio 1995, Balaban et al., 1992). The importance of computer system design is underlined in the compositional process and therefore a detailed understanding of the computer system itself is required. Di Scipio (1995) conducted a study of three Italian composers, including himself, working on electroacoustic pieces. During the study he focused on the role of representation to demonstrate its influence on the musical direction of the composers. He examined the computer systems, focusing particularly on visual interfaces and compared his findings with written scores made by the composers. Di Scipio's attention was focused on the role of sound design in electroacoustic composition; consequently, he suggests that the audio processing features of a computer music system are paramount to the compositional design process.

Multiple case studies

The qualitative multiple case study approach chosen for this study enables exploration of a phenomenon within its context, which ensures that research questions are examined from a variety of viewpoints. This will allow for multiple aspects of the ‘orchestral simulation’ phenomenon to be uncovered and understood. Two central approaches that guide case study methodology are proposed by Robert Stake (1995) and Robert Yin (2013), whose approaches ‘seek to ensure that the topic of interest is well explored, and that the essence of the phenomenon is revealed’ (Baxter and Jack, 2008, p.545). The advantage of this approach is that the researcher is able to closely collaborate with the participants, while enabling participants to tell their stories (Crabtree and Miller, 1999) and explain their views, which provides the researcher with a better understanding of participants’ actions (Lather, 1992, Robottom and Hart, 1993).

Such a qualitative research approach allows a researcher to identify issues from the perspective of study participants and understand the meanings and interpretations participants apply to behaviour, events or objects (Hennink et al., 2010, p.9): ‘it seeks to understand a given research problem or topic from the perspectives of the local population it involves’ (Mack et al., 2005, p.1).

The seven professional film composers were purposefully selected to represent a wide range of current computer-assisted film-scoring compositional practice. The selection of experienced and, in most cases, very high-profile film composers will strengthen the research findings by supporting the assumption that the practices investigated are of high quality. Such practice has previously been utilised by Gruber (1981), Di Scipio (1995), Brown (2003), Gardner (2011) and others in their analyses of creativity using case study candidates from various domains who were clearly identifiable as significant practitioners; for example, Einstein, Ghandi, Stravinsky, Mozart, Hirschfelder, Reich and Darwin. The composers selected in this project represent a diverse cross-section of ways in which orchestral simulations are created for the purpose of the film score as well as the ways in which digital music technologies are used for composition in film music contexts. A sample size of seven professional film composers provides for a reasonable range of individual differences among composers and is at the upper limit of manageability given the detailed level of data collected.

Examining artists' work

When examining the compositional process, the fullest understanding is to be gained by examining not only the composer but also the computer system and context in which they interact. Mihaly Csikszentmihalyi (1996), in his investigation into creativity, advocates that to truly understand the creative process, an examination of all elements that constitute the system must occur, which includes studying the particular person (in this instance the film composer), field (film music) and domain (computer music knowledge). Similarly to Csikszentmihalyi, Brown (2003) suggests that composers reside in an intricate group of activities and situations that form their compositional context. Brown proposes a framework of creativity that includes three major components: the social context (time and place in which a composer is acting), the physical context (the space in which the composer encounters objects) and the personal context (memories, conceptions, perceptions, understandings, motivations, intentions, and opinions of the composer; Brown, 2003). Building upon components of Csikszentmihalyi's and Brown's research and ultimately because the focus of this research is the composer's creative process of creating orchestral simulations (mock-ups) for the purpose of the film score and the diversity of activities and approaches required to use digital music technology in film music contexts along with the nature of the interactive relationship between composer and music materials, a contextual perspective is adopted for this study that includes:

- **Physical (environmental) context—**visual, physical and audible objects surrounding the composer that influence communication between composer and computer system during the process of composition.

- **Creative context**—the composer's activity in the various stages of the creative process (e.g. conceptualisation, composition, performance, improvisation, analysis).

- **Interactive context**—the range of ways in which composers interact with computer systems and musical materials (e.g. performer–instrument, composer–audience and real-time performance versus mouse-based note entry).

In choosing the contextual approach, I believe that contexts are rich enough to provide sophisticated data to facilitate observations and make discussions about them useful. Each contextual perspective reveals certain characteristics of compositional practice and how that particular context influences the use of computer technologies in such practice. Further, case study examples are used to illustrate each contextual perspective, to demonstrate the applicability of the theory.

More importantly, the use of a multiple case study provides the best method for investigating composers' actions and their creative thoughts during the process of film music composition; at the same time, it reveals the way composers utilise digital music technologies for producing orchestral simulations and the effect such technologies have on the creative process of film composers. The use of parallel case studies provides an opportunity to compare and contrast compositional experiences and prevent the study becoming idiosyncratic; moreover, the experience and diversity of the selected composers ensures a high degree of confidence in the trustworthiness of the data.

This approach is in line with research by Di Scipio (1995), Csikszentmihalyi (1996) and Brown (2003) on creativity, where they demonstrate that qualitative methods are effective for researching the role of context in creative activities. For this purpose, a qualitative rather than a quantitative research method of investigation was chosen.

Data collection

The folowing strategies were used for collecting data and research material for the case studies:

- conducting interviews with professonal film composers working in the field of feature story film, television and video
- observation of the composers' studio practice
- analysis of academic studies conducted in the areas of film music, creativity, computer-assisted composition, computer music performance and computer interface design

- analysis of available professional sources and composer interviews as a way of establishing prevailing views on topics in the field.
- Analysis of the existing online 'how to' video materials of professional film composers that speak directly to the main research aims

All interview sessions were conducted with composers via email, Skype or in person. Twenty-two interview sessions took place with composers over the duration of 4 years. Skype and in-person interviews were both audio and video recorded, and telephone interviews were audio recorded. All interviews and their recordings were undertaken with both the verbal and written agreement of participants. As per the James Cook University Human Research Ethics Committee requirements, the composers signed a consent form provided to them before their first interview session had begun.

Data analysis

All transcripts, researcher notes, literature quotations and other written data were stored as text files and the computer software QSR NVIVO (Richards, 1999) was used for data retrieval, transcript analysis, coding, pattern matching and theorising. The coding categories were established after each data collection period and are presented in Appendix C. The data were analysed to determine whether they support or challenge claims about film-scoring practices made in the professional and academic literature. Together with the process of transcription and coding undertaken following each interview and each observation of a film composer's studio practice, I undertook to write a research journal in which I summarised the composers' compositional process of creating orcehstral simulations as a way of becoming more familiar with the data and to identify issues for follow up in subsequent interviews. A summary of the research journal is presented in Appendix A. A constant comparative analysis of data emerging across case studies was conducted to develop a theory, in a process known as grounded theory (Glaser and Strauss, 1967). The themes that emerged during the data analysis process and the significance assigned to them was based both on how often the themes occurred across the cases and their importance in each case.

Criticism of the multiple case study method

Several potential risks were identified that were considered of importance in this study. If these risks occur, they may have some effect on achieving the research objectives. The major risk to the project was the potential for interview subjects to become unavailable because of work commitments. To overcome this potential problem, the gathering of data from interviews took place during several interview sessions over a period of 3 years. This significantly decreased the possibility of problems with availability.

The second potential risk was that of over generalising the research findings, given that the aim of this multiple case study is to examine a phenomenon that represents a general film-scoring practice. With this in mind, I have tried to increase the authenticity of this research project by:

- selecting highly experienced practitioners, to increase the genuineness of the data

- conducting multiple cases to enable comparison and contrasting of data
- collecting data from interviews, professional literature and by observing composers during a session of compostion, to prevent the risk of bias towards any one approach.

Because of the interpretive nature of the process, participant self-serving bias was acknowledged as another potential risk to this project. Being alert to this I have worked towards its prevention where possible. These interviews constitute reflections on the composing practice and reveal the composer's own subjective issues and apprehensions. What each of the interviewed composers identified in this process was significant, as it represented their main concerns and where they directed their energy and focus. Because of the interpretive nature of the information collected from interviews, the interview data were used to gain insights into the compositional practice and for cross-examination with other data sources to verify facts and increase the truthfulness of the information gathered.

In the next chapter I describe the concept of orchestral simulation and present it as the creative product that film composers are required to produce. The purpose is to inform the reader about the complexity of processes involved and to provide an explanation for what orchestral simulation—as the required outcome of a composer's work—is intended to represent.

Chapter 4: Orchestral Simulation

This chapter examines orchestral simulation as the creative product film composers are making for the purpose of the film score. I hope to demonstrate to the reader the complexity of the processes involved and provide an explanation for what orchestral simulation as the required outcome of a composer's work is intended to represent. Before examining the process of creating orchestral simulations for the purpose of the film score in more detail in subsequent chapters, it is important to understand what orchestral simulation is, as this is the creative product film composers are required to produce.

Understanding of the nature of the creative product has long played an important role in the study of creativity, and continues to be a significant matter of interest of those involved in the assessment of creativity (Ashby and Johnson, 2013, Besemer and Treffinger, 1981, Treffinger, 1980). A justification for this, as Briskman et al. (2009) suggests, is that creative processes can only be identified via our prior identification of their scientific or artistic products. He goes on to argue that we consider a person and the process involved as being creative because they succeed in producing a creative product (Briskman et al., 2009). Consequently, the first step in this investigation is to understand the creative product as an outcome of the film composer's work.

It can be argued that in the film music industry composers are artists but at the same time are service providers. A service they provide is a creative product that needs to meet the high standards of the film industry and a specific brief. Today, high standards in the production of film music require the use of computer technology in the process of film scoring and creating a wide range of musical possibilities perfectly tailored to the needs of the production, ensuring a high level of quality of musical results (Ellis-Geiger, 2007, Karlin and Wright, 2013, Love, 2013, Morgan, 2016).

Given the technological advancements of recent years, the effect of the technology on the creative process of professional film composers, as well as the role of technology in the creative process, is changing drastically. Like many other revolutions in history, changes in the film industry were brought about by improvements in technology. Technology brought changes to how composers learn, how they work and what they produce. Utilising technology during creative acts has become increasingly necessary as the basis for successful achievement of tasks in the film-scoring business. During the evolution of the film industry, before technology revolutionised the film-scoring process, composers were essentially working with the same tools as were used by Bach, Mozart and Beethoven—a piano, clavier (Bach), pencil, paper, metronome, pad of manuscript and, if necessary, orchestrators and copyists who expanded and transcribed their meticulous scores (Darby and Du Bois, 1990).

Today, every film composer is a ‘one-man show’ because typically, as this chapter will demonstrate, to create orchestral simulation the composer has to ‘wear many hats’, being the orchestrator, performer, conductor, the audience, recording engineer and mixing engineer. As explained in Chapter 2, this is because before making a final decision about which score to use, film producers and directors expect composers to present their work to them in the form of well-executed orchestral simulations.

Creating orchestral simulations or ‘mock-ups’ that imitate live orchestras (or smaller ensembles) has become a requirement in the film industry and therefore, an essential part of the film-scoring process. It requires creating expressive and convincing simulations of real orchestras internally inside the computer:

> A lot of people do those. They are everywhere. Heaps of composers doing that. Everyone has to do it, you can’t be a film composer today if you don’t have those skills (Yeo, interview, 2018).

> The old days are gone when you just had to sit in front of the piano and say this is going to be an oboe, this is going to be a flute; they never really got that and now it's almost expected that you have to do an electronic mock-up version of your themes, that you are going to do something so that they I can hear, something that can give them the sense of what it's going to sound like with the real orchestra (Mann, interview, 2017).

> If I'm doing a mock-up, it's because all I want to do is play it to a producer or director, generally somebody I know, and just say ‘Look, this will give you a rough idea of what I'm talking about, I will give you a demo of what it would be like with a real orchestra’ (Rowland, interview, 2017).

This has had a major effect on the creative process and skill profile of professional film composers and ultimately on how and what they are required to produce. New requirements in the film industry driven by developments in music technology have led to major changes in the way film scores are being made. To adapt to this change, it is essential that professional film composers incorporate technology into their working process because, as argued by Brown, technology provides necessary assistance every step of the way during the process of composition and makes the accomplishment of tasks possible:

> A computer music system is able to assist a composer at all stages of the music-making journey. At each stage a computer assists to the degree that it enables composers to realize their intentions, to explore pathways, to help reveal new sonic possibilities, to make decisions between possibilities, and to realize the final product (Brown, 2003, chapter 8, p.21).

In saying that, to achieve full support for one's creative decisions, having the technological means alone is not enough. To realise a product such as an orchestral simulation requires that the composer possesses a range of skills and know-how to use the technology meaningfully. When art and craft are combined the outcome is a product that meets the high standards of the demanding film industry. Partos elaborated further:

> Just as any musician needs virtuosity, a film composer must use the technology and good technique to translate his ideas into something that a director or producer can understand (Partos, interview, 2017).

To create an orchestral simulation, musical knowledge and ability to play musical instruments is just one part of the skillset. Film composers must use computer software and hardware to play and record every instrument in the virtual orchestra inside the computer, and much more. The composer must consider how instruments in the orchestra blend together, how they interact with one another and the environment they are in, and then recreate all of that inside the computer. Thus, what actually is an orchestral simulation and what is it that professional film composers are trying to achieve by creating one? Interviews with participants in this study emphasised on numerous occasions that the goal composers are trying to achieve is to create an expressive musical performance using computer technology to convey musical properties of live orchestral performances to the movie director or producer and ultimately to the audience:

> A lot of directors want something that has the emotion of an orchestra and my goal is to try to give that emotion with samples, to fulfil the emotional obligation of the story (Rona, interview, 2017).

> Every sound, every sample and instrument that I use has to have some quality that will evoke a specific emotional response from the audience, and all those samples have to work together (Partos, interview, 2017).

In other words, film composers have to create a simulation that represents an orchestral performance, a creative product that simulates both the sound and behaviour of a real orchestra.

The necessary behavioural characteristics of the real orchestral performance that composers are trying to simulate include the ability to follow tempo and make simultaneous real time adjustments to various expressive parameters including volume, articulation, phrasing and so on. To produce a realistic performance the composer has to create a product whose goal is 'to deliver an acoustical message in a virtual reality system from the source to the receiver as it would happen in a real-world situation' (Savioja et al., 1999). A composer of a film score has a specific task to perform to deliver a creative product. Using computer technology and their creativity, through melodies, rhythms, articulations, phrasing, harmonisation, orchestration and sound manipulation, the composer creates a product so that their message can reach and be understood by the audience.

The complexity of the processes involved and what the required outcome of a composer's work is supposed to represent suggests that the orchestral simulation may be identified as an internal representation of the external or the outside world. The concept of internal representation of the outside world, or 'mental representation', is an important aspect in psychology (Lehmann et al., 2007). In their text *Psychology for Musicians: Understanding and Acquiring the Skills*, Lehmannn et al. (2007) use the example of walking through a room to explain this concept. To navigate from one end of the room to the door at the other end, the authors explain, one has to take note of the obstacles along their way to avoid them. If one has to navigate the same room in darkness or with their eyes closed, they would have to estimate the location of each of the obstacles in their head to determine their own location while moving. This internal image is unlike a colour photograph, in that it is a basic form of the external image. Hence, one does not for example, consider the ceiling or the exact colour and design of a chair's material.

Musicians make similar representations while making music and this process has been called 'audition', 'artistic image' or 'inner hearing' (Lehmann et al., 2007). It is the process of both mentally hearing and understanding music, even when no music is present (Gordon, 1999). Debate on the psychology of music and the way music is processed by the listener extends to issues of cognitive psychology, or even the existence of mental representations, is beyond the scope of this project. Nonetheless, some attention is given to this topic in later chapters when discussing the way music is processed and perceived by the composer, such as the way the sound of an instrument is identified regardless of its pitch or loudness, or how the composer responds emotionally and subjectively to musical sound signals during the process of creating virtual orchestral arrangements and replication of sounds using computer technology.

When it comes to film scoring and creating orchestral simulations using computer technology, internal representation—or thinking about music in a way that the brain is able to give meaning to the sounds is a complex procedure. The difference is that now, instead of only thinking about and 'hearing' instruments, melodies and sounds in their head without those sounds being externally present, the composer has the tools that allow him or her to reproduce those sounds internally inside the computer. Instead of imagining how the music would sound or waiting for live musicians to perform their music, today, because of the available technology, the composer can orchestrate, perform, record and be able to audition each instrument in the orchestra and the entire orchestral ensemble performance on a computer in real time. In addition to all this, the composer is able to manipulate every instrument in the orchestra and every sound parameter, and modify its physical properties to create an expressive virtual orchestral performance that simulates both the sound and behaviour of a live orchestral performance.

Unlike the example of walking through a room, where Lehmann et al. (2007) argue that 'ceiling and colour of a chair are not important' in the process of creating orchestral simulations, such seemingly irrelevant features are important in a way that even the smallest details such as bow position or the amount of release[5] matter and could ultimately make the difference between poorly and well-executed orchestral simulation. The important thing to keep in mind when talking about creating orchestral simulations and virtual orchestral arrangements is the fact that the main sound source used by film composers is recorded samples of live performances. What this means is that the sampled instruments that film composers are using in their arrangements are the actual recordings of live musicians performing real acoustic musical instruments. Such recordings include high-quality recordings of individual notes played by various instruments one by one across their entire musical range. Each note and/or phrase is captured and performed with different expressions, articulations, and techniques, using different microphone setups and different environments such as performance stage, studio or concert hall, etc.

The combinations of thousands of recorded samples are organised in digital hardware or software sample players, this enables the appropriate samples to be played back when keys on a MIDI keyboard or other MIDI controllers are struck with different strengths. For example, when the composer plays a middle G softly on the MIDI keyboard, the 'soft middle G piano' sample (a short recording of the softly played middle G note on the piano) is played back by the sampler. Once the composer releases the key, a sample of the 'middle G string soft damping with hammer action noise' is played back, simulating the sound of the acoustic piano key's release. MIDI keyboard keys act like start and stop buttons that trigger playback of the appropriate combination of samples. The reason for such detailed recordings of sampled

[5] In **music**, **release** is a parameter of **musical** sound over time—the time it takes for the note to fall from the sustain level to zero (silence) when released.

instruments is that it creates an orchestral recording that gives the impression of a real orchestra's performance. This goes for every other sampled instrument in the virtual orchestra that composers use; their character and expressive playability is captured and designed to be played so that the composer can perform those instruments with the same expression as can a violin, clarinet or piano player. As outlined in the following chapters, sample manipulation, editing and audio mixing techniques, as well as the use of different MIDI controllers, are also required to create more realistic performances and add expression to the sound by changing certain characteristics of it.

All of the above demands a unique approach to film scoring and above-average or high-level musical and technical knowledge. The film composer must develop a new set of skills, techniques and understandings that have not been a requirement and part of a composer's skillset in the past. As many film composers have been in the film-scoring business for a long time, since before modern computer technology became a necessary component of their creative practice, they have had to adapt their approaches to film scoring because of these new technologies:

> I used to collaborate a lot with the musicians and make changes based on their input. If I had a melody for a particular instrument I would give a score to a soloist, have him spend some time with it, then come back with the performance and feedback, I didn't have to think a lot about how he is going to perform, that was his part of the job, to deliver an accurate and expressive performance. Today is a completely different thing, more often than not I have to put myself in someone else's shoes, so to speak. One moment I am a composer, the next moment I am a violin player or a mixing engineer (Simjanovic, interview, 2016).

Other composers interviewed for this study shared a similar experience to Simjanovic, and agreed on one thing: today, as a composer you do not necessarily need to be able to play any musical instrument to a high standard; however, you do need to understand the mechanics of the instruments in the orchestra, their limitations and capabilities, to overcome the challenge of not just achieving a great sound quality but of making the virtual performance realistic:

> When you're dealing with samples you've got samples of enough quality and you have to be able to play them with enough dexterity and do whatever else you need to do to make it equally as believable (Rowland, interview, 2018).

It is clear that unlike in the past—when composers composed music, performers performed, orchestrators orchestrated, conductors conducted, sound engineers engineered—delivering a product today that can be understood by the audience requires that composers take on multiple roles. Film producers and directors expect to hear a complete score that sounds well produced, even before musicians have come to play. Regardless of whether the orchestral simulation will be used in the film or eventually replaced and performed by areal orchestra, it is the composer's skills, their mindset and the creative processes involved that have evolved and changed that make the entire creative process and creation of the creative product possible.

Today, a creative product such as an orchestral simulation is a product of a single person. The final outcome of the composer's creative work, as this thesis aims to demonstrate, presents a mixture of various compositional tools, skills, creative thoughts and abilities brought into existence through a creative process that requires a thorough blend of art and craft to be demonstrated at all times. In the following chapter, I begin by examining the compositional interface as the compositional tool that composers are utilising throughout the process of creating orchestral simulations for the purpose of the film score. As one link in the chain that makes the entire process of creating orchestral simulations possible, the compositional interface at a composer's disposal represents a necessary tool that can also influence an artist's decisions and shape musical outcomes.

Chapter 5: Compositional Interface

This chapter examines the composer–computer interface used in this study and its influence on compositional approaches to film scoring. The objective is to understand the nature of the computer interface composers are utilising as well as why and how composers interact with this type of technology, specifically referring to the use of input and output devices with supporting software. This examination explores three areas of interface: the physical, the visual and the audible. Computer systems examined in this chapter consist of general-purpose computing tools as well as hardware and software specifically designed to present musical ideas to, and receive compositional instructions from the composers.

Utilising digital music technology during the process of film music composition has a two-way influence: general computing activities affect the compositional process and musical ideas but at the same time digital music technologies provide new and diverse opportunities for film music making. It has been advocated that for a new medium (such as computer music technology) to provide technological neutrality and prove itself useful in conventional terms, it must be invisible by working in familiar ways (Brown, 2003, Holtzman, 1995, McLuhan, 1964). An example of this can be observed in the number of computer music tools that simulate or even emulate existing ones. For example, synthesiser keyboards resemble piano keyboards; music publishing software follows the conventions of paper scores; MIDI sequencing and audio recording software often imitates tape recording devices and terminology; DAWs imitate recording studios or virtual musical instruments; and plugins often emulate the sound and behaviour of hardware synthesisers and hardware studio recording equipment. Brown articulates this approach when he writes that:

> Behind this imitative process of design and use are both the pragmatic desire for a new medium to prove itself useful in conventional terms, and the more deeply seeded desire for technological neutrality—for the computer to be invisible by working in familiar ways (Brown 2003, chapter 5, p.1).

However, over recent years as a result of advances in computing power, a different perspective—and one that is more prevalent in the established film composer community—is that digital music technologies provide new and different opportunities for music making. The interfaces developed in line with this attitude use non-traditional metaphors in an attempt to provide new opportunities for sonic outcomes and stimulate different ways of thinking. As a result, a number of computer music software programs (e.g. Reason, Ableton, Bitwig, Jazz Mutant Lemur, Vienna Mir Pro, NI Reactor) and hardware configurations (e.g. Roli's Seaboard, LinnStrument, various tablet applications) have been created that employ complex computer algorithms to provide the composer with additional opportunities for direct and indirect (i.e. real time and non-real time) sound creation and sound manipulation.

The aesthetic influence of these computer interfaces on musical outcomes is welcomed in the computer music community. Some film composers wish to explore musical textures beyond the conventional and exploit digital music technologies to manipulate and create musical outcomes.

This analysis does not consider the structure of composition, musical skills or musical intelligence. Rather, the examination focuses on the compositional interfaces utilised by composers interviewed for this study during their film scoring process of creating orchestral simulations, and the actions of those composers interacting with these interfaces, beginning with a description of the physical interfaces and moving onto descriptions of audible and visual/graphic interfaces.

Physical interface

For the composers participating in this investigation, the use of physical interfaces was central to the process of film music composing utilising digital technology. This type of interface provided a starting point in the process of communication between film composer and computer by acting as a communication channel through which the film composers expressed their ideas and aims to a computer. The physical interface provided control over a broad range of computer software functionalities where all program tasks were executable through the interface, which included note entry and note editing, sound manipulation, event selection, arranging, song playback and program management. Further, the expressive potential of the physical interfaces, as well as the possibility for real-time interaction between composer and computer system, classifies this type of interface as one of the most important tools during the film-scoring process of creating orchestral simulations.

Physical interfaces used by composers in this study included the computer keyboard and mouse, MIDI keyboard, various MIDI controllers and in some cases a musical keyboard (synthesiser) connected via MIDI. In the following chapters the term MIDI controller refers to a device with a selection of keys, knobs, buttons, sliders and/or computer touchscreen monitors and tablets with supporting software. All of these interfaces transmit MIDI data to external sound modules (synthesisers), computer software synthesisers and hardware or software sequencers.

The computer keyboard was mostly used to type words and numeric values for compositional parameters and for keyboard shortcuts. While DAWs provide many useful default key commands there is also a large number of additional functions that the composers wished to assign to computer keyboard keys as keyboard shortcuts. Frequently performed tasks such as project navigation—moving between windows or events—and zooming in and out, or more complex tasks were performed using the computer keyboard. This was evident with all interviewed composers, who relied heavily on the computer keyboard to navigate and communicate with the DAW. When asked about the reason for this, Simjanovic explained:

> A workflow can be made more efficient using a computer keyboard and key commands providing that you have patience because it takes time to set everything up and to practice using them. Creating mock-ups is time consuming; that requires a lot of editing, using keyboard shortcuts speeds up the process a lot (Simjanovic, interview, 2017).

Alongside a computer keyboard, the computer mouse was used for operating a graphical user interface (GUI) and for operations such as manipulation of sonic events (i.e. drawing automation parameters, entering and dragging MIDI notes, selection and positioning of MIDI and audio events, musical symbols, etc.).

The MIDI keyboard was the physical interface most used by the composers in this investigation. All of the interviewed composers relied heavily on MIDI keyboards to explore their ideas and to play musical phrases into the DAW. Along with traditional functions of keyboards such as those used to play notes on the keys, composers also wanted to have permanent control over various sound parameters. This was evident for Partos, Yeo and Holkenborg who relied on the ability of their MIDI keyboards to provide additional control over their performance, preferred software instruments, effects, DAW channel strips, sound filtering and track automation. Composers extensively used their additional controls on their MIDI keyboards to play, stop and loop musical events inside the DAW, adjust volume and add expression to their real time performances:

> I always use MIDI keyboard and faders on the keyboard to add different expression and to control volume and vibrato and all that kind of stuff. I can play and then say use mode wheel to add expression more like a performer (Yeo, interview, 2019).

The selection of MIDI keyboards differed between composers from an 88-key fully weighted (piano-style keyboard action) MIDI keyboard with or without any built-in sounds to a small MIDI keyboards with pads, potentiometers and sliders.

MIDI keyboards used by the composers provided a wide range of precise controls for sound manipulation and control of their DAWs, virtual software synthesisers, samplers and plugins. In addition to piano keys, pitch and modulation wheels, MIDI keyboards used by the composers consisted of sliders and potentiometers for additional control. A MIDI keyboard controller with customisable and configurable controls (knobs, sliders, pads, etc.) was an important compositional tool for Mann, Simjanovic, Holkenborg and Yeo as this provided extensive control over their software, whether it was a virtual instrument or DAW.

Most of the time, the interviewed composers made frequent use of a MIDI keyboard in combination with a computer mouse to test different ideas and to record their MIDI performances. They used recorded MIDI materials and if necessary made adjustments to the data after the recordings had been made to transform their performances. Alongside a MIDI keyboard, the composers used a keyboard synthesiser connected via MIDI to explore their ideas. This approach was an important part of their compositional process as such explorations were always recorded directly into the DAW.

One of the most powerful features of MIDI keyboards and other physical controllers is the MIDI mapping capability, which during this investigation allowed composers to create custom controller mappings that were unique to their workflow or performance. To add nuance to their performance, MIDI mapping capabilities enabled composers to apply different performance strategies such as expressive articulation and expressive intonation to their music. These are referred to as 'expressive performance actions' (Kirke and Miranda, 2009), a performance strategy composers apply to their music that makes their performance sound alive and different from the so-called 'perfect' performance a computer would give (Friberg and Sundberg, 1999, Kirke and Miranda, 2009).

The use of expressive performance actions provided the composers with the ability to express a certain emotion (e.g., happiness, sadness) and mood through a piece of music. For composers, the use of MIDI mapping features in performance and during sequencing was a major factor in adding 'life' to their musical performances. Simjanovic explained:

> It allows me to add nuances to my music with mod wheel, sliders, potentiometers and keys. As I play different things on my MIDI keyboard I can change the sound of the instrument in real time, while I am playing it. I can change the tempo and dynamics of a musical phrase and express emotion that way as I play each instrument (Simjanovic, interview, 2017).

To apply expressive performance actions, record various MIDI data (CC)[6] and utilise a number of additional keyboard functions, where the hardware itself was used to play musical phrases into a computer, those devices needed to be configured for communication between the interface and computer software to function properly. With MIDI mapping the composers were able to remotely control computer software and software instruments from their physical interfaces. MIDI mappings were saved along with each composer’s project song; this way composers were able to create unique MIDI mapping sessions for every project and also share MIDI mapping settings between projects by importing/exporting common MIDI mappings.

Holkenborg, Partos and all other interviewed composers used CC messages to add expression to their performance and to convey performance or patch data for parameters other than those that have their own dedicated CC message types, such as note on, note off, aftertouch, pitch bend and/or program change. By mapping various sound parameters such as the ADSR envelope parameters to MIDI controller sliders they were able to achieve a natural transition from one note to the next as they were performing the musical phrase. To simulate a legato phrase comprised of

[6] In MIDI terms, a continuous controller (CC) is a MIDI message capable of transmitting a range of values, usually 0–127. These data can be interpreted by the computer in various ways. CCs are commonly used for functions like MIDI controlling volume (#7), pan (#10), data slider position (#6), mod wheel (#1) and other variable parameters (Winkler, 2001).

notes, while playing the notes on the keys with his right hand, Holkenborg used sliders with his left hand to vary the amounts of decay and release of the first note and attack of consecutive notes to connect the tones together, which provided a close enough simulation of legato. Such an expressive articulation performance technique enabled control over different articulations, which was crucial to adding 'life' to his performance.

As one of the most important cues in music performance, articulation contributes to the character of the performance by allowing players to control the way in which two consecutively played notes are acoustically connected (Bresin, 2001b). When the composers chose to play notes in a more staccato (short and pronounced) way, by moving the mod wheel or sliders on the MIDI controller, they were able to change their playing style into a legato (smooth) way. In the same manner, when playing instruments with continuous tuning such as cello, violin or trombone, by using CC messages mapped to a controller they were able to play vibrato and make notes slightly sharper or flatter, thus affecting the instrument's intonation. The use of expressive playing techniques requires that a composer has an understanding of CC messages and the ways software instruments respond to those messages. It requires mapping the controller to a correct corresponding parameter in the software, to control parameters from continuous controllers and change the sound of the instrument as the composer plays different musical phrases.

Apart from the computer keyboard, mouse and MIDI keyboards as direct touch control of the DAW, plugins and software instruments, another important physical interface used as a controller by the composers was a computer touchscreen tablet and/or monitor with supporting software. The strong point of this type of interface is that it provides composers with a fully customisable palette of knobs, sliders, buttons and X–Y pads. Each customised control can be assigned a MIDI channel and CC number to control different parameters of their music production software, enabling the composers to create a custom controller to best suit their workflow and needs.

At the time of this study, Holkenborg, and Rona were using touchscreen technology extensively during the process of composition. Rona was using the Jazz Mutant Lemur software application on two of his iPad tablets. He created custom templates to:

> make it very fast to not only control DAW faster, but also to help with my automation and also MIDI control for instruments in effects and to be able to do filter sweeps or any other modifications I want (Rona, interview, 2016).

While Rona was using widely available commercial software application, Holkenborg utilised a custom-built fully customised multi-touchscreen application (see Figure 5.1) originally built for film composer Hans Zimmer. With the touch of a finger, the application allowed him to manipulate and automate captured MIDI data, select groups of tracks, instantly view different sections of his project, recall his favourite software instruments and quickly navigate through his template.

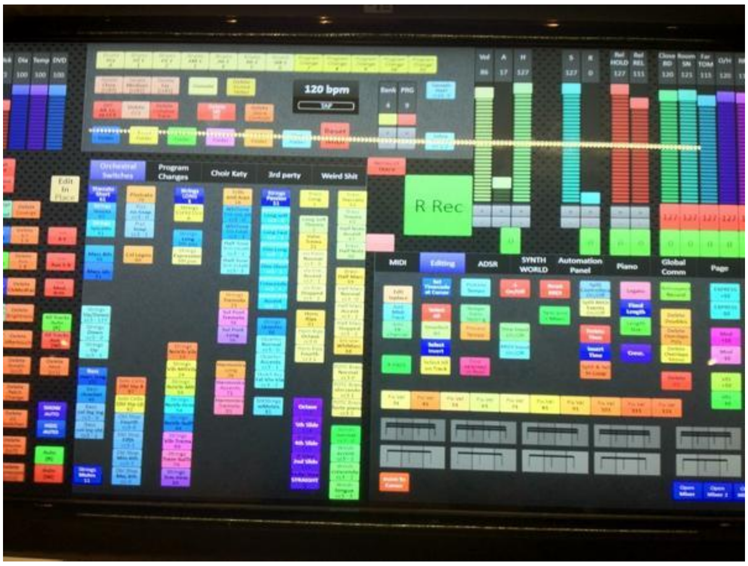

Figure 5.1: A view of Holkenborg's customised multi-touchscreen for Cubase
(source: https://www.youtube.com/watch?v=RSl_unnPab0&list=PLPDbiB89zUSI-bAKsef_UC87OMsHrv_tR&index=10&t=0s)

Alongside the aforementioned physical controllers, a fader control surface was the only other physical interface used. All interviewed composers employed these to control and edit the volume of multiple tracks, panning, equaliser (EQ), effects and other MIDI parameters. Although they used the computer mouse occasionally to control virtual faders and other MIDI parameters, fader control surfaces were more convenient for such applications as the composers felt physically closer to them.

As with traditional instrumental playing, where every detail, every small control variation or modulation (e.g. tremolo or a vibrato) has to be addressed physically by the performer (Jordà et al., 2007), physical interfaces provide direct control of all aspects of the production of sound. The efficacy of MIDI keyboards, as with other physical controllers, was dependent upon the composers' musical preferences and their skill to efficiently incorporate this type of technology into the creative process. The efficiency of physical controllers and the software that drives them is clearly related to a composer's ability to utilise their functions to capture their musical intentions and to convey an expressive musical performance using sample-based orchestral instruments.

Direct and indirect (symbolic) use of physical controllers

During this investigation, it became clear that there is a significant difference in the way physical interfaces are used for input and manipulation of musical materials in the computer; a difference between the capture of data as direct performance and the capture and transformation of data as indirect or symbolic input.

The capturing of data as direct performance involves real-time MIDI controller performance to a DAW with or without a virtual metronome while the sequencer is recording. It includes direct entry of all transmitted MIDI data besides note data. Every keystroke, movement of a potentiometer, fader and slider on an MIDI keyboard or any other physical controller that sends MIDI messages is captured. MIDI messages that control musical qualities beyond harmonic progression and melodic movement are also performed and recorded in real time. This includes variations in timing, dynamics and articulation, which are the primary means that a performer has available to make music expressive and communicative (Repp, 1996, Walker, 2004). By executing multiple tasks simultaneously, this approach enables control and capture of expressive variations, the nuances that lend unique character to a musical performance.

The artistic control of dynamics presents a particular challenge for a film composer who must deal with several tasks at the same time. It is up to the composer to choose the appropriate actions and provide the fine detail; in particular, how strongly to play tones, how to shape the dynamic progression of melodic phrases, how to give appropriate dynamic shapes to expressive melodic gestures and how to give repetitive rhythmic figures a characteristic dynamic profile.

For example, while working on the *Mad Max: Fury Road* project, during his performance Holkenborg wanted to record slight variations in pitch and articulation (crescendo and diminuendo) to a passage he was playing. This involved simultaneous use of MIDI keyboard keys to play the musical phrase. He used a pitch wheel to slightly raise and lower the pitch of a note, and sliders to gradually increase or decrease the dynamic levels of successive tones. Changes in pitch, timing, dynamics and articulation allowed Holkenborg to capture his idea as a musically expressive performance in real time. Similar to Holkenborg, for Partos the use of a direct performance presented a connection between his creative ideas, expressive performance and that of recorded sounds:

> The benefit of real-time performance is that it allows me to instantly capture my ideas while I am playing the keyboard. It is sort of a starting point for further tweaking inside the DAW (Partos, interview, 2016).

In contrast to direct real-time performance, an indirect or symbolic input involves data entry using a computer mouse. As music performance usually necessitates carrying out sequences of movements on a musical instrument to produce auditory effects, (Keller and Koch, 2008), it can be argued that indirect use of a computer mouse for data input differs from a direct performance when a composer is not actually 'performing'. They are not sequentially pressing keys on a MIDI keyboard to play and record their performance but instead is using the computer mouse to step enter note data, automation, articulation, volume and velocity data in a non-sequential way.

An alternative to direct input during which pressing a key on a MIDI keyboard or moving sliders and potentiometers determines a number of characteristics: for example, pressing a key on a MIDI keyboard can determine the musical pitch (musical note), loudness, articulation and duration. These can be determined depending on which key is pressed, how hard it is pressed and for how long the key is held, respectively (Müller, 2015). For the composers, the use of the computer mouse for indirect or symbolic input involved selecting and entering the characteristics of musical notes separately. Pitch, duration and loudness were entered individually using the computer mouse. Further, articulations that affected the note duration such as legato or staccato had to be entered step by step by modifying the duration of the note: for example, in the case of legato this meant extending the duration of the note and in the case of staccato, decreasing the duration of the note. During the process of creating orchestral simulations, Rowland might do a pass and then go back and add some more controlling information. After his performance was recorded he would then go back and nuance it, often by writing controller information such as volume and velocities to make his recorded performance more expressive (Rowland, interview, 2018).

The main characteristic of this approach is that it enables advanced manipulation of captured gestures. This includes manipulation of sound parameters such as volume, velocity, ADSR, timing, pitch, loudness and timbre. This procedure is a significant part of a compositional process utilising digital technology as it adds nuances to captured performances, which makes music sound alive and human rather than lifeless and mechanical (Lehmann et al., 2007). The process of manipulation or use of ’corrective functions‘ (Hosken, 2014) to correct and manipulate captured gestures is explored further in more detail in Chapters 6 and 7, which examines the creative compositional process and the variety of expressive detail film composers modulate to successfully create an orchestral simulation that simulates both the behaviour and character of a real orchestral performance.

As indicated above, the composers used both methods, but spent most of their time predominantly on indirect, symbolic input. A direct-performance-oriented method was only used extensively for exploring and experimenting with different instrumentations and textures for capturing the composer’s ideas. Indirect or symbolic input was a preferred method for manipulation and additional editing of captured performances.

It has been argued that planning music-like actions involves anticipating their auditory effects (Keller and Koch, 2008), meaning that music-like actions are triggered by the anticipation of their effects. In the case of both direct and indirect use of physical interfaces this indicates that a composer has to be conscious of the desired performance, that they must anticipate and be aware of the auditory effect of their actions because these have an effect on the representation of musical events. This requires a set of skills besides musical knowledge and musical ability; it requires understating of the physical characteristics of sound and how the composer’s direct or indirect manipulation affects the expressiveness and cohesiveness of the virtual orchestra and its musical performance.

Audible interface

In this part of the chapter the significant role of audio playback during the process of film music composition utilising computer technology is examined. This examination describes a film composer’s audio monitoring arrangements; how audio monitoring quality interacts with the music representations utilised; how audio feedback reflects other compositional activities; how audio monitoring is integrated into the compositional process; and how audio feedback from the computer is co-dependent with a composer’s musical intentions and understandings.

Each of the composers made extensive use of audio feedback during composition. The continual playback of recorded material was a common practice carried out by composers to confirm that what they had composed was what they had imagined. Audio playback enabled composers to evaluate their work and their musical ideas, and develop their compositional directions through stimulation of different opportunities. For the interviewed composers whose musical ideas were recorded inside a DAW, audio playback was essential in supporting judgments about the positive outcomes of their intentions. Audio feedback was used as a constant check of appropriate musical direction and to ensure that the compositional outcomes matched the composer’s emotional understanding of the film music; in other words, that what they had envisioned was what they were hearing coming out of the studio monitors.

Beyond the general similarity among the composers of relying on audio monitoring during the process composition, the quality and type of audio playback differed to a large degree. Partos was mainly interested in ensuring the playback accurately represented timbre because most of the time his focus was on morphing acoustic instruments with electronic elements in his scores, to create a palette that was innovative and unique:

> Even though I use electronics as the vital part of my palette, when using samples of acoustic instruments, I want them to sound as close as possible to real instruments in order to get more emotional moving in my scores (Partos, interview, 2017).

To achieve satisfactory results, he used a high-quality audio monitoring system capable of delivering a playback that revealed small nuances and details in sound as well as possible; a playback that had the ability to give off a truly uncoloured sound.

Similar to Partos, the quality of the sonic representation was of critical importance for Holkenborg. The ability of the audio playback system to reveal every detail in sound influenced his decisions when choosing the appropriate mixing techniques and orchestral libraries for his musical performances. The variation in timbre, articulations and overall character of the individual musical instruments and instrument sections were clearly distinguishable between different sampled instruments on a high-quality audio playback system.

The accurate sonic representation provided by Holkenborg's playback system enabled critical listening of the physical details of the music, such as pitch, loudness, timbre, frequency response, dynamic range, imaging and balance, to evaluate how musical instruments in the orchestral arrangement were blended together. As a result, he was able to break the composition down sonically to perceive and evaluate his work.

The differences between an incomplete mock-up and the expressive simulation of orchestral timbres were clearly audible on a high-quality monitoring system as Holkenborg listened to the audio playback. He relied on his knowledge of orchestral instruments and the accuracy of sonic representation to make orchestration judgments and achieve satisfying results. For Holkenborg it was paramount that his orchestral simulations had all the musical properties of a real orchestral performance so that the emotional message of the movie scene could be communicated to the audience.

The ability to hear and comprehend the physical aspects of sounds in the orchestral arrangement was an important factor for Simjanovic as well. It enabled working with the issues that arise in musical performances. It allowed both Simjanovic and Holkenborg to hear and understand how the performances integrated together and how the physical aspects of musical events affected the expressiveness of the performances:

> Creating orchestral simulations requires a lot of manipulations, I am changing articulation, loudness, pitch, duration and spatial properties of the instruments all the time until I am satisfied. During that process I am relying on what is coming out of my speakers in order to make the right choices (Simjanovic, interview, 2017).

Audio monitoring systems for the interviewed composers were important because the results of their work were designed for playback in movie theatres over large cinema sound systems. Using high-quality components, their monitoring systems were set up at head height in a perfect triangulated arrangement with the listening position.

The sonic elements in Holkenborg's, Rona's and Partos's work included a combination of samples and synthesised timbres. They constantly used samples of acoustic sounds as source material and utilised acoustic instrument sample libraries, most noticeably string and piano samples at times. Holkenborg's studio was equipped with high-quality mid-field studio monitors in a far-off triangulated position—a different speaker positioning from the more common near field monitoring used by other interviewed composers.

A closer examination of physical characteristics of a composer's audible interfaces shows their influence on music representation. The audible interface represents music in certain ways. It identifies timbral qualities and performabilities of sample libraries and reveals the characteristics of sampled instruments that composers value most. Composers demand particular qualities from audio playback systems, which together with differences among sample libraries, computer hardware and monitor positioning, provide composers with different views of the composition.

One of the most important sonic qualities of an audio playback system for Simjanovic was a flat frequency-response curve. In describing the importance to him of employing a monitoring system with a wide and flat frequency-response range he explained:

> I have flat frequency-response studio monitors that go down to 20 Hz, meaning that all frequencies, even the ones below the threshold of human hearing, are

outputted equally and nothing is boosted or cut. This is important because it means that what I hear is a true representation of what my mix and production sounds like (Simjanovic, interview, 2017).

More attention to sonic detail was evident in Rona's and Holkenborg's choices of monitoring. The important quality of audio playback systems utilised by both composers was the aspect of stereo imaging. Stereo imaging refers to the quality of the recorded sound and its reproduction and how the spatial location of sound sources is perceived by the listener, both laterally and in depth (Anderson and Casey, 1997). To Rona and Holkenborg, an audio playback system was considered truthful in its representation of the sound image if the location of the performers on the stage could be clearly identified. This was an important factor for Rona when choosing the appropriate monitoring system for his studio as it allowed him to hear how virtual instruments were positioned in the stereo image:

> I can hear each instrument in virtual orchestral arrangement being positioned exactly where I want them to be. I can distinguish between instruments that are placed left and right or at the back (Rona, interview, 2017).

For the film composers who were mixing orchestral performances in the final recordings of a work, both timbral quality and performability of the virtual instruments were important. In addition, the quality of orchestral simulations was a significant factor: it required impressive and detailed recreations of live performances so that compositional mock-ups sounded convincing to the film producers and directors for whom they worked:

> You have to remember that before the audience hears it, the director and the producer have to hear it, and so you have to write it for them to like it (Rona, interview, 2017).

Further, orchestral sounds need to be of the highest quality possible as those sampled sounds may end up in the production as final recordings. For the composers in this study, issues of acoustic simulation were of great importance. The orchestration and timbral aspects were critical elements during their process of creating orchestral simulations. The transparency and accuracy of audio recording, production, transformation and playback were critical to achieve such goals.

Creating a similarity to acoustic sound sources was a major factor in Holkenborg's compositions. Holkenborg played to the listener's familiarity with the acoustic source, where certain features were amplified or modified to provide a different perspective on the sounds. He focused on playing with the believability of sounds as produced by human gestures. By manipulating with different articulation techniques, his goal was to add a 'human factor' to his recordings. Small deviations and imperfections that occurred naturally had to be created by the composer to produce authentic recordings of the virtual orchestra.

To achieve the desired quality, Holkenborg would specify in Cubase the exact type of articulation to suit a situation and sonic requirement. His compositional methods relied heavily on the processing of audio and the capability to manipulate audio sources in Cubase in real time. Audio feedback was critical to his ability to make considered decisions about how successful he was in achieving desired outcomes.

In composing drums for *Mad Max: Fury Road (2015)*, Holkenborg demonstrated the importance of being able to hear a simple change in timbre and articulation in audio playback and how audio feedback was a critical factor in being able to move the process forward:

> So you hear that working with key notes instead of velocity actually maintains the relationship of the rhythm way better. Do you hear that release? That's just fantastic. You can hear a completely different character (Holkenborg, interview, 2017).

Holkenborg's interest in small nuances clearly indicated his interest in timbral aspects of the audio feedback. He listened for structural relationships and patterns of the pitch and rhythm of his drum sample libraries when choosing the most suitable sounds for a particular scene. What he 'heard' was stimulated by the audio feedback rather than represented by it. He described this process as 'auditioning'.

A continual dependence on audio feedback during the process of composition demonstrates its importance. When listening to the audio feedback, the composer is judging the progress and success of their work to a point where audio feedback becomes not only a representation of the music, but the music itself. The significance of a true audio representation and accuracy in detail during the process of composition is justifiable because the audible interface is the medium on which composers rely when making choices and final judgments about their work. Audio feedback provides accuracy and transparency of audio recordings and emphasises artefacts in the sound material. However, understanding all aspects of the compositional process of creating orchestral simulations requires looking beyond audio feedback and its influence on the composer's intentions, motivations and compositional outcomes. It requires understanding how the composer's listening proceeds beyond the physical aspects of sound to the visualisation of the sound they are auditioning.

Visual/graphical interface

In the computer-based composing environment, for an audible and temporal art form such as music, the most prominent characteristic of the music representation is its presentation via a computer system's visual interface. In the process of creating orchestral simulations, the visual interface serves as one of the methods of communication between the artist and the computer system; as such, it has a powerful and suggestive influence on the composer. One of the reasons for such influence may be explained by current personal computer design, which uses a screen display as a dominant mode of feedback (Brown, 2003).

A computer's visual interface seems most critical in the processes of composing, as it provides a visual representation of composing processes and access to methods of continuing and developing the processes further. For the composers, visualisation included notational scores, oscilloscope-like waveform displays, virtual mixing desks, virtual plugins and virtual instruments. These processes, for the case study composers, enabled composing, recording and editing of sonic events as well as different forms of audio manipulation such as volume, velocity, articulation, spatial properties and timbre manipulation.

Generally, the composing visual interface has more to do with presentation than representation. The choice of presentation is based primarily on the composer's choice of visual interface(s) and the way that a particular interface presents audio. One of the most important aspects of the visual interface and one that was most commonly used by composers as a way of viewing the music was a temporal display. The main characteristic of a temporal display is that it shows the density of audio events over time. It enables scores, MIDI events and waveforms to be displayed simultaneously.

Temporal displays of music inside a DAW are built on the familiar structure of common practice notation (CPN) scores and in the case of the interviewed composers were direct computer imitations of CPN scores. Depending on their workflow, different variations of temporal display of audio over time were utilised by different composers.

Simjanovic, who developed scores using notation software, often used a display that enabled editing and display of both score and MIDI events (see Figure 5.2). Partos made frequent use of waveform editing as well as MIDI editing views to manipulate samples and MIDI events. Holkenborg worked in MIDI editors, manipulating with samples presented as MIDI events; while Rona, who predominantly worked with displays that provided an overview of MIDI events, occasionally made use of waveform editors for recorded audio sections. He used a display that provided an overview of MIDI events and waveform simultaneously. Composers used the waveform display for rudimental editing and MIDI event display for MIDI editing.

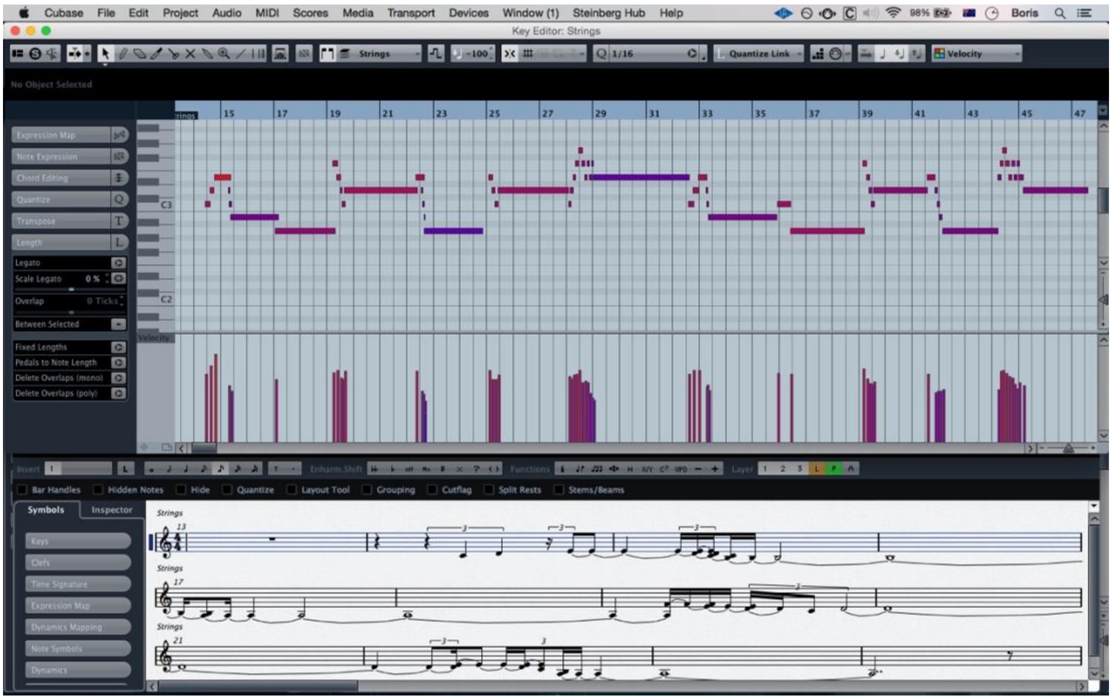

Figure 5.2: Cubase score and midi display

Depending on the composer's preferred DAW, the editing process was similar in appearance but the visualisation of music for working at a detailed note-by-note level varied. At a detailed level, the composer's workflow and choice of supporting software influenced display preference to a great extent. Supporting software such as EQs, compressors, envelope generators, spatial effects and samplers provided visualisation of editing and manipulation processes in the temporal display view.

Rowland and Mann visualised their editing in the temporal display view, but used less direct manipulation than other composers. They worked predominantly by playing different samples rather than transforming and manipulating them. Unlike Rowland and Mann, the process of audio editing used by Yeo, Rona, Partos, Holkenborg and Simjanovic involved detailed and direct manipulations of sampled instruments using software plugins and editing tools inside a DAW. In explaining his reasons for this, Simjanovic said:

> Sometimes I want to really microscopically edit things so I do it in there because I can literally see on the screen what is wrong with my music, I can see every little change I make to the sound (Simjanovic, Interview, 2017).

Similar to Simjanovic, for composing *Mad Max: Fury Road*, Holkenborg made substantial use of automation tracks and edits for the MIDI CCs inside Cubase's visual MIDI editor, which displays audio events/music as MIDI blocks, in tracks arranged vertically, over time portrayed along the horizontal axis (see Figure 5.3).

Figure 5.3. Holkenborg's MIDI session from Cubase
(source: https://www.youtube.com/watch?v=VkNeXS0Lmxc&list=PLPDbiB89zUSI-bAKsef_UC87OMsHrv_tR&index=5&t=0s)

This type of visual interface provided Holkenborg with audio-visual feedback that allowed him to pinpoint particular elements of the music that required improvement in some way. This allowed him to visually identify issues in his orchestral arrangement; such as time signatures, note duration, note velocity and loudness.

There appeared to be uniformity among the interviewed composers in their desire and necessity to utilise visualisation during their compositional process. Computer visualisation was employed to assist overall structure, as with Rona's and Rowland's use of Pro Tools, Yeo's use of Digital Performer and Holkenborg's, Partos's and Simjanovic's use of Cubase. Apart from using audio feedback to reflect on their work, the composers relied heavily on computer visualisations and used them almost microscopically for displaying a high level of detail.

Composers working with MIDI and audio events require a visual interface that acts like a dynamic score. Composers who pay particular attention to micro-details and complexity present in all human performances of acoustic instruments utilise a visual interface as a necessary tool to create the most detailed and nuanced performances. This suggests that the visual interface is critical in the communicative process and acts as a medium between film composer and computer of communication in the process of creating orchestral simulations in a representation system understood by both parties. This is directly influenced by the composition in progress. All of the functional software chosen was individual to the composers in this study.

Compositional software

The number and variety of software programs used by the composers was quite large, but was not exhaustive of all systems or representative of those most commonly used. A concise synopsis of each system and its most important functions is now provided. An in-depth analysis of compositional software is outside the scope of this project and for more detail the reader is referred to specific documentation relating to each, including Cubase (Hepworth, 2013), Logic (Nahmani, 2017), Pro Tools (Collins, 2012), and software user manuals for other applications (Collins, 2012).

Digital audio workstations as sequencers

All case study composers used DAWs as sequencing programs. Holkenborg, Simjanovic and Partos used Steinberg's Cubase sequencer as their central composing tool; Rowland used Logic; Rona used Avid's Pro Tools; and Yeo and Mann used Digital Performer. The visualisation and data structures of all MIDI sequencers share similar concepts and appearance; therefore, for the purpose of this study, the description of sequencing programs is general and based on the Cubase program used by Holkenborg, Simjanovic and Partos.

One of the most dominant characteristics of sequencers is their implementation of the MIDI protocol, which enables data manipulation at the micro-structural level. Input to MIDI sequencers is usually achieved via capture of gestures from a MIDI controller such as a MIDI keyboard, synthesiser or computer mouse. Sequencers interpret and store gestures sent by gesture controllers as MIDI information. These gesture events during playback send MIDI information to external and/or internal synthesisers and samplers to trigger audio playback.

The most important aspects of the MIDI data representation for this study are pitch, time and dynamic elements (articulation). MIDI pitch values are quantised to the Western chromatic scale. Microtonal fluctuations are possible via pitch-bend messages or by using automation tracks. The dynamic of a note event is measured on a 127-increment scale from silence to maximum level.[7] Timing accuracy varies between sequencers but is typically close to millisecond resolution. When Cubase stores a MIDI note's position, it makes a measurement in absolute values, called ticks. The current resolution limit is 1,000 ticks per 1/16 of a note.

The accuracy of playback is subject to the computer hardware configuration and operating system used by a composer. However, in professional implementations such as those used in this study, message latency is insignificant. Sequencers specify timbral information by indicating a particular sound selection on a connected hardware or software synthesiser or sampler. MIDI controller data may be assigned to adjust timbral parameters on those instruments, but the connected device handles all audio rendering.

MIDI events can be of any length and are located within a track. They all have the same attributes including volume, velocity timbre assignment and spatial position. The track is analogous to a part in a CPN score. A sequencer can group any number of tracks into a song, sometimes called a score or simply a sequence file. In sequencers, MIDI data manipulations are possible at the micro and macro scale. Any MIDI parameter can be adjusted through a variety of visual and numeric displays on an individual, group or track level. There are many available editing functions, including copy, paste, move, duplicate, transpose, extend, arrange, reverse and invert selected events or phrases.

Sequencers also provide an option to transform audio information into MIDI events, which extracts MIDI from audio files. This feature takes a monophonic audio

[7] For a full description of MIDI messages, see Huber (2007).

performance and extracts MIDI timing and pitch information from it. It provides a MIDI part in place of the audio file. Such extracted MIDI data enable a composer to double the part with any other instrument or to use those data with the sequencer's scoring features to provide notation of parts for other musicians. All these functions provide efficient ways to make manual edits to MIDI data. One aspect of the software used by the composers in this study was the choice of notation software.

Notation software

The DAW data structure was discussed previously in this chapter, so this section focuses more on the set of functions and tools for music notation and score printing provided by DAWs and third-party notation software, such as Avid's Sibelius, used by composers in this study. The micro-structure of music notation programs is similar to that of DAW sequencers in their note arrangement orientation. Like DAWs, music notation programs allow MIDI playback and their structural foundations are clearly based on the CPN score metaphor. For this purpose, Sibelius and DAW notation editors deal with a sequential ordering of note and rest events, with a focus on pitch and duration attributes.

Performance parameters for notation programs are more general than those for MIDI sequencing packages, being applied to regions more often than to individual notes. For the purpose of interpretation, notation software and notation editors (see Figures 5.4 and 5.5) follow CPN's use of specific musical notation symbols such as '***pp***' and '***ff***' to indicate dynamics and '***mp***' or '*più* ***f***' for more subtle variation in loudness between notes or phrases. However, these dynamic indications are always relative and '***pp***' never indicates a precise level of loudness; it merely indicates that music in a passage marked thus should be considerably quieter than '*ff*'. This dynamic resolution is less fine scale than the 127 steps in the MIDI velocity scale.

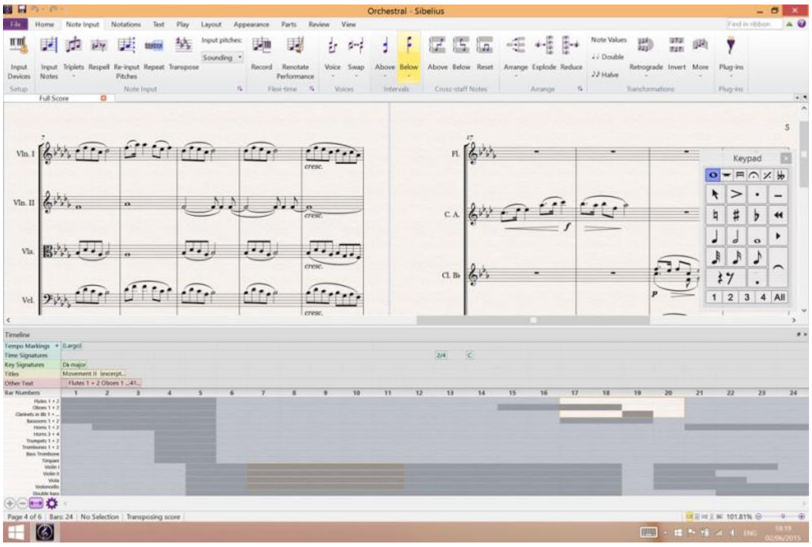

Figure 5.4: A typical graphical view in Sibelius

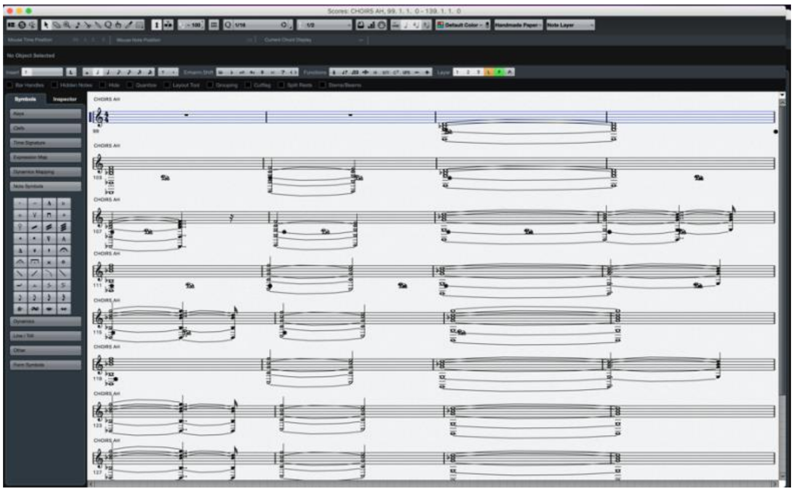

Figure 5.5: Cubase notation editor

In addition to sonification of the data structure elements, these programs maintain data about various visual notations that can be applied. These include lyrics, text comments, phrase markings and articulation marking. Because of the acoustic performance focus of score output, notation programs and editors specify timbral settings through the assignment of a sound (instrument) to a part. For computer playback the score uses a MIDI protocol to communicate with external and/or internal synthesisers and samplers. Sibelius and DAW notation editors utilise 'bar' measure as a macro-structuring element. Notes and rests are arranged in a link list within a bar, and bars are arranged as a linked list within a stave. A number of staves form a score. If required, selected events and bars can be copied, moved, deleted, transposed, time stretched and reduced.

Software instruments and plugins

The creation and processing of audio and MIDI events was a significant part of the compositional process for the case study composers. Apart from the difference in DAW programs used, the software packages used were specific to each composer. These software packages were considered an essential set of tools among case study composers so the brief purpose and most important functions of each are described separately in the following sections.

Native Instruments KONTAKT

KONTAKT is the industry-standard sampler from Native Instruments, a musical software development company based in Germany. KONTAKT uses an audio engine and advanced set of sample manipulation tools for creative sampling and sample playback. Its data structure is similar to that of a synthesiser: in its source, a KONTAKT is a generator of sound that outputs unprocessed signals in response to incoming MIDI messages; these signals are then processed in a variety of ways and sent to the output.

The difference is that the sound generator inside a synthesiser creates its source waveforms entirely by electrical or mathematical means (Pejrolo and Metcalfe, 2017, Russ, 2004), often being limited to a range of well-defined waveforms; whereas a sampler such as KONTAKT can use any kind of previously recorded (sampled) audio data such as acoustic instruments, sound effects, vocals and any standard waveforms (sine, triangle, square, pulse, etc.).

The entire functional range of KONTAKT's sampling environment is split up into smaller sections. This functional division is reflected in the user interface, where most elements that belong to specific tasks are kept within a separate pane, tab or dialogue window.

The browser inside KONTAKT (see Figure 5.6) provides a convenient way to organise and access on a composer's system all KONTAKT-relevant files, such as instruments, multis or banks. It also provides a number of additional utility functions such as importing instruments from various third-party sampler formats, managing and browsing the contents of KONTAKT's database, or loading and saving instruments and multis. KONTAKT's database keeps track of all files on a computer system that can be used by KONTAKT; it allows browsing and quick search, and access to data without having to go through the large amounts of data stored on internal and/or external hard disk data storage devices.

KONTAKT's virtual rack operates in one of two instrument modes. In multi-instrument mode, the rack provides an overview of all instruments that are currently in this mode, along with some general parameters. In instrument edit mode, it provides an adjustable and flexible view of its module panels, and modulation tables and editors of this instrument mode.

The outputs section of KONTAKT is a mixer-style environment in which the composer can adjust output levels, group individual channels and assign output channels to physical outputs or input channels inside a DAW mixer. In addition, the output section has an option to use signal-processing modules that operate on the output signals of all instruments inside KONTAKT. Finally, the virtual on-screen keyboard provides a convenient way of generating note and controller events. It indicates where different zones and key switches of the currently selected instrument are placed. This feature provides a quick overview of the range of selected instruments that can be played and which keys switch between the different articulations.

Figure 5.6: A typical graphical view in KONTAKT

Vienna Ensemble Pro

Vienna Ensemble Pro (VEP) is a mixing and hosting application that enables connection of multiple computers using an Ethernet protocol, to distribute processing power among the connected machines without the need for further audio hardware. The software consists of three main parts: the Ensemble Pro application, the server and a plugin. The VEP application can be used as a stand-alone audio and MIDI application or as the host application in conjunction with any sample library and/or 64-bit and 32-bit VSTi/AU software plugins.

The purpose of the server application is to connect different computers using the VEP plugin, on the network. This feature allows for communication between connected computers using instances of the VEP software. Each computer within the network can have multiple instances of the VEP plugin that are connected via the server application. This allows the VEP software to be used in two different ways. First, a composer can choose to have two computers connecting to the same server, sharing the same set of sample libraries, software instruments and plugins. Second, and the preferred option among the case study composers, a composer can have different instances of VEP on each computer for different types of instruments. For example, Holkenborg was using six computers, each hosting one instance of the plugin. This setup allowed him to host string instrument sample libraries on one computer, a brass section on the second computer, percussion on the third computer and so on, effectively making each computer act as a different instrument section within the virtual orchestra.

The VEP visual interface consists of two main areas: a vertical channel list on the left, which shows every instrument, plugin and bus on the mixer; and the main interface window, which shows either the editor for the currently selected instrument or plugin, or the VEP mixer (see Figure 5.7). The channel list offers shortcuts to almost every control for a channel, from routing to inserts and sends. Each instrument or plugin channel can be assigned a MIDI input port and channel. The VEP main mixer is a fully featured mixer that allows the use of insert effects as well as sends to outputs or buses on every mixer channel. Further, each audio output from the VEP mixer can be routed back to the DAW sequencer for further mixing and processing. Mixer channels also offer panning options, allowing the composer to make the stereo field narrower, or completely mono if desired.

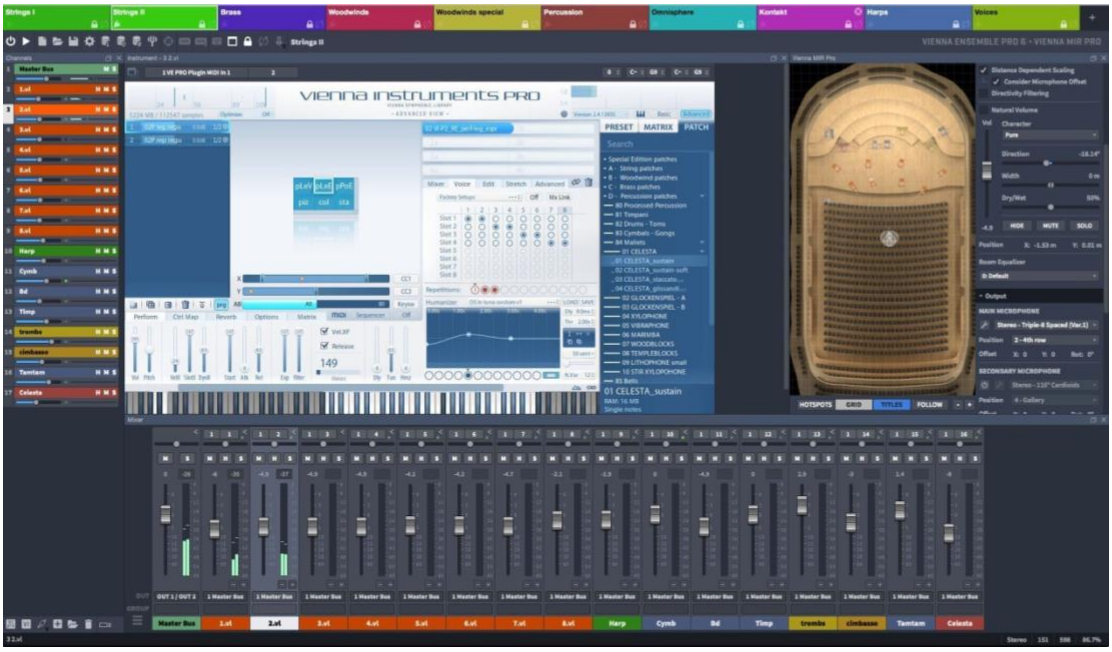

Figure 5.7: VPO visual interface

Another important feature is the option to add input channels to the VEP mixer, enabling audio to be routed from the inputs of the audio interface into the VEP mixer. This was a very important feature for the composers who used VEP software as this option enabled them to use audio outputs from their hardware sampler player and route them through their audio interface into the VEP mixer. One particularly important feature of VEP in network mode, particularly when it comes to tempo-synced low-frequency oscillations (LFOs) or delays, is that software instruments and plugins hosted inside VEP are able to receive correct timing information from the DAW sequencer.

Vienna Multi Impulse Response

Vienna Multi Impulse Response (MIR) is an integrated mixing and reverberation software package for spatialisation and reverberation of virtual orchestral instruments or any other type of audio signal. The software package provides over 53,000 impulse responses[8] of world-renowned concert halls, churches and recording facilities. MIR combines specific directional frequency profiles with reflectional information from every instrument, assembling all of the acoustic interactions into an accurate recreation of musicians playing their instruments in place and in space (VSL, 2002). MIR's impulse responses are taken from a multitude of sources and main microphone positions. MIR handles directionality both from the listener's perspective (the microphone) and from the signal source's perspective (the instrument). The software does not capture and emulate only room characteristics, but individual instruments' characteristics as well. This is very important because of differences in sound radiation of orchestral instruments.

An additional important feature of Vienna's MIR is a microphone technique and positioning of microphones in space. There are a number of microphone emulations such as Blumlein, ORTF and NOS available to choose from that allow complete control over the proximity effect and off-axis response, and the ability to alter polar patterns. For a chosen venue, composers have the option to select and combine different microphones into pairs and place them at four positions inside the virtual space: conductor, seventh row, fifteenth row and gallery.

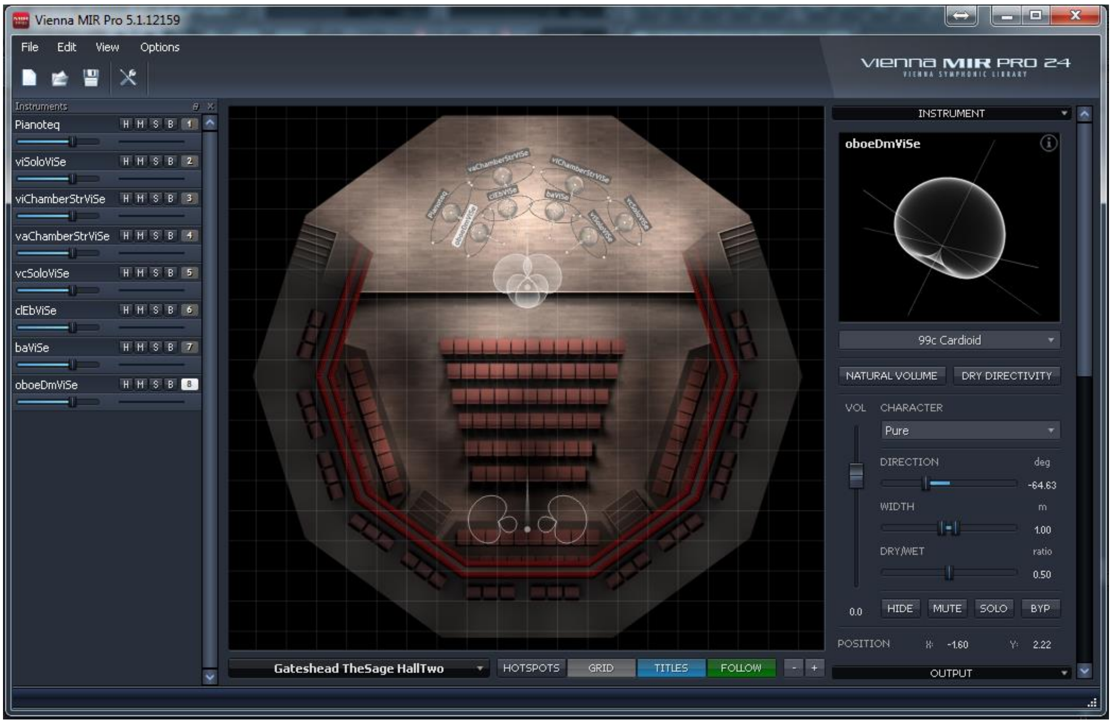

Figure 5.8: Vienna MIR microphone placement

All the instruments within the orchestra are represented by an icon on the virtual sound stage (see Figure 5.9) and each instrument can be placed at any position on the sound stage with its own volume, stereo width and directional settings. The directivity characteristics of each instrument are applied before the convolution of impulses, making the result dependent on the frequency distribution and volume an instrument is emitting in various directions (VSL, 2002). For example, if the composer needs a more ‘distant’ sound from an instrument they can turn the instrument icon away from the main microphone to gather more reflections from the rear walls; if they are looking for a more pronounced left–right positioning impression for a certain instrument, they can turn the instrument in the appropriate direction.

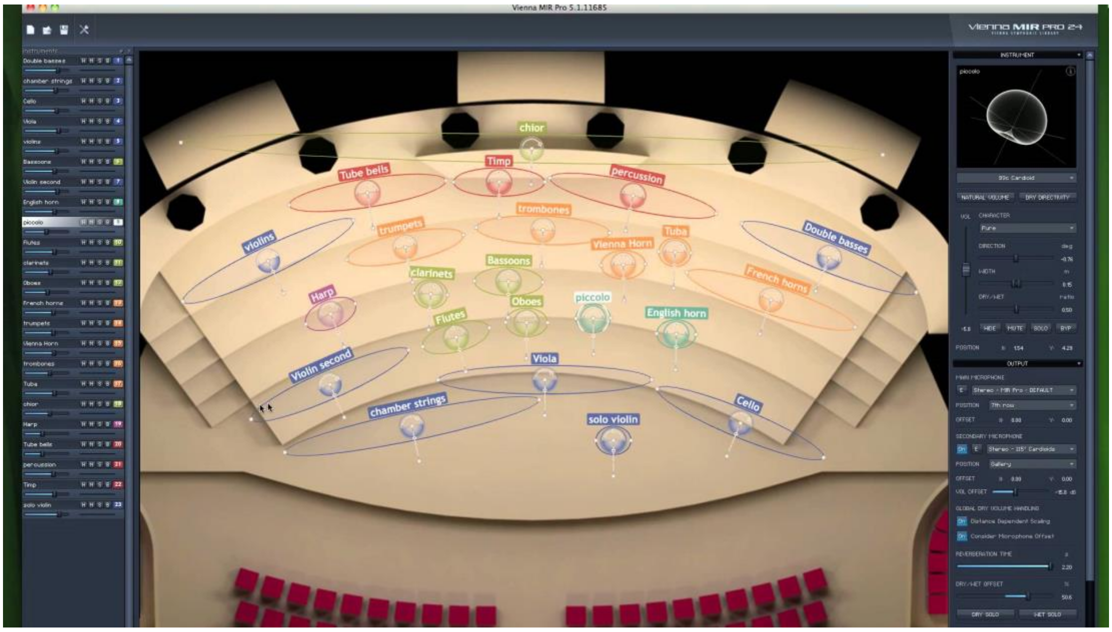

Figure 5.9: Vienna MIR virtual soundstage

The positioning of microphones and instruments on the stage (see Figure 5.9); the distance between individual instruments and instrument sections; and space characteristics—including the materials from and by which sound variously is reflected and absorbed—are emulated to create a realistic listening experience, an experience as if the music is being performed by a live orchestra in the actual acoustic environment.

Conclusion

This chapter has examined the diversity of computer music interfaces employed by the composers interviewed for this study. There was great similarity between composers in terms of how and for what purpose their compositional interface was used (i.e. reliance on visualisations, and audio quality). For the case study composers, the computer interface presented a medium through which they transmitted their music; at the same time, it presented a medium through which they perceived and understood their music.

The hardware of physical controllers and the software of visual and audible interfaces provides a communication channel between the composer and computer system. In the same way that music is created through the interaction of musician and instrument, orchestral simulations are created between a composer and the computer music system as his instrument. As such, an understanding of the compositional interface is a necessary step towards a better understanding of the process of creating orchestral simulation. In the following chapter I explore how utilising computer music technology enables composers to organise their film-scoring compositional processes of creating orchestral simulations from beginning to end according to their individual circumstances.

Chapter 6: The Creative Process

The majority of the literature (empirical, hypothetical and composers' accounts) advocates that the music composition process proceeds in stages over time (Collins, 2016), with evidence for procedures that can be applied repeatedly between these stages (Brown, 2003, Chen, 2006, Csikszentmihalyi, 1996, Ellis-Geiger, 2007, Hickey, 2003, Love, 2103, Sloboda, 1985, Wallas, 1926, Webster, 2003). The overall picture is one that does not fully consider the changes in the way film scores are being made as a result of the continual developments in music technology over the past 15 years. Such changes have had a major effect on film composers' creative practices, namely their approaches to film scoring and their thought processes during the process of music composition.

This chapter aims to gain insights into compositional practices by analysing the diversity of new approaches employed during the process of creating orchestral simulations for the purpose of the film score. I explore how composers organise their compositional processes from initiation to completion and how different circumstances influence the film-scoring process of creating orchestral simulations. Each of the case study composers worked in a particular way and their stories are presented throughout this chapter to illustrate how they proceed through different steps during a film-scoring process of creating orchestral simulations.

The creative process is viewed here as a staged process where each stage reveals particular aspects of compositional practice. The analysis shows if and how this practice is influenced by the use of computer technology. Examples from the case studies are used to illustrate the creative process and to demonstrate the applicability of the theory. In this way I hope to demonstrate the complexity of the film composer’s compositional practice and of their role during the film-scoring process of creating orchestral simulations.

Preparation

Setting up the templates

A great deal of the work that goes into creating orchestral simulations using computer technology occurs before the first composition stage has even begun. The process of conceptualising and translating musical ideas into melodies, harmonies and rhythms begins with good organisation and careful preparation. Appropriate organisation can effectively expedite the creative process, and in the case of orchestral simulations is achieved by creating orchestral templates.

The way in which templates are designed reflects a number of critical decisions concerning how professional film composers work. The working template is one of the composer's most useful tools; it allows for easy recall of a large palette of sounds that the composer uses on a regular basis and provides a reliable way to begin each project. In addition, a working template ensures that every composer’s new project begins with the right collection tools and settings. For Bruce Rowland, his orchestral template presents a familiar working environment that enables him to use orchestral instruments to capture his ideas. Once he had established the kind of feel and sound that he is striving to achieve, he would then create a template in Logic that would load all his favourite instruments or sounds that he needed to call upon quickly, to capture his original idea. Sometimes he would also use his standard template and add to it his favourite sounds or solo instruments, or additional sounds he planned to use in a project on which he was currently working. Similar to Rowland, Yeo liked to create a specific template for her projects that consisted of instruments that would be used for those particular projects:

> For every film or series that I work on I like to write the music that is idiosyncratic to that series. Because of that I do spend half a day before I start every film or series and create a template for that series (Yeo, interview, 2018).

This suggests that orchestral templates support composers' creativity and serve the needs of their current project and many different projects over time; but most importantly a working template provides a consistent and familiar creative environment. To be successful in developing and demonstrating creative abilities, it is important to establish a supportive working environment (Amabile et al., 1996, Peterson, 2001). It is advocated that unlike unfamiliar surroundings, a familiar environment can provide support and make a person far more efficient (Brown, 2003).

To work efficiently in a familiar creative environment, many composers create orchestral templates. Some composers in this study built substantial templates consisting of many sample libraries at their disposal:

> I have a big template and I can transfer those parts of the template into other sequences if I need to. I can pull out of it, or I can start with it, add to it, subtract from it. My orchestral template is about 120 tracks; it's not a template with every possible instrument I could ever think of ever using. There's quite a few I leave out and add them if I need them. That way it's a little faster to work with, a little

easier to scroll around, and for a lot of my work it's the one that works very well (Rona, interview, 2017).

Other composers had smaller writing templates made up of sounds they used most frequently:

> I have learned over the years that a smaller writing template is more suited to my needs and workflow. I have found that having a massive template that's filled with every sample library I have makes my work process cumbersome at times. A smaller writing template is more manageable and it demands less of my computer as well (Simjanovic, interview, 2017).

and others had specialised templates built for groups of sounds. Holkenborg's orchestral template consisted of many virtual and hardware instruments split into groups: wind, brass, percussion, strings, world instruments, choirs, software synths and external analogue synthesisers. It was a large template consisting of hundreds of tracks; its massive size was purposely built to meet his immediate needs (Figure 6.1).

Figure 6.1: Screenshot of Holkenborg's orchestral template setup in Cubase
(source: https://www.youtube.com/playlist?list=PLPDbiB89zUSI-bAKsef_UC87OMsHrv_tR)

Similar to Holkenborg,, Jeff Rona had built a custom template that incorporated external instruments and effects into his workflow:

> I've done some custom templates to make it very fast to not only control the DAW faster, but also to help with my automation and also MIDI control for instruments and effects, to be able to filter sweeps or any modifications I want (Rona, interview, 2017).

Regardless of the template size and purpose, managing templates to fit the composer's workflow was an important part of their creative practice. From the moment computer music technology became a necessary compositional tool, composers strived to plan and organise their workflows to maximise the effectiveness of their creative outputs, especially when working to strict deadlines. Careful planning and organisation allows composers to determine what tools they need, how to arrange them in a useful and meaningful way and how to avoid unnecessary interruptions, which can have a number of negative effects on their creative processes.

Negative consequences can occur when time available to work on a critical task is insufficient. Unwanted interruptions consume time that could otherwise be spent on important tasks. In his study, Perlow (1998) illustrates that recurring interruptions can make an individual distressed in his efforts to complete work and can create the sensation of having more responsibilities than time available in which to fulfil them. To be a professional film composer means to handle a large number of different tasks during the process of composition. In the film-scoring business, time is in limited supply; when strict deadlines need to be met, the composer has to be efficient above all and make sure that every minute spent is used well:

> It's a time-saving device, because you don't want to keep finding the same thing (laughing) that is taking you a week to find. Also, for each sound I would have spent a bit of time putting effects on it and equalising and making sure the palette works as the whole together. And also, instruments have been EQed to sort of stay out of vocal frequency range. So, it's a time-saving device (Partos, interview, 2017).

> In film-scoring business delivery deadlines are very strict; you need to be finished by a specific date all the time. A template saves precious time and keeps me concentrated and efficient (Rona, interview, 2017).

Additional negative effects related to time pressure may include heightened feelings of stress and anxiety, as the person being interrupted recognises that less time is available and that they may be falling short of reaching task milestones (Perlow, 1999). Jett and George report that 'such negative consequences of intrusions are most likely to occur when the person being interrupted has a sense of urgency about completing critical tasks' (Jett and George, 2003, p.495) . Further, 'intrusions can hinder an individual's ability to reach a state of total involvement in the task being performed. Such states occur when a person is intrinsically motivated and actively engaged in a task without a sense of time consciousness. These conditions are generally associated with concepts of flow or timelessness' (Jett and George, 2003, p.495).

A state of total involvement or 'flow' is an important aspect of the process of composition because it is in the mental state of being completely present and fully immersed in a task that composers are efficient and productive musical ideas are flowing (Csikszentmihalyi, 1996). For Simjanovic, a working template prevented unnecessary interruptions and kept his mind focused on specific tasks:

> A well-organised and working template is indispensable and keeps me focused on my work. It provides me with all the tools I need for a particular project. All my samples are preloaded, I don't have to stop, search and wait for samples to initialise; everything I need is there for instant recall (Simjanovic, interview, 2017).

Similar to Simjanovic, Partos described why for him templates were an important tool that prevented unnecessary interruptions that might have had negative consequences on his workflow:

> I find that I'm using different paths even when I'm composing to when I'm mixing. It's different head space. If I have to stop and search for stuff on the computer when I am in the middle of a session, that really disrupts my creativity (Partos, interview, 2017).

Both of the above statements clearly show the importance of templates, which not only provide composers with the set of tools required for successful realisation of various tasks during the process of composition, but are themselves a tool that creates a supportive working environment preventing unnecessary interruptions that can have a negative effect on creative thought and ultimately on the creative process of professional film composers.

Developing the concept

> *Concept is the heart of the score, it is the primary idea, it could be small or large, modest or grandiose, which functions as foundation upon which score is built (Karlin and Wright, 2013).*

The first of many challenges the professional film composer must overcome during the process of creating orchestral simulations is the concept of the film score. If developed from a clear concept, it will have a consistent attitude and style, and such an approach will help maintain a film's dramatic integrity. Computer technology has added a new conceptual dimension to the process of film scoring and has consequently transformed the process into an immensely integrative and technical art form. The film composer now conceptualises their work through an intellectual process that integrates the physical workspace (the studio) and the virtual technologies available through computer applications, simulations and virtual instruments (Love, 2103). When the composer reaches the 'conceptualising' step in the scoring process, they must make several crucial musical decisions. It is during this process that the composer establishes the foundational element of any good score: the score concept (Karlin and Wright, 2013, Schelle, 1999). As argued by Karlin and Wright (2013), 'the score concept is the primary idea that functions as a foundation upon which the score is built'. Its main purpose, regardless of the medium and the compositional methods used, is to connect the ideas, environment and characters with music. At this point, the composer will gain a sense of the tone of the movie scene and will begin to picture the types of instruments, arrangements and music styles that can be provided by suitable textures.

Directing a great deal of attention towards developing the concept is the first step in creating a successful film score and for many film composers it is the most important one. From the moment a film composer begins to consider their first dramatic material, they are defining and developing this focused, central idea to develop a musical concept for the film. More often than not, the concept of the score will be developed around an inherent feature of the central character or characters. The concept can also be developed around other aspects of the narrative but frequently these aspects will make connections with the central character or characters (Karlin and Wright, 2013). If the musical concept evolves from the dramatic theme of the narrative, it becomes an important statement that reflects the overall attitude and emotional effectiveness of the film. The concept was often discussed by the composers in this study in terms of melody, musical style or instrumentation; for example:

> The first thing I do when I work on a film I watch the film obviously, I try to learn all the characters what their relationships would be to each other, who are important players in the movie, what are the important situations and potentially important places and then what I try to do is to define vocabulary and the policy of the score. Vocabulary of the score could be looked at; the style of the music could be talked about; with instrumentation it can get into a lot more detail—the harmonic language, the type of melodies. If it's a love story it’s probably going to have a more melodic single melody. If it's a psychological thriller though, it's probably going to have a much more angular melody; the type of harmonies that I would use in one vs the other—is it a genre or is it a certain style of movie? I try to figure out my vocabulary; what is it going to be my pallet that I'm going to use.

> It's like an artist that goes for a blank canvas—he goes where do you start; you have to start by figuring out what your subject matter is going to be; what your colour palette is going to be; what is going to be the best way to express whatever it is you want to express (Mann, interview, 2017).

For the composers, thinking about colour palette and what instrumentation might best express their ideas was a very important part of the concept developing process:

> Most of the time the right instrumentation will make the sound appropriate for the genre, but it will also allow for effective portraying of the characters and overall mode of the scene (Partos, interview, 2017).

This is the moment during the conceptualising stage of the creative process where technology in many ways comes into effect. Simjanovic made this point quite strongly:

> When I think about the film, I try to think and feel the movie, that's when the idea happens and in many ways the technology plays an important part in all of that; it allows me to express and try any idea that I have; I can instantly hear if the music is working or not. I can improvise, I can experiment with different instrumentations and develop my ideas further (Simjanovic, interview, 2017).

This suggests that computer music technology plays an important role during the phase of the composing process of creating orchestral simulations in which the composer is developing the concept of the film score. The importance of computer music technology is that it provides composers not only with the right set of tools but also with the ability to express and externalise their ideas using those tools. In addition, computer music technology allows composers to experiment with different instrumentations, and assists them in generating novel, useful ideas and successfully implementing those ideas.

Apart from choosing the right instrumentation, there are other parameters that composers need to be aware of when developing the score concept and creating their virtual orchestras. In industry settings, decisions made around the use of virtual instrumentation are largely governed by budget, the composer's own technical skills and the wishes of the director (Ellis-Geiger, 2007). In almost every case, the film director or producer has the final word. The composer has to be mindful of this and conceptualise accordingly:

> Basically, I would sketch a piece of music in a scenario where I am doing something where eventually I'm going to record an orchestra. I will mock-up all of the acoustic stuff, all of the orchestral stuff and I will sequence all of the electronic and orchestral stuff so I can play the entire piece for the director. Because one of the problems that I know that my colleagues have dealt with is the idea that they do these virtual orchestrations and play stuff for the director. And then the director says, 'What is that instrument?' and I say, 'It's an oboe.' And he says, 'I don't like that sound.' And so, then they'll change the oboe to a flute by choosing a different patch (Mann, interview, 2017).

> The filter is always the filmmaker, whether it's a movie, a TV show or a game, everything passes through the filter of the filmmaker, director, producer. A lot of directors want something that has the emotion of an orchestra but isn't a generic orchestra. If it's low budget, then you may decide, 'well I don't need to put wood, I don't need live woodwinds, I'm going to use sample percussion and that's going to be fine' (Rona, interview, 2017).

Apart from the film director, whose wishes certainly have a major effect on what film composers are required to produce, other important factors that might influence the conceptualising process are the budget and the style of music composers are creating:

> If you are mocking up an orchestral score that’s going to be recorded by a real orchestra, in that case you have to look at your budget, you have to look at how many players you have, as in do you have six strings, eight strings, ten strings, twelve strings; how many first violins, how many second violins? Because of the danger of using like a big fat string, you know 16 violins, for example, if you have say 8, your end result will sound disappointing compared to your samples because your sample sound will be so enlarged and you give it to the small string section and small string section sounds thin. If you have to finish the product out of the box so to speak. If you have to finish that product using virtual instruments, in that case I would choose whatever (Yeo, interview, 2019).

> You know, the concept of an orchestra has a meaning. Winds, brass, strings, percussion. You know, maybe choir. Boom, that's orchestra. If you're writing symphonic music of course, you usually stay with the traditional generic orchestra because you don't know who is going to perform the music. And that's the concert world. In the film world, we get to make it up every time. So you know if you write for the piano, you write differently than when you are writing for the string score, which would be different when you are writing for the cello, different if you are writing for a choir, different if you are writing for the orchestra, different if you are writing for a rock band, different if you are writing an ambient score. It depends, it really depends on the style of the score and of

> the music, you know every style of music will have a different style of approach sonicall (Rona interview, 2017).

Whether it is the budget, director's wishes or number of performers in the orchestra that might have an effect on the conceptualising process, and ultimately on the music a film composer is making, they must be aware of such factors and work within these parameters from the start. The distinctive features of each ensemble must be accounted for during the process of creating orchestral simulations.

However, it is not unusual for a composer to conceptualise a piece of music that might sound effective when performed by real players but that may not sound lifelike using virtual sample-based orchestral instruments, because of current technical limitations in virtual instrument technology. Thus, when creating virtual orchestral performance that will be ultimately performed by real players, it is important that a composer has a clear understanding of the kind of ensemble for which they are writing, as each instrument and every player in an orchestra has strengths and limitations. Virtual sample-based instruments come with different strengths and weaknesses across their solo instrument, small ensemble and large section libraries. These strengths and weaknesses arise not so much from the capability of the players, as from the contents and arrangement of sampled materials in each library and the way in which each library patch has been made responsive to human input. These details are of a great significance in the process of conceptualising a film score, and must be accounted for.

It is important to understand the limitations of all instrumental forces, as these will affect how composers write. Such limitations will most certainly influence conceptualisation and the composition of the cue or arrangement:

> There are things that the electronics cannot do and that has affected the way people write. Because nowadays you'll hear a lot more situations where composers will give the strings, sustain notes, just pads, just longer sustained notes and put all the movement in the percussion because those samples don't do well, they don't do moving strings very well (Mann, interview, 2019).

In addition, to create realistic and expressive performances using computer technology, it is necessary to understand not just the intricacy of each instrument, but also intricacies of how an ensemble of musical performers will behave in a live context (e.g. individual variations in timing, articulation, dynamic, intonation). These subtleties must be accounted for in the composition and production process.

If the objective is to construct an expressive and convincing simulation of acoustic instrumentation from virtual sample-based instruments, then the orchestral simulation must be conceptualised and written precisely for the virtual instruments that will be used. Musical materials need to be composed and developed to arise from a subset of instrumental gestures where the instruments sound most realistic. Instruments will exhibit weaknesses in certain areas. These weaknesses have to be identified and mitigated to ensure the most realistic and expressive performances are recorded.

Virtual instruments typically exhibit some consistent weaknesses. Pizzicato sequences where the same note is plucked in quick sequence result in an identical or very similar articulation to be presented in rapid succession, leading to the impression that a sample is being used and repeated for each note. Some software sample players (e.g.

Native Instruments KONTAKT) try to mitigate this problem by randomising different samples of the same pitch for each articulated note, but the limited variation in articulation is still often noticeable. For Partos, these weaknesses in a sample library became noticeable when attempting to perform a solo instrument performance:

> If I'm using virtual instruments, you tend to compose to the idiosyncrasies and limitations of it rather than having the melody in your head and finding an instrument to play that melody; you're more often disappointed your virtual Instruments can't replicate what's in your head. You have to know what is in your sample library, if you are mocking up something directly you tend to compose to the limitations of your pallet. It is easier to produce a realistic orchestral sound as opposed to a realistic solo performance (Partos, interview, 2017).

This may be explained by the fact that in human performances of acoustic instruments, there is a large amount of nuance and complexity in most aspects of the production of notes and phrases. Few, if any, articulations of the same note sound the same. This complexity is present in all human performances of acoustic instruments (Juslin, 2001, Palmer, 1997, Percino et al., 2014). However, it is this complexity that is most difficult to emulate or reproduce when using virtual technology. Beyond micro-detail, a range of different articulations are associated with phrasing patterns. In string instruments this might include bow direction, bow position, legato, vibrato, glissando and so on. When an acoustic instrument is heard in isolation, these details are clearly audible. Different compositions or music cues emphasise or foreground these elements to different degrees. Some forms of music depend on a complex presentation of these articulations as a core feature of the genre. In other genres or compositions, the musical materials are very 'section based' and such individual details are less noticeable because of the effect of aggregating many players. More ambient styles often focus on a reduced range of articulations, foreground pitch duration and density in preference to complex phrasing.

A film composer's job is to conceptualise and create the music that interacts with visuals to help the audience experience the characters' feelings and emotions and to understand the film as a whole (Douek, 2013). It comes down to the composer's skill to create music that fits with the overall mood of the narrative as well as the demands of the different scenes in the film. During the conceptualising stage the composer must consider what kind of mood they need to create for the overall feel of the film, a large framework, as well as for the scenes within this framework. The first and one of the best ways to do this is to start with a sonic palette. Thinking about and choosing the instrumentation the composer creates the overall 'sound' they are going to use:

> For me I use instrumentation to colour my compositions to enhance the dramatic approach that I need, and I need that variation to do that. Electronics also gives you a different vocabulary of sounds so when you sit down and say, 'OK I'm going to use this kind of electronics', so if I'm working on an electronics type of score the first thing I do is to try to unite the score by picking my sound canvas, it is just like picking an orchestra (Mann, interview, 2017).

Likewise, the variety of sounds that computer music technology provides was of great benefit to Rowland. He liked to start by literally just recording on the piano; after that, he would replace those piano sounds with different sampled instruments to see what would work better for the rough mix. Similarly, Simjanovic, Partos and Rona were using the technology to aid their conceptualising processes:

> At the very start when I am still developing the score concept I usually have a pretty good idea what sounds I'm going to end up using but the most appealing part is seeing what sort of interesting sounds and soundscapes I can come up with by combining and experimenting with different sounds I have in my computer. I start with one sound and from there; I try to experiment with different sounds to see if they work with what I have created so far (Simjanovic, interview, 2017).

> I use the technology to aid the idea and the conception of my process, to mock up what I'm thinking. I'm always playing with various instruments; what sound could play that melody. Sometimes musical ideas in improvisation are spontaneous, even with something as generic as a piano, I like to explore and experiment in order to get the specific sound I want (Partos, interview, 2017).

> So there are times that I set up the piano and I have a piano in a different room. I set up my piano and with a little pencil and sketch pad and I get an idea I let it down and I run to my studio quick quick to get onto the computer as fast as I can to create electronic scores. I spend time designing sounds that will inspire the score. So I might develop a set of interesting new sounds and then come up with ways to compose with those sounds (Rona, interview, 2017).

These quotes provide a useful demonstration of how technology affects the conceptualising process and individuals directly, where composers as creative content producers have access to tools that enhance their creative thoughts and their creative abilities. The role of technology in the creative process can be best understood from a theoretical point of view, whereby including technology in the process of creative thought to create ideas, multiple components converge and their interplay produces creative thought (Csikszentmihalyi, 1996, 1999, 2002). In this instance convergence involves an interaction of individual (film composer and computer technology), field (film music) and domain (the knowledge of music and computer music software). The composer interacts with computer media, working on the information provided by those media and extending it through cognitive processes to evaluate, reject or select the best and most suitable new ideas.

Technological media such as a computer music system provide a conceptual musical space in which a composer can explore and further develop. It focuses the composer's attention and gives them the experience of 'untrammeled freedom' (Csikszentmahlyi, 1996, p.250). Yeo, Simjanovic and Rona found satisfaction in exploring and experimenting with different samples:

> Technology gives you a lot of options, some samples are very inspiring and they are built that way; they are built to have a lot of shape within the sound a lot of variations within the sound that you can use, explore and experiment with (Yeo, interview, 2019).

> Technology provides you with many opportunities to explore and experiment. In many ways it affects and enhances your creativity; for example, If I am writing a Middle Eastern theme, the usual combination of instruments would be sitar, saz, duduk, dulcimer, etc., to get that natural Middle Eastern feel, but then why not try and see if I can possibly add something different, something unconventional (Simjanovic, interview, 2017).

> Depending on the style of the score and of the music. So you decide you want really big brass and you know you want something very violent, so you add these additional instruments. Maybe you have four tubas, and maybe you have the cimbasso, and these other instruments to get an unusual sound. I think every composer wants something that sounds like them a little bit. It's like building an instrument that never existed before using sound technology. And then exploring that sound and figuring out how to write for it. And then come up with something cool (Rona, interview, 2017).

This process of compositional exploration is one of externalisation of ideas as documented by Brown in his studies. Brown argues that 'Exploring is a semi-guided process of seeking elements for inclusion in a composition and ways in which those elements can be structured' (Brown 2003, chapter 7, p.10). According to Brown, 'The goal of this exploration is often not a single point that can be clearly seen, but rather a loosely formed conception with partially defined boundaries' (Brown 2003, chapter 7, p.10). The process of developing the score concept using computer technology is one of conscious exploration and experimentation with musical materials but at the same time it is to some extent an instinctive process. It is the activity that begins with an initial idea that with the help of technological media evolves, I would argue, from what Brown states is a 'loosely formed conception with partially defined boundaries' into a clearer form, a melody or dramatic theme.

During the conceptualising stage, every composer in this study had a personal way of working with technology but the common goal for all artists throughout this process was to encourage creativity and see technology as an accompaniment rather than as a driving force. Rowland and Simjanovic shared their views:

> I use technology to get a particular sound that I want: give me a couple of different solo violins, give me an ensemble, string section. Give me a solo flute, give me an oboe, give me a choir of angels and a glockenspiel, etc. I am very old school. I found that technology is getting in the way of creativity. My attitude is: all I want to do is think about writing music. Using technology to explore and experiment is a part of the process but generally, rarely would I change my mind because of the technology. Generally, if you come up with an idea, you've generated the idea in your mind, but I think you've also generated what you want it to feel like (Rowland, interview, 2019).

> You really have to be careful when using technology. You have so many options to choose from, endless possibilities, it’s easy to get trapped in all of that (Simjanovic, interview, 2017).

The process of conceptualisation—that enigmatic concept artists use to develop the idea—is not some ambiguous product of the mind. It is a process that is influenced by and depends on many factors such as the wishes of a film director, style of the music, playability of sample libraries and budget. At the same time, this concept-developing phase is a process that can be suppressed or amplified using computer tools and scenarios. Computer music technology provides endless possibilities and the more advanced the film industry becomes technologically; the more composers and film directors and producers begin to depend on computers on a daily basis. This kind of dependency on technology can be a disadvantage as much as a benefit, because it can have an effect on the final outcome of the musical materials simple because it is so easy to start with an idea and then get lost in a universe of endless possibilities.

Production

Having developed the concept for the score the next step in the process is to begin developing specific musical solutions. Every decision made about the music, whether it involves writing motifs or orchestrations, further defines the score. Besides fulfilling a film producer's and director's visions and wishes for particular projects, the film composer's job is to create a means of communication through interaction with visual imagery. Next to images, the audience is trying to make sense out of the complex interaction between dialogue, music and ambient sounds where each of these individual components carries meaning; but most importantly, meaning arrives from their interaction.

During the production stage of the composing process the composer's attention is directed towards creating musical events that support the action on the screen and serve the greater good of the film experience. This approach requires that through creation of orchestral simulation, film composers employ music and the emotional effect of the music's structure to extend and explore the aural experience. The unique value of this approach lies in the composer's ability to use computer technology at their disposal and create expressive and convincing virtual orchestral musical performance to effectively communicate with the audience.

Expressive musical communication

Music, as well as speech, can be thought of as a process of communication. If one goal of expressive music performance is to instantiate properties of music to the listener (Walker, 2004), then the process of transferring musical expression to an audience using computer technology can be best described as communication of combined musical knowledge and technical skills from composer to listener.

In the context of orchestral simulations, a composer's intention to produce an expressive computer-generated performance largely depends on the particular sample-based instrument that is going to be used and how that particular instrument or group of instruments is going to perform within a virtual orchestra. A certain level of expression may be communicable across different instruments; however, differences in expressive performance characteristics, such as timing, dynamics and articulations, become apparent because of the physical configuration and the acoustic properties of the instrument (Baily, 1977, 1985). Such instrumental differences are important to an understanding of musical communication and will have an effect on the nature of musical communication via each instrument between composer and the audience, especially since the quality of sampled instruments largely depends on capturing a complete range of playing conditions including the tonal characteristics produced by acoustic instruments and all of their performance gestures. Rowland made this point quite clearly:

> As a composer, what you are doing is this. You are looking at the scene, and you think 'How is this scene affecting me emotionally?' Then, when you decide whether it's making you sad, or whether it's making you whatever, you write your score accordingly, using the sampled instruments accordingly. So in other words, if it's sad or wistful, you're probably going to use piano and oboe, and maybe harp or something like that. If it's a chase and the cowboys are chasing the Indians, it's most likely going to be cavalry trumpets and lots of percussion and all

> that kind of stuff. What you're doing is you're manipulating the audience to feel the same way that you want them to (Rowland, interview, 2017).

The choice of musical instrument can be an important factor in shaping the performance and in many cases may be a significant component of the communicative process. As argued by Walker, "Performed music contains systematic deviations from the notated values of timing, dynamics and articulation, which can communicate expressive content to a listener" (Walker, 2004, p.ii). A composer's task during this phase is to find the best tool for the project and through different approaches create a performance that can convey their message and effectively communicate with the audience:

> Some sampled instruments are more expressive then others and not every sample works for every situation. You have to spend time finding them and working on them, that involves going back and forth between finding the most suitable sample, playing that sample, listening to how it sounds and editing if needed until you are satisfied (Simjanovic, interview, 2018).

> Every sound, every sample and instrument that I use has to have some quality that will evoke a specific emotional response from the audience. So I am listening to the work that I've created as an audience (Partos, interview, 2018).

This suggests that this stage of the composing process is essentially a communication process where the composer is not just a composer; but is a performer and listener (e.g. audience) as well.

In a performance-oriented theory of communication, this process of communication is defined as a communicative chain of the form **Composer -> Performer -> Listener**;

where information is transferred from the composer and performer to the listener by means of a shared musical knowledge (Kendall and Carterette, 1990). Since part of being a skilled music performer entails being familiar with one's instrument (Ducasse, 2003, Kay et al., 2003, Meyer and Palmer, 2003, Sudnow and Dreyfus, 2001, Sundberg, 2000), as a performer the composer's conception of artistic playing cannot in fact be achieved without consideration of the physical instrument they are trying to simulate or even emulate. Every computer software and virtual instrument in the orchestra has constraints and the composer's task is to be aware of different constraints across instruments, which may affect interpretive aspects of a performance.

The processes of creating a score by a composer and interpreting a score by a performer, and ultimately the listener, are necessarily very different operations and are explicitly identified by semiological models. A semiological view suggests that for two members of the chain to communicate, one member—the producer—creates a score and the other member—the receiver—receives this score and analyses it in an attempt to extract some meaning from it (Walker, 2004). The important point here is that any meaning that is extracted belongs inherently to the receiver; the meaning is not a direct transmission of the producer's message (Eco, 1976, Peirce, 1935, Walker 2004).

The producer has certain intentions that they wish to communicate to the receiver and the instantiation of these intentions is the musical performance produced. This performance symbolises meaning for both producer and receiver. According to semiological views, these two meanings are the result of two different processes—a creative process by the producer (e.g. composer) and an interpretive process by the receiver (e.g. audience)—and are therefore not necessarily identical (Walker, 2004).

In the context of a film score, the composer and performers of a composer's score have a very specific interpretation of a piece of music, and the audience is not directly privy to this interpretation. The audience have direct access only to the acoustics of the performance, not the intentionality that produced the acoustic. Therefore, the audience as listeners, according to Nattiez, must extract the intentions of the composer and the performer from 'systematic variation in the signal' (Nattiez, 1990) or, in the case of orchestral simulations, from the 'expressive virtual orchestral performance' created and performed by the film composer. The crucial difference here between a semiological model and the process of creating orchestral simulations is that the composer is the composer, performer and audience at the same time. This means that the composer as a listener has direct access to the intentionality that produced the acoustic.

This production stage of the process of making orchestral simulations for the purpose of a film score is simultaneously a creative and interpretive process. Unlike in the semiological model—where two processes are experienced by different individuals who may have different musical and instrument-specific knowledge that influences the way they compose, perform and perceive music—this phase is a one-person process in which a single person fulfils multiple roles of composer, performer and listener:

> through the most part that I'm working on the film, I've got the composer hat on and then really start listening fully like an audience too. It takes a while to take

> that composer's hat off, or the producer's hat off or the arranger's hat of and sort of listen to it like an audience; normally I just kind of have to … I often write a piece of music then once it's finished then I'll put it against film, and just watch the film and then see if it works (Yeo, interview, 2019).

> You have to look at the music not just as a creator of that music but as a member of the audience as well. At some point during the process I have to stop being a composer and ask myself how would the audience react to the music I just made (Partos, interview, 2017).

> There's all that psychology, and sometimes the psychology is, well what's emotional to an average member of the audience, so there is this process where you're still asking yourself, 'How will the average audience member respond?' (Rona, interview, 2017).

These statements indicate that this is a stage of the process where emphasis is on the composer, who is involved and is responsible for both creative and interpretive processes.

As a comparable process we can reflect on the motor theory of speech perception (Liberman et al., 1963, 1967). The motor theory claims that perceivers are able to interpret speech simply because they are speakers themselves. In terms of orchestral simulation, where the composer is the performer and a listener, the interpretive processes of a listener results in a truthful interpretation of the expressive musical performance because the listener also possesses the same kinds of musical familiarities as the performer. Why? Because it is the same person. In other words, the emotional messages can be effectively communicated between the composer, performer and listener because the creative and interpretative processes are both understood.

During the interpretive phase of the production stage, the film composer is focused on the feeling and meaning of the musical events, in other words the focus is on the emotional intention of the musical performance that is manifested through the sounds it produces. If the meaning of the music does not come across clearly in the production, it might confuse and have a different effect on the listener. If the music does not provide an appropriate level of support for the visual images—in other words, if the 'arousal potential' is not appropriate—the listeners will reject the music (Juslin and Västfjäll, 2008):

> First step is that I'm happy that this piece of music has fulfilled the emotional obligation of the story in that moment. And of course, every piece of music in a score ties in some way to the other pieces in the score. But sometimes you have to just be focused on, here's a scene, and two people are talking, and it's very quiet and very emotional, is the music giving the full emotion without any distraction? If I feel that the music is getting too intellectual or too busy, then I'll go in and start to take parts out. My goal, personally, is to try to give the most emotion with the fewest notes and the fewest instruments. I'm more of a minimalist than some other people. So number one is, have I achieved what I tried to achieve emotionally? And is the writing clear? You know, are there any notes that are unnecessary; are there any parts that are unnecessary; are there any counter lines that are unnecessary? Is there anything that if I took it out, it would still be good? If the answer is yes, then I take it out (Rona, interview, 2017).

During this phase the composer is seeking the meaning and interpretation of what is being played. Different sounds and instruments give distinct meaning and perspectives to what is happening on the screen. The composer might choose one instrument for a particular scene only to realise after repetitive and careful listening that a different type of instrument might be better suited for the same scene. Many times, a composer chooses instrumentation because of what that instrumentation says. Fast music with a strong, high-spectral component evokes different emotions than does slow-tempo music with different acoustical cues (Lehmann et al., 2007). It is important that film composers listen for the differences in the message musical events are carrying during interplay with the visuals.

These small details come across in a subtle way with music. Music production must take into account these subtleties for the feeling of the music to be properly conveyed to the listener. The ability to hear the incompatibility between music and visuals and make the necessary adjustments to performances is an important step during this phase of the film-scoring process because the end goal for a composer is to communicate their message to the general audience whose interpretive process might differ from that of the composer and from one another. Some audience members may better interpret musical structure if they possess certain musical familiarities (e.g. audience members who are also music performers), while the majority of the general audience may not have such a perceptual advantage (Kendall and Carterette, 1990, Palmer, 1997). Most research into interpreting cinematic elements, of which film music is one, has been directed towards psychological principles that might explain the manner in which audiences interpret film. While extensive, the research in this area is beyond the scope of this project. The focus of this project is the composer, their approaches to creating virtually orchestrated performance using sample-based instruments and the thought processes during this process of composition.

It is argued that to successfully transmit its meaning to the audience and manipulate their learned associations and behaviours, music has to be transmitted by means of agreed cultural codes such as minor keys for sad, major keys for happy, fast tempo for action; as well as style, timbre, *leitmotiv* and musical and filmic form (Buhler and Neumeyer, 2014). During the production stage of creating orchestral simulations, the film composer uses sounds and sound patterns to communicate with the audience to stimulate or manipulate their emotional response in different ways. Rowland illustrated this:

> Okay, imagine this. You've got a screen, you've got a young woman, let's say, now that automatically makes her vulnerable probably. But let's say for the moment a young woman, sitting there at a table, bare table in a bare room, okay? Now, there's a knock on the door. You don't see anybody; you hear a knock on the door. Now, depending on what you're going to play, and depending on that woman's reaction … so let's say, automatically, there is no reaction at all from this woman, okay? But all you hear is a woman sitting at a bare, wooden table in a bare room. No furniture, nothing. And there's a door, and there's a knock on the door. She looks across to the door. You can make that person about to come in an axe-murderer. You can make that person supposedly about to come in her children. You can make that person about to come in a clown. These things are pretty diametrically opposed, but you know where I'm going with this? It is the

> composer; it is what you are manipulating the audience to feel. And you can play tricks. You can make this person an axe-murderer, and the woman can be terrified, then she opens the door and it's her children standing there. So you've led the audience up a garden path and then you've basically cancelled the film. You're playing games. I'm not saying you should be doing this, but I'm saying that music can do this. So you have to be careful in how you react, and to what degree you manipulate that feeling. Now, these are unusual circumstances, this is not what music always does. But what music always does is it colours the scene in some way. It either helps what the director is portraying on the screen, or it can easily go against it. You have that power. The principle is the same whether you're working with live orchestra or if you're creating mock-ups. The end goal is exactly the same (Rowland, interview, 2019).

These techniques and their variations are all valid approaches that can be used in a score depending on the film genre, instrumentation, dramatic requirements, wishes of the director/producer and ultimately sensibilities of the composer.

The most important implication of musical communication during this phase is the creation of specific sound(s) or a piece of music to evoke the audience's emotional response. In most cases it is a distinctive and consistent recurring musical idea that is associated with characters, action, story or other essential features in a dramatic piece. In this way, the composer creates and controls the audience's emotional response by making identifications that are clearly recognisable by the audience. In psychology, this process is referred to as 'evaluative conditioning', by which a piece of music can evoke emotion because it has been paired repeatedly with other positive or negative stimuli (e.g. visual stimuli) (Juslin and Västfjäll, 2008). For example, a specific sound or piece of music may have occurred repeatedly at the same time with a particular event or character. In musicology this phenomenon is the well-established, accepted and tested ‘leitmotif’ musical technique of film composers (Kassabian, 2001):

> While I'm watching the movie for the first time I try to figure out is there a character that I'm going to have the theme for. Very common is the *leitmotiv* concept that was developed by Richard Wagner. It is the whole idea of creating a theme for a character that will run in parallel with the characters; the example might be if you have a character in a movie who was a respected politician during the day but he's a serial killer during the night because that's the way he cleans up the city. It might be the same thing but in a very different type of variation; basically, film scoring is pretty much themes and variations. You're going to have a theme for a character for a situation if you have a theme about bank robberies you’re gonna have a theme that is played when a bank robbery is in progress; when things start going bad it would be a variation of the theme, a darker variation of that theme (Mann, interview, 2017).

Further, after providing viewers with an opportunity to associate a particular sound or piece of music with the narrative, the film composer uses the same musical event to arouse the audience’s emotional response and to match or amplify the narrative content even before the character or particular event appears on screen. This is the so-called ‘musical expectancy’ phenomenon where music produces emotions because ‘listeners actively generate expectations (mostly unconsciously) for what is to follow’ (Krumhansl and Agres, 2008). Over time, through repeated pairings, the music eventually comes to evoke a specific emotion even in the absence of the association with visuals. During this phase, the composer generates the prediction with music simply because the same musical event has occurred in the past. A good example of this is John Williams's *The Imperial March* concerto from the Star Wars franchise that made Darth Vader one of the most recognisable villains to ever grace the screen.

The implications of computer music technology during this activity are quite clear. Tom Holkenborg summarised the process, in particular in relation to the theme in *Mad Max: Fury Road* that he wrote for the main female character Furiousa, a heroine with a very deeply troubled past who we get to know throughout the film:

> After many conversations that I had with George Miller, the director, and many attempts to try to write this theme, eventually we settled with the theme that we are both very happy with. Very simple and very emotional and it lent itself very well into arrangements and into action. So I want to take you through that process. I've got piano loaded in my Cubase template, I've started on a piano a very simple and very recognisable melody on a piano, which usually really helps me to focus and to get clarity, So the piano that I'm using is this beautiful 8DI0 1969 Legacy piano. It has all these really wonderful settings that you can change: EQs, release, some effects; it has pedal volume that I really like. After that I started adding more instruments. I've added viola first, after that I doubled the melody line with the violas and the cellos; I experimented a lot. For more emotional writing I added string sections, violins, cellos, basses. I've started working on harmonising the melody and eventually I turned it into an orchestral arrangement, into an electronic arrangement, various different types (Holkenborg, 2015).

This is where music technology has a creative effect on the film-scoring process, with the opportunities it provides to record and experiment with different instrumentations and music styles. Partos further explained:

> It's an experiment, trial and error, playing, recording, then playing and recording again, manipulating the recorded performances until I am satisfied, until the atmosphere I created works well with what's happening on the screen (Partos, interview, 2017).

As with any experiment, composers as performers and listeners at the same time must make careful choices about the features they will utilise, exploit and measure. If the composer wishes to address the characteristics of performed music they need to include the relevant deviations of timing, accent, timbre articulations and so on in their virtual performance. The goal is to find a balance between musical expressions and characteristic features of particular instrumental performances, because what is important is the instrumental musical performance that works best with the picture, the two entities operating as one. Having said that, to deliver an expressive virtual orchestral performance and ultimately to satisfy the wishes of the film director or producer more often than not requires that orchestral simulations have all the musical properties of a real orchestral performance that can be interpreted by the listener. The composer must successfully perform all appropriate actions including timing, bowing, phrasing, articulation and so on, so that the emotional message of the movie can be perceived by the listener. Regardless of genre, every product of a composer's work has the same basic goal: to communicate expressively to the audience. It is up to the composer to create an artistic representation, which requires both a clear overall conception and incorporation of all relevant details into that design in a meaningful way.

The essence of creating expressive musical performance is in nuance—that subtle, sometimes almost imperceptible manipulation of sound parameters, attack, timing, pitch, loudness and timbre that makes music sound alive and human rather than dead and mechanical (Lehmann et al., 2007, p.85). Orchestral simulations are no exception, starting from the music's structure, motifs, character themes and so on, the composer has to use the computer music tools at their disposal to communicate with the listener; sometimes this is achieved only through realistic performances. As with a real acoustic performance, realistic and expressive instrument simulations depend on number of factors: individual timbres, slurs, the transitions between notes, fast runs and detached hard attacks, lightly tongued or bowed note transitions. These note transitions are the connective tissue of musical expression (Sundstrup, 2009). If the composer's job is to create a realistic orchestral performance, then the virtual orchestra must respond with an expressive-sounding performance. Whether composers play live from a MIDI keyboard or enter musical notes directly into a sequencer, every section in the orchestra has to be transformed into a natural-sounding section. The composer must employ technology in creative ways to maximise the expressivity of the virtual orchestra and deliver a product that has all the elements of the real orchestra. In other words, film composers have to use a diverse set of skills and tools to be able to create a product that represents a realistic and expressive instrumental performance using computer technology.

During the production phase of the creative process, musical expression only exists within the context of it being interpreted as an art form by the composer. From this perspective, it makes sense to think of the composer's judgments of expressive performance as valid measures of performance characteristics. A composer's judgment of expressive performance in many ways depends on their ability to act predominantly as a listener, almost detached from the compositional process where as argued by Brown, 'the composing medium, computer or score, is objectified' (Brown, 2003, chapter 7, p.4). From the composer's viewpoint, it is a process in which they are critically listening to the physical details of music such as pitch, loudness, timbre, frequency response, dynamic range and imaging to evaluate how musical instruments in the orchestral arrangement are blended together. This requires the composer's subjective response to musical sound signals; a known process in psychoacoustics where subjective psychological responses are evoked by physical properties of sensory stimuli in the environment, in this case acoustic stimuli (Deutsch, 2013).

From this perspective, it is important to break a composition down sonically, to stand critically apart from the composition to perceive and evaluate its actuality. This is a challenging process as it requires focusing on individual instruments and their subjective properties of musical tones (pitch, timbre, loudness). It demands an extraordinary frequency-analysing power of the composer's ear, which is fundamental to their perceptual functioning (Rasch and Plomp, 1982). Sound pressure levels, time differences of a few milliseconds and frequency differences can have a profound effect on the subjective response of the listener (Deutsch, 2013). Only through the composer's ability to hear, evaluate and analyse complex sounds are they able to discriminate simultaneous tones in music:

I mean the best way to get samples to sound like a real orchestra is to understand orchestration. When you've studied enough or figured it out. That's something you can do by ear if you have really good ears, if you are really good listener, you can do it yourself. If you lack that ability to hear and listen critically you know, then you need somebody to show you how to do it, how to listen and pay attention to small details, nuances, relationship between instruments, loudness, positioning of instruments… (Rona, interview, 2017).

The ability to hear and comprehend the physical aspects of sounds in an orchestral arrangement is important because it allows the composer to work with issues present in all musical performances. It allows them to understand how performances integrate together and how the physical aspects of musical events affect the expressiveness of the performances.

More often than not throughout the process of creating orchestral simulations, specific frequency areas of performances overlap each other and prevent each performance from being heard clearly. This scenario prevents the individual instruments from being clearly audible when presented in a complex arrangement. For example, the frequency content in a viola recording may potentially conflict and cause disturbance with the clarinet recording as a result of both instruments sharing a very similar space in the frequency spectrum (Benade, 1990, Krumhansl, 2001).

Similarly, because of the effect of aggregating many instruments in the orchestral arrangement, the assessment of the sound intensity (loudness) when two or more tones are presented simultaneously is a complicated matter. This situation is common for orchestral ensembles where different instrument sections are playing chords or harmonies, because the total loudness is greater than when the same amount of energy is concentrated within one critical band (Rasch and Plomp, 1982):

> The more instruments you have in your orchestral arrangement the bigger the challenge is to make them all sound as one compact orchestra and not like a group of individual instruments. You really have to listen carefully and apply some creative mixing techniques when you are crafting the music for the film to give the audience the sense that they are listening to a real orchestral performance (Simjanovic, interview, 2016).

This is an important part of the process where as a critical listener, the composer's task is to separate, organise and modify each individual sound into a sound universe so that all instrumental parts come across as clearly and audibly as possible. The ability to hear in greater detail opens up the opportunities for elaboration and refinement. When the composer acts as a critical listener they are relating to the musical events as sound objects where each musical event becomes material for composer's mind. This process provides the composer with insights into the physical parameters of the sound and the importance of these parameters to the orchestral performance. Critical evaluation of physical aspects of musical events is a difficult but rewarding process and as such is the foundation of the interpretation and the composer's judgment of expressive performance.

It is important that during the production stage, the composer's working style is constantly shifting and changing between that of composer, performer and listener, since these shifts result in differences in compositional activities and in the resulting music. As an outcome of this, the multiple roles performed by the composer result in different musical experiences and perspectives during the process of composition. During this stage a composer’s attention is directed towards musical objects or events that are situated in the context of the film, which involves an interplay between the music and narrative as a whole. From this perspective, musical objects and events have purposes for all of the parties involved and no music happens unless it is fulfilling a purpose for someone or is being used for something. The composer’s fundamental compositional goal is to produce sound patterns that express emotion that is jointly recognised and experienced by the audience. This demands the composer’s focus on the audience’s perception and emotional response while watching the film.

At the same time, during this stage of the composing process the composer’s attention is directed towards the expressive characteristics of the musical performance. From this perspective, the composer’s focus is shifted towards technical aspects of the sound and physical details of the music. Both perspectives of musical experiences are valid and provide important insights into different approaches during the film-scoring process of creating orchestral simulations using computer technology as a primary tool for music composition.

Conclusion

Traditional interpretations of the compositional process have been largely developmental, assuming that composition begins with a clear musical idea or inspiration, followed by a process of transcription and elaboration (Hickey, 2003, Wallas, 1926, Webster, 1988, 1992, 2002). What this chapter has demonstrated is that the process of music composition where computer technology is the primary tool begins with good organisation and careful preparation. This early stage of compositional practice is essential because it provides a consistent and familiar creative environment where ideas are conceptualised and, in later stages with the aid of computer technology, logically articulated. This process of composition using computer technology is an activity that can be suppressed or amplified using computer tools and scenarios and as a production process involves a complex mixture of different perspectives and relationships between a composer and the musical materials. Throughout this activity the film composer acts as composer, performer and listener, which enables them to conceptualise, craft and interpret music materials. As a composer they have certain intentions that they wish to communicate to the audience; as a performer, through their musical performance and the sounds it produces, the composer's emotional intention is manifested to the listener. As a listener, the composer's task is to extract the intentions of the composer and the performer to perceive the emotional message of the musical events and to critically evaluate physical aspects of the sounds and their relevance to the resulting virtual orchestral performance.

Viewing compositional practice from these multiple perspectives will, I suggest, improve understanding of the compositional process; in particular the role of professional film composers as well as the role of computer music technologies in contributing to that process. In the next chapter I examine the process of creating expressive virtual orchestral simulations, and the variety of expressive detail film composers modulate to successfully create an orchestral simulation that simulates both the behaviour and character of a real orchestral performance.

Chapter 7: Engineering the Performance

Having examined in previous chapters the compositional tools, approaches to film scoring and thought processes during the process of composition I now examine the process of engineering an expressive orchestral simulation for the purpose of the film score in which the composer utilises computer technology. In doing so I hope to demonstrate the complexity of the compositional process and the diversity of skills and practices required to complete various tasks during the process of composition. This chapter examines the process of creating an orchestral simulation and how, through the composer's deliberate manipulation of recorded samples of live performances, an expressive virtual performance is created that meets the rigorous standards of the film industry. The next section examines in more detail some specific processes and tools that composers are using during the process of composition and how they coordinate their actions to create the optimal co-variation of expressive performance parameters in the virtual orchestral ensemble.

Expressive orchestral simulation

Music performance is usually a collective involvement, with a number of individuals grouped together in ensembles of different sizes and configurations. Regardless of the musical genre, the common goal of all musicians in the ensemble is to communicate information about musical structure and expressive intentions to co-performers and audience members by deliberately introducing variations in performance parameters such as tempo, intensity, articulation and sound quality (Keller, 2014). The challenge for a film composer, however, is that these expressive instruments are no longer only a matter of individual variation, but rather of inter-individual co-variation. What this means is that variations designed to convey information about musical structure and expressive intentions must be matched across multiple instruments when the aim of an ensemble is to sound unified. Such expressive intentions refer to the specific musical character with which a performer or group of performers wishes to inspire a piece (Keller, 2014, p.2).

It has been argued that one of the main functions of musical expressivity is to instigate and represent emotions (Budd, 2002, Davies, 1994). For that reason, many musicologists have focused their research on the communication of emotions by means of performance expression in music (Clarke and Doffman, 2014, Fabian et al., 2014, Gabrielsson, 2002, Gabrielsson and Juslin, 1996, Juslin and Madison, 1999, Sundberg et al., 1995). Such communication of emotions by means of performance expression in music is achieved through sound-producing movements that are required to create or control the sound of the instruments (e.g. bowing movements create the sound on a violin while the other hand fingering controls pitch and intonation) (Goebl et al., 2014). Execution of these movements changes with the performance requirements of the score, such as the particular instrument played (Dogantan-Dack, 2014, Keller, 2014), articulation (Keller, 2014), tempo (Goebl and Palmer, 2009) and dynamics (Dalla Bella and Palmer, 2011).

During the performance, the performer is able to convey different basic emotions within limits set by the inherent character of the piece by manipulating expressive cues such as tempo, articulation and loudness. A slow tempo may, for example, make the music sound sad, and loud music tends to be perceived as angry (Madison, 2000).

Research on expression has also identified the primary parameters of musically expressive performances as changes in pitch, timing, dynamics, articulation and timbre (Clarke and Doffman, 2014, Madison, 2000, Repp, 1998). This includes musical motives, phrases, sections, beat subdivisions and groupings of beats into bars, melodies, and duration- and intensity-based accents (Fabian et al., 2014). Such studies have also indicated that systematic variability—the note-to-note differences in timing, articulation and loudness—may play a role in the expression of emotions and that mastery of this variability is regarded as the signature of a distinguished musician (Madison, 2000). Differences in expressive detail among performers may be achieved through deviations from nominal durations within a single phrase (Repp, 1998). In live orchestras these deviations are realised during the performance, while in the case of orchestral simulations they are realised solely by the film composer and his deliberate manipulation of recorded materials (i.e. samples).

During live orchestral performances the score, whether through explicit instructions or implicitly through interpretation of emotional or structural content, might be seen as the source of a performer's expression (Cook, 2014). However, in the case of orchestral simulations, there is no score that acts as a source; rather, a set of sampled musical instruments and software or hardware tools at the composer's disposal allow him to mimic the variety of expressive details in musicians' performances. If the goal is to create an orchestral simulation that simulates the character and behaviour of a real orchestral performance then this approach has a musically specific goal, which is to create an expressive system by simulating the typical expressive properties of each instrumental performance in the virtual orchestra:

> What you need to do is place yourself in the performers' shoes, you have to be sure that performers are able to physically play your music on their instruments. You have to think about that before you start recording MIDI data, it is an orchestration and composition problem later down the road, if your simulation is eventually going to be performed by real orchestra (Simjanovic, interview, 2017).

This statement highlights a common approach among film composers when crafting a virtual orchestral arrangement and pinpoints frequent problems composers are facing, which is the possibility to produce music cues using VAI that are beyond the ability of human performers alone:

> If you start to write triple f in the trumpets or if you go out of range, first of all you are going to hear, the samples are going to screech. They are going to sound terrible and then yeah you might run into the problem. And actually, I've seen people do this. People who write super loud music on samples and they think that a brass section can play like this for 6 hours, and you know 2 hours into it and everybody is blow up their lips, they can't really play anymore (Rona, interview, 2018).

As in live orchestras, every instrument in the virtual orchestra has its limitations and the composer must work within these parameters from the outset, and the particularities of each instrument must be accounted for in the performance. Therefore, it is important for a film composer to understand and be aware of such limitations, as these might influence the composition of the cue or the arrangement. Creating an expressive orchestral performance using virtual sample-based instruments requires that a composer understands not just the complexity of each instrument, but also how a performer and the ensemble of musical performers behave in a live context. In the following sections I examine in more detail some specific processes and tools composers are using during the process of composition and which parameters of musically expressive performances the film composer manipulates during the process of creating orchestral simulations for the purpose of the film score.

Intonation

Playing in tune with co-performers in the orchestra is a fundamental requirement. To do so, in live performances, ensemble performers adopt the same system of musical temperament by adjusting the ratios of acoustic frequencies defining the pitch intervals that they produce (Keller, 2014). In different musical traditions, the tuning of an exact pitch can alter according to the harmonic context in which it occurs (Ternström, 2003). To make things more difficult, it is not unusual to use purposeful deviations in tuning for expressive purposes (Parncutt and McPherson, 2002). This is important if composers are using musical instruments from different 'genre-specific' sampled libraries. Film composers need to be careful about how different instruments are tuned in the virtual orchestra and if necessary, make appropriate compensatory adjustments such as slightly altering the pitch of the sampled instruments or even re-recording an acoustic instrument to match its tune with the rest of the instruments in the virtual orchestra.

This is particularly important when using percussive sounds for specific genres. It is not unusual for the pitch of sampled snare drums or toms to be at odds with that of the strings or other instruments in the virtual orchestra. Therefore, the specific intonation of percussive instruments does have the ability to 'make or break' the recording. Adjusting the pitch of the instruments during post-editing is not always a viable solution as this alters the frequencies in the original recording, which can make the recordings of percussive instruments sound unnatural. Further, the decay profiles of sampled percussive instruments in sample libraries are also tuned to give the intended sound in context of a song. A slow tempo arrangement for example might utilise percussions with a longer decay time to 'fill the space' between the musical notes. That being said, longer decay times might overcrowd the music in a faster-paced arrangement and the pitch of the decayed percussive sound might interfere with the sound of the rest of the orchestra. Therefore, if recordings of percussive instruments are tuned to the wrong pitch, most of the time the only option is to pitch shift (i.e. transpose the sample) or replace the sound with an appropriate sample. However, if this is not the case then the only practical solution is to record a sound that fits the overall picture.

Recording percussive and other instruments in the orchestra for particular tasks is not an unusual practice among film composers in general. For example, Hans Zimmer is well known for having created his own private collection of sampled orchestral instruments, which includes recordings of 344 players at the London AIR Studios (Hans Zimmer, Masterclass, 2017). Recording and tuning of percussive and other instruments in the orchestra for particular genres or to the specific key of the song being played was also practised by the composers interviewed for this study:

> I have created this really interesting instrument that I've recorded and played myself. I was positioning myself in four parts of the room with the drum kits playing all these toms at the same time but I would do it in four takes; one take in

> each corner of the room doing the same thing over and over again. I also sampled the complete marching band kits. As a matter of fact, I have a few of them and especially the high drums, they are really interesting (Holkenborg, 2015).

In this way Holkenborg was able to create a personal library, which provided him with perfectly tailored instruments for his compositions and allowed him to use different articulations and instruments that matched his orchestra in both tune and character. Such a library simply gave him more options than existing commercial libraries.

One of the most common problems with virtual MIDI orchestras is the fact that they are always perfectly in tune, especially if composers are creating instrument sections from individual instruments (e.g. using 16 first violins, 14 second violins, 12 violas, 10 cellos and 8 double basses to create a 60-piece string section). While a real acoustic string section is likely to be slightly musically out of tune, creating a rich sound, virtual instrument sections have a tendency to be perfectly and constantly in tune with the rest of the orchestra with which they are playing (Pejrolo and DeRosa, 2016). This is why film composers dealing with large orchestras sometimes try to make the sound of their virtual ensembles a bit 'worse' by using samples of instruments from different libraries or by slightly detuning different sections of the ensemble using a 'fine tune' adjustment parameter that varies the tuning in cents of a semitone. In this way, detuning is achieved across sections of the ensemble by using a very small percentage of the fine tune parameter (equal or close to 0) between different sections of the ensemble. Detuning can also be used across the piece when applied among different passages of the piece instead of among different sections. A rationale for applying detuning is to recreate some of the slight imperfections that human players would naturally display, to give 'life' to a performance:

> If you have for example 16 violas in a string section, if you listen carefully you can hear that each viola sounds slightly different, each instrumental performance has slight imperfections and that's what almost in every case makes that performance sound rich, and when the audience listens to that music their ear is subconsciously drawn to the delicate nuances of those live performing instruments, So when you apply a small amount of detune to your samples or when you are playing around with dynamics, articulations and other stuff, what you are trying to do is to mimic the behaviour of a real orchestra (Simjanovic, interview, 2018).

Articulation

Articulation is one of the most important cues in music performance, as it contributes to the character of the performance and allows control of the way in which two consecutively played notes are acoustically connected (Bresin, 2001a). The degree of overlap/separation of successive sounds makes an obvious contribution to the expressiveness of the orchestral ensemble. Performing musicians may vary articulation to alter the expressive character of their performance. Short, separated 'staccato' sounds may imbue a passage with a light-hearted or agitated quality, while sustained, overlapping 'legato' sounds may suggest a longing or solemn quality (Gabrielsson and Lindström, 2001). During the orchestral performance, different musical genres and orchestral arrangements have different expressive goals, which may require articulation to be matched or mismatched across instrumental parts. Matching articulation requires the perceptual onsets and offsets of sounds produced by performers in the orchestra to be aligned (Keller, 2014). Such alignment is important because sounds generated by different instruments have different amplitude envelopes. Therefore, differences in ADSR portions of sounds need to be taken into account to achieve consistency in perceived articulation among performing musicians.

In response to this, different articulation gestures (e.g. legato, staccato, pizzicato) are sampled and stored in the software or hardware database, while others (e.g. vibrato, portamento, crescendo) are generated by adding them to the melody contour. These variations provide the naturalness and flexibility of synthesis, making it convenient for the composer to use stored articulations or create new ones for a specific context. To apply the desired articulation, film composers mainly use two techniques: key switch (KS)-based tracks and multiple MIDI tracks for articulations. A KS is a MIDI note that triggers a different playing technique for any given instrument inside the orchestral library.

Professional sample libraries (e.g. VSL, East–West, LA Scoring Strings, Garitan) make use of KS to activate particular techniques or articulations without the need to load separate samples. A KS is a key on the MIDI keyboard that corresponds to a particular MIDI pitch that switches between samples (see Figure 7.1).

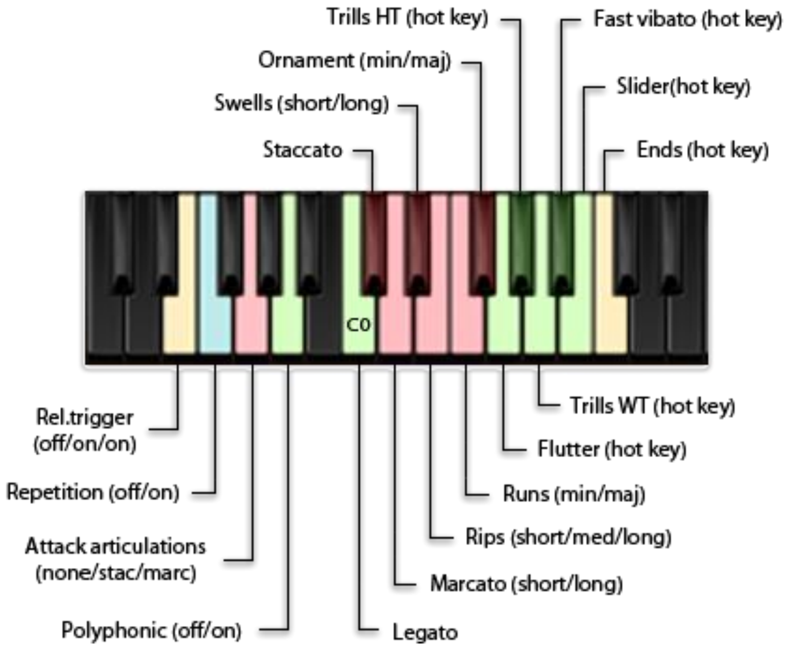

Figure 7.1: Key switches

Unlike KS techniques where one MIDI track contains multiple articulations that are controlled via a KS, the multiple MIDI track articulation technique simply means there is a separate MIDI track for each articulation. For composers who prefer to input their articulations using a MIDI keyboard, KSs can sometimes be challenging to navigate in real time while composers are recording their performances. Because of that, before recording, composers often input KSs to the MIDI tracks for a patch to change automatically while they overdub the notes on top of it. The downside of this method is that KS MIDI notes will show up on the MIDI track together with MIDI musical notes in the piano roll, which can be visually confusing during editing (see Figure 7.2).

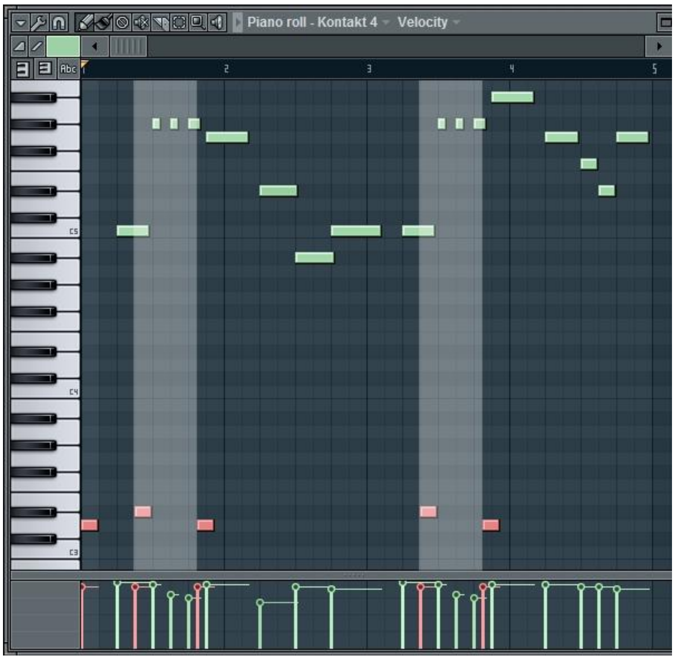

Figure 7.2: Red = KS MIDI notes; Green = musical MIDI notes

This method can also be problematic if the composer wishes to print their music directly from the sequencer, as KS MIDI notes will be presented as musical notes on the sheet music. To avoid this potential issue, another way of applying a KS by composers is to add another MIDI channel under the first one, assign that channel to the same MIDI output so it affects the same patch in the composer's sample library, and then record the KS onto that MIDI channel. This method keeps KS notes visually separate from musical notes. However, some of the interviewed composers still preferred to keep everything in one place:

> Key switches are included in the same MIDI track, and I assign them to anything that's outside the register of the instrument. I like the samples that I can apply the key switches to, because I like to have one sample for the instrument or generally one thing for one instrument and then I can use key switches to change articulations, if I am writing for real orchestra, then when I export the media to

> create the scores, it's all on one track, it's much easier for the orchestrator if I give him the key switch information (Yeo, interview 2018).

Others preferred a mixed method:

> I'll set up different MIDI channels for those different key switches, because if I'm getting it arranged or something… whatever makes things easier for the arranger to look at (Partos, interview 2017).

Using KS=based tracks and multiple MIDI tracks for articulations is a convenient way to add expression to an instrumental performance because it allows composers to record and play articulations in real time or during the playback, as articulation in both methods can be automated like any other MIDI CC data. Depending on the orchestral libraries and the composer's workflow, they might choose one way over the another; nonetheless, both techniques are valid as they provide the same end result.

However, if the desired articulation is not achieved through the use of KSs, or if the particular orchestral library does not contain the samples of the instruments recorded with the required types of articulation, the only option to achieve the desired outcome is to record a live performance. Since the orchestral sample libraries used by today's composers contain thousands of samples and articulation variations, it is highly unlikely that a composer would struggle to find the desired articulation and not be able to fully utilise the potential of orchestral libraries. Still, in some cases, especially when solo performance is required, composers might choose to record a live performance to achieve the desired result:

> Solos are different than ensemble performances; there is something that is dynamic about a real instrument that does weird things and different things to the senses than samples do (Rowland, interview 2018).

The main reason for solo performances being difficult to emulate using orchestral sample libraries is that in human performances of acoustic instruments, there is a large amount of subtle, sometimes almost imperceptible, manipulation of sound parameters, attack, timing, pitch, loudness and timbre (Lehmann et al., 2007, p.85). This complexity that is present in all human performances of acoustic instruments in most aspects of the production of notes and phrases is most difficult to emulate or reproduce when using virtual instruments. Beyond micro-detail, a range of different articulations is associated with phrasing patterns. In string instruments this might include bow direction, bow position and various articulations such as legato, vibrato, glissando and so on. To capture those nuances and add expressive articulation and expressive intonation to their music, professional film composers often choose to record a live performance when solo performances are required.

Dynamics

Dynamics—the shaping of a musical statement through differentiation in loudness—is another important 'expression tool' for the professional film composer during the process of creating orchestral simulations. Musical 'dynamics' in ensembles is transmitted through variations and contrasts in perceived loudness. On acoustic instruments this is proportional to sound intensity and the force used in generating the sound (Keller, 2014). Similarly, in solo performances where a solo instrument line is exposed in the musical texture with other musical material present, a key source of expression is the individual's dynamic relationship with the group, manifested as a tension between the perceptual foreground and background—that is, between the soloist's melodic line and the ensemble's harmonic accompaniment (Bauer, 2014). Such variations and contrasts in perceived loudness between performing musicians influence ensemble cohesion by affecting the balance between instrumental parts in terms of their relative loudness (Keller, 2014). In addition to varying the notes and rhythms of their lines, dynamics thus suggest themselves as a primary means by which performing musicians can provide variety and creativity in their performances (Ashley, 2014).

In an attempt to portray how performers in the orchestral ensemble vary the intensity of their sounds to achieve optimal blend, when using orchestral sample libraries, professional film composers must consider several factors. The first issue refers to the degree to which each performer in the ensemble can hear their own sounds among their co-performers' sounds, the so-called 'self-to-other ratio' (Ternström, 2003). The need to optimise this ratio is balanced against the need for parts to blend. In addition, individual performers have preferred intensity profiles that are reflected in the way in which they instinctively shape the dynamics of a piece (Repp, 2000). When individuals are performing together in an ensemble, they must adjust potential differences related to idiosyncrasies in their preferred intensity profiles (Keller, 2014), which requires interdependency among parts in the ensemble in fluctuations in dynamics (Lee and Schögler, 2009, Papiotis et al., 2012).

Although fluctuations in dynamics have to be correlated across performances in the ensemble, depending on the complexity of the film composer's orchestral arrangement and ultimately on what is happening on the screen, fluctuations in dynamics can vary throughout an orchestral performance:

> A lot can be achieved with samples just by manipulating the loudness. I look at the picture and try to adjust the music to reflect that. Slow movements have different emotions than fast movements; also the number of instruments that I am using in the arrangement matters. Solo parts require different treatments than parts where two or more instruments are playing at the same time, especially if in one scene I am playing only one instrument and then the full orchestra in the next one (Simjanovic, interview, 2017).

Transitions form passages where solo performance is required in passages where two or more instruments are playing, and vice versa, demands that the film composer adjusts the variations in perceived loudness and performs some instruments louder and others softer when paired with other instruments as opposed to when performing the instruments alone. This technique requires that the expressive features of intensity profiles produced when playing solo are dampened or exaggerated in response to contingencies emerging through interaction with co-performers (Keller, 2014).

During observations for this study of the film composer's creative practice, it was particularly noticeable that through variations in dynamics, the composers were able to produce satisfactory results in terms of creating musical expressiveness and emotional effect with a virtual orchestra. Using this technique, slower movements were often emotionalised through the use of softer passages, usually performed with fewer instruments, while an emphasis on melodic climaxes was achieved by the increasing dynamics and then gradually decreasing the intensity and playing the instruments very softly. This included everything from quite loud, dramatic crescendos and diminuendos to subtle variations in velocity, expression and volumes in a single passage.

Velocity, volume and expression

When the composer performs and records a performance using a MIDI controller, depending on how hard or soft they hit the key, the DAW being used assigns a value between 0 and 127 to each note being played. This MIDI parameter is called velocity, and it is meant to mimic the natural strength variations in human playing (Dannenberg, 2006). A velocity value between 0 and 127 represents a measure of how rapidly and forcefully a key on a keyboard is pressed when the player initially presses the key. This measurement is intended to simulate the behaviour of a piano mechanism: if the key is struck more forcefully on a piano, a note will sound louder (Dannenberg, 2006).

The velocity parameter is part of the MIDI Note-On event,[9] so it can take place only once per note. Sampler players such as Native Instruments KONTAKT, VIPLAY and East– West PLAY use velocity to select which sample to play. For most instruments, sample libraries contain samples recorded with multiple loudnesses (i.e. volumes) for each note; based on how hard a key on a MIDI keyboard is pressed (i.e. the velocity number), a sample player decides which sample to playback. Each sampled note is divided into layers on that scale, and whatever layer is chosen for playback is

[9] The MIDI note-on message is sent when a MIDI note is released (ended). The note-on message is a MIDI channel message and as a result of that is restricted to one of 16 pre-defined MIDI channels.

determined by the velocity by default. These layers consist of different dynamic levels for the same note. Since musical instruments tend to have different timbres at different volumes, the velocity affects not only the loudness of the instrument played but the timbre, at the same time. As a modulation source, velocity is determined when the note begins and keeps the same value as long as the note is held. However, expression (CC11) is a CC that can affect a note while it is playing (Pejrolo and DeRosa, 2016).

Velocity and expression MIDI parameters work differently from volume. When played louder, the instrument gets louder in volume and the inherent sound, or 'timbre' of the instrument, also changes. In live situations when a performer plays a note on the instrument with a certain articulation and particular volume it sounds a certain way and can vary greatly in the way it sounds when played loud and soft (Bauer, 2014, Dibben, 2014, Dogantan-Dack, 2014, Schubert and Fabian, 2014). The patches in professional sample libraries are velocity sensitive and thus when the composer plays notes at different velocities, they do not play the same patch at a corresponding volume. Instead, depending on the velocity number (how high or low is the velocity) when the composer hits a key, a completely different patch is triggered, which makes the performed phrase much more realistic than if just manipulating the volume of the recorded MIDI notes. The important thing to understand here is that expressive playing during live performances affects not only the volume of the instruments played but also their timbre; thus, a note played at low velocity would sound unnatural if the composer simply raised the volume instead of changing the velocity of the MIDI notes. This is because although the MIDI volume only changes the intensity of sounds over time, dynamic playing is more complex, since harmonic content is continuously changing as well:

> It's much more useful to use velocity rather than volume, that way you can play a patch the way you want. For example, If I need a player to play fortissimo (ff), in that case it is no practical to use lower velocities that will trigger pianissimo (pp) patches and then just try to bring the volume up because it would just produce unnatural sound. What you want to do Instead is to play notes at higher velocities, which will trigger samples recorded at a higher dynamic and then use expression (CC11) or the mod wheel (CC01) to get a more natural sound (Simjanovic, interview, 2016).

Selecting the dynamic layer by key velocity is a useful technique with instruments where the note immediately decays away it has been played (e.g. piano), but is less so for music that sustains after hitting a key on a MIDI keyboard (e.g. strings, woodwind pads). This is an issue for the composer as they need to be able to control the dynamic and intensity of their strings or woodwinds while holding down the notes on a MIDI keyboard. With those types of instruments, during live performances, a string and woodwind player controls the dynamic changes by bow and air-moving pressure respectively. Such changes in intensity do not occur at the attack moment, but in the sustain portion of the sound.

Once the note is struck on the MIDI keyboard, the tone (timbre) of the sample played cannot change even if the volume does; however, the tone of real instruments does change as the volume changes. A softly played French horn note, for example, besides having a difference in volume has a very different timbre from a loudly played note. For short notes, this is not an issue. The problem presents itself when the composer wishes to hold a note with a crescendo (volume increase) or decrescendo (volume decrease). For instruments that sustain, it would sound unrealistic to hold the exact same dynamic throughout the entire duration of a note, even if the performer is intentionally trying to do this; there would invariably be some slight variations in intensity, especially if the note is held over a longer period of time. Thus, to simulate the natural behaviour of strings, brass and woodwind instruments and to control the finer shapes of their dynamics during the entire duration of the notes played, while playing samples using a MIDI keyboard film composers often use velocity in conjunction with CC expression (CC11) and the mod wheel (CC01) to create the most realistic musical lines.

To control dynamics and facilitate change from one sample to another (and therefore a change in timbre) while the note is played, some professional sample libraries use dynamic cross-fade (DXF) (e.g. East–West) or velocity cross-fade (VXF) patches (e.g. Vienna Instruments). Such virtual instruments usually use the mod wheel (CC01) to apply DXF/VXF functions. This utility is implemented by combining two or more samples inside a single patch, so that when the composer plays a DXF/VXF instrument, they actually start two or more samples playing at once. A mod wheel is then used to specify how loudly to playback each sample. Depending on the algorithm, with the mod wheel in a position all the way down the composer may hear, for example, 0% of sample A and 100% of sample B; as they push the mod wheel up, they can hear more and more of sample A and less and less of sample B. The advantage of this method is that it provides better dynamic control since the composer can change both loudness and timbre at the same time continuously while the note is being played. This technique can be used during a live MIDI keyboard performance or during mouse-based note entry as mod wheel CC MIDI data can be are recorded and automated inside a DAW.

Percussion instruments are another section of instruments that can significantly benefit from adjustments in dynamics. MIDI percussion instruments can easily fall victim to the ‘machine gun effect’, where repeated notes of the same sample begin to feel mechanic and abrasive rather than musical; adjusting the velocity can help reduce this effect (Pejrolo and DeRosa, 2016, Sundstrup, 2009). Many computer-generated simulations use the same sample patch for each repeated note that has the same pitch and dynamic. The result sounds artificial as the same sampled note is performed in sequence, which does not produce the intricate deviations in tone, dynamics and articulation that each repeated note would display when performed by a live instrumentalist or instrument section. Some software sample players (such as Native Instruments KONTAKT) try to mitigate this problem by randomising different samples of the same pitch for each articulated note, but the limited variation in articulation is still often noticeable. To overcome this problem, professional film composers often shift the velocity up or down by a random amount within a limit and also randomly move the position and length of MIDI notes:

> Instead of just working with the velocity I am moving the notes randomly around up and down to get all these types of articulations that sound slightly different, you get a more natural drum rhythm (Holkenborg, 2015).

Another type of instrument articulation that can suffer from the machine gun effect is trills. It is fairly common that mid-size libraries do not include such articulations and even when trills are included they may not cover all the intervals a composer might need. The problem with programming trills for a virtual MIDI string section is that just triggering very rapidly and alternating between two notes at a given interval will not yield very realistic results and will again produce a machine gun effect, a repetition of two notes that does not sound like an acoustic trill. The main reason for this unwanted result is the fact that every time the composer triggers a note, a sound generator inside a sample player activates the full envelope generator for the amplifier, including the attack section, generating an unrealistic trill effect (Pejrolo and DeRosa, 2016).

When an acoustic instrument plays a trill the bow moves across the fingerboard without 'retriggering' each note of the trill; instead the fingers on the fingerboard are used to alternate between the two pitches of the trill (Goebl et al., 2014). A virtual translation of such an effect may be achieved by bypassing the attack section of the envelope for each repetition after the first triggered note, leaving a smooth transition between the two notes that form the trill (Pejrolo and DeRosa, 2016). This can be achieved using a string patch that has moderate to fast attack, moderate to short release and a long sustain, and programing the pitch bend on the MIDI keyboard so when used it would alternate the pitch and intervals of the notes (e.g. thirty-second or sixty-fourth notes). This technique is somewhat effective for trills that span from minor second to minor third. For bigger intervals, depending on the patch and sound engine, the quality and realism of the final result will vary because of the speed at which the pitch bend parameter reacts (Pejrolo and DeRosa, 2016). Today, use of this technique is quite rare among composers as it takes a lot of time to obtain the desired results. Instead, composers prefer to use specific sample libraries that cover all the trill intervals they might need for their composition, as the results are much more effective and realistic.

In this section, the focus has been on the dimensions of sound that live musicians modulate for structural and expressive purposes and how, through manipulation of expressive performance parameters, composers recreate the sound of a real orchestra. This section has shown that the dimensions of sound that live musicians manipulate for structural and expressive purposes include basic properties such as pitch, timing, articulation, dynamics and timbre. These basic properties are what film composers pay the most attention to during the process of creating expressive orchestral simulations for the purpose of the film score. Apart from manipulating the individual instruments, the main focus of the film composer during this procedure is the relationship between instrumental parts with respect to pitch, timing, dynamics, articulation and timbre. Interpersonal alignment between musicians and changes in these fundamental and expressive performance parameters is necessary to support ensemble cohesion, as they are all contributing to musical expression. So far, the focus throughout this chapter has been mostly on the single elements and sound-producing movements (i.e. effective gestures; Delalande, 1988)) required to control the sound of the instruments. In the next section, the focus is on the orchestral ensemble as a whole, a multi-instrument entity that acts as one but is brought into existence by various distinctive sonorities, all covering a wide range of the audio spectrum.

Mixing and audio processing a virtual orchestra

Mixing and audio processing, also called 'signal processing' refers to a process of modifying an audio signal by inserting a signal processor—a device designed to modify audio signal in particular ways—into the audio chain and manipulating its adjustable parameters (Hodgson, 2010, p.283). This practice plays an important part in the process of creating expressive orchestral simulations as it allows the film composer to assume the role of a sound (i.e. audio mixing) engineer whose task is to place each instrument and instrument section of the virtual orchestra effectively in the stereo field environment and let each instrumental part come across as clearly and audibly as possible. In other words, throughout this activity, the role of a film composer is to combine the different sonic elements of their recorded musical into a final version of a virtual orchestral performance.

These important goals involve paying particular attention to four aspects of the mixing process: volume balancing, equalisation, dynamic range compression (DRC) or simply compression and spatial processing, which includes reverberation, delay and panning in no particular order. It is important to examine and analyse each step separately to understand this process and ultimately gain a more in-depth knowledge of the composer's skillset and common techniques required for producing a virtually orchestrated performance using sampled orchestral instruments.

Equalisation

Equalisation is an audio processing technique that adjusts the amplitude at various frequency ranges to increase the perceived 'depth' of a mix, or to prevent one element in the mix from masking another (Dibben, 2014). Using EQs to adjust the amplitude of the signal in certain frequency ranges, the equalisation technique was originally employed by recording engineers to 'compensate for the distorted frequency response of early microphones' (Hodgson, 2010, p.286). The term 'equaliser' goes back to early telephone engineering, when the loss of high frequencies over long distances had to be corrected so that the spectrum of the sound at the receiver end matched the sound spectrum initially transmitted (Välimäki and Reiss, 2016).

In the context of creating orchestral simulations for the purpose of the film score, film composers use EQs to manipulate the frequency content of various instruments and instrument sections in the virtual orchestral ensemble. The use of EQs allows composers to amplify or reduce the sound in specified frequency bands to create balance and clarity among instruments and also, if needed, to adjust the quality and character of the sound:

> Every sample I use, I process. If I'm using an oboe for melody, I might make it a little brighter. If I'm using it for harmony, I may make it a little darker, until I find the perfect balance (Rona, interview, 2019).

There are different types of EQ for various applications, including parametric, semi-parametric, shelving, fixed, sweepable, peeking, paragraphic and graphic (Välimäki and Reiss, 2016); however, the most EQs commonly used by film composers in this study were parametric EQs controlled using potentiometers (Figure 7.3) and graphic EQs that allow multiple frequency bands (such as 7, 15 or 31 bands) to be adjusted using sliders (Figure 7.4).

Figure 7.3: Universal Audio - Parametric EQ

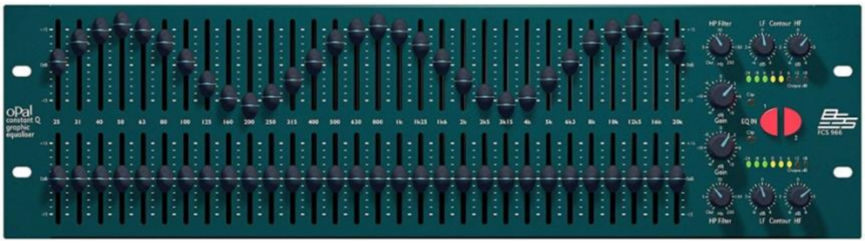

Figure 7.4: Universal Audio - Graphic EQ

For professional film composers, using EQs is an important aspect of the mixing and audio processing stage. It requires understanding of a number of factors such as audio frequencies of each individual instrument in the orchestra (Figure 7.5); how equalising devices operate; how to effectively utilise their functions to manipulate audio frequencies; and how the audio frequencies of each individual instrument fit within the overall frequency spectrum of the virtual orchestral ensemble.

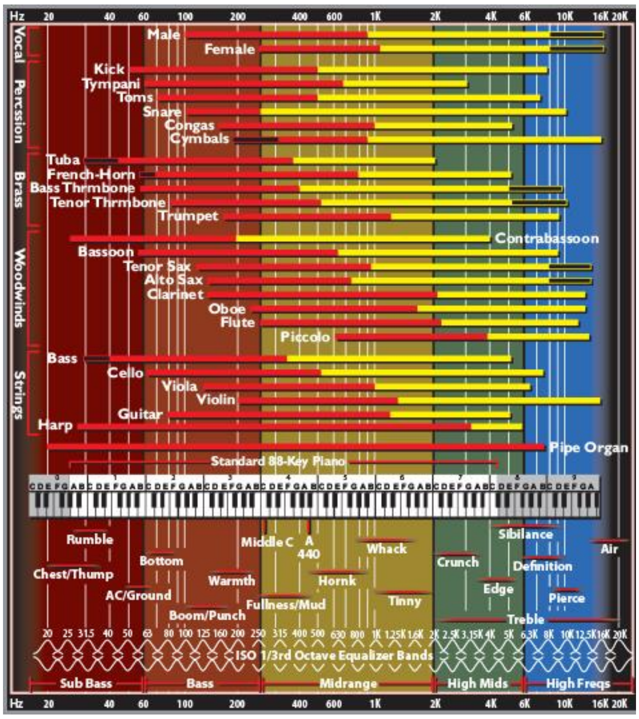

Figure 7.5: The fundamental frequencies of orchestral instruments

The equalisation settings in a virtual orchestral environment can vary depending on the particular sample and the sample library used. However, regardless of which sample or sample library is used, the overall goal is to achieve clarity and depth at the same time in the audio recording. Based on the frequency range covered by individual instruments and by each instrument section in the orchestra, during this phase the film composer's goal is to focus their attention on specific frequencies that are important for each instrument or instrument section, to create a balance and reduce the amount of 'masking' created by other overlapping frequencies from neighbouring instruments:

> For each sound I would have spent a bit of time equalising and making sure the palette works as the whole together. I'm much more analytical and I'm much more particular about how the things are EQed. I am trying to get that balance

> right, it's EQing those sounds so all the sounds have their own space, have a space in a sonic frequency sense (Partos, interview, 2019).

This is because many frequencies overlap and thus have the tendency to create problems. Each instrument in the orchestra features a certain frequency range that is distinctive for that particular instrument. Through equalisation, composers seek to prioritise frequencies that are distinctive for each instrument in the ensemble and, by using EQs, to address frequencies that do not belong to that range and that may overlap with the ranges covered by other instruments. In other words, since each musical instrument in the orchestral ensemble occupies a specific frequency range (see Figure 7.5), in a full orchestral arrangement equalisation is used to cut frequencies that can be occupied by other instruments and accentuate those that are unique to instruments a composer is equalising. It is important to note that each musical instrument extends its frequency range through the generation of harmonics that go higher than their fundamental frequencies (Pejrolo and DeRosa, 2016). Most of the time the harmonics have a lower intensity and thus require fewer interventions with equalisation compared with the fundamentals.

In general, when it comes to equalising there are no specific rules; how it is done depends on the arrangement, musical content and number of instruments in the orchestra. In saying that, there are few useful equalising techniques that were common among the interviewed composers. Partos liked to look the monitor to 'see where the frequencies are peaking and attenuating those frequencies' (Partos, interview, 2017). A similar equalising technique can be used when composers wish to make certain instruments stand out in a mix of instruments:

> If I want one instrument to stand out, I find the most characteristic area of that instrument and then use EQ to cut some frequencies in that area for everyone else (Simjanovic, personal interview, 2016).

Together with spatial processing (i.e. panning and reverberation), professional film composers often use equalisation to increase the general impression of 'depth' in a mix. The human brain tends to interpret 'duller'—specifically low-frequency—sounds as less proximate than sounds containing mostly mid-range and high-end frequency content (Hodgson, 2010, Izhaki, 2017). Because of this phenomenon, equalisation is a useful technique when a composer wishes to enhance the front-to-back impression of various instruments in the virtual orchestral ensemble. By applying equalisation cuts and boosts at select frequencies across their mixes, film composers can accentuate the high-end frequency content of some instruments, and the bass and mid-range components of other instruments, to increase the general impression of depth that a mix creates.

Dynamic range compression

While equalisation changes the amplitude of an audio signal at select frequencies, DRC is a an audio signal-processing operation that reacts to and changes the amplitude of audio signals across the frequency spectrum (Hodgson, 2010). In other words, DRC is an effect used to narrow the dynamic range of an audio signal by bringing the loud and quiet parts closer together in volume, making the natural volume variations less obvious. Dynamic range refers to the difference in volume between loud and soft passages of the audio signal. For this purpose, professional film composers use an 'audio compressor', a dedicated electronic hardware device or audio software dynamic processor used to reduce or compress an audio signal's dynamic range by reducing the volume of loud sounds or amplifying the volume of quiet sounds (Kirchberger and Russo, 2016). Depending on the design, audio compressors can have different sets of user-adjustable control parameters and features that allow composers to adjust DRC signal-processing algorithms and components.

The major parameters for a compressor are the threshold (the volume at which the compressor operates), ratio (the rate of compression), attack, release and output or make-up gain (volume increase) (see Figure 7.6).

Figure 7.6. Universal Audio - Audio compressor

The threshold parameter is usually expressed in decibels (dB) and is used to set the level at which the compressor comes into effect and starts changing the dynamics of the audio signal. When the amplitude of the input signal registers above that threshold (e.g. if the threshold is set at –10 dB, everything below this level will not be affected by the compressor, but everything louder than –10 dB will be compressed), the dynamics processor will attenuate the input signal, by a select amount called the ‘ratio’ or ‘range’ depending on the device used and how it is set. The way that the ratio/range operates is that if the ratio is set to 1:1, there will be no compression at all; if the ratio is set at 4:1, then for every 4 dB of sound that goes over the threshold, there will be 1 dB of output above the threshold. Therefore, if the signal exceeds the threshold by 20 dB, the compressor reduces this signal by 4:1, which produces an output 5 dB above the threshold. By setting ‘attack’ and ‘release’ times, individually, composers are able to specify how fast and for how long they desire the compressor to work after it has been triggered. Attack controls the time measured in milliseconds that the compressor takes to act on the input audio signal, once the sound level has exceeded the threshold level. Release controls the time in milliseconds that the compressor takes to allow the audio signal to return to normal once it has dropped below the threshold. Since the overall volume level of the signal will be reduced after the audio signal has been compressed, output or make-up gain control is used to increase the output gain coming out of the compressor, to match the volume of the compressed signal to the volume levels of the rest of the audio material in the mix.

During this study, the interviewed composers were typically applying DRC at several stages and for a number of reasons during the mixing and audio processing phase. DRC was used to shape the amplitude of instrument sounds across the frequency spectrum to create a more consistent dynamic range (e.g. to give instrumental sounds with a short decay a longer sustain or to reduce sibilance of sampled and recorded vocal performances). For example, DRC was used as an artistic effect to emphasise or de-emphasise particular aspects of a recording, such as the attack portion of the sound of the instrument; to emphasise different levels between quiet and loud parts of instrumental performances; or to make the overall sound of the orchestra more coherent, to minimise excessive loudness changes within a song. The reduction in dynamic range that results from DRC was also helpful when the composers wanted to increase the audibility of low-level components of the music when the music was played quietly in the background in a movie scene. Further, DRC was employed for pragmatic purposes to adapt the dynamic range of music to the technical limitations of recording or playback devices. However, DRC can and had been used most of the time by the composers to tame the dynamics of instruments; increase the loudness of individual instruments or groups of instruments in the orchestra; and increase the overall energy of the entire song (stereo mix):

> As I pull every instrument into my composition I will do the processing necessary; if a drum loop has too much dynamics I'll compress it. I like to process sounds; that's my favourite thing. So you know, you want the French horns to be punchy. Is it okay to use a compressor? Of course it's okay to use a compressor (Rona, interview, 2019).

Another useful implementation of audio compressors by the film composers was the use of a parallel compression technique to add more punch and depth to drum and percussion sounds. This type of compression was achieved by mixing unprocessed 'dry' or lightly compressed drum and percussive sounds with a heavily compressed version of the same sounds:

> I often use parallel compression on stereo percussion buses to reduce the dynamic range by bringing up the softest sounds rather than bringing down the highest peaks; this way I can maintain the transients via the dry signal (Simjanovic, interview, 2017).

Transient material can indeed be emphasised or de-emphasised using compression depending on how the composer wishes to treat the audio signal. In audio, a transient is a short-duration signal that represents a non-harmonic attack phase of a sound source (i.e. an impulse or spike of energy that occurs as a waveform that builds quickly from silence to a peak). In practice, transients are often associated with the attack of 'snappy' instruments such as percussions, although every instrument exhibits transient attack energy to some degree. Therefore, each time composers use compressors they are going to affect the transients in some way, as the transient peaks are what compressors see first.

Spatial processing

Spatial processing refers to the use of three-dimensional effects such as reverb, delay and panning to manipulate the apparent size, position and characteristics of the virtual acoustic environment and sound sources within it (Dibben, 2014). Alongside compression and EQ, spatial processing is an essential element in creating a good mix as it brings an orchestral simulation to life by creating realism, depth and space.

Reverberation

In psychoacoustics and acoustics, reverberation refers to the continued or prolonged existence of sound after a sound has been produced (Kinsler et al., 1999). Reverberation is created when a sound is reflected, causing a large number of reflections to build up and then decay as the sound is absorbed by the air and surfaces of objects in the environment (Toole, 2017). This phenomenon is most perceptible when the sound source terminates but the reflections continue decreasing in amplitude until they are no longer audible. Reverberation does not occur only inside indoor spaces, but also in outdoor environments where reflection naturally exists. The only environment where reverberation does not naturally occur is inside an anechoic chamber.[10] Apart from that, reverberation occurs when a person talks, sings or plays an acoustic musical instrument in a performance space with sound-reflective surfaces.

Reverberation is a natural phenomenon that can be simulated using a digital hardware or software effect reverberator called 'reverb', which uses various signal-processing algorithms to simulate the reverberation effect in a variety of spaces. Since reverberation is caused by a large number of echoes, to create a large, decaying series of echoes and simulate the time and frequency domain response of a specific room, reverberation algorithms use various algorithms that precisely simulate conditions such as room dimensions, absorption and other properties. Depending on the model and reverberation algorithms, digital reverb effects can have a different set of controls and features that allow users to adjust various reverberation parameters. It is important to review some of the most common features found on hardware and software digital reverb units since professional film composers need to understand and be aware of such features, which are used to control the behaviour of different reverbs algorithms.

Some of the most common features of hardware and software digital reverb units are as follows.

Early reflections. According to standard definitions, early reflections are the first sounds that arrive at the listener's ear after being reflected from one of the

[10] An anechoic chamber (anechoic meaning 'non-reflective, non-echoing, echo-free') is a room designed to completely absorb reflections of both sound and electromagnetic waves.

boundaries of a listening space, such as the ceiling, floor, front wall, rear wall behind the listener, left and right side walls or any other reflective surface inside a listening environment (Jot, 1999, Olive and Toole, 1989, Toole, 2017). Early reflections, measured in milliseconds arrive at the listener's ear later than the direct sound, often in a range of 5–100 ms, but can arrive before the onset of full reverberation. Early reflections provide information about the size of a room and provide a sense of distance for sounds in a room. They have an important role in determining the general character and sound of the room (Jot, 1999, Olive and Toole, 1989, Toole, 2017).

Reverb time. The reverberation time is perceived as the time taken for the sound to die away after the sound source ceases emitting the sound. Reverberation time is defined as the length of time required for a sound to decay 60 dB from its initial level. The rationale for using 60 dB is that the loudest crescendo for most orchestral music is around 100 dB and a typical background noise level for a good music-making area is around 40 dB. Thus, the standard reverberation time is derived from the difference between the loudest crescendo of a typical orchestral sound and the desired background level for good music (Llorens, 2015).

Room size. This parameter establishes the size of the simulated room; it affects whether the paths the waveforms take while bouncing around in the virtual room are long or short.

Decay time. This parameter controls how long it takes for the reflections to run out of energy.

Damping. When sounds bounce around in a space that is made of hard surfaces, the reverb's decay tails will be bright and more defined. With softer surfaces (e.g. wood or if the space is filled with people), the reverb tails will start to lose high frequencies as they bounce around which as a consequence will produce a warmer sound.

High- and low-frequency attenuation. Both parameters restrict the frequencies that are going into the reverb.

Diffusion. This reverb parameter control is used for creating an effect that properly resembles the source material. When diffusion is increased, it pushes the early reflections closer together, which makes the sound more 'thick'.

Pre-delay. This parameter represents the difference in milliseconds between the direct sound and the reflections, and typically lies between 0 and 100 ms. The pre-delay parameter defines how close a person is to the sound source in a room. The longer the pre-delay, the closer the dry sounds appear in comparison with the boundaries of the simulated room.

Reverb density. Lower densities provide more space between the first and subsequent reverb's reflections. Higher densities place reflections closer together.

Professional film composers need to understand these important features of hardware and software digital reverb units as they have an effect on the overall reverb character and ultimately on the overall character and realism of an orchestral simulation.

During observations of the professional film composers' creative practice in this study, it was found that they were using two different types of digital reverb units: **algorithmic and convolution** reverbs.

Algorithmic reverbs use a mathematical formula (an algorithm) to calculate and simulate how sound behaves in a virtual space defined by a set of parameters (Välimäki et al., 2012). Conversely, **convolution** reverb is a process used for digitally simulating reverberation by using the mathematical convolution operation. This operation uses a pre-recorded audio sample of the impulse responses (IRs) of the space being modelled and the sound to be echoed to produce the effect. IR recordings are convolved with the incoming audio signal to be processed. IRs are added to the input signal through convolution, effectively creating the illusion that the audio signal (i.e. an acoustic instrument) was recorded in the space being modelled (Adriaensen, 2006, Välimäki et al., 2012).

In the context of creating orchestral simulations for the purpose of the film score a key aspect to be considered during the mixing and audio processing stage is the type and amount of reverberation that composers need to use for their virtual orchestras. For this purpose, some composers including Partos preferred to use algorithmic reverbs:

> I use algorithmic Lexicon reverb, simply because I can fine tune and set every parameter of the reverb, they are more flexible (Partos, interview, 2017).

Unlike Partos, Rowland and Simjanovic preferred using convolution reverbs:

> I prefer the convolution, but it's horses for courses and it really depends what tends to work, but I like a good convolution, definitely (Rowland, interview, 2019).

> I like to use convolution reverbs; to my ears they have more detailed sound, I like to use them especially on woodwinds and strings when I am mixing (Simjanovic, interview, 2017).

while Yeo preferred using both algorithmic and convolution reverbs:

> I use a combination of both. I usually have two reverbs; one is like a real space and the other is the algorithmic reverb (Yeo, interview, 2019).

Since the significance of placing sample-based acoustic instruments in a natural and realistic environment plays an important role in producing a realistic virtual orchestral performance, convolution reverbs are a go-to solution when composers wish to ensure the accuracy of real acoustic responses inside virtual spaces. Depending on the size of the orchestra and complexity of the arrangement, choosing the most suitable convolution reverb is important as each IR (pre-sampled acoustic space) features not only different acoustic responses but reverberation times as well.

The process of creating orchestral simulations involves dealing with a wide range of ensembles and frequencies. Thus, to choose the most appropriate reverb for their orchestras, professional film composers must consider several factors including whether the orchestra is performing fast-tempo cues or slower and more sustained pieces of music. They have to think about the balance between acoustic ambience and clarity of the virtual instruments that are playing in the orchestra:

> When using reverbs, you have to find the correct balance between the amount of reverbs and clarity of the instruments; too much reverb will destroy the mix, especially when adding reverb to low-frequency instruments such as large drums, basses and cellos. If the low end has too much reverb it will make your mix muddy (Partos, interview, 2018).

The reason for composers needing to be careful when adding reverb to low-frequency instruments such as large drums, basses and cellos is that low frequencies tend to travel further in space and therefore in a real acoustic environment they usually carry the reverberation longer than do high frequencies (Kinsler et al., 1999). Thus, composers use the built-in high- and low-frequency attenuation section to restrict the low frequencies going into the reverb section and to attenuate, if necessary, some of the reverb's low end.

When using algorithmic reverbs, a technique that can be particularly effective is the use of slightly different reverberation settings for each individual section in the virtual orchestra. Using this approach will deliver a much more realistic presentation of an acoustic environment that will using the same reverb settings across the entire virtual orchestra. In live situations, in real concert environments, each section of the orchestra is positioned differently and therefore the reverberation will affect each section slightly differently. Setting up different reverberation parameters such as reverb time, early reflections and room size for different sections of the orchestra will dramatically improve how the virtual orchestra sounds and give the impression of the acoustic response of different zones of a concert environment. Using this approach requires careful adjustments to reverberation parameters for each individual section in the virtual orchestra.

Positioning (panning)

Panning refers to the placement of sound elements in the sound field. It is the process of distributing either mono or stereo sound signals to a new stereo or multichannel sound field (Izhaki, 2017). In both stereo panning and multichannel panning, the ratio at which power is distributed between the left and right and/or surround channels determines the position of the sound source (Perez-Gonzalez and Reiss, 2010). Since the human brain relies on direction and distance to identify a sound source (Beament, 2003), in the context of orchestral simulations, 'virtual' positioning of acoustic sound sources in spaces is achieved using a combination of creative choices and technical constraints based on the composer's perception of sound source localisation.

In practice, the composer has to take into account all instrumental forces in the orchestra, and the interaction between them, to devise the correct panning position for individual instruments. Although there are no absolute rules to panning, there exists a set of tacit understandings and conventions when it comes to 'virtual' positioning of acoustic sound sources in spaces, which have emerged from composers' experiences using the tools in production contexts. To create a realistic and natural-sounding environment, the composer has to maintain the spectral balance so that the overall energy of the mix is evenly split across a sound field. To minimise spectral masking, musical instruments with similar spectral content need to be placed apart from each other (Bartlett and Bartlett, 2009). This is important because it will create a mix where listeners can clearly distinguish individual instruments.

Further, if composers wish to emphasise high-priority sources (i.e. soloists), they will keep them positioned towards the centre of the sound stage to make them sound clearer and more prominent. Thus, if a composer was orchestrating a piece with a solo part, they would usually position the soloist closer to the centre of the sound stage; at the same time, lower-priority sources are more likely to be positioned towards the left or right side of the sound stage to avoid grouping too many instruments in the same area, which can lead to a masked and muddy sound. This technique is similar to that used when sound engineers are mixing modern pop or rock music where the lead performer would often not be panned. This relates to the idea of matching a physical stage setup to the relative positions of sources (Perez-Gonzalez, 2010).

In a similar manner, panning principles applied to low-end instruments (e.g. double bass, trombone, tuba) are such that these instruments are usually kept in the centre or close to the centre of the stereo image to retain a more accurate balance. There are two main reasons for doing this. First, it ensures that the low-frequency content remains evenly distributed across speakers (White, 2000). This minimises audible distortions that may occur in the high-power reproduction of low frequencies (Perez-Gonzalez and Reiss, 2010). Second, the position of a low-frequency source is often psychoacoustically imperceptible, since humans in general cannot correctly localise frequencies lower than 200 Hz (Benjamin, 2006).

As mentioned earlier in this chapter, composers can use slightly different reverberation parameters and volume settings to recreate how an instrument would sound if placed on different parts of a stage. When crafting the illusion of realism, composers can also use panning to augment their reverb setup to accurately create a sense of depth and placement of instruments on a virtual stage.

If we consider reverb as a device used to change the depth of a mix by simulating the sense of spatial depth and width to sound and distance between the listener and the instruments, then panning would be considered as a means of changing the horizontal positioning of the instruments in the mix. To simulate left-to-right and front-to-back positioning of the instruments in the mix, as well as the distance between the listener and the instruments, some of the most advanced convolution reverbs available on the market (e.g. Vienna MIR) have built-in features that allow composers to position sound sources on the virtual stage by simply moving an icon (representing the sound source) on a three-dimensional plan (the stage).

As described in Chapter 5, Vienna MIR's graphic interface (see Figure 7.7) is designed to allow users to place precisely in space all the instruments and instrument sections in the orchestra. In the case of orchestral simulations, this feature is extremely useful as the positioning of instruments and sections in the orchestra is critical for a successful and realistic presentation.

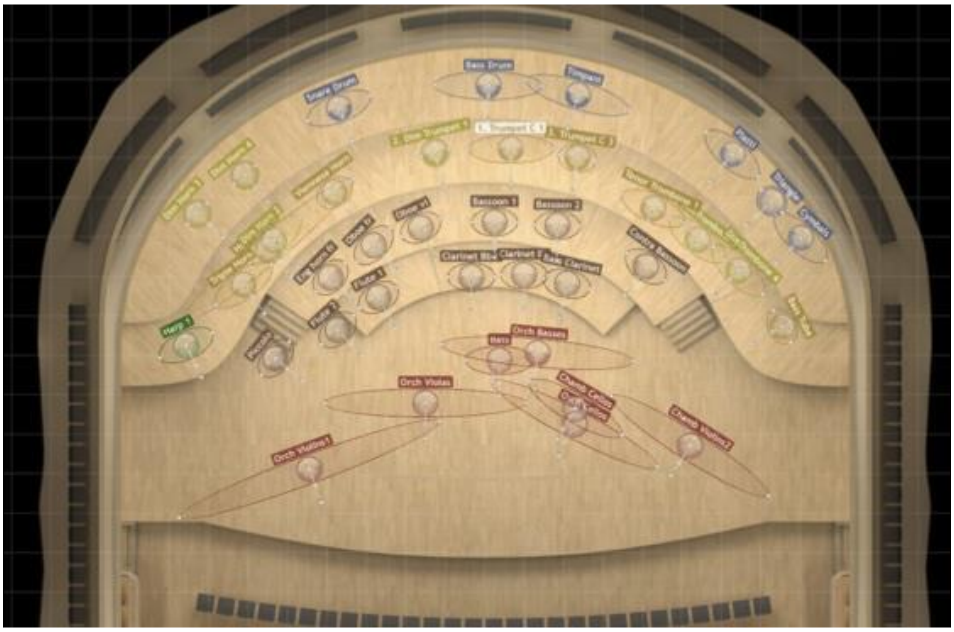

Figure 7.7: Vienna MIR virtual soundstage

It is widely accepted that there is no standard form for an orchestra or its seating arrangement; its size and positioning will vary to suit the needs of the music. Such requirements may be specified by the composer or implied by the style and period of the repertoire to be performed (Smith, 2009). When it comes to the arrangement of a modern orchestra (Figure 7.8), in general, string instruments are positioned at the front of the stage, with woodwind and brass instruments behind, and then percussion instruments at the very back (Pejrolo and DeRosa, 2016). However, where each individual instrument section is placed horizontally depends largely on the size of the symphonic orchestra:

> The standard orchestral arrangement is a useful reference because all the players in an orchestra are seated the way they are for a reason. To achieve a good balance I usually position brass and percussion instruments in the back, with woodwinds and strings in front of them. In terms of horizontal positioning, to avoid conflicts, sections with similar ranges and timbres are positioned opposite

each other in the stereo field: violins left, horns left, cellos right, trumpets to the right (Simjanovic, interview, 2017).

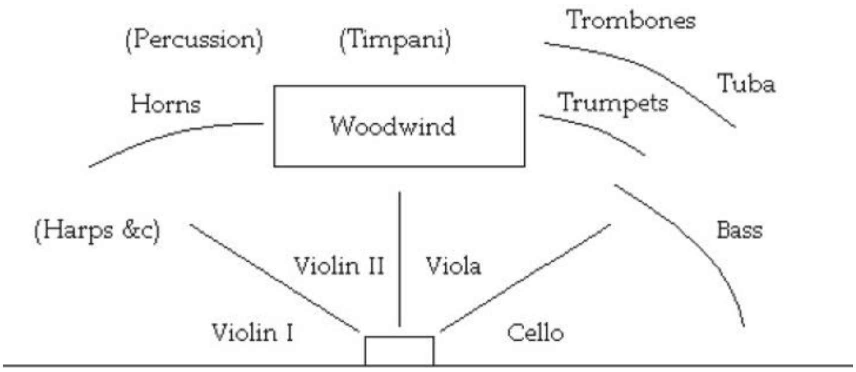

Figure 7.8: Modern seating arrangement for a full orchestra (Smith, 2009)

Positioning instruments on the virtual sound stage is an important part of the panning process. If the composer's goal is to construct a realistic orchestral simulation, they need to follow some basic rules, as 'correct' positioning will simply make their music sound more convincing—a point no one can argue against.

With regard to positioning of the instruments on the virtual sound stage, composers usually follow some basic rules. However, if the composer is clear about the ideas they wish to express with their music they may choose to deviate from typical seating arrangements if experimenting and seeking a unique or unfamiliar texture. Depending on the music, dynamics, context and the composer's intentions, they can choose to position the orchestra one way or another but at the end it all comes down to the composer's ear.

Volume balance

Volume balance refers to the volume level relationship between musical elements.

This is an ongoing process that starts when the first sample is played and continues through each phase in the process of creating orchestral simulations, all the way to the end. Whether composers are performing or manipulating audio or MIDI data, they are simultaneously moving faders and focusing on the overall volume level relationship between musical elements so that every instrument and instrument section is heard in the right relationship to the others.

Most of the time volume balancing is performed via volume automation. Nearly all DAWs now have a dedicated fully featured automation system that allows composers to record, edit and automate virtually all mixer and effect parameters including fader movement data with great precision. Such data is usually represented by a number of 'break points' that represent positions where the composer can write parameters, faders values and lines that shows how the DAW intends to interpolate intermediate values (Figure 7.9).

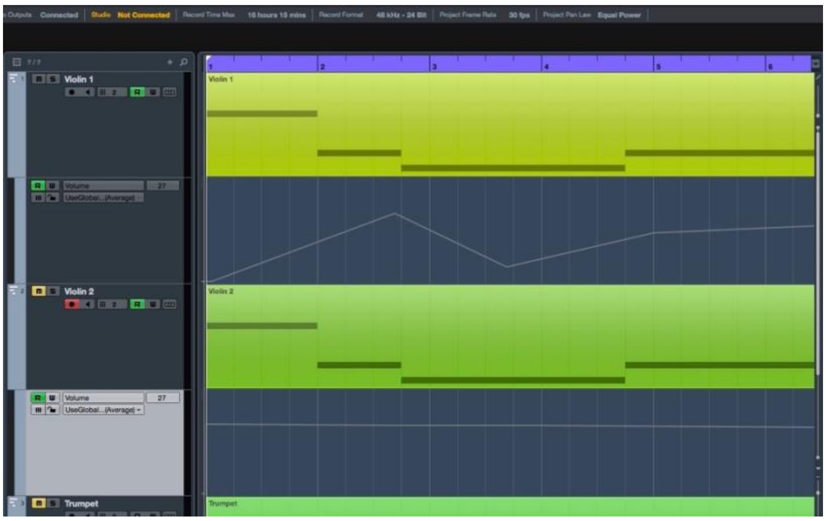

Figure 7.9: Cubase - Volume automation lines

There are two commonly used methods to add volume automation to a mix. The first is real-time mode, which involves setting the volume parameter as ‘write’ (recording) mode, starting playback of the audio/MIDI channel or the entire song, and either physically moving faders on a control surface or using the mouse to manipulate on-screen virtual faders. When recording of the fader movements is complete, during the playback, on-screen faders will follow the movements the composer made during the automation 'write' phase. The second approach is entering automation data using a computer mouse. Either way, once the automation data are recorded they can be further edited inside an 'edit' or 'arrange' window.

Automation editing enables composers to address and automate every aspect of the performance with great precision, including the volume level of individual notes or a choir performance, syllable by syllable. This method also provides practical visual aid as automation lines can be organised so that the composer can choose to view them either superimposed on, or directly adjacent to MIDI events or an audio waveform display of the track to which they relate. This allows composers to draw in edits that correspond accurately to changes in the MIDI or audio recording.

Conclusion

This chapter has shown that the variety of expressive detail film composers modulate plays a crucial role in creating expressive orchestral simulations for the purpose of the film score. With the help of today's computer music technology, composers have the ability to manipulate audio signals and shape the basic elements of complex waveforms produced by acoustic instruments while maintaining sonic integrity. By modifying expressive properties of each instrumental performance in their virtual orchestra, including pitch, articulation, dynamics and timbre, film composers are simulating sound-producing movements that are required to create and control the sound of acoustic musical instruments. The variety of expressive detail, and the spatial characteristics of virtual acoustic environments and sound sources within which film composers modulate for artistic purposes allows them to alter the expressive character of their virtual performance and create orchestral simulations that simulate both the behaviour and character of a real orchestral performance.

In the following chapter I present a conceptual model of the film composer's compositional practice that covers most actions and thought processes that take place during the process of creating expressive orchestral simulations for the purpose of the film score, regardless of the compositional tools composers are utilising, and their musical and compositional styles.

Chapter 8: Virtual Orchestration—Conceptual Model of Creative Practice

Chapters 5, 6 and 7 focused on compositional tools and the variety of the composer's activity throughout the process of creating orchestral simulations in which composers utilise computer music technology as the primary tool for music composition. I explored how composers organise their compositional processes from initiation to completion according to their individual circumstances, and described some of the diversity of computer-assisted compositional practice in terms of the equipment utilised and compositional processes involved. In this chapter, I outline a new model of creative practice and introduce a taxonomy of compositional activities that I identified as employed by all interviewed composers regardless of their musical and compositional styles, the musical outcomes of their work and the equipment utilised. When composers are engaged in the act of creating orchestral simulations, they go through multiple steps and in each step of the process their understanding and interpretation of the musical materials is altered in such way that they have a unique perspective on things they do and hear. I refer to this experience as 'virtual orchestration' and in this chapter I present a conceptual model of creative practice that encompasses and describes most actions and thought processes that take place during this creative activity and were common to all the composers interviewed for this study.

To recap, virtual orchestration is the art of creating orchestral sounds through the use of computers, digital sequencing, samplers and sample-based VAI for the realisation of musical works. It is a process of using and manipulating recorded samples of real acoustic instruments to generate an expressive and convincing musical performance through sample-based orchestral simulation. This process of composition is a continuous multifaceted compositional activity that involves a complex set of relationships between different compositional states of mind and compositional activities in which film composers experience music and interact with musical materials and media in various ways. Virtual orchestration proceeds in stages over time and all procedures can be applied repeatedly between stages.

This model of creative practice is a result of a thematic analysis of the data gathered during an examination of the work practices of seven professional film composers during their process of creating orchestral simulations for the purpose of the film score. As described in Chapter 4, this examination included semi-structured interviews with the composers, observations of their studio practice and inspection of their compositional tools. This allowed for documentation and identification of the various types of composer involvement presented in this thesis and incorporated into this model of creative practice. After all interviews had been transcribed, categories were identified through a thematic analysis of the transcriptions, which involved a process of open coding (Miles and Huberman, 1994; Khandkar, 2009)). The derived coding categories indicated the diverse range of themes that emerged from the data. At the same time, during the detailed examination of the research data, there was an intentional search for themes emerging across the cases as both similarities and recurrences. This approach involved identifying topics that occur and reoccur, as well as looking carefully for key words and phrases emerging across interviews (e.g. 'hear', 'play', 'find', 'sample', 'listen', 'emotional') that the composers frequently used when describing their activities, feelings and experiences throughout the process of creating orchestral simulations for the purpose of the film score. The coding categories are listed in Appendix C and an example of a coding framework and word frequency count of key words and phrases that emerged across interviews is provided in Figure 8.1 and 8.2.

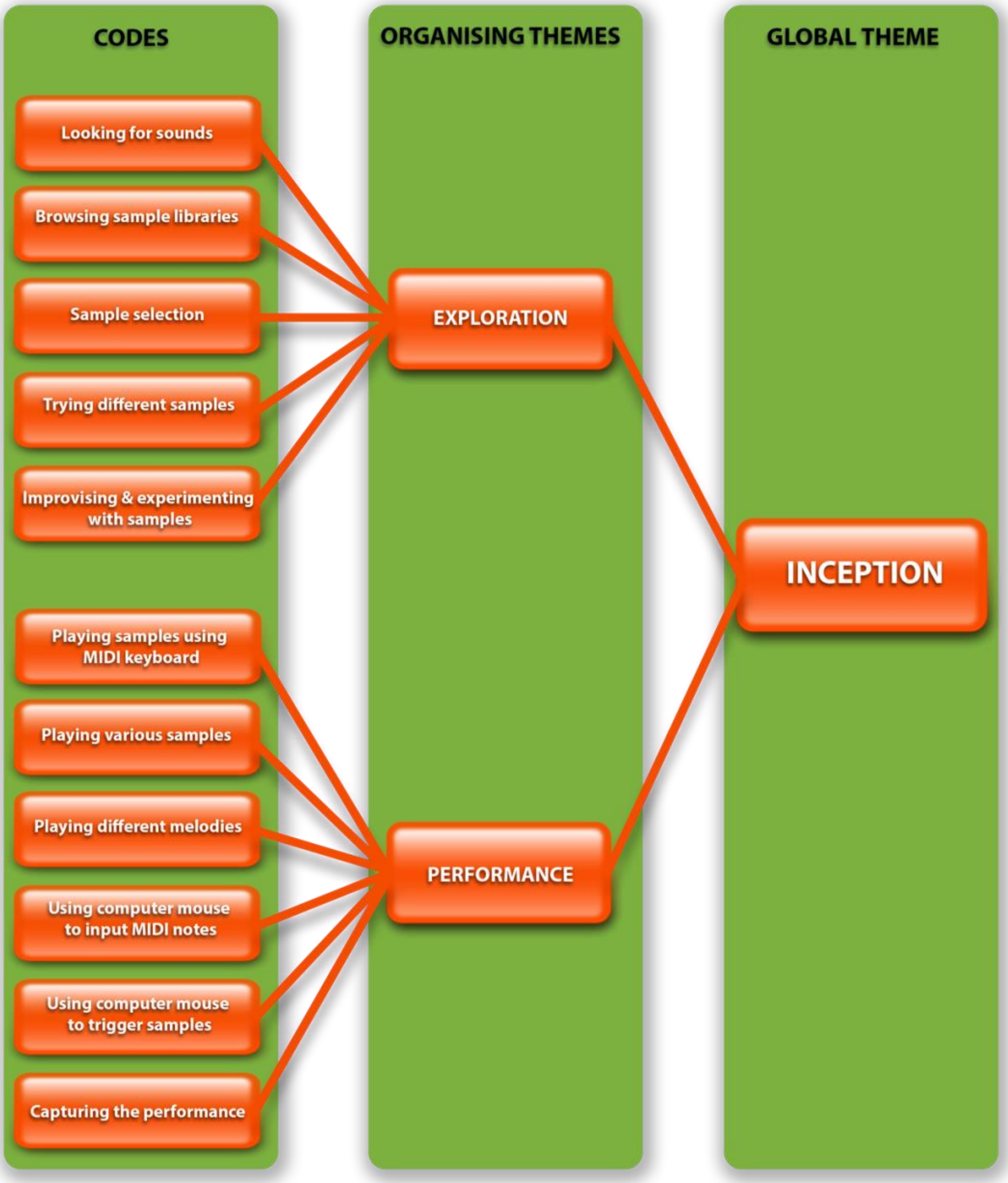

Figure 8.1. An example of a coding framework

KEY WORDS	WORD FREEQUENCY COUNT
playing	259
player	23
listen	24
listening	75
hear	90
manipulation	18
sample(s)	118
find	45
emotional	39
mixing	91
articulation	42

Figure 8.2: An example of a word frequency count

Based on the theme frequencies, their significance and regularity of occurrence across the cases studies, as well as the contexts in which particular words and phrases were used, the emerging themes indicated a process of music composition containing a number of fundamental compositional activities shared by all composers regardless of their musical and compositional styles or the equipment they used. There are three main stages and related activities in the proposed model: inception, interpretation and simulation (Figure 8.3).

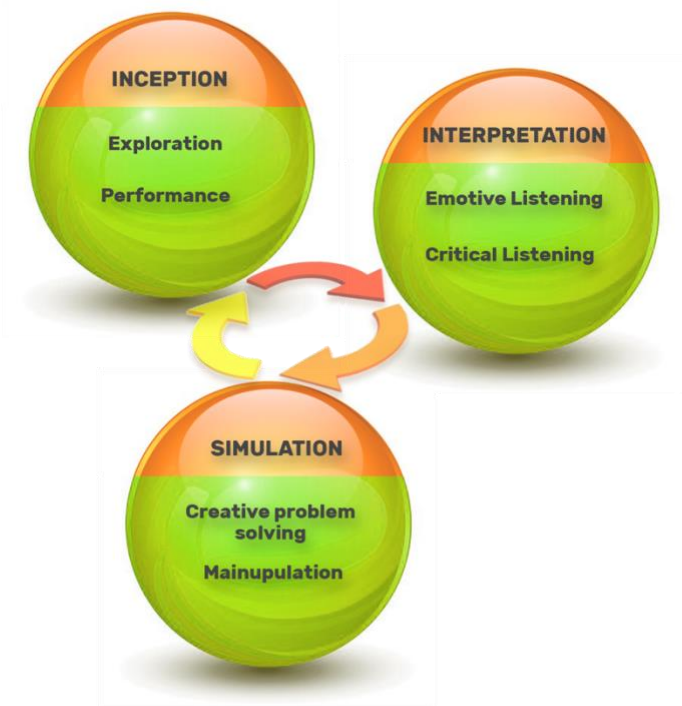

Figure 8.3: Virtual Orchestration stages and activities

The order in which these stages and activities are outlined does not indicate any specific hierarchy and a composer may repeatedly switch between stages while performing different activities. During this process of composition, composers are often mostly in one stage or another even if just for a brief period, as they frequently switch back and forth between stages and can be in multiple stages performing different activities at the same time. Further, while each composer may have a propensity to spend more time in some stages than in others, all of the composers went through all of the stages and performed each of the activities at some point.

The reason for identifying compositional activities in this way was to provide a better understanding of the composer's creative practice and their role throughout this compositional process. I draw connections between composers' experiences and the writings of musicologists regarding creativity and psychology when describing virtual orchestration, in greater detail through the identification of activities. The activities are important because they are practices that reveal and explain how composers are approaching the process of creating orchestral simulations in a variety of ways. They relate to the composers’ experiences of creating orchestral simulations and how they perceived that process when they were going through the different stages of the process. In the following section, I first present a brief description of the three compositional stages in the model and then describe in more detail the activities and that define this model of creative practice.

Inception stage

This stage of the process can be best described as simultaneously improvisatory or intuitive, and conscious. During this phase, composers conceptualise and create a musical foundation for further development of a film score and make several crucial musical decisions regarding their objectives for the project. At this point, composers are trying to gain a sense of the tone of the movie scene and begin to connect their ideas with music. This is the stage where composers begin to explore the types of instruments, arrangements and music styles that can be provided by suitable textures while experimenting and improvising with the resources to create music.

Interpretation stage

The interpretation stage is best characterised as the auditory processing stage in which composers are both critically and analytically listening to music to perceive and interpret sound information. This phase of the composing process, which is influenced by the composer's personal feelings, tastes and opinions, requires the composer's subjective response to musical sound signals. During this phase, composers are interpreting both the feeling and meaning of the musical events as well as the expressive characteristics and physical details of the music that are most important for capturing the intended feelings. Although critical and analytical listening are two separate entities, it is not unusual for both of these practices to occur simultaneously. Understanding the way in which the sound of musical instruments is behaving and how the particular sound is supposed to make the audience feel are important parts of the composing process and skill set of professional film composers.

Simulation stage

The simulation stage presents a phase of the composing process where composers employ computer technology in creative ways to maximise the expressivity of the virtual orchestra. To communicate their musical ideas and their expressive and emotional intentions to the audience, composers must use a diverse set of skills and tools to create convincing and expressive virtual instrumental performance that simulates both the sound and behaviour of a real orchestra. This process requires that composers respond intellectually and effectively to the musical events to explore different possibilities through the identification and solving of various problems. This analytical approach involves utilising technical knowledge and the composer’s previous experience to apply theories and concepts, inform new situations and creatively solve practical problems.

Inception stage activities

Exploration activity

For the composer involved in the process of creating orchestral simulations, computer technology is used for the externalisation of their intentions. The composer uses technology to project and bring their musical ideas to the outside world, particularly to other people through detailed orchestral simulation of the acoustic orchestral performance. By interacting with technology during this exploratory phase the composer is consciously experimenting with musical materials. The composer is using the information provided by technology and through cognitive processes; they evaluate, reject or select different options to find the best and most suitable musical materials (Figure 8.4).

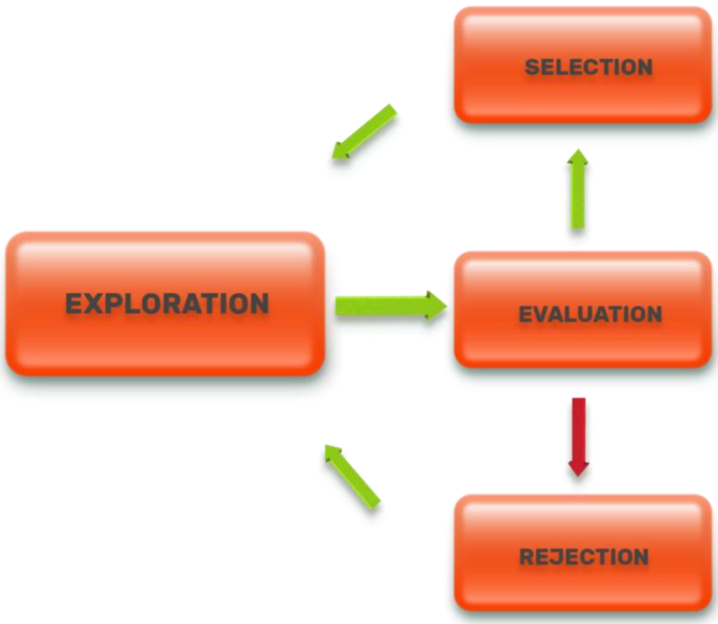

Figure 8.4: Exploration stage – Cognitive processes

Throughout this continuous exploratory process, the composer is searching for the most suitable compositional tools and musical textures that can be included in the composition, and ways in which such musical elements can be arranged and organised to provide satisfactory musical outcomes.

The end result of this creative activity is not always predetermined since the ideas the composer is trying to express may be influenced by computer technology and by certain sounds they encounter during the exploration. When exploring various compositional tools and highly detailed orchestral sample libraries consisting of hundreds of individual samples, it is important for a composer to know exactly what tools they need while trying to decide between two or more equally attractive solutions. Such decisions require a clear sense of purpose; thus, during this activity it is important that the composer knows what precisely they are trying to accomplish.

This requires clarification, a characteristic of exploratory activity as stated by Brown in his studies: 'the outcomes of a creative process may not be clearly preconceived, but the experienced explorer can identify a useful discovery when it arises, thus the compositional process involves clarification as well as construction' (Brown, 2003, chapter 7, p.10). To be efficient and avoid being stuck or uncertain about what tools to choose, the composer first needs to clarify their goals; most importantly, what is it that the composer is trying to achieve with his orchestral simulation.

Apart from providing the composer with the necessary tools for their compositional activities, a technological medium such as a computer music system provides 'a conceptual musical space that a composer can explore and build within' (Brown, 2003, chapter 7, p.10). This metaphysical musical space focuses the composer's attention and gives them the experience of unrestricted freedom. However, this freedom comes at a cost as choosing one sample among many can be time consuming. Sometimes, a composer will spend hours or even days searching through their templates and libraries to find and create appropriate sounds for their compositions.

This means that during this activity the composer must constantly deal with multiple choices provided by computer technology and make the correct decisions regarding the material presented by a computer. At some point throughout this exploratory activity, the composer has to make a final decision and select or reject the material generated. Although computer music technology provides many possibilities to explore and experiment, which constantly creates new musical associations, at some point throughout this process the composer has to carry out final creativity and judgment. To make appropriate decisions and be able to judge the practicality of computer-generated suggestions, the composer needs to establish criteria for assessing the quality and effectiveness of the musical materials. Such criteria depend on many factors:

> Before I even start going through my sample libraries, I need to know what samples I need, what I need to look for. If it's a particular instrument, articulation or something else, it depends on the type of music I compose, the tone of film music or the wishes of the film director most of the time (Simjanovic, interview, 2017).

> It's based on a story, based on a film, based on the style of the film; it could be based on a budget. It could be because you are mocking up an orchestral score that's going to be recorded by a real orchestra. So in that case you have to look at

your budget, you have to look at how many players you have (Yeo, interview, 2018).

It's important I think to remember that this is the music that the director or producer chose, not the composer. The filter is always the filmmaker, whether it's a movie, a TV show or a game, everything passes through the filter of the filmmakers, director, producer. So as a composer, as I'm writing, I'm asking myself all the time, ‘Okay, I like this, and I've done everything I can; do I think the director's going to like it?’ (Rona, interview, 2017).

It has all these really wonderful settings that you can do here, EQ, release, it has some effects, it has paddle volume that I really like. It’s a beautiful piano just to play on; it almost has like a music box quality to it, something that you can play (Holkenborg, 2015).

I am really interested in what the scene feels like, so I'm very old school, to the extent that I look at something and to me, the scene cries out or screams out sometimes saying you need to have this kind of approach (Rowland, interview, 2018).

The first thing I do is to try to unite the score by picking my sound canvas, I have to look at the character, the story, then the next thing is how many themes are going to be and what the dramatic variations of those themes have to be; is it spooky is it mysterious, is it melancholy, what are the variations? When I'm composing my themes, I make sure that I'm testing the themes in various dramatic settings that they have to be done. I use instrumentation to colour my compositions to enhance the dramatic approach. I need variation to do that (Mann, interview, 2017).

As can be seen from the composers' statements, the motivation to conceptualise the score and the choice of musical materials for their orchestral simulations depends on many factors: a particular project's requirements and the composer's personal preferences; the wishes of a director or producer; whether the orchestral simulation will be performed by a real orchestra; the number of players in the orchestra; the budget; the style of the film; what kind of emotional effect a composer is trying to portray with their music; the number of articulations provided; and the playability of a particular sample or sample library. These are all elements that the composer needs to consider when conceptualising the film score and when establishing criteria for assessing the quality and effectiveness of the musical materials they are choosing for their composition. Regardless of these criteria, which may differ between projects, what was important and common to all interviewed composers for this study was that this exploratory activity involved setting the rules and parameters within which the composer conceptualised, explored, selected and rejected the computer-generated material. Because of the vast number of possibilities that computer music technology provides, the composer must clearly define their musical space and be aware of their goals' only then will they be able to make the correct decisions and continue to search for and select the appropriate materials for their composition.

Performance activity

Performance activity is the compositional activity during the inception stage of the process of creating orchestral simulations in which the composer is using a computing system to play samples of real acoustic instruments to capture their performance. Since creating an expressive orchestral simulation requires more than just using a computer medium to play samples, the performance activity can be best described as the initial step whereby recording their performance, the composer is creating a musical foundation for further developments.

Throughout this activity, the composer is using a computing medium (typically a MIDI keyboard) as the instrument to express and externalise their musical ideas and transmit them to a listener. This process involves performing an instrument or a set of instruments to create the musical events and musical sections needed for the film. During this activity, the composer is approaching the process of composition as both composer and performer; this provides composers with varying perspectives. Every sound, every sample that the composer plays can have an effect on their overall compositional approach. Playing samples to express the ideas a composer has envisioned makes this activity an extremely stimulating and productive phase of the creative process, leading the composer to musical solutions that may not have occurred to them without the availability of these particular colours. It is not unusual for a composer to spend hours during this activity going through their libraries, playing appropriate sounds for their compositions.

An important characteristic of this activity is that involvement in this process is assisted by the immediacy of interaction, as DAWs respond in real time to instructions given by the composer by playing keys on the MIDI keyboard. The collaboration between composer and computer medium, during which the artist receives immediate feedback from the computer system, creates an environment in which composers can test their ideas, the best of which can then be used for composition. This involves performing music extemporaneously, with little or no preparation, by improvising variations on existing melodies, or creating new melodies, rhythms and harmonies. This process of composition is similar to musical improvisation, where performers are spontaneously creating musical works as they are being performed (Alperson, 1984, Wright, 2010). A characteristic of this improvisatory approach to musical performance is that it provides composers with the opportunity to test their music in the context of the film. Through performing and improvising with different melodies, rhythms and harmonies, this approach enables composers to employ music and hear and feel how the emotional effect of the music structure influences the narrative:

> Sometimes musical ideas in improvisation are spontaneous; you are looking at the monitor and you try to feel the movie. You are watching and playing at the same time (Partos, interview, 2017).

> I pick up sound sources and I start playing, It's all about feelings and context. It's simply going with the 'flow'. My inspiration at that given moment while I am thinking about the movie. While I am playing I can access several sliders at the same time with my other hand so I can play as expressively as I can (Simjanovic, interview, 2017).

Engagement in this performance activity is characterised by the amount of involvement and the dependence on intuitive knowledge. This approach combines performance with communication of emotions through music; it focuses on the creativity and expression, rather than the accuracy of a performance. This activity was an important part of Holkenborg's compositional practice during his work on *Mad Max Fury Road (2015)* and *Run All Night (2015)*. During this phase of the compositional process, his attention was directed not so much towards the accuracy of his playing, but towards creating and capturing melodies and the emotional effect these melodies were expressing. He commented:

> It's a sketchbook, so everything doesn't sound finished, you'll hear some distortion here and there, sometimes it is too quiet; you will hear a few mistakes here and there, but what I really wanted you to see is what the initial ideas were (Holkenborg, 2015).

Simjanovic and Yeo made similar remarks:

> It is all about capturing those moments of inspiration when I am fiddling around with samples, trying various things. Even if I make mistakes here and there it doesn't really matter; whatever I decide to keep is going to be edited anyway down the road (Simjanovic, interview,2017).

> I got the keyboard there, and faders on the keyboard are mapped to a different expression and volume and vibrato. So while I play things in I can press the key switch to change my articulation; then I can play and then say use the mod wheel on one of the faders on my keyboard to add expression more like the performer. So, I generally play each part in, and I use faders and modules and stuff like that to add expression. You can see now I never do a perfect performance, particularly when you are writing quickly (Yeo, interview, 2019).

Observations of the composers' processes suggested that this activity was open-ended and exploratory in nature; it encouraged creativity where the emphasis was on exploration, invention and capturing an expressive performance. At the same time while the composers were experimenting with various types of instruments and music styles, throughout this activity, they were capturing their ideas and creating a rough or unfinished version of their work for further refinement. This process of composition involves an element of improvisation as well, because sometimes composers are spontaneously creating musical works as they are performing.

Interpretation stage activities

Analytical or emotive listening activity

The concept of analytical or emotive listening in this context refers to activity in which the film composer is focused on interpreting the feeling and meaning of the musical events they have created. In other words, the focus is on the interpretation of the emotional intention of the musical performance that is manifested through the sounds it produces. This is an active approach to music listening, unlike everyday passive listening where people are exposed to music in their surroundings.

During this activity, while listening to the music they created, composers are interpreting both the feeling and meaning of what is being played in the context of a film. For composers, the instrumentation, musical structures and contexts in which music is heard evoke different emotions and give distinct meanings and perspectives to what is happening on the screen. This is not surprising: many empirical studies have indicated beyond any doubt that factors such as dynamics of musical structures, articulation (Lavy, 2001), changing levels of tension that emerge as a piece of music unfolds (Krumhansl, 1996); as well as extra-musical factors such as the listener's mood (Sloboda, 1992), the situation in which the music is heard (Konečni, 1982) and the motivation for listening (North and Hargreaves, 2000) are responsible for evocation of emotions in listeners and audiences. Further, musical expression studies have shown that the broad emotional characterisation of music as perceived by listeners familiar with Western musical idioms is mediated by musical parameters such as timbre, intensity, tempo and mode (Lavy, 2001). Research has indicated that the timbral quality of a musical sound consistently influences perceptions of emotional tension (Nielzén, 1993). For example, fast music is associated with joy and activity, whereas slow music is associated with sadness or solemnity; a high intensity makes fast music seem more energetic while slow music appears more serious or solemn; a low intensity, on the other hand, makes slow music appear sad (Lavy, 2001). In addition, major keys are invariably associated with positive emotions, while minor ones are associated with negative emotions (Scherer, 1977).

When describing their experiences and some of the characteristics and atmosphere of the music they created, the interviewed composers often used words such as 'exciting', 'dramatic', 'sad', 'warm', 'emotional' and happy. To composers, those words carry meaning and express how they feel while listening to their music. The kind of emotions music evokes in the composers and how they react while listening to what their music expresses will influence their decisions and how they evaluate if and to what extent specific moments in the narrative should be emphasised with music. This is a very personal and subjective activity in the sense that what is perceived and how composers as listeners are affected—either emotionally or intellectually—is not observable to other people.

When the audience watches a movie they have certain expectations and the music is expected to fulfil those expectations (Karlin and Wright, 2013, p.129). A film score must do what the audience expects; it needs to make them happy or sad, to move them in some way or another. To make sure that music they create will influence and suggest an audience's emotional reaction to what is happening in the film, during this activity film composers are focused on listening for the differences in the messages that musical events are carrying during interplay with the visuals and in what ways they might affect the audience. These small details come across in a subtle way with music:

> A sound or musical instrument that works for every scene or style of music doesn't exist. What I am listening to is if the instrument or a melody is best suited for the particular scene. It is important that the music accompanying the scene has the same emotional impact on me as it would have on the audiences. Your role as composer is to manipulate the emotions of the viewer. Often, I say to people, 'I'm an emotional manipulator, that's what I do for a living'. And it's true (Partos, interview, 2017).

> So in my musicianship, of course I'm thinking, does this phrase, do these chords project the emotion that I feel is what the scene needs? And so there's all that psychology, and sometimes the psychology is, well what's emotional to an average member of the audience, but more importantly, what will the director or producer say, 'Yes, this music conveys the emotion that I want the audience to experience' (Rona, interview, 2018).

It has been argued that a film audience is emotionally aroused because they conjure up visual images while listening to the music (Juslin and Västfjäll, 2008). The emotions they experience are the result of a direct interplay between the music and the visuals. It has also been advocated that musical stimuli are especially effective in stimulating visual imagery (Osborne, 1980, Quittner and Glueckauf, 1983) in the same way that imagery can be effective in enhancing emotions in response to music (Band et al., 2001–2002; see also Västfjäll, 2002a, p.183). The visuals have a composition of their own but when combined with appropriate musical events, they form a new entity that creates a particular atmosphere and adds a sense of realism to the film. For this reason, composers are listening not only to musical colours that will evoke the tone and attitude of the film, but to how and if these sounds are compatible with dramatic elements. By doing so, composers are making sure that the music they create provides a harmonious complement and is an integral, inseparable part of the visual scenery. Music production must take into account these subtleties for the feeling of the music to be properly conveyed to the listener. Focusing on how music interacts with visuals is an important aspect of the composing process of orchestral simulations as it allows composers to identify whether any adjustments need to be made to performances or instrumentations. When choosing instrumentation and melodies for particular scenes, composers are careful about listening to what that instrumentation is saying. A theme played on one instrument might carry a different emotional message than the exact same melody played on a different instrument. Mann and Simjanovic explained:

> I'll give you a really good example; you think about and pick your instrumentation many times because of what that instrumentation says. If you write a love theme and you play the melody on an oboe, it’s going to sound like a love theme but if you try and play the exact same melody on a clarinet because it plays with no vibrato it's a little more stand-offish; it almost sounds like a longing love theme as opposed to a love theme that's actually in motion. So if two people are together

> you can play with the oboe but if it's two people that are missing each other you could play the same love theme on a clarinet and you get that longing element attached to it (Mann, interview, 2017).

> It is important to think about what kind of emotion and atmosphere your music and the instruments playing that music are creating in the context of the film. Fast tempo music made with a string orchestra will create a different atmosphere than fast music made with percussion (Simjanovic, interview, 2017).

The composer's perception and their emotional response to the music during this activity are determined by contextual factors. Any purposful account of music's role in the composer's emotional responses involves recognition and listening to the music in the context of a narrative. Throughout this activity, composers' attention is distributed across a complex situations and music is only one a part of it. In this way, music becomes part of the construction of the emotion for composers through the way in which they interpret music and orient to it. Composers' responses to music are an outcome of their reaction to the ongoing context in which the music is embedded. This approach asserts that every musical object or event in the film is situated in the context of the film, which involves an interplay between musical events and what is happening on the screen. This approach focuses on the interplay between music and narrative as a whole. Musical objects and events have purposes for all of the parties involved and no music happens in the film unless it is fulfilling a purpose for someone or is being used for something.

Critical listening activity

This procedure refers to an activity during the interpretation stage of the process of creating orchestral simulations where composers are critically listening to the physical details of music such as pitch, loudness, timbre, frequency response, dynamic range, imaging and so on, to evaluate the expressivity of a virtual musical performance and how the musical instruments in the orchestral arrangement are blended together. This is the activity that requires a composer's subjective response to musical sound signals. It is a known process in psychoacoustics where subjective psychological responses are evoked by physical properties of sensory stimuli in our environment; in this case acoustic stimuli (Deutsch, 2013).

Throughout this activity, composers are acting as listeners, almost detached from the compositional process. This phenomenon is described by Brown, where he describes the composer as an ‘audient’ who ‘stands apart from the compositional process—detached, in a state almost of dis-engagement—where the composing medium, computer or score, is objectified’ (Brown, 2003, chapter 7, p.5). From this perspective, it is important to break the composition down sonically, to stand critically apart from the composition to be able to perceive and evaluate its actuality. This is a challenging process that requires focusing on orchestral performance as a whole. At the same time, it requires focusing on individual instruments and their subjective properties of musical tones (frequencies, timbre, dynamics, loudness, etc.):

> You have to pay attention to every instrument and instrument section in the orchestra if the goal is to approximate the sound of a real orchestral performance (Rona, interview, 2017).

> You have to listen to how it sounds isolated as well as how it sounds relative to the other sounds that it is interacting with (Yeo, interview, 2019).

This process demands an extraordinary frequency analysing power of a composer's ear, which is fundamental to their perceptual functioning (Rasch and Plomp, 1982). Sound pressure levels, time differences of a few milliseconds and frequency differences can have a profound effect on the subjective response of the listener (Deutsch, 2013). Only through the composer's ability to hear, analyse and evaluate complex sounds are they able to discriminate simultaneous tones in music:

> Similar to how musicians learn how to identify notes, you also have to learn how to identify those same sounds but as frequencies instead. (Rona, interview, 2017).

> You can't know what's wrong unless you know what's wrong… When you spend your time listening to live acoustic performances, you develop a memory of how instruments actually sound and how they interact. When I am listening and analysing my own simulation that's what I am I listening for, frequencies, nuances, little details that make a real performance real (Simjanovic, personal interview, 2017).

The ability to hear and comprehend the physical aspects of sounds in orchestral arrangements is important because it allows composers to work with the issues that are present in musical performances. It allows them to understand how the performances integrate together and how the physical aspects of musical events affect the expressiveness of the performances. Because of the effect of aggregating many players, composers have to deal with many issues when crafting virtual orchestral performances. These include the sound intensity (loudness) when two or more tones are presented simultaneously or when specific frequency areas between performances overlap each other which prevents each performance from being heard clearly as a result of different instruments sharing a very similar space in the frequency spectrum. Such scenarios prevent the individual instruments and instrument sections from being clearly audible when presented in complex orchestral arrangements.

It is crucial that composers understand that volume imbalance and frequency content in the recordings of some instruments may conflict and cause a disturbance with the recordings of other instruments. Paying attention to the physical behaviour of the instruments and the interaction between notes in a phrase is another important part of this listening activity. When a musician performs, the tone of the musical instrument is generated by a human who introduces intricacies both intentionally and unintentionally. Through musical phrasing, physical parameters of the tones (e.g. ADSR) evolve (Risset et al, 1982} and in musical contexts the evolution of these parameters throughout a phrase is important. Each sound has its own dynamic evolution: sounds generated from percussion or piano, for example, have a fast attack, whereas sounds generated from flute or violin have a sweeter and more gradual attack (Leccese, 2018). For instance, when a trumpet player plays trumpet, the shape of the envelope changes systematically according to melodic context, dynamic level and articulation. As they play their instrument they will increase breath pressure to prepare to move upward, making the latter part of the note louder (Dannenberg, 1998). Similarly, in the case of the violin and more generally the bowed string instruments, this aspect is governed by the use of the bow. The execution is essential for the determination of the sound envelope: the notes may have an initial peak, reach a maximum at the end or maintain a constant volume without any peak in particular, according to the will and needs of the musician (Leccese, 2018, p.2). All of this points to the need for composers to concentrate to some extent on these details in virtual musical performances they have created:

> The beginnings and endings of each phrase are important; what I hear as a bad sample-based orchestral score is the attack and release part of the notes played. The sound of the instruments doesn't just always start instantly at full volume and cut off right at the end. When a violinist plays a phrase at the end, there must nearly always be a slight diminuendo at the end of the last note, and this is not just volume. You have to consider all those details when choosing and playing samples if you want to make an effective orchestral simulation (Simjanovic, interview, 2017).

> To replicate the manner in which a performing musician shapes a phrase you have to listen to how the notes are being played, how are they connected, how the note starts, if its short or long attack, how long does the note sustains for, how it ends, all of that (Partos, personal interview, 2017).

> Even if a human player wanted he would not be able to play all the notes in a phrase nearly identical, there will be slight variations; you have to utilise this in virtual performance, more or less, depending on how detailed you want your orchestral simulation to be (Rona, interview, 2017).

These are all important points for a composer to consider when listening to their virtual orchestral performances. When the composer acts as a critical listener they are related to the musical events as sound objects, where each musical event becomes material for the composer's mind. This process provides the composer with insight into the physical parameters of the sound and the relevance of these parameters to the resulting orchestral performance. Critical evaluation of physical aspects of the musical events is a difficult but rewarding process and as such is an important approach to composing orchestral simulations. The ability to hear in greater detail opens up opportunities for further developments and improvements; it enables the composer to separate, organise and modify each individual sound into a cohesive virtual orchestral performance.

Simulation stage activities

Manipulation activity

This activity occurs during the process of creating orchestral simulations where the composer is consciously manipulating musical materials to create an expressive virtual orchestral performance. This process, which consists of deliberate manipulation of musical events, allows composers to manipulate the physical parameters of sounds to shape them into a desirable form.

To achieve satisfying results and create an optimal balance and blend of instruments in the orchestra, during this process the composer uses computer tools to perform modifications on the original sounds in two ways: either by independently changing articulation, loudness, intonation, duration and spatial properties of the sounds produced by various musical instruments; or through timbral transformation, by modifying the timbral characteristics of the sounds.

In the first instance, the goal is to transform the sounds in a way that maintains timbral identity while changing intonation, duration, articulation, loudness and spatial properties—or ‘classical musical processing’, as stated by (Risset and Wessel, 1982). For example, manipulating the articulation of a violin performance (e.g. legato, sostenuto, accent) does not change the timbral characteristics of the violin. A violin is readily identified as such regardless of the way it is played. Further, the violin remains a violin whether it is heard in a small chamber or in a large concert hall. On the other hand, when manipulating and expanding the timbral identity, which refers to the ‘colour’ or quality of sounds, (Wessel, 1979, p.45), the objective is to change certain aspects of the tone of the instruments, to alter the timbre while preserving the richness of the original sound. In this case, by using signal-processing software and hardware (e.g. audio compressors, subtractive and additive EQs) to manipulate and modulate both the amplitude (volume) and frequency of the harmonic content of the musical instruments, the composer is able to achieve the desired performance and create an optimal balance and blend of instruments in the orchestra. With complete control over the physical aspects of sounds, composers can articulate musical compositions on the basis of timbral as well as dynamic and spatial variations. Depending on the level of the composer’s expertise, wishes of the film director, project requirements, budget and time constraints, this could be a labour-intensive effort even with the most sophisticated software and hardware. All interviewed composers were involved in this manipulation activity to varying degrees. This activity is a subjective process that involves a high level of self-awareness, meaning that it requires a composer to trust their own judgment in regard to the quality of their work.

The more aspects of a performance that the performers of real physical instruments have to control in real time, the harder it is for a composer to create an expressive simulation. This applies to solo as well as ensemble performances. Creating a detailed and expressive orchestral performance involves manipulation of individual instruments and instrument sections within the orchestra; a complex task that requires coordination of several elements simultaneously.

Manipulation of musical events involves the deliberate application of skills and techniques towards clear musical goals where the composer's relationship with the compositional medium is characterised by the seeking of control over material and tools. During this process, film composers are using their skills and techniques to control compositional media and articulate their musical statements by manipulating the musical materials. The skills composers possess are applied towards musical expression via manipulation of the musical materials. At any point during this phase the composer has to know what type of action needs to be performed with respect to their perceptions about the current state of the composition. Computer technology provides the composer with the means to apply their skills towards musical expression and enables them to shape recorded material to suit their musical needs.

Creative problem-solving activity

This process refers to creative thinking activity during the simulation stage of the process of creating orchestral simulations where the composer functions as a creative thinker. This process is concerned with generating solutions to problems that are useful and at the same time innovative. During this phase a composer responds intellectually and effectively to musical events to explore different possibilities by identifying and solving various problems.

This approach involves utilising technical knowledge, computer skills and the composer's previous experiences to apply theories and concepts, inform new situations and creatively solve practical problems. Further, it requires that the composer thinks not only in the manner of a composer/performer but as a sound designer and/or sound engineer, which enables them to respond to the physical aspects of the performance and technical qualities of the composition in a deeper way. This phase involves focusing on the various physical aspects and technical elements of the musical events that make up the music. The ability to examine information in detail to identify key or important elements and their strengths and weaknesses, allows the composer to generate step-by-step procedures to solve particular problems.

Like any other creative thinking process this process begins with problem definition (Csikszentmihalyi, 1999), which in turn leads to information gathering and selection of the concepts used to understand this information (Mumford et al., 2012). During this phase a problem is perceived and identified, and ideas are generated for a solution. However, it is not sufficient to just generate ideas; these ideas must be evaluated and solutions based on these ideas presented (Basadur et al., 2000, Osburn and Mumford, 2006). Further, possible answers to a problem are explored and gradually transformed into viable solutions. Tasks that require composers to think in different ways about music ideas and how to combine them in a piece of music challenge them to be flexible to generate a variety of ideas and responses, and consider these from the perspectives of a composer, performer, audience and sound engineer.

The ability to generate solutions and view situations from multiple perspectives can provide new insights and generate new ideas. In the context of virtual orchestration, creative thought is a process of idea generation and evaluation of ideas. Through a conceptual combination, new knowledge emerges that in turn allows for idea generation and evaluation of ideas. During this process of generating new ideas composers are experimenting with various methods until they find the most successful solution for a problem. Whether the composer is searching for an appropriate sample, melody, articulation or compositional tool for the job, this process generally produces a series of failed associations before a creative solution emerges. If the composer gives up too soon, it is likely that they are not allowing their most promising ideas to emerge. Several studies have shown that the most creative ideas tend to arise after many others have been considered and discarded (Parnes, 1961; Ward, 1969; Beaty and Silvia, 2012). Continuing a course of action despite difficulties may promote creativity by reducing the possibility that people quit too early, leaving their best ideas undiscovered (Lucas and Nordgren, 2015). Many creative ideas emerge only because composers continue to work on a problem, rather than giving up in the wake of non-satisfying initial results.

This kind of persistence is one of the main characteristics of this activity; the composer must be persistent, that is, to be able to generate a large number of ideas or solutions and to make a conscious effort to continue to generate alternatives even when they are partly satisfied with what they have created. A persistent composer is able to push past the first 'usable' solution and generate several more 'usable' solutions to benefit from having options to test and select from. In this way, the composer is able to enhance they creative ideas or concepts by creating more ideas and transforming old ideas into new ones with greater potential.

Characteristics of virtual orchestration

In this chapter I have presented a new theory of compositional practice that involves a complex set of relationships between different compositional states of mind and compositional activities in which film composers experience music and interact with musical materials and media in many ways. This compositional practice proceeds in stages over time where all the procedures are applied again and again between stages. Throughout this process, the composer's involvement in the act of composition oscillates between compositional activities, such that the composer is most of the time in a condition of multistate involvement. As has been shown, composers frequently switch between stages while performing different activities and can be in one or another stage as situations demands. This is a continuous process of composition where compositional activities are not performed sequentially in any particular order; rather, they are arranged as in the continual circular diagram shown in Figure 8.5, according to a phenomenological progression.

Figure 8.5: Virtual orchestration—compositional stages and activities

Composers are often mostly in one stage or another, even if just for a short period, as they repeatedly go back and forth between stages and can be in multiple stages performing different activities at the same time. At the left side of Figure 8.5, exploration and performance activities, are those in which the composer explores the types of instruments, arrangements and music styles that can be provided by suitable textures while improvising with the resources to create music. During this phase, while creating a musical foundation for further developments of the film score, the composer is acting intuitively and consciously to make several crucial musical decisions regarding their compositional goals.

At the right side of Figure 8.5 are activities involving the composer taking a position of analytical distance where he they are listening to music to perceive and interpret sound information. Throughout this phase. the composer’s activities are influenced by their previous musical knowledge, personal feelings, tastes and opinions, and they require the composer's subjective response to musical sound signals. While engaged in these activities the composer is involved in musical tasks at an emotional level and makes subjective judgments about the state of their compositional materials. During this phase, composers are interpreting both the feeling and meaning of musical events in the context of the narrative as well as the expressive characteristics and physical details of the music that are most important for capturing the intended feelings. At the bottom left of the diagram are the activities in which a composer is deliberately involved in the manipulation of musical materials, employing computer technology in creative ways. This process requires that composers respond intellectually and effectively to the musical events to explore different possibilities through the working through of various problems and potential solutions.

A characteristic of this compositional practice is that it consists of a number of interlinked activities including different degrees of intuitive to conscious thought, and from emotive to analytic experiences where the composer can approach the process of composition in a number of ways. A composer's attitude towards compositional processes is influenced by a particular project's requirements and their personal feelings and opinions; rather than by any special sequence of activities or the use of one or another compositional tool.

Chapter 9: Conclusion

This thesis has concerned itself with an investigation of the film composer's creative practice of creating orchestral simulations for the purpose of the film score. To best understand this process, it was necessary to understand first-hand what composers do, through observation and examination of their approaches to creating virtually orchestrated performances using computer technology and their thought processes during this process of composition.

To effectively address the research question, one of the most important things was to select the most suitable methodology for the project. As the focus of this study was to investigate film composer's creative process of creating orchestral simulations for the purpose of the film score, a descriptive approach using qualitative multiple case study methodology was adopted. The qualitative multiple case study approach chosen for this study enabled exploration of a phenomenon within its context, which ensured that research questions were examined from a variety of viewpoints. This allowed for multiple aspects of the 'orchestral simulation' phenomenon to be uncovered and understood. Such qualitative research approach allowed to identify issues from the perspective of study participants and understand the meanings and interpretations participants applied to behaviour, events or objects. This was achieved through an investigation of computer-assisted film music composition, informed by an extensive discussion concerning the use of computers and virtual sample-based instruments in various stages of the creative process of the computer-assisted film composer, and exemplified by the actions of seven stylistically different professional composers working in the field of feature film as the primary valid source of data. The exploration included semi-structured interviews with composers, observations and analysis of their studio practice and inspection of their tools.

The seven professional film composers were purposefully selected to represent a wide range of current computer-assisted film-scoring compositional practice. The selection of experienced and very high-profile film composers strengthened the research findings and ensured that the practices investigated are of high quality. Given the detailed level of data collected, a sample size of seven professional film composers provided a reasonable range of individual differences among composers.

In choosing the multiple case study methodology approach, this study showed that the use of a multiple case study provided the best method for investigating composers' actions and their creative thoughts during the process of film music composition; at the same time, it revealed the way composers utilise digital music technologies for producing orchestral simulations and the effect such technologies have on the creative process of film composers. The use of parallel case studies provided an opportunity to compare and contrast compositional experiences and prevent the study becoming idiosyncratic; moreover, the experience and diversity of the selected composers ensured a high degree of confidence in the trustworthiness of the data.

Taken as a whole, the evidence from this study shows that the process of creating orchestral simulations is a multifaceted compositional activity, which involves a complex set of relationships between different compositional states of mind and compositional activities in which film composers experience music and interact with musical materials and media in various ways. This creative activity is a process of a single person that presents a mixture of compositional tools, skills and abilities brought into existence through a creative process that requires a thorough blend of art and craft to be demonstrated at all times.

The evidence from this study shows that the computer interface (physical, audible and visual) utilised by film composers during this creative cycle has a significant influence on the compositional process and compositional outcomes. This is manifested in the way that the design of a computer music technology dictates the potential views and manipulations possible. At the same time, the efficiency of a computer interface and the software that drives it is clearly related to the composer's ability to utilise its functions to present their musical intentions and convey a detailed, expressive and convincing musical performance. For the case study composers, a physical, audible and visual compositional interface was the medium through which they transmitted, perceives and understood their music.

As with traditional instrumental playing, where every nuance, every modulation or small control variation has to be addressed physically by the performer, physical interfaces provide film composers with direct control over all aspects of the production of sound. The efficacy of physical controllers is dependent upon the composer's musical preferences and their skill in efficiently incorporating this technology into their creative process. A continual dependence on audio feedback during the process of composition demonstrates the importance of audible interface as a compositional tool. When listening to audio feedback, composers are judging the progress and success of their work to the point where audio feedback becomes not only a depiction of the music but the music itself. The significance of a true audio representation and accuracy in detail during the process of composition is important because the audible interface is the medium upon which composers rely when making choices and final judgments about their work. Audio feedback provides fidelity and transparency to audio recordings, emphasising the artefacts of sound material.

Further, because the process of creating orchestral simulations requires working with MIDI and audio events, a visual interface provides necessary assistance as it visually represents the audio outcome of the composition. Composers who pay particular attention to micro-details and the complexity present in all human performances of acoustic instruments utilise visual interface as a necessary tool to create the most detailed and nuanced performances. This all suggests that the hardware and software of compositional interfaces is critical in the communicative process and provides the channel for communication between composer and computer system. In the same way music is created through the interaction of musician and instrument, orchestral simulations are created between a composer and the compositional interface as his instrument.

Traditional formulations of music composition as a multistage process (e.g. inspiration, preparation, elaboration) can be applied to the process of creating orchestral simulations. This study has demonstrated that this process of composition, in which computer technology is a primary tool for composition, begins with good organisation and careful preparation. This early stage of compositional practice is essential because it provides film composers with a consistent and familiar creative environment where ideas are developed and, in later stages, logically articulated. As I have shown, the process of developing ideas starts at the piano, MIDI keyboard or in a composer's mind. Often, early ideas are metaphysical or metaphorical ideas that are then suppressed or amplified using computer technology. Ideas are developed around intrinsic features of the central characters or aspects of the narrative of a film but at the same time are influenced by computer technology as the composer's compositional tool. When the composer utilises computer technology as their compositional instrument the effect of that instrument is evident. For a composer, it is important to understand and account for the limitations of all instrumental forces, as these influence conceptualisation and the composition of the cue or arrangement. The expertise of a composer, I argue, is to clearly define the musical concept for the film and then translate that concept using computer technology into an expressive musical performance.

Translating the concept into a musical performance is a production process in which a single person fulfils the multiple roles of composer, performer, listener and sound engineer. This is a stage where emphasis is on the composer who is involved and is responsible for both creative and interpretive processes. It is important that during this stage, the composer's working style constantly shifts and changes between being composer, performer, listener and sound engineer, as these changes result in differences in compositional activities and the resulting music. As an outcome of this, multiple roles performed by the composer result in different musical experiences and perspectives during the process of composition. During this phase of a composing process the composer's attention is directed towards musical objects or events situated in the context of the film. The composer's fundamental compositional goal is to produce sound patterns that express emotion that is jointly recognised and experienced by the audience. This requires the composer's focus on the audience's perception and emotional response while watching the film. Throughout this phase the composer's activities are influenced by their personal feelings, tastes and opinions, which requires their subjective emotional response to musical sound signals. While engaged in these activities the composer is involved in musical tasks at an emotional level and makes subjective judgments about the state of their compositional materials.

At the same time, during this phase of the composing process, the composer's attention is directed towards the expressive characteristics of the musical performance. From this perspective, the composer's focus is shifted towards technical aspects of the sound and physical details of the music. This involves the deliberate application of skills and techniques towards clear musical goals where the composer's relationship with the compositional medium is characterised by the seeking of control over material and tools. Computer technology provides composers with the means to apply their skills towards musical expression and enables them to mould the recorded material to suit their musical needs. With the help of today's computer music technology, composers have the ability to manipulate audio signals and shape the basic elements of complex waveforms produced by acoustic instruments while maintaining sonic integrity. This allows composers to alter the expressive character of their virtual performance and create orchestral simulations that simulate both the behaviour and character of a real orchestral performance. Both perspectives of musical experiences are valid since they provide important insights into different approaches to how musical ideas are transformed into virtually orchestrated performance using computer technology as the primary tool for music composition.

In saying that, translating musical ideas into an expressive virtual musical performance goes beyond the computer hardware, software or musical style of the composer. I argue that professional film composers are effective because they exercise their skills through a compositional process that involves a complex set of relationships between different compositional states of mind and compositional activities in which they experience music and interact with musical materials and media in many different ways. During this continual process of composition, composers are often mostly in one stage or another, even if for a short time as they are repeatedly going back and forth between stages and can be in multiple stages performing different activities at the same time. As shown in Chapter 8, composers are continuously switching between stages while performing different activities and they can be in multiple stages as situations demand. Throughout this process, the composer's involvement in the act of composition oscillates between compositional activities such that a composer is most of the time in a condition of multistate involvement. The importance of multistate involvement in computer-assisted music composition demonstrates the complexity of film music compositional practice and the versatility of professional film composers.

A characteristic of this compositional practice is that it is a mixture of a number of interlinked activities, which include different degrees of intuitive to conscious thought and emotive to analytic experiences where the composer can approach the process of composition in a multitude of ways. From the beginning to the end of this process, composers focus their attention on their understanding of the music, clarifying their intentions and using their skills to achieve those intentions. The composer's involvement in compositional processes is influenced by their personal feelings and opinions and can be suppressed or amplified using computer tools and scenarios. Computer technology as a compositional tool enables the process and its applicability is evaluated by the degree to which computer technology provides different possibilities, which in turn leads to productive creation of music.

Significance of the study and suggestions for further research

The literature review for this project (Morgan, 2016, Borum, 2015, Karlin and Wright, 2013, Brown, 2001) indicated that this area of practice is yet to receive systematic scholarly attention. There are no precedent studies and no specific sources in the literature that directly address the research questions posed in this thesis. The use of computer music technology is pervasive in all professional screen music scoring contexts, yet little is known about the creative process of creating orchestral simulations for the purpose of the film score, beyond the anecdotal observations of composers in the field. Thus, this research project represents a significant step towards an improved understanding of the composer's role in the process of film music composition and how computer technology has affected this process. It constitutes an important contribution to the diverse community of educators, practitioners and researchers who are working closely with new computer technologies in the fields of music composition, music technology education, and the film industry. The findings will be useful to inform the film composer's process where creative decisions are constantly being made around how to create orchestral simulations and how to incorporate and meaningfully *use* computer music technology during the process of film music composition. The research findings provide a systematic way of making these decisions and understanding more clearly the benefits and limitations of various approaches.

The findings in this research make it useful to a broad range of scholars who are both music experts and non-experts, scholars who have interest in the creative process. Experts in music or music composition can compare their own methods with compositional methods of the professional film composers and the particularities of their problem finding, decision-making and problem-solving processes. In this regard, this study provides valuable information for the field of music composition teaching practice, where a clearly defined need exists for more comprehensive and thorough examples of particular features of compositional processes. For non-musicians interested in the creative process, the description of the emotional states of composers and their cognitive processes during the process of composition may resonate with others given similarities to their own experiences of creative process and allow them to reflect on differences.

In the area of compositional theory there is the opportunity to extend this project in a number of ways, including through investigation of a larger number of composers in a more diverse range of styles and cultures. Such studies could corroborate or disprove the findings made here and, more usefully, improve the understanding of music composition and compositional tools not just in the film-scoring context but in other music genre projects such as folk music traditions, non-Western music and electronic dance music. Expansion of this model of creative practice into other disciplines is a promising pathway for research.

One obvious question is how the findings of this research might be used in a classroom and how to implement music composition by means of music technology in education. The virtual orchestration model of creative practice, its stages and activities as presented in this thesis cover the wide range of approaches employed by professional film composers and would seem useful as a template for examining the progress of developing film composers (students). The curriculum could be constructed in a way that students are exposed to activities that require them to act in each of the stages at some point. Examining the curriculum from the perspective of student experiences, based on the stages and activities presented in the virtual orchestration model, would be an extension to the work of Chen (2006), Newman (2008), Swanwick (1994), Gardner (2011), Brown (2003) and others who advocate for activity-based taxonomies such as improvising, composing, listening, performing, problem solving and reflecting or revising. This would allow students to break down the processes of composing and decision making in composition into a series of small steps. This complex process of music creation would stimulate the student to develop the capacity to think about the process of composition and sound in a detailed way.

The utilisation of music technology during the process of music composition clearly illustrates the point that such technology enables direct manipulation of sounds, which involves a different approach and transformation of the knowledge and skills used in traditional ways of composing and performing music. Simultaneous control over different musical elements throughout the process of composition, as well as the ability to truly manipulate the various musical elements into an expressive whole, would greatly empower students musically and expand their formal musical skills in a computer-based compositional environment. This multidimensional approach to creating music, which enables control over basic elements (pitch, dynamics, timbre, duration, tempo, texture and form) would foster multidimensional thinking in music and allow students to concentrate on individual musical elements. This would also force students to think in sounds and experience the expressiveness of their own music performance.

Further, the model of creative practice presented in this study identifies various aspects and operations that are essential for producing a creative product. First, computer-assisted composition provides immediate feedback, which in turn provides conditions in which students could audition their composition immediately throughout the process of their work in both final and draft forms. This would allow students to make informed, conscious decisions regarding different aspects and activities that are essential in producing a creative product. This would enhance the creative process of students, particularly those without musical training. By enabling students to personally experience the results of their film music composition using computers, important music learning would take place as different musical ideas were tried, revised and improved throughout different phases of the process. Second, a film scoring process using computer technology requires skills in critical thinking, analytical thinking and problem solving. This process of composition utilising technology constantly presents interesting problems to solve, offering students a chance to develop and improve their skills and their abilities in the areas mentioned.

There are many ways a musician or composer can attempt to get the most from their digital orchestra to achieve that sense of expressiveness and realism. Some technologies offer endless possibilities, while others have limited options; some are easy to operate, while others are complex and require detailed attention. With technology assisting in achieving the desired results, undoubtedly, computer software and hardware—along with elements pertaining to the musician or composer, such as their level of skill and technical proficiency—play an important role in making music nowadays. However, other parameters are just as important in this process and needed to be addressed; they are equally important to understand if a truly sophisticated end product is to result.

To reveal aspects of advanced film composers' compositional practice, I have examined seven professional composers against a theoretical background of current ideas about film music composition, musical expression, creativity and the philosophy of technology. As time and technology move forward, inextricably linked technology evolves; at the same time composers and their creative process also evolve. At present, when music technology is widely used as a compositional tool during the process of film music composition, it is necessary to understand what composers do and more importantly why they do it, so we can better understand and appreciate the role of the film composer and the complexity of their creative practice that utilises technology for musical expression.

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Appendices

Appendix A: Research journal summary

The data collection process began in 2016 by examining approximately 15 hours of video material of professional film composer Tom Holkenborg (aka JUNKIE XL) in his studio while he was working on two future films *Mad Max: Fury Road (2015)* and *Run All Night (2015)*. The data gathered from observation and analysis of this research material—researcher's notes as well as the full transcript of 15 hours of video footage in which Holkenborg created and explained his process of creating orchestral simulations—provided me with insights into his film-scoring practice from initiation to completion, during which he utilised computer music technology as the main compositional tool. This data revealed how he organised the process from beginning to end, his various activities during the process, what compositional tools he used, his creative thoughts, subjective issues and apprehensions. Based on the transcriptions of the video material and researcher's notes, the coding categories indicated a diverse range of themes that emerged from the data. (see Figure A1).

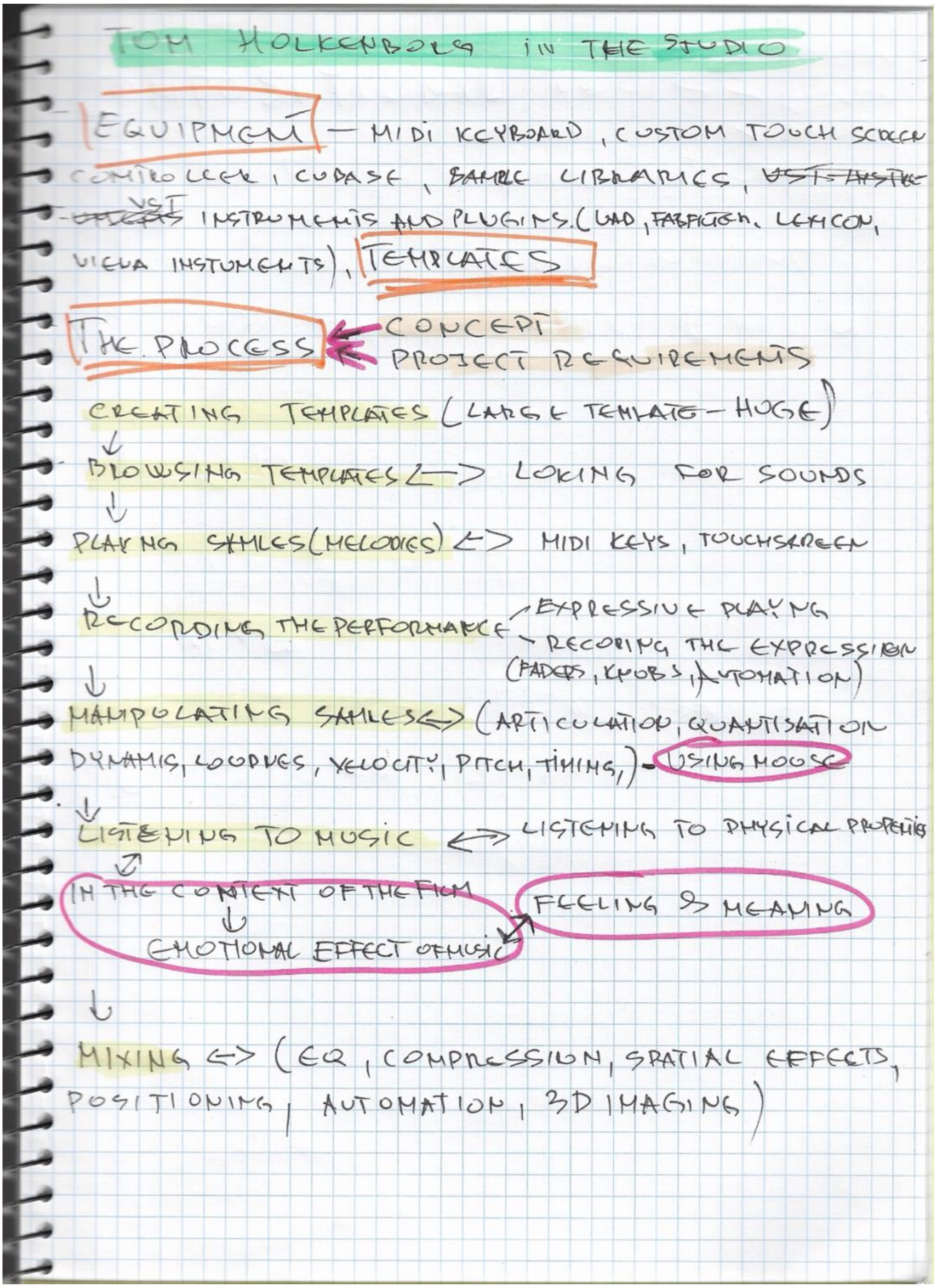


Figure A1: Researcher's notes and summary of Tom Holkenborg's creative practice

Soon after the examination and analysis of data gathered from observations of Holkenborg's studio practice, I began conducting interviews with six other professional film composers. I decided to keep the amount of questions to a minimum during this round of interviews as I wanted composers to explain their process of creating orchestral mock-ups in their own words; what they did from beginning to end and what tools they used during that process.

The rationale for this was to remove biases that might arise from the use of leading questions and avoid leading the respondent to a specific answer. These interviews took place in 2017 over Skype and in person. The length of each interview ranged from 1.5 to 3 hours. This round of interviews was an important step during the data collection and data analysis process as it allowed me to create a wider and more in-depth picture of the process of creating orchestral simulations, since the findings were based on the data gathered from not just one but seven professional film composers. The data gathered from this round of interviews enabled me to expand the initial coding categories into a more detailed coding framework (see Figure A2) as they showed how the composers worked according to their individual circumstances, what tools they used and how they organised their processes from initiation to completion.

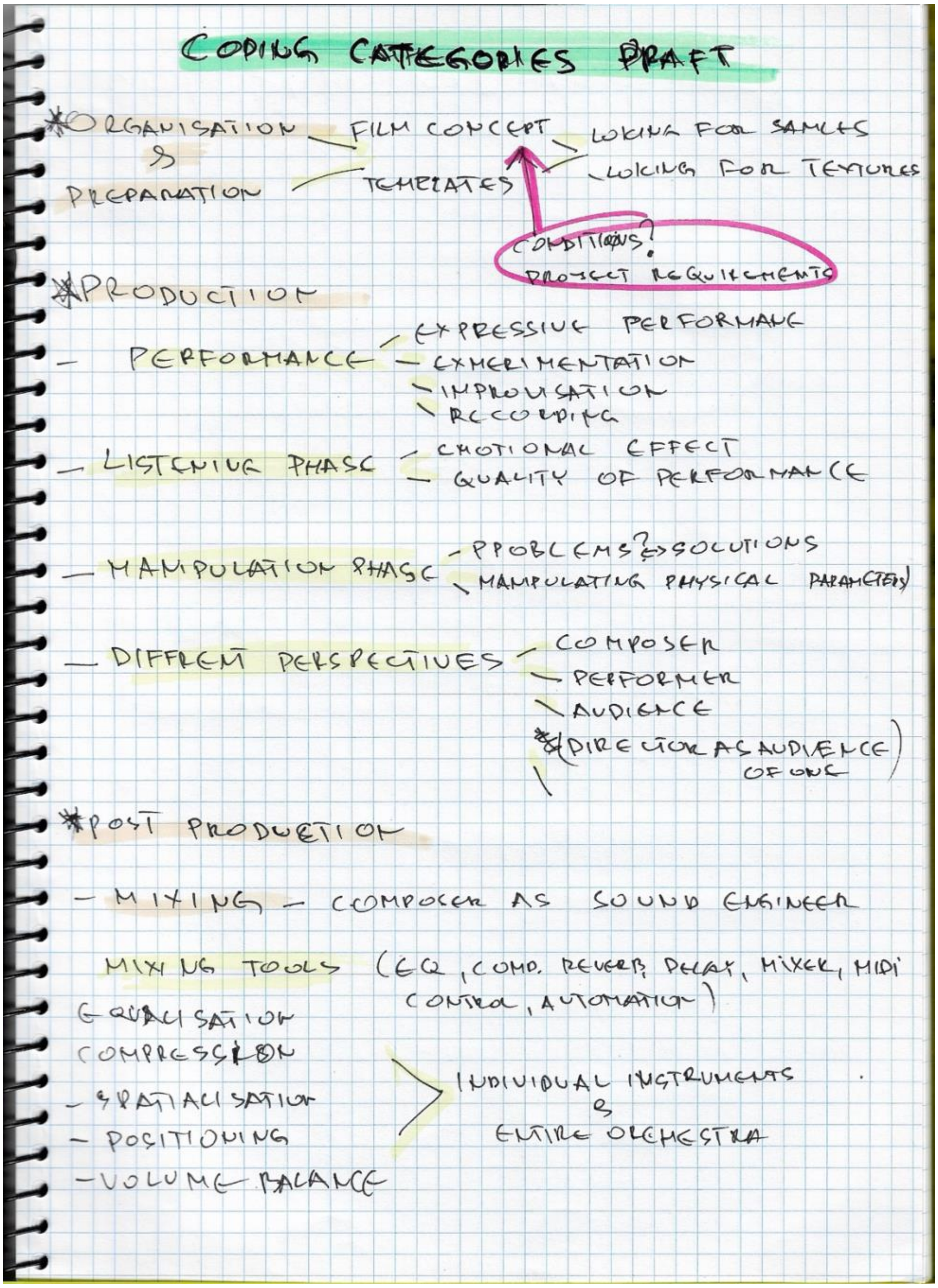


Figure A2: Researcher's notes and draft coding categories

The data from this round of interviews and observations revealed many similarities and few dissimilarities between composers. To construct a theory that was representative of the general practice, I had to investigate further and determine whether or not such minor dissimilarities among composers were relevant in the larger context.

For example, if we consider the process of sample manipulation, the data from the first round of interviews showed that each composer manipulated samples to some extent. Depending on different circumstances, a composer might spend hours or even days processing and manipulating samples to make them as expressive and as convincing as possible. Observing the composers in action and asking them to explain this process revealed how they did things and what tools they needed to accomplish a specific task. Observing and interviewing composers performing such actions showed that all composers were doing exactly the same thing in a slightly different way, using different techniques, or using the same tools in a different way to complete the exact same tasks. One composer might change the articulations of an instruments by a certain amount and apply an amount of reverb to a sample to some degree; while another composer might change the articulation in a different way or apply that same reverb slightly less or more. Continuing in the same manner, one composer might position (pan) the instrument or instrument section to the left while another might position to the right and so on.

To determine whether those dissimilarities were relevant in the larger context I had to discover why the composers engaged in such actions in the first place during the process. Therefore, asking questions about why they performed an action was a logical next step, as it could potentially reveal the reasons behind composers' actions and ultimately whether these reasons were the same for all composers regardless of how they did it or what specific compositional tools they used.

To gather the additional data that were crucial to this study, another round of interviews was conducted. These interviews took place in 2018 over Skype. This time, the composers were asked a number of specific questions that related to their thoughts and rationale for their compositional activities because. It was considered that responses to such questions might provide a deeper understanding of the creative practice, how composers perceive the practice and what is the nature of the interactive relationship between composer and music materials.

The data gathered from this round of interviews revealed the missing elements from previous interviews and observations of the composers' studio practice. This helped me to create a final and very detailed coding framework consisting of codes, coding themes and global themes (Appendix C). Together with the data collected from previous interviewing sessions and observations, the research findings from this round of interviews made it possible to more comprehensively identify similarities and contradictions

Negative data such as specific techniques and to what extent each composer was manipulating a sampled instrument were labelled as insignificant in the larger context as they would only lead to a very subjective description of the practice that had no effect on the fundamentals of the practice, which is 'what composers do and why they are doing it'. It was important in this case to reveal the process of creating an orchestral simulation, what was involved in the process and what were the reasons behind a composer's actions throughout the process of making orchestral simulations. In a similar manner, negative data such as the ways in which the composers used equalizers, compressors and reverbs, or how they mixed or manipulated physical properties of instruments were discarded as they simply showed numerous ways of doing the same thing. What turned out to be more important after analysing the research data was the discovery that all interviewed composers were using the same compositional tools for the same purpose and that all were performing the exact same actions over and over from initiation to completion (see Figure A3), and for the same reasons.

All of this this led to the research findings and arguments presented in Chapter 4–7 and ultimately, to the discovery of compositional practice presented as a theory in Chapter 8, which encompasses and describes most actions and thought processes that take place during this creative activity and were common to all composers involved in this study—regardless of their project requirements, musical and compositional styles, specific compositional techniques and type or brand of equipment they were using.

After the first full draft of the PhD thesis was complete, in early 2019, a final round of interviews with professional film composers took place. This round involved more of a discussion that an interview process with the composers as I wanted to explain to them what I had done so far and how the information they provided during the interviews had contributed to this academic research, and to check the accuracy of the data collected during previous rounds of interviews and observations.

I found that this research process was similar to the music-making process, where at the beginning of the process different ideas were formed. At first those ideas were incomplete but as the research progressed, additional new ideas and directions emerged through the repetitive process of examination and clarification. Throughout that process, some ideas were clarified and others were dismissed as further data and evidence were collected, until a clear picture of the professional film composer's creative practice emerged from the research data.

COMPOSER	ACTIVITIES								
	creating orcehstral simulations	using computer music technology - hardware and software (DAW's, sample libraries, vst plugins, physical, visual and audible interfaces)	**conceptualisation** choosing instrumentation based on what that instrumentations says emotional message	**conceptualisation** chosing instrumentation based on musical style	**conceptualisation** chosing instrumentation based on project requirements (TV show, TV commercial, featured film, documentary, video game, wishes of the director)	**conceptualisation** chosing instrumentation based on the budget	creating and using templates	using MID keyboard to play samples and melodies	experimenting and improvising with samples
HOLKENBORG	✓	✓	✓	✓	✓	✓	✓	✓	✓
SIMJANOVIC	✓	✓	✓	✓	✓	✓	✓	✓	✓
ROMA	✓	✓	✓	✓	✓	✓	✓	✓	✓
PARTOS	✓	✓	✓	✓	✓	✓	✓	✓	✓
MANN	✓	✓	✓	✓	✓	✓	✓	✓	✓
ROXYLAND	✓	✓	✓	✓	✓	✓	✓	✓	✓
YEO	✓	✓	✓	✓	✓	✓	✓	✓	✓

COMPOSER	ACTIVITIES								
	using computer mouse for note input, to manipulate musical event and to control software	using MIDI keyboard to perform music expressively **(composer as perfomer)**	using MIDI comtrollers (sliders, potentiometers, mod wheel) to add expression to performance	recording the expressive performance	**manipulation** (articulation, pitch, timening, dynamics, loudnes, velocities) in order to create expressive performance	listening to music as a member of the audience **(composer as audience)**	listeing to the emotional message of the virtual musical performance	lisening to physical properties of recorded music (individual instruments and the entire orcehstra)	**mixing** (equalisation, compression, volume balance, positioning/panning, spatialization) **(composer as sound engineer)**
HOLKENBORG	✓	✓	✓	✓	✓	✓	✓	✓	✓
SIMJANOVIC	✓	✓	✓	✓	✓	✓	✓	✓	✓
ROMA	✓	✓	✓	✓	✓	✓	✓	✓	✓
PARTOS	✓	✓	✓	✓	✓	✓	✓	✓	✓
MANN	✓	✓	✓	✓	✓	✓	✓	✓	✓
ROXYLAND	✓	✓	✓	✓	✓	✓	✓	✓	✓
YEO	✓	✓	✓	✓	✓	✓	✓	✓	✓

Figure A3: Researcher's notes, a check list of composers and their actions during the process of creating orchestral simulations for the purpose of the film score

Appendix B: Sample interview questions

1. Can you walk me through your process of creating orchestral simulations, in your own words; what do you do from beginning to the end?

2. What equipment do you use, hardware and software?

3. Why does a professional composer need all this hardware and software equipment?

4. Do you use templates for each of your projects?

5. Do you have different templates for different projects, TV shows, movies, video games, TV commercials?

6. In terms of sample libraries that are included in your templates, how do you decide which samples to choose for your work? Based on what?

7. Why is having templates important for you?

8. Do you know in advance what kind of virtual instruments you're going to use for your compositions when you are about to start creating orchestral mock-ups?

9. When you are about to start looking for samples for your composition, what do you think about in terms of what qualities in samples you are looking for?

10. What exactly are you listening to when you are looking for samples that you are going to use for your virtual orchestras?

11. Based on what you are making final decisions, when choosing samples for your

compositions?

12. When you are about to start a new project and you are thinking about melodies and motifs, do you experiment with different instruments to see how a particular melody would sound when played with different instruments?

13. When you talked about using the correct instrumentation for evoking a specific kind of emotions, do you think that different instruments bring different atmosphere and evoke different kinds of emotions when put together with visuals?

14. When you're making an orchestral simulation that is actually going to be performed by a real orchestra as opposed to a simulation that's going to end up in a film as a simulation, do you have a different approach when choosing samples for your compositions?

15. How long does it usually take to find the sample that you want to include to your composition?

16. Do you get inspired sometimes by a random sample that you encounter while browsing sample libraries?

17. Have you ever had a situation where you had to change your concept because you could not find the right sample for the job?

18. Are you always trying to record your performance as expressively as you can?

19. What is the most important thing to think about if the goal is to create a realistic musical performance?

20. When you have created something and then you step back from being a composer and you're just listening to your music as a member of the audience, what exactly are you listening to? What are the most important musical aspects of your virtual performance that you are focusing on?

21. When you're listening to the music as a member of the audience, how do you know that what you have created is working or not; that you're satisfied with your creation?

22. How difficult is it for you to distance yourself from being a composer and a performer and listen to your music just as a member of the audience?

23. When you are manipulating your virtual performances, what exactly are you listening to?

24. How often do you manipulate individual articulations, dynamics, volumes, velocities and other stuff that you do?

25. Do you make your own samples and samples libraries?

26. Do you mix your own orchestral simulations?

27. While you do your own mixing, what do you usually do?

28. What are the most important details that you are focusing on when you are listening to your orchestral simulation during the mixing process?

29. How hard it is to shift your focus away from music as a whole and concentrate on listening to each individual instrument and its physical properties?

30. During the mixing stage, do you have any preferable techniques that you always use?

31. When you talked about limitations of computer-generating instruments and sounds, what's the effect of that on your creativity since you have to work around those limitations? You want to do something but you can't so you have to adjust. Does that happen very often?

32. What does computer technology mean for you as a film composer when you are making mock-ups?

33. What are the most important things that the film composer needs to think about and do if they want to create a realistic and expressive virtual performance?

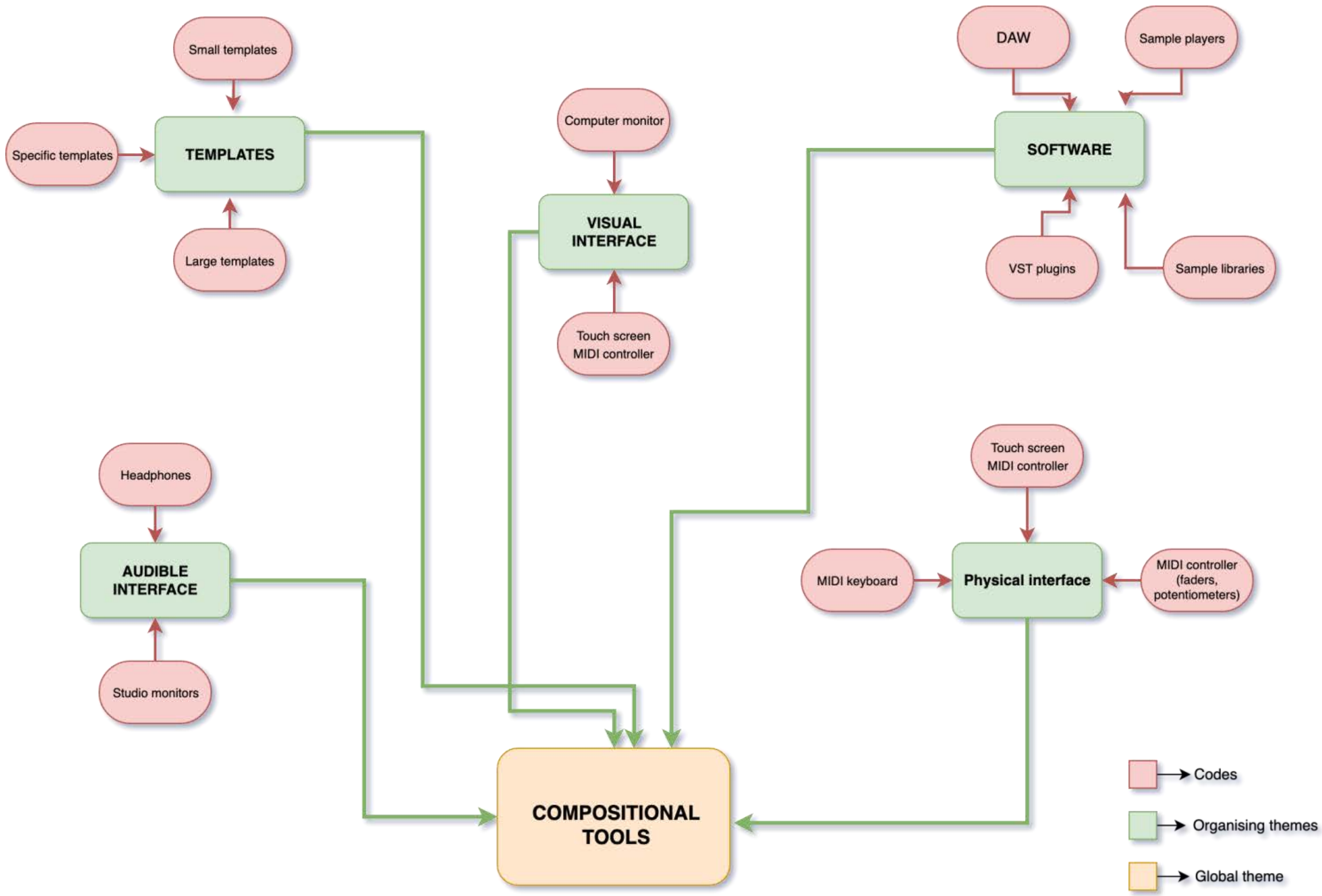
34. What would you say was the biggest change in terms of how film music is being composed today as opposed to how it was before creating mock-ups became a necessary part of your film-scoring practice?

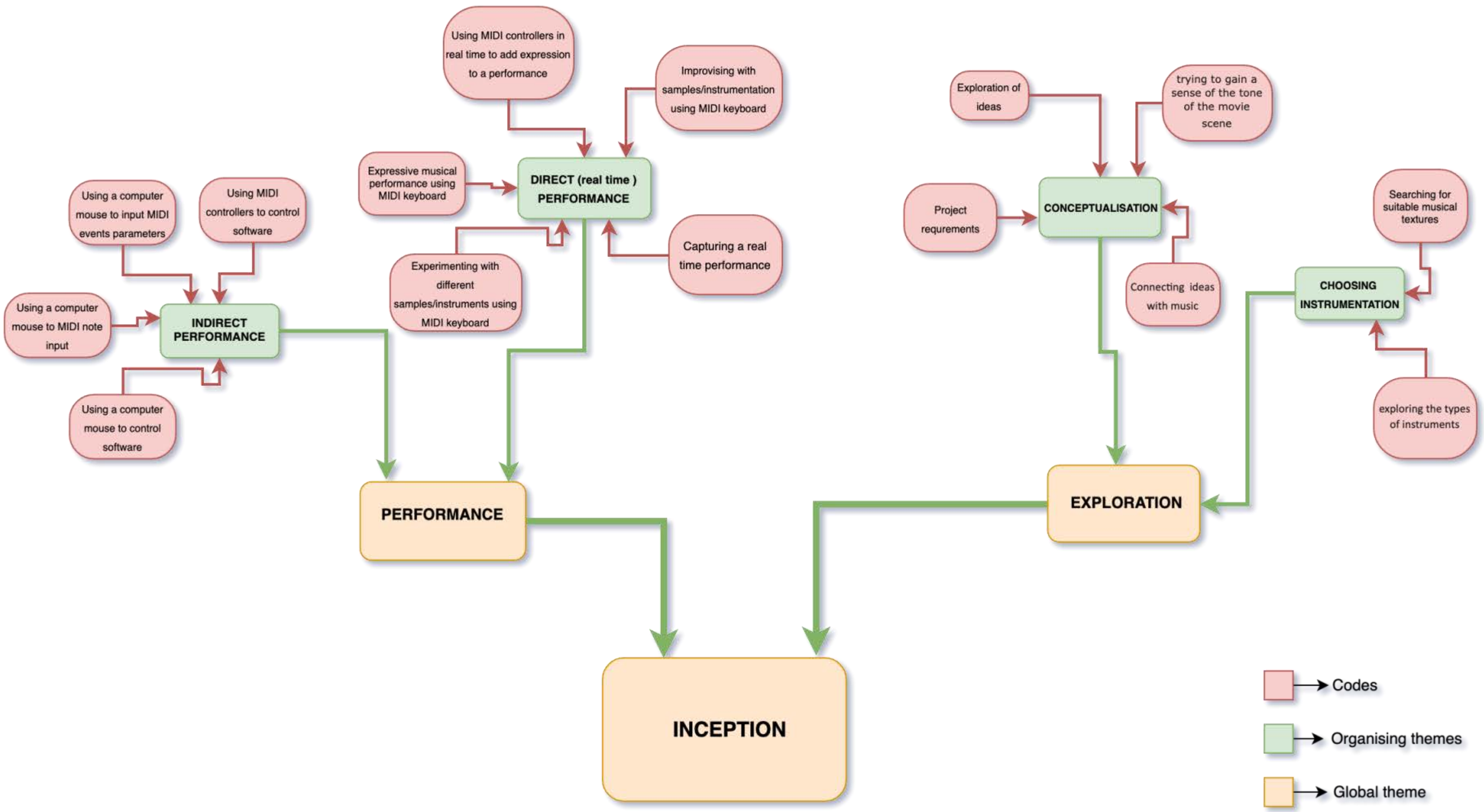
35. To what extent does all this technology at your disposal influence your conceptualisation process?

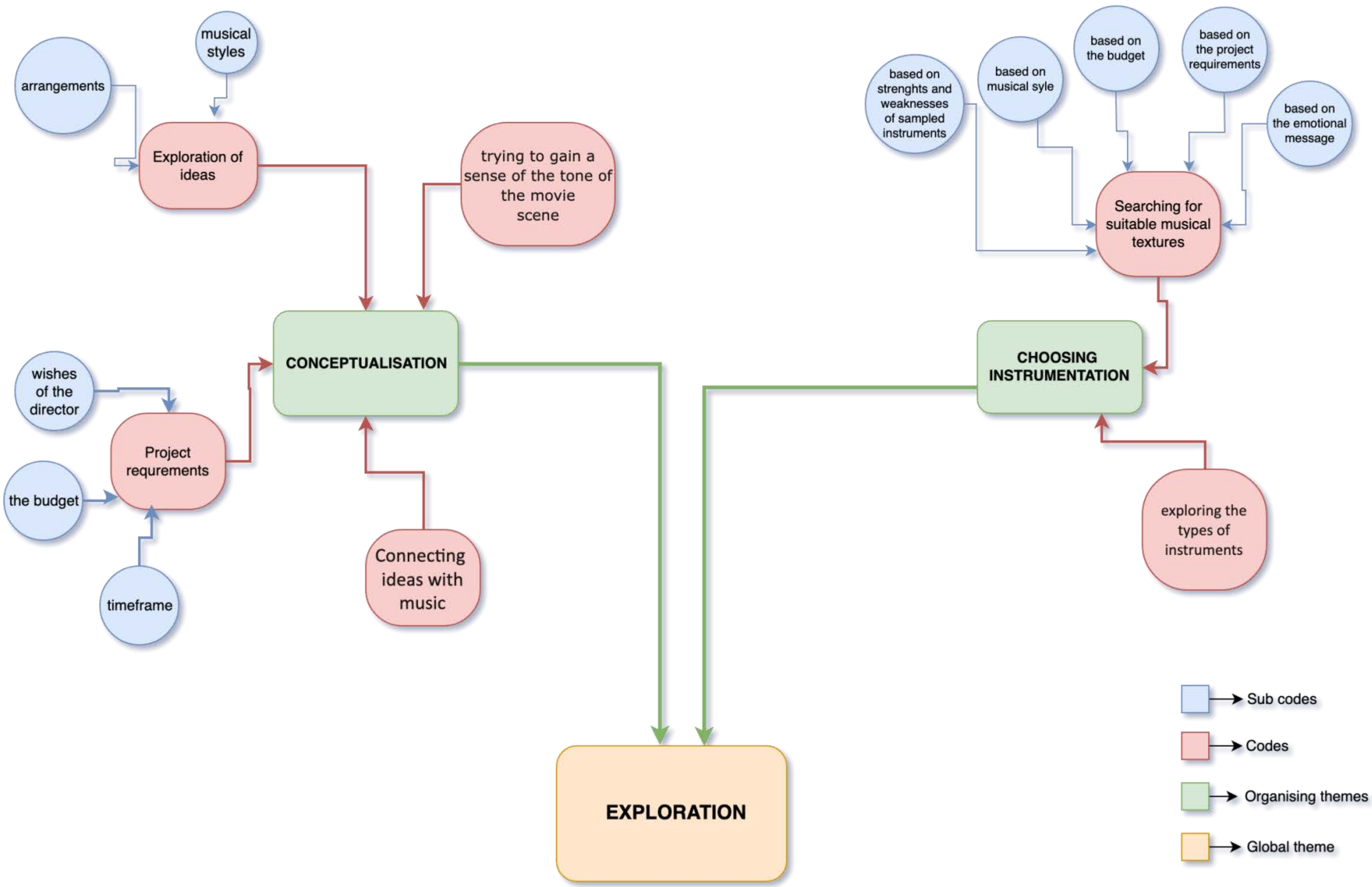
36. What would you say was the biggest change in terms of how film music is being composed today as opposed to how it was before creating mock-ups became a necessary part of the film scoring practice?

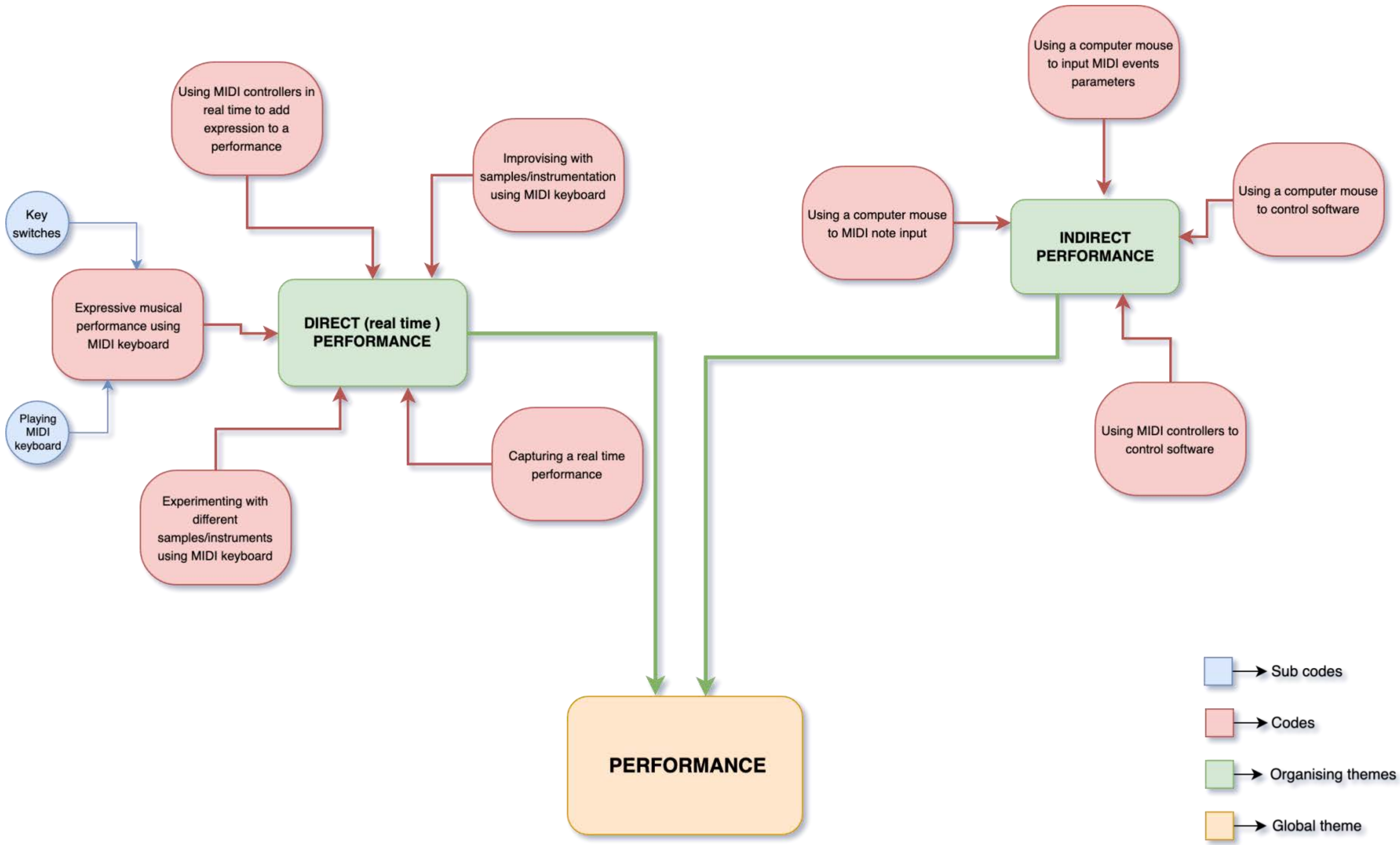
37. Because of everything that computer technology brings to the table, do you think that today a person can be a professional film composer without having the ability to play musical instruments or without a formal musical education?

Appendix C: Coding categories

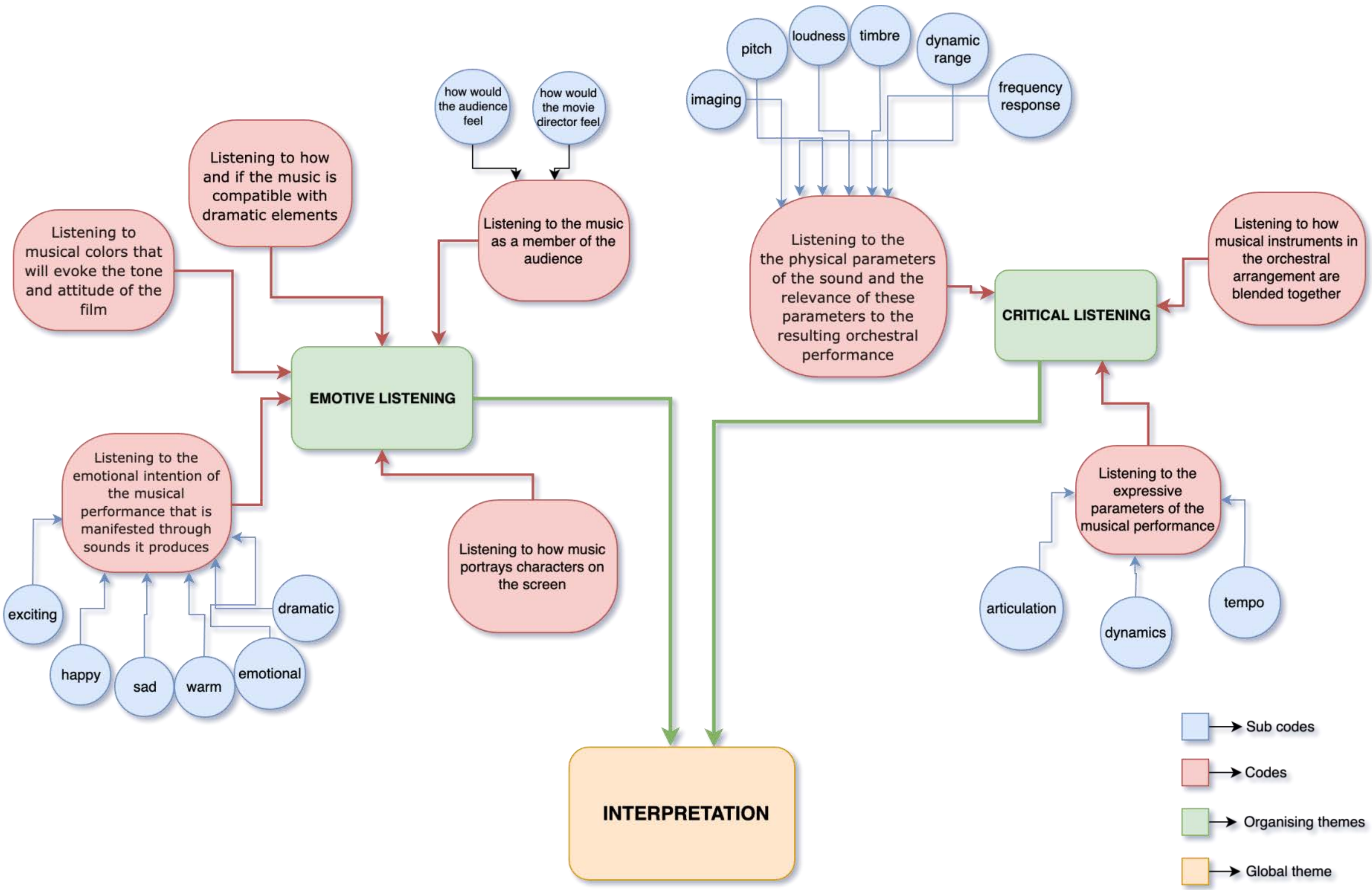


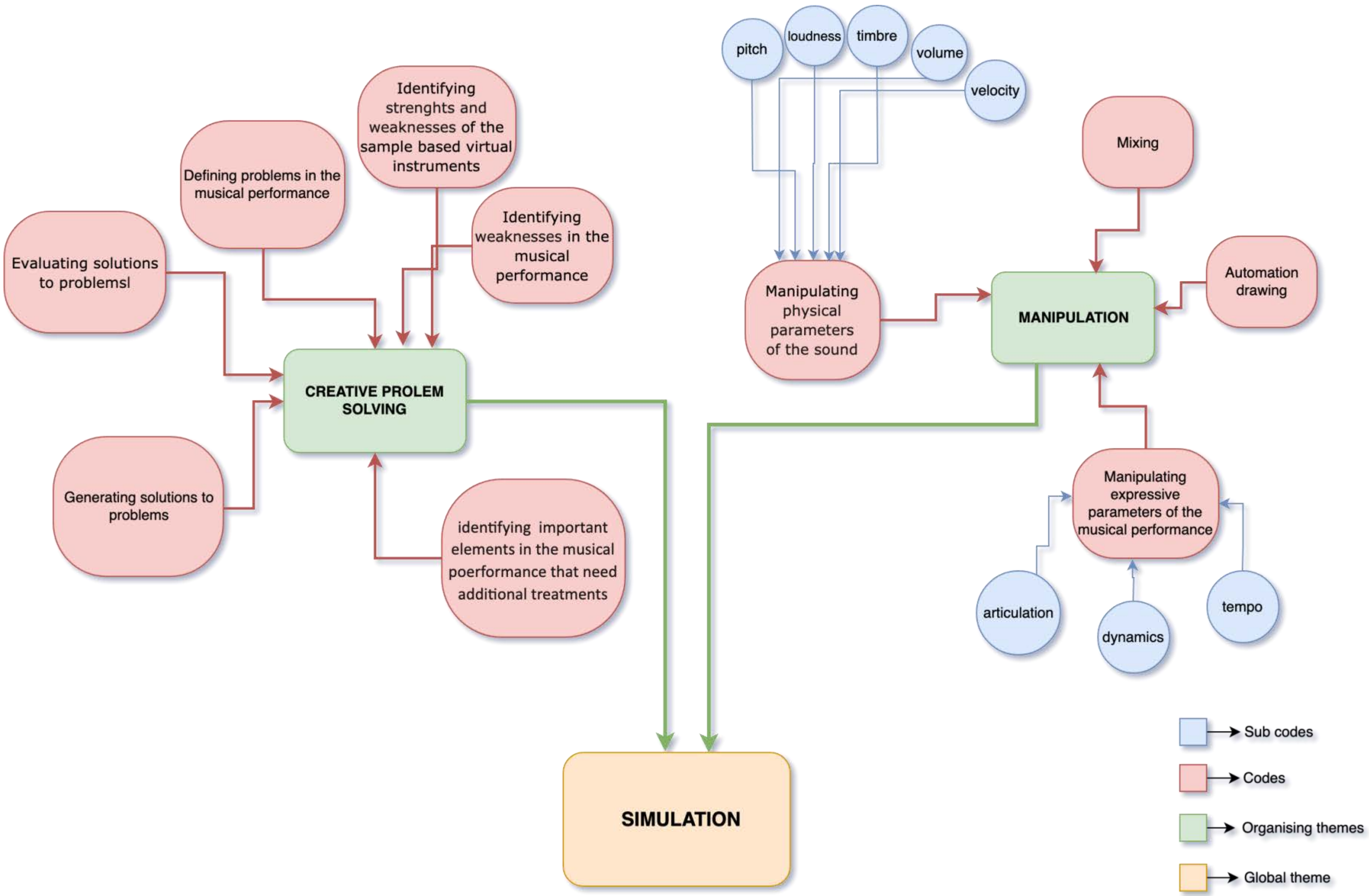

Using MIDI controllers in real time to add expression to a performance
Improvising with samples/instrumentation using MIDI keyboard
Expressive musical performance using MIDI keyboard
DIRECT (real time) PERFORMANCE
Capturing a real time performance
Experimenting with different samples/instruments using MIDI keyboard
Using a computer mouse to input MIDI events parameters
Using MIDI controllers to control software
Using a computer mouse to MIDI note input
INDIRECT PERFORMANCE
Using a computer mouse to control software
PERFORMANCE
Exploration of ideas
trying to gain a sense of the tone of the movie scene
Project requrements
CONCEPTUALISATION
Connecting ideas with music
Searching for suitable musical textures
CHOOSING INSTRUMENTATION
exploring the types of instruments
EXPLORATION
INCEPTION
Codes
Organising themes
Global theme


musical styles
arrangements
Exploration of ideas
trying to gain a sense of the tone of the movie scene
CONCEPTUALISATION
wishes of the director
Project requrements
the budget
timeframe
Connecting ideas with music
based on strenghts and weaknesses of sampled instruments
based on musical syle
based on the budget
based on the project requirements
based on the emotional message
Searching for suitable musical textures
CHOOSING INSTRUMENTATION
exploring the types of instruments
EXPLORATION
Sub codes
Codes
Organising themes
Global theme

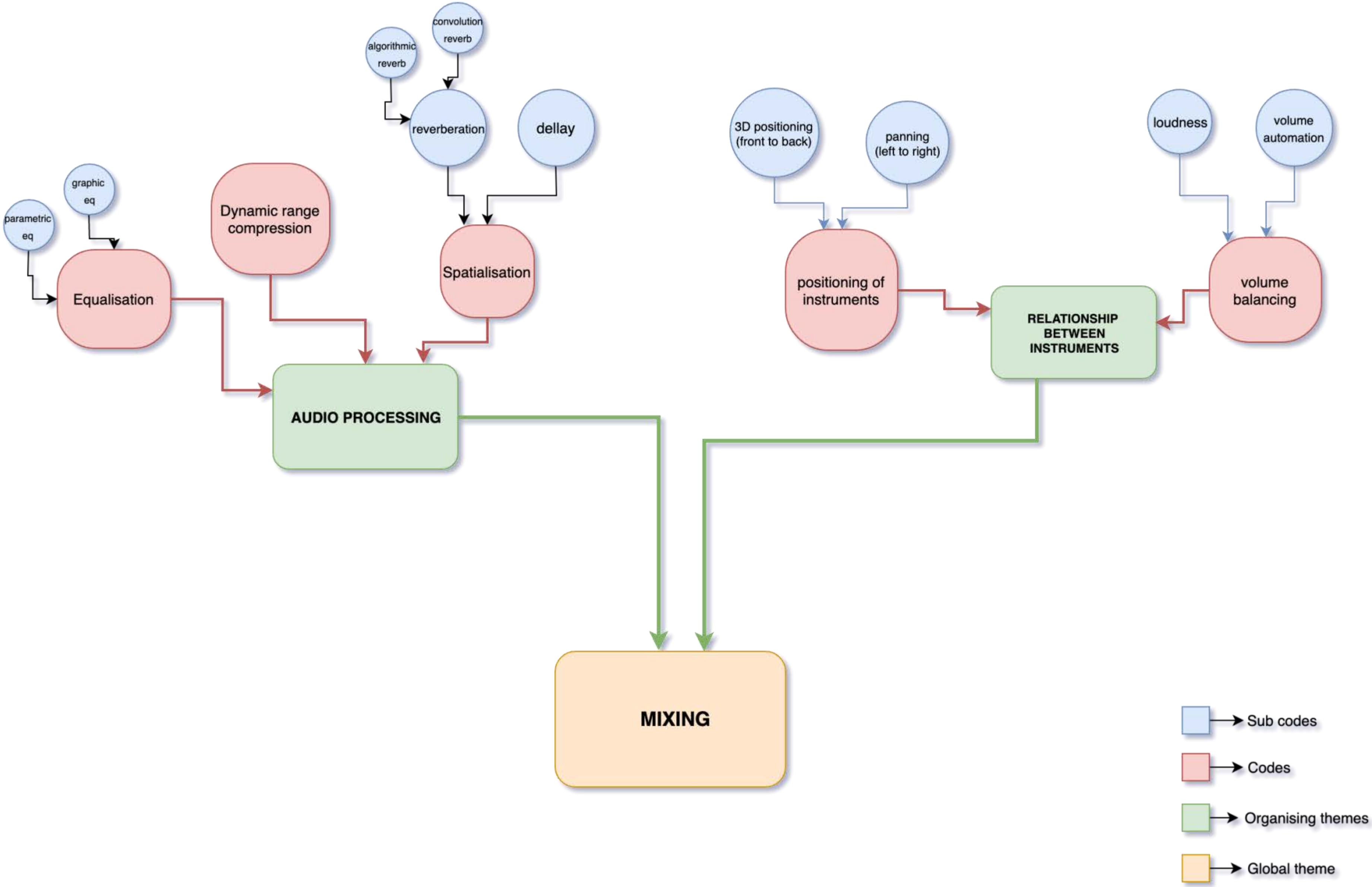


Using MIDI controllers in real time to add expression to a performance
Improvising with samples/instrumentation using MIDI keyboard
Key switches
Expressive musical performance using MIDI keyboard
DIRECT (real time) PERFORMANCE
Playing MIDI keyboard
Experimenting with different samples/instruments using MIDI keyboard
Capturing a real time performance
Using a computer mouse to input MIDI events parameters
Using a computer mouse to MIDI note input
INDIRECT PERFORMANCE
Using a computer mouse to control software
Using MIDI controllers to control software
PERFORMANCE
Sub codes
Codes
Organising themes
Global theme


how would the audience feel
how would the movie director feel
pitch
loudness
timbre
dynamic range
imaging
frequency response
Listening to how and if the music is compatible with dramatic elements
Listening to musical colors that will evoke the tone and attitude of the film
Listening to the music as a member of the audience
Listening to the the physical parameters of the sound and the relevance of these parameters to the resulting orchestral performance
CRITICAL LISTENING
Listening to how musical instruments in the orchestral arrangement are blended together
EMOTIVE LISTENING
Listening to the emotional intention of the musical performance that is manifested through sounds it produces
Listening to how music portrays characters on the screen
Listening to the expressive parameters of the musical performance
exciting
happy
sad
warm
emotional
dramatic
articulation
dynamics
tempo
INTERPRETATION
Sub codes
Codes
Organising themes
Global theme



pitch
loudness
timbre
volume
velocity
Identifying strenghts and weaknesses of the sample based virtual instruments
Defining problems in the musical performance
Identifying weaknesses in the musical performance
Evaluating solutions to problemsl
Mixing
Manipulating physical parameters of the sound
MANIPULATION
Automation drawing
CREATIVE PROLEM SOLVING
Generating solutions to problems
identifying important elements in the musical poerformance that need additional treatments
Manipulating expressive parameters of the musical performance
articulation
dynamics
tempo
SIMULATION
Sub codes
Codes
Organising themes
Global theme


convolution reverb
algorithmic reverb
reverberation
dellay
graphic eq
parametric eq
Dynamic range compression
Spatialisation
Equalisation
AUDIO PROCESSING
3D positioning (front to back)
panning (left to right)
loudness
volume automation
positioning of instruments
volume balancing
RELATIONSHIP BETWEEN INSTRUMENTS
MIXING
Sub codes
Codes
Organising themes
Global theme