Sound Design for Nonlinear Artefacts

Models for Sound Design in the Transformation between Linear and Nonlinear Artefacts

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Abstract

This thesis contextualizes the portfolio of related works that I created in the period from 2009 to 2011, which involved applied sound design for both linear and nonlinear artefacts, within the fields of fine art and urban design. It recounts the research, the concepts and the themes that inform the works in the portfolio. The main subject matter is the difference between linear and nonlinear artefacts and how this influences the sound design for these artefacts. The study discusses the design decisions based on a proposed framework of concepts, models and definitions. The framework is devised from a study on the theory and practice of sound design for existing nonlinear artefacts, such as digital games and virtual reality. The material is explored in, and reinterpreted for, the contexts of fine art and urban design. The conceptual relation between these two fields is explained. There is a focus on the refashioning of content from linear to nonlinear formats and reverse, as this is an essential element in the design of the presented works. Key issues addressed are: the difference between linear structures as a fixed trajectory, and nonlinear structures as fluid systems; their difference in time-structure; transformation between these formats; and synchrony between sound and visual elements. A semiotic approach to nonlinearity is connected to the architecture of adaptive systems. From there concepts for sound design are formulated.
The resulting framework that is provided from the point of view of the maker can form a counterpoint to the many cultural studies on the subjects that focus on the experience of the user.

keywords: *sound design, linearity versus nonlinearity, narrative and systems, adaptivity, digital games, remediation, refashioning, recontextualisation, representation, acoustic ecology, synchrony*

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Preface

I started my career in fine art. I was educated in painting, drawing, graphic arts and sculpture and received my BA degree in Fine Art in 1978. My works were sold and presented in art galleries and exhibition rooms. I also created works for architecture, which were applied to public buildings, such as schools. Although I was successful with my activities as a fine artist, something kept me, to some extent, dissatisfied. My oeuvre incorporated 2-dimensional drawings, paintings, graphics and some 3-dimensional installations. Years after I finished their production, all the works I created, remained unchanged. They were physical objects, static and fixed. I found out I was more interested in creating artefacts that were an expression of change and fluidity. I therefore began to experiment with animated paintings, in the form of the projection of both slides and abstract film, and created artefacts that dissolved and transformed from one state into another. Based on these experiments, in 1982 I was commissioned to provide an installation for an architecture festival, where I created my first interactive piece in public space. It was made up of 3-dimensional slide projections on a building[1], which changed, based on traffic movements. Interactivity in art was just emerging in the beginning of the 1980s[2], and there was barely any ready-made technology available to realise my concepts. These were also the early stages of the development of the personal computer.[3] A custom designed hardware computer was fabricated and programmed to my specifications, which allowed for changes in the projections depending on the changes in the traffic flows around the building. The traffic department of the city helped me with the installation of sensors in the form of

[1] The 'Bijenkorf'-building in the centre of Rotterdam, designed by architect Marcel Breuer.

[2] 'With the American artist Myron Krueger the development of computer-controlled Interactive Art started. He began as early as 1969 to conceive spaces in which actions of visitors set off effects.' (Dinkla 1994). In the beginning of the 1980's interactive art installations started to appear in Europe. 'In Amsterdam in 1983 the Australian Jeffrey Shaw produced his first interactive installation.' (Dinkla 1994).

[3] The Apple II, one of the first personal computers, went on sale in 1977. It was limited in the possibilities for interfacing with other systems and not suited for the project.

hollow rubber tubes that were placed on the surface of the road[4]. Vehicles driving over the tubes generated air pulses that were converted into electric pulses. These electric pulses were counted and the intensity of the traffic in the streets that run along the building and in the neighbourhood could be specified. By making use of, so called, 'classifiers', in addition to the number of vehicles length and speed were also recorded. An algorithm translated these data into an aesthetic experience of images on the building that 'breathed' along with the activity on the location. With this I created my first piece that changed depending on context. It was 'context aware' as we would now call it.

During my study at art college I played guitar and wrote songs in several bands and music was my other major interest (that had actually commenced before my first attempts in the visual domain). Later I began to compose music and design sound for my own film experiments. Artists and film makers around me appreciated my musical output and asked me to compose for their films and other projects too. I noticed that I felt more comfortable in the domain of music and sound, especially as it involves motion and change over time. More importantly, the resulting artefacts only exist as long as they are sounding. From this, I gradually developed myself into a composer and sound designer for film, television, radio and theatre. In the late 1980's as interactive media became widespread, I became involved in composition and sound design for these media and also for computer games.

Since the 1990s I have been also active as a lecturer at the Utrecht School of the Arts, where I am involved in higher education and research on sound design and composition for nonlinear artefacts. In this capacity I have broadened my knowledge and understanding, especially during practical projects and in the many discussions with students and colleagues.
In 2008 I was asked to give a presentation on sound and meaning to a group of architects and urban designers. This was the inspiration for an extensive research on the subject of sound in public space, which again resulted into a

[4] These counting tubes, that stem from the 1960's, are still in use today for measuring the intensity of traffic on a certain location. See Appendix 3. for an illustration.

series of new invitations for lectures, consultancies and sound design assignments for urban planning and development projects.
Today, music and sound for nonlinear artefacts and sound in public space are my main fields of interest. It is easy to see how all these activities are interrelated. All involve design of music and sound for real time applications in nonlinear contexts. It feels inspiring to do sound design for the real world after practicing years of music and sound design for film and entertainment. Besides, exploring sound and its behaviour in the real world is very helpful when designing sound for real time fictional worlds.

In 2006 I was approached by fine artist Robbie Cornelissen to design sound for an animation film based on his drawings. Immediately I was intrigued by the challenges of transforming drawings, which are fixed, timeless artefacts, into film, which is an artefact with a trajectory in time. Robbie and I agreed to stay within the domain of fine art as much as possible, and to attempt to avoid linear narrative. This started a cooperation that led to work for another animation movie and sound design for an exhibition, which was in fact, in part, a transformation of the second movie into a nonlinear, real time format.
My interests and fields of work have thus come full circle. Starting out in the nonlinear domain of fine art and public space, then switching to linear domain of sound and music for film, I now re-entered the domains of public space and fine art. This time taking part in the creation of nonlinear artefacts, using sound instead of images. The works that form the portfolio of this MPhil are part of this most recent chapter of my explorations.

Contents

1
Introduction

Contextualization of the portfolio

This is a Practice-Based MPhil and therefore it is linked to my design practice. The final presentation includes both a creative practice component in the form of a portfolio of related works, created during the research period from 2009 to 2011, and this thesis that contextualizes my practice. This exegesis recounts the research, the concepts and the themes that inform the works in the portfolio. Models and definitions are proposed that form a new framework for my design practice. In addition to my work as a composer and sound designer, my practice also includes lecturing. The framework is partly based on research I did on music composition and sound design for digital games and other nonlinear artefacts, in the course of my occupation as lecturer on composition and sound design for adaptive systems, at the Utrecht School of the Arts.
This thesis is accompanied by a Data DVD that contains documentation on the portfolio and film clips that are used as illustrations for the text. It also includes a PDF version of this thesis.

Motivation for the research

The first motivation for the research is clarification. In the field of composition and sound design for nonlinear artefacts, one encounters a disturbing lack of consistency in terminology. In the discourse on the subject this leads more than once to misunderstanding of concepts and ideas. Divergent, and often contradictory, premises and interpretations of terms, result in many repetitive discussions. This indicates there is a serious need for a uniform topology, which involves unambiguous definitions, a system of terms that are interrelated and

can be arranged in models, that can be used for design practice and teaching of design.
Secondly, we need more models that allow for a conceptual approach for makers. Much analysis has been done from the user side of nonlinear artefacts. Research on design usually centres on technical issues or on the workflow of the design process. The dissimilarity between linear and nonlinear artefacts in their time-structure, and as a result the way meaning is created, demands a supplementary conceptual framework for design. This research makes a start by combining models on the creation of meaning, with those on the construction (or architecture) of indeterministic systems. The result is a framework for sound design for nonlinear artefacts.
The research is a reflection on my own context, from and for my own design practice. The aim of the research is to formulate a lucid framework that is meant, in the first place, for my own personal use and hopefully helpful for anyone operating in the same field.

Context

During the 20th century several developments in the creation, distribution and interpretation of information could be discerned. Exciting technological advancements, new scientific views and social change influenced each other in their developments. The century started with the first applications of the new inventions of film and radio, and later television (Van Dulken 2000, chapter 3). These technologies were developed in accordance with the then prevalent industrial paradigm of production and distribution. The industrial approach involves the design of one perfected model that is subsequently duplicated in a factory, and from there distributed based on an economic model of scarcity. Both the technologies themselves and the media content for these technologies were produced in a centralised way and their distribution followed a linear hierarchical path. Industrialisation led to the development of factories for large-scale production (More 2000, pp. 9-29). To start such a production and distribution chain was very capital intensive, and thus it was reserved to a limited number of big companies and organisations. In the history of film we

see the formation of an oligopoly in which a small number of companies cooperated to close the market to competition (Thompson & Bordwell 2003, p. 39). Until the end of the 1940s (with the arrival of domestic television) these companies not only produced the films, but also owned the theatres where they were shown (Balio 1985, pp. 122-123). Film, therefore, can be seen historically as the epitome of the industrial production and distribution process, as is the recording industry in the domain of music (Gronow & Saunio 1999, pp. 135-187). In the same way radio and television use a centralised model for content distribution in the form of broadcasting. Within these technologies, that together with the technology of printing became defined as 'the media', the distributed content has a fixed and finished, pre-produced form. The role of the consumer of these media is passive, in the sense that there is no real time influence on the content. Parallel to all these inventions we have seen a development towards stricter legislation concerning intellectual property and copyright[5], which was necessary to maintain the industrial distribution and business models. These rulings at the same time secured and strengthened the concept of authorship and the notion of authority of the creators and distributors of information content.

At the same time in science, philosophy and politics new ideas emerged. Tendencies towards thinking in terms of relativity resulted in changing views on the phenomenon of observation and the role of the observer (Bor 2003, pp. 377-388). In physics the paradoxes of quantum theory and the concept that 'any event will appear to occur at a different point in time and space to different observers in different frames of reference' revolutionised our view on the world (Whitfield 2012, chapter 32). New theories on perception and relativism led to new ideas on representation. From the 1970s constructivism and deconstructivism in literary studies started undermining the role of the author in the creation of meaning (Barthes 1977, pp. 142-148). By increasingly widespread use of communication technology people became better informed. Further technological developments handed over the production tools to more and more people. The cost of means of production for media content fell

[5] The concepts of copyright, exclusive rights on a work and authorship started with the invention of the printing press in the 15th century (Wikipedia 2013).

sharply and they became generally available and affordable. This resulted in democratisation and decentralisation of production, leading to concepts like the 'prosumer', where the consumer also actively takes part as a producer of content in an information network. The outcome of all these changes was a transition from a centralised industrial economy to the decentralised networked information economy that we know today. A transition from fixed, finished, centrally produced artefacts to fluid, adaptive, decentrally produced artefacts. This change in distribution method from a hierarchical pyramid to a network was paired with a rapid change from physical to virtual goods.
Not only the methods of production and distribution of artefacts have changed from linear to nonlinear, but also the structure of many of the artefacts themselves are becoming more and more nonlinear. In science from the 1950s concepts such as 'stochastic processes' (Doob 1953, pp. 46-102) and 'indeterminism' (Monod 1972, pp. 3-22) were promoted.
In the present day, in media and art there is an increase in new formats for expression with the notions of nonlinearity and indeterminism as a starting point. We can observe a tendency whereby the role of linear narrative as the main distributor of fixed meaning in culture and society is changing. It is taken over by fluid spaces of possibilities for signification in networks, in which author and user have become interdependent for the creation of meaning. These new models have a great impact on the formats of media and art, and their creation and interpretation. The structure of digital games, for instance, can be regarded as a fluid nonlinear system of possibilities for participation that differs immensely from the fixed linear narrative structure of film.

Design models and production methods for nonlinear artefacts slowly evolve from those for their linear predecessors. Their approach is often based on old habits, in the same way that the first movies were in fact registrations of theatre productions and the first film music was based on the traditions developed in opera (Davis 1999, pp. 39-44; Gorbman 1987, p. 28). At the start of sound film sound was rather a matter of recording than of design. Further technological advancements allowed for more complex sound production. Today in many film productions sound design has become a highly developed device for

storytelling. A good example are the films of Joel and Ethan Coen where sound plays a key role in the representation of the narrative (Barnes 2007).
Design and production models for nonlinear artefacts show a similar evolution. Practices that were common to film production formed the starting point for music and sound design for digital games. Just as film needed a different approach for music and sound than did theatre, nonlinear formats need concepts that differ from those for film. For example, the big cinematic orchestral scores as heard in many adventure and FPS games are often problematic, because the pre-eminently linear musical style clashes with the disjointed nature of the narrative. Satisfactory solutions are only slowly emerging and the structural and conceptual differences between linear and nonlinear artefacts are finally identified. The structure of many nonlinear formats in combination with their change in distribution from a hierarchical path to a network based model also challenges our ideas about authorship.
The works in the portfolio present a series of experiments with these new formats and possibilities of creation of meaning and nonlinearity. They use the concepts from my study on nonlinearity and music and sound production for digital games, and are applied within the context of fine art.

Definitions and basic concepts

To demarcate the research field and to ensure consensus on the use of terminology, definitions and basic concepts, as they are used and developed throughout the thesis, are formulated in appendix 1. To keep the document clear and accessible, and not to interrupt the flow for the reader, this part is not included in the main text.

Structure of the research, the thesis and chapter layout

Chapter 1

In this chapter, after an introduction, the motivation and the context for the research are set forth, followed by a description of the structure of the research and the thesis.

Chapter 2

Chapter 2 first presents a description of the works in the portfolio and their position within the MPhil. It is important to see the works **before** (and sometimes while) they are being discussed in the thesis. Next, the research questions are formulated in relation to the challenges of the design process, and the description of the followed research method to answer them.

Chapter 3

Chapter 3 contains a critical review of relevant literature and repertoire. This positions the MPhil within the discourse on sound design for linear and nonlinear artefacts. Some important sources on subjects that are adjacent to the initial demarcation of the subject are not reviewed in this chapter, but are discussed at places where they become relevant to the discussion.

Chapter 4

In Chapter 4 first the key issues in regard to sound design for nonlinear artefacts are addressed and the differences with design for linear formats are set out. Existing concepts and models, also from adjacent disciplines are explored. These are re-interpreted, combined, adapted and extended into a new framework, that is used for, and formed by, the design process of the works in the portfolio.

Chapter 5

The application of the newly devised framework in the design process of the works in the portfolio is discussed in Chapter 5. The mutual influence of the framework and the design process is addressed.

Chapter 6

In Chapter 6 the research questions are recapitulated. The method, the concepts and the proposed framework are evaluated.

Appendices

The appendices present an overview of basic concepts and definitions as used throughout the thesis, extra illustrative material and overviews. It also includes a list of movie clips and the contents of the Data DVD.

2

Description of the portfolio and the design method

Description of the works in the portfolio

Introduction

The following projects form the portfolio for this MPhil. For the understanding of the argumentation in the exegesis it is important to read this section and to see the works **before** (and sometimes while) they are being discussed in the text. In the case of reading the printed version of the thesis it is most practical to have the Data DVD-rom, containing the files, ready to play, in the drive of a computer. Whenever required, links to the relevant files on the DVD are given in the text. The works and their design process are further discussed in chapter 5, where they are placed in relation to the framework from chapter 4.

Sound design for Robbie Cornelissen

Since 2005 I have been working on a number of projects for fine artist Robbie Cornelissen. Cornelissen has established a career as a draftsman, creating large black and white drawings with graphite on paper[6]. Recurring themes in his oeuvre are spaces and architecture. Around 2004 he started experimenting with computer animation. The worlds that were first depicted in static drawings were now presented as a 3-D animation in which the viewer can wander through the spaces. This led to a collaboration in which I was asked to design music or sound for his animations. The first project I worked on was the sound design for the animation *Het Grote Geheugen (The Capacious Memory)*. This work was

[6] See appendix Chapter 5. for an illustration.

completed in 2006, and its design process was instrumental in the formulation of the framework that was employed in the works that followed.

The following works are part of the portfolio:

1.
Sound design for the animation: *The Labyrinth Runner* (10.25), 2009
(animation technique: Daniel Dogour)

In this work the concepts and techniques from the first animation were further refined and explored. A difference with the first animation is that it contains elements of linear narrative.

2.
Sound design for the art exhibition: *Studio Vertigo*, Centraal Museum Utrecht, 2011

In 2011 Robbie Cornelissen was given the opportunity to compile a big exhibition of his work in a number of exhibition rooms of the Centraal Museum in Utrecht. Robbie considered several ideas to transform parts of the animations into the 3-dimensional space of the exhibition rooms and give the visitor of the exhibition the possibility to actually walk inside the world of the animations. To this purpose a number of installations were designed and the sound design for them was based on the vocabulary that I developed for the animations. One new work for the exposition was the *Zwarte Kamer* (*Black Room*). In a room, together with some drawings, a large black cube, was placed. The cube consisted of a construction of wood and the surface was covered with large paper drawings in dark graphite that gave the impression that the cube was an immense 3-dimensional black drawing. I created an interactive sound installation for this piece that reacted on several circumstances at the exhibition, among them the behaviour of the visitors. The concepts for the sound design formed an exploration of the conceptual framework as described in Chapter 4. The installations only had a temporary character and after the

breakup of the exhibition now only photographs, some video material, and sound recordings exist.

Sound design for public space

3.
Sound design proposal for the *Museumplein*, Amsterdam, 2009

I was asked to advise on the sound aspects for the redesign of the Museumplein, the main square in the cultural centre of Amsterdam. I took this assignment as a design project, starting from the premise that the soundscape of urban space can be considered a complex adaptive system. I approached it as a sound designer, first investigating the existing acoustic qualities and from there, based the design on the requirements for acoustic communication in relation to the varying uses of the square.

Connection between the works in the portfolio

The connection between the projects in the portfolio is that all deal with research and design with various aspects and degrees of nonlinearity and adaptivity. In addition, all projects include sound design for spaces, virtual and real. Projects 2 and 3 were real time applications of sound design.

Order of the presentation of the works in the portfolio

In this thesis the works in the portfolio are not all presented in chronological order. As a means to create a continuous narrative of the development in the cooperation, the sound design projects for the works of Robbie Cornelissen are grouped together in chronological order. Although the sound design for public space project took place before the sound design for the exhibition *Studio Vertigo* it feels as an interruption of this narrative to present it in line with its chronological occurrence. However, the projects all influenced each

other and working on the *Museumplein* project amplified the awareness of sound in real space.

Design Process and Research Questions

Although formally it is not required to formulate a research question in a practice based MPhil trajectory it is addressed here because the formulation of this question in advance was essential to the challenges of the design process of the projects in the portfolio. In practice design and research were intertwined within a nonlinear process.

Main research question

The main research question in relation to the design of the works in the portfolio is:

How does the transformation of artefacts from a linear mode into a nonlinear mode and back influence the sound design for such artefacts?

The first two projects of Robbie Cornelissen involved the transformation of a nonlinear artefact, drawing, into moving images. An important aspect of the sound design was the attempt to help separate the time related linearity of the artefact itself, moving images, from that of the representation within the artefact[7]. The intention was to keep the nonlinear aspects of the drawings (and of fine art in general) in the experience of the representation in the animations, although the artefact itself had a linear structure. Because animation is a linear, time related device. The second animation '*The Labyrinth Runner*' contained some linear narrative elements, which was an interesting challenge in how to incorporate this in the mainly nonlinear approach of the sound design. The design for the exhibition required a new transformation: from a time related linear artefact into real time (= nonlinear) 3-dimensional space. Themes from the animations were presented as installations in a museum.

[7] An extended description of the principle of differentiating the linearity of the structure of the artefact from the linearity of the structure of the representation is given in Appendix 2. under Basic Concepts and Definitions.

Subquestions

The main question raises the following sub questions:

1. Sub questions on linearity and nonlinearity:

- What discerns linearity from nonlinearity?
- What are the key differences between linear and nonlinear artefacts?
- What is the role of narrative in the linearity of artefacts?
- What is the role of sound design in linear structures?
- What is the role of sound design in nonlinear structures?
- Which roles of sound design in linear structures are still useful in nonlinear structures?

2. Sub questions on the creation of nonlinearity:

- How can nonlinearity be designed?
- What is the role of nonlinearity in relation to sound design?

3. Sub questions on sound design and linear animation:

- What connection does sound make to the image and what is the result of this connection in relation to narrative?
- What is the role of synchrony in in regard to the following issues:
    - signification (construction of meaning)?
    - the construction of a credible (virtual) reality?

Design and Research method

In advance of the design of the works in the portfolio I will devise a conceptual framework for design for nonlinear artefacts. This framework is explored, re-interpreted, evaluated and adjusted in practice. From there, in a nonlinear way, practice and theory will mutually influence each other. The research for this

MPhil is both research **for** design and research **through** design. Just as well one could state that it concerns design **for** research and design **through** research.

Initial research

The design method was initially informed by the results and reinterpretation of explorative research I have done for my teaching practice on game audio, in both sound design and music composition. This involved research on literature and repertoire on:

- Digital games and virtual reality
- Semiotics of time structure in nonlinear artefacts
- Semiotics of narrative - Syntagm versus Paradigm
- Systems theory
- Nonlinear and indeterminant systems, such as adaptive and chaotic systems

The results of this exploration will be incorporated in the framework.

Clarification of terminology, concepts and models

The research deals with the confusing terminology used in the field. During the research and design process clear definitions and models were devised.

The dissimilarity between linear and nonlinear artefacts in their time-structure, and as a result the way meaning is created, demands a supplementary conceptual framework for design. This exegesis makes a start by combining models on the creation of meaning, with those on the construction (or architecture) of nonlinear systems, into a framework for sound design for nonlinear artefacts.

3
Critical Review

Introduction

The design concepts for the works in the portfolio of this MPhil are based on, or related to, traditional and topical sound design practices in a diversity of disciplines and domains. This chapter comprises a critical review of the discourse on, and repertoire of, these practices and explains how they relate to the portfolio. It presents a critical review of literature and specifies the position of the MPhil within the practice of the different contexts. A key issue in the review is how nonlinearity is handled in the various domains. Sources that are relevant to the thesis are reviewed, thereby demarcating the research and design area. Many design principles are rooted in the tradition of sound design for film and some relevant references that form a foundation for the design process of the portfolio are discussed. A part of the portfolio consists of sound design for animation. The similarities and differences with the domain of cinematic animation are denoted. There are also links to sound art. Of particular interest in this field are the relation of sound to space and the nonlinear design properties. Digital games are an important frame of reference for nonlinear design. Although the context of the portfolio is not game design but fine art and design for public space, many concepts for the development of the design framework in this exegesis are derived from the study of game design and sound design for games. From this perspective relevant literature on this subject is examined. The discipline of acoustic ecology plays a role in the sound design for public space, that is also part of the portfolio. Sources on adjacent fields connected to the context of this MPhil are also reviewed.

Theory and practice of sound design for film

The practice of sound design originates in the contexts of theatre and cinema. Many general design principles are based on the tradition of sound design for linear film and are therefore relevant to this thesis. Pivotal works on the theory and practice of sound design for film are the publications by Michel Chion, David Sonnenschein, Rick Altman and Elisabeth Weiss & John Belton. Michel Chion's *Audio-Vision* (1994) is a standard work, that is often referred to for basic principles and it defined much of the terminology that is used in the dialogue on sound on screen. David Sonnenschein's book *Sound Design* (2001) is seen by many as an accessible and essential primer for students in the field. One chapter explores the relations of sound design, narrative and dramatic development. A comprehensive insight into the many sound innovations in the history of cinema can be obtained from the essays, by some of the most important film theorists, collected and curated by ElisabethWeiss & John Belton in *Film Sound: Theory and Practice* (1985). Belton and Chion, among others, also contributed to the series of articles that are bundled in *Sound Theory Sound Practice* (1992), edited by Rick Altman. It offers theoretical perspectives, from the creative use of unintelligible speech to the relation of the image scale and the sound scale, a very important aspect of sound design choices. Historical issues, such as the influence of the use of recorded and magnetic sound are discussed. Often neglected domains, such as sound for documentary, are also covered. Many publications on film sound deal with the practical and technological aspects of sound production. *Audio Post Production for Television and Film* (Wyatt & Ameys 2006) is a current 'technology driven' introduction to audio post production, that does not consider any conceptual design issues at all. Worth mentioning are the books by the acclaimed audio engineer Tomlinson Holman (*Sound for Film and Television*, 2002) and Ric Viers' *The Sound Effects Bible* (2008) and *The Location Sound Bible* (2012).
The design methods of many celebrated sound designers, among them Gary Rydstrom, Pat Jackson, Walter Murch, Ben Burtt, Randy Thom, Graham Hartstone, Alan Splet and Skip Lievsay, are disclosed through interviews, analysis and discussions on the web.

The websites *www.filmsound.org*, *designingsound.org* and *www. offscreen.com* are primary sources for information, production stories and theoretical articles. *The School of Sound*'s biennial international symposium in London is a series of masterclasses by professional practitioners, artists and educators. The conference explores the art of sound in film, the arts and media and facilitates a fruitful platform for exchange of ideas.

All this material, together with the actual movies it describes, forms a framework that confirms that sound in film is a highly developed device for shaping linear narrative. The history of sound for film also demonstrates that sound can be particularly strong in conveying nonlinear concepts, such as space, location, ambience, atmosphere or even abstractions as a character's motivation. As an example: in an interview with Macaulay (2009) sound designer Skip Lievsay calls the collaborative work on *Barton Fink* (Coen Brothers 1991) 'a crowning achievement in terms of sound design and effects' notably 'in terms of an abstract and non-linear sound'. The sound design helps to create 'an atmosphere of unease that not only highlights Barton's state of mind but also complements the film's ambiguities' (Barnes 2007). It is interesting to note that nonlinear sound concepts in film are often realised by the connection of sound with spaces (see also the section 'Sound art and space' in this chapter), which is also the case in *Barton Fink*.[8]

Theory and practice of sound design for animation

Since the portfolio consists partly of sound design for animation it's position within the context of sound production for animation must be determined. There are few sources available on the subject and just a handful of books and articles can be found. Curtis (1992, p. 191) attributes this to the economic dominance of live -action feature films in the filmmaking industry. In 1928, Walt Disney released his first sound animation *Steamboat Willy,* featuring the folk song *Turkey in the Straw* (Beauchamp 2005, p. 44). In *The Sound of the*

[8] Multi-layered meaning is a form of nonlinearity. The Coen Brothers' movie *A Serious Man* has a plot that actually questions the existence of causal chains in real life, resulting in a movie with a web of nonlinear, multi-layered meanings.

Early Warner Bros. Cartoons Curtis (1992, pp. 191-203) discusses the tradition of the use of sound in Hollywood studio animation. He describes the practice at Warner Bros. as an activity within the triangle of economics, technology and art. Warner Bros. is not unique in this respect, but 'it provides a striking example'. Inspired by the success of Disney studios in using popular songs, Warner Bros. started to use it's extensive music catalogue as the basis for their animations. Curtis (1992, p. 201) argues that the distinction between diegetic and non-diegetic is completely untenable in this context. Whereas in live-action film sound is motivated by the image, it is the opposite in the early Hollywood cartoons[9]. From this practice Warner Bros. in-house composer Carl Stalling developed a pastiche composition style, in which sound effects were part of the music, where a hit on the head was represented by a percussion instrument (*Rabbit Fire* 1951). All this led to a soundtrack in which there was no real division between music and sound effects (Curtis 1992, p. 196), a design approach that became known as 'effects scoring' (Beauchamp 2005, p. 46). The effect of 'synchresis'[10] (Chion 1994, p. 5) assured the credibility of even the most rudimentary sound effects. In the *Loony Tunes* episode *Rabbit Fire* (1951) Carl Stalling used many prosodic effects, the musical imitation of rhythm, stress and intonation of speech. The linear motion in the music completely dictated the action, with an extreme form of synchronisation between sound and image, a technique that became known as 'mickey-mousing' (Curtis 1992, p. 202). The frantic rhythmic lines in the music lent the animations a huge amount of kinetic energy (Beauchamp 2005, p. 44). Sound and music are still a provider of kinetic energy in contemporary computer generated animation in Hollywood, while the main approach to sound and music design corresponds to that of a current live-action movie. Examples of this can be observed in the films *Finding Nemo* (Stanton & Unkrich 2003) and *Stuart Little* (Minkoff 1999), which is a combination of live-action and computer animation. Today we see a large number of diverse animation categories and styles, that stretch from experimental form studies within the domain of fine art, the violent science

[9] The Warner Bros. animations are presented to the public as *Loony Tunes* and *Merry Melodies*.

[10] Synchresis is the effect that when sound and visual occur at the same time they are automatically accepted as a single event by the viewer.

fiction of Japanese anime, to complete animation tv networks for children. Each of these domains have their own traditions in the use of sound. In *Whap! Zing and a Holler: Animation Sound Design* Michael Geisler (1999) shares his sixteen years of experience in audio post production for animation, explaining that the design approach for animation sound can be as diverse as the many different genres that he encounters. Animation for digital games, which also displays a diversity of styles, is a specialism, in that the interactive features require a system with possibilities for scripting.

In the practice and tradition of cinematic animation we notice a focus on linear formats, to a great extent prompted by the use of distinct linear music. In that sense, in the main, it has no relation to the work of the portfolio that operates within the nonlinear field of fine art. For that reason it has not been a further subject of study except for the purpose of comparison. The strong effect of synchresis, which is a key factor in all animation sound, however, is also a vital element in the sound design of the works in the portfolio, as is the secure synchrony between sound and image. Sound as a provider of kinetic energy also plays a role.

Theory and practice of sound design for digital games

Digital games are an important nonlinear context and the key issues of the use of sound in games are an essential subject of study that informs the design considerations for the works in the portfolio. There are writings on games related to as good as any possible discipline, from the perspective of culture, psychology, literature, philosophy, politics to a business viewpoint. Nearly all studies on games are written from the viewpoint of the user. Within this overwhelming amount of publications there is a comparatively small discourse on music and sound in nonlinear artefacts, that for the major part takes place on the internet and at conferences. Although there is a vivid debate on game sound and music (e.g. on the website www.gamasutra.com) not much information is disclosed on the actual design and systems used by developers. Intellectual property arguments dictate secrecy. Just a small number of books

deals with the actual creation of sound and music for games and other nonlinear artefacts. Half of these publications are not of much use for advanced designers, as they focus on beginners and discuss general aspects of the technique of audio production, and the business aspects of being a composer and sound designer for games (Brandon 2005, Marks 2008). Scripting has become a standard for manipulating non-musical sound effects in nonlinear contexts. Game development tools, such as *Unity*, *FMod*, and *WWise* have possibilities for programming the 'behaviour' of pre-produced, recorded sound files in varying circumstances. *Audio Programming for Interactive Games* (Wilde 2004) addresses the subject by using commercial and third-party audio APIs. Audio APIs (Application Programming Interfaces) are libraries of code that can directly address the audio components of personal computers, tablets and game consoles. The book presents practical examples of how to use the audio programming libraries and so-called 'middleware' products, such as the *Beatnick Audio Engine, FMod, DirectX Audio, GameCODA, MacOs Core Audio* and *OpenAL*. Real time sound synthesis, a common practice in early arcade and computer games, has once more gained in popularity, although the current term for this technique is 'procedural audio' (http://www.procedural-audio.com 2013). *Designing Sound* (Farnell 2010) is a book about sound as a process rather than sound as data. It offers a comprehensive overview of the theory, and comes with a large number of coding examples for the (open source) visual programming language *Pure Data*. A comparable source (although less complete) for *Max/MSP,* the commercial variant of *Pure Data,* is *Electronic Music and Sound Design* (Cipriani & Giri 2013). In spite of the words 'electronic music' in the title, the book does not present computer composition techniques, but just examples of sound synthesis. In addition to the mentioned books, on the internet there is a large body of articles and conference papers that deal with often very small, mainly technical issues, from real time synthesis of sword sounds to management of audio files within game audio engines. They offer little in terms of a conceptual approach to music design and sound design for digital games.

Conceptual models for sound design in digital games

Compared to the many conceptual discussions on film sound, development of conceptual models on the creation of audio and audio systems for games is still in its infancy. Especially how to deal with sound and music in relation to nonlinearity is underexposed. Only a small circle of designers and researchers is exchanging ideas. In his PhD thesis *Captivating Sound. The Role Of Audio For Immersion in Computer Games* Huiberts (2010, p. 10) writes:

> As it is no longer possible in many production teams to have only one sound or music designer with all the expertise, there is the need for the **conceptualisation of audio** in a cooperative context; an articulation of concepts, structure and the functioning of audio.

Slowly conceptual frameworks that deal with the why and how of music and sound in a nonlinear context start to appear. Remarkably, a technological book explaining *DirectX 9 Audio* (Fay 2004), a 'suit of tools and technologies for interactive music and audio'[11] developed by *Microsoft,* presents an interesting conceptual approach for nonlinear sound and music design. *DirectX* offers a flexibility that is comparable with working with MIDI. Instead of using samples of recorded musical phrases, which is a common procedure for game music, it enables the music designer to manipulate music within its very structure, on note level. It is possible to write scripts for harmonic development, melodic variation and groove levels that will be executed in real time during gameplay. The book proposes a conceptual model for an algorithmic composition system. Although the system was used for the games series *Halo* (2001-2013), first published by *Microsoft* on the *X-Box*, and *Worm Blast* (2002-2011), initially developed for *Microsoft Windows,* the concept has not become very popular with other developers for competing platforms to those of *Microsoft*.[12] Building on the definition and concepts of the 'soundscape' by Schafer (1977) Grimshaw in *The Acoustic Ecology of First-Person Shooters* (2007) introduces the notion that the sound world of games is in fact an 'acoustic ecology'. 'Like a

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[11] *DirectX* is a collection of so called 'APIs', application programming interfaces, code that determines how multimedia software components interact with each other.

[12] Microsoft has continued to update DirectX 9 since 2002 and it is present in the latest Xbox and Windows Phone 8 and Windows 8 (The Verge 2012).

real-world ecology, most actions result in a sonic consequence which provides information to the participants in this ecology' (Grimshaw 2007, p. 41). In *From Pac-Man to Pop Music* Collins (2008) collects a number of articles, by a diversity of authors, on game audio. Although many of these articles are written from a marketing or technology standpoint, the selection presents some more conceptual approaches as well, to what the book calls alternately 'dynamic' or 'adaptive' music. Jasper Kaae (2008, pp. 75-91) proposes the use of composition techniques of the twentieth century avant-garde and minimalism, without accounting for the suitability of these types of music in the popular game culture.

The article *IEZA: A Framework For Game Audio (*Huiberts & van Tol 2008) for the first time presents a schematic division of game sounds based on their function within the game and, importantly, from the perspective of the designer. Game sounds are divided in a two dimensional matrix with the two axes Diegetic/Non-diegetic and Setting/Activity. 'Setting' is the geological or cultural setting of the game and 'Activity' sounds are connected to gameplay. This results in a division of game sounds into 4 classes: 'Zone' and 'Effect' on the diegetic pole and 'Affect' and 'Interface' on the non-diegetic pole. 'Zone' and 'Affect' sounds are related to the setting, while 'Effect' and 'Interface' sounds are connected to activity. The aim of the framework is to be used as a model for analysis and production in education and to design 'better understandable sounds'.

An interview with sound designer Ben Minto (www.waves.com 2011) reveals that a tight synergy between audio and visual components demands to 'step outside of the purely audio role and get involved with the design of animation or particle effects'. In an other interview (Deutsch 2011) Minto discusses a division of game types and places them somewhere between the two ends of the scale 'arcade versus simulation'. In simulation games the consideration is what happens in the 'real world', whereas the arcade variant demands a more heroic approach, often translated in hyper realism. The article presents a matrix that plots games on the two axes 'arcade-simulation' and 'real-hyper real'. Although this differentiation applies to game design as a whole, it has clear implications for the design of sound.

In a section of *Game Sound Technology and Player Interaction* (Grimshaw, ed. 2011) a number of writers present frameworks and models for game sound. In *Time for New Terminology?* Jørgenson (2011, pp. 78-98) discusses the use of the terms 'diegetic' and 'nondiegetic' sounds in connection with digital games. The many semiotic layers in games can make the distinction difficult. To solve the problem she proposes five new categories, but Huiberts & van Tol (2008) already provided the adequate IEZA framework in 2008. Moreover, the distinction diegetic/nondiegetic in games is perhaps no longer important as is the case in animation (according to Curtis (1992, p. 201)). Wilhelmsson & Wallen (2011, pp. 98-131) combine the IEZA framework (Huiberts & van Tol 2008) with a model presented by film sound designer Walter Murch in his article *Dense Clarity - Clear Density* (1998). Murch's model integrates theory on auditory perception with mixing techniques that distribute 'the cognitive load over the brain'. Starting point is the difference in processing of the brain of what Murch discriminates as 'encoded sound' (such as language) and of 'embodied sound' (such as music). Many sound effects fall somewhere mid-way. Murch uses a colour-scheme arranged in a half circle and places sounds in the mix dependant on their 'encoded or embodied qualities'. In the interpretation of Wilhelmsson & Wallen the function of every sound for a game is evaluated according to the IEZA framework and then the sound's properties are placed on Murch's half circle. In order to design a clear and distinct sonic environment every sound is given values for a set of variables, such as dynamic range, dominant frequency and cognitive load. The combined model is used by Wilhelmsson & Wallen as a toolset for a production and every sound is categorised in a table with values for the dynamic range and frequency band it occupies. As an example: 'encoded sounds, primarily speech, have a natural position in the human frequency response curve' (Wilhelmsson & Wallen 2011, p. 125). The combined model is an interesting proposition. However, apart from being very labour-intensive the method is possibly too analytical and not very intuitive. In the article, the method is not evaluated.

Troublesome terminology and models

The debate on digital games is confused by the many studies, both performed by designers, users and academics. As noted earlier in this chapter, games are studied from the inside, within the context of their creation, but also from the outside in the fields of semiotics, cultural studies, literary studies, narratology, psychology, business and many more. There is much disagreement on the used terminology and models. The situation is further complicated by the fact that in this interdisciplinary debate the vocabularies of opposed fields of study are combined and intermixed. In many cases this leads to a mismatch of meaning in a particular field. To illustrate this: in the context of game sound and music there is a fundamental inconsistency in the use of the word 'adaptive'. In the article *Defining Adaptive Music* on Gamasutra, the website on *The Art and Business of Making Games* Andrew Clark (2007) formulates 'adaptive music' as follows:

> Adaptive music is music in which a primary concern in its construction is a system for generating significantly different performance versions of a piece in response to a specified range of input parameters, where the exact timing and/or sequence and/or quantity and/or presence and/or values of input parameters are not predetermined, and where the desired output of the system is coherent and aesthetically satisfying within the musical tradition(s) selected by the composer.

Todd M. Fay (2004, p. 6) states: '*Adaptive audio* is audio that changes according to the state of its playback environment.' In his book '*Audio For Games*' Brandon (2005, p. 85) asserts: 'Adaptive audio has been defined many times since game audio began; currently it is understood as any audio that is nonlinear or nonreactive in a game.' In this context the interpretation of the words 'nonlinear' and 'nonreactive' is problematic. How can audio be nonlinear? Can it react to something? On the website of the *Interactive Audio Special Interest Group*, Brandon (2009) cites Thomas Dolby saying that 'Adaptive audio systems provide a heightened user experience through a dynamic audio soundtrack which adapts to a variety of emotional and dramatic states resulting, perhaps, from choices the user makes'. Collins (2007, pp. 263-264) defines 'interactive audio' as audio that refers to sound events occurring in reaction to gameplay, that can react to the player directly'. In her

book *Game Sound - An Introduction to the History, Theory, and Practice of Video Game Music* (Collins 2008, p. 139) she speaks of 'adaptive audio' as 'sound that occurs in the game environment, reacting to gameplay, rather than responding directly to the user'. The problem with definitions like these, is that sound by itself can not react to anything. It is the game system that responds to gameplay, and uses sound as a medium to communicate this to the user. A person can react to the bark of a dog. But it is not the bark, but the dog that reacts to the screaming that results.

In a more recent publication Berndt (2011, p. 75) regards music to be nonlinear 'when the musical progress incorporates interactive and/or non-deterministic influences.' In practice, in the production and analysis of games, the words 'adaptive', 'interactive', 'dynamic', 'nonlinear' and 'reactive' are used ubiquitously and interchangeably to refer to sound or music that fits the nonlinear trajectory of gameplay. What is meant is that the **system** that produces the music is 'adaptive', 'interactive', 'dynamic" or 'reactive' to the 'nonlinear' states of the game and that sound or music is the linear output of that system, in the same way that speech is the linear output of the process of nonlinear thinking. So why is a strict formulation important? As we will see, the confusion of terms limits the understanding, conceptualisation and construction of such systems and overall the handling of sound and music in games. For that reason, in this thesis the above-mentioned adjectives are avoided in combination with the words audio, sound and music and reserved to describe properties of systems. In many cases the metaphorical sense of a word is substituted for the literal import and reverse. In semiotic analysis or cultural studies of games, concepts, such as 'narrative', are regularly considered on a meta-level that is not of much use for designers who want to construct games or other nonlinear artefacts. This exegesis aims to formulate definitions and concepts that are useful from the perspective of the designer, the maker, and can be used for design guidelines.

Sound Art

Sound art comprises a variety of art practices that operate at the intersection of music and fine art, instigated, from the 1950s to 1960s, by movements such as the *Groupe de Recherches de Musique Concrète*, acoustic ecology and conceptual art, and developments in electronic music (Kahn 2001, chapter 4; LaBelle 2006, pp. 24-28). Sound art puts an emphasis on 'sound' as a specific category. 'Musique concrète', invented by Pierre Schaeffer (Schaeffer 1952), places real world sounds at the centre of musical composition. Acoustic ecology focuses on the auditory components of the environment (Schafer 1977) and in electronic music, the creation of the sound itself is a central part of the composition process. Sound art can take many (often hybrid) forms from 'sound compositions', performed in concert venues to art installations, performances in art galleries, museums and public space and so-called 'sound walks'.[13] Public radio transmissions were also used, among others, by Max Neuhaus with *Radio Net* in 1977 (www. max-neuhaus.info 2013) and John Cage's *Sound Day* on Dutch public radio in 1978 (NTR Podium 2011). In the discourse of sound art many characteristics and the role of sound are being discussed, including sound culture, psycho acoustics, sound perception, sound sculpture, noise and silence, electronics and audio and media technology (Kahn 2001, LaBelle 2006). The use of the term 'sound art' itself has become a point of discussion because in the course of time the demarcation of the field has become quite diffuse. At the introduction of the exhibition *Volume: Bed of Sound* at the Contemporary Art Centre in New York, sound artist Max Neuhaus (2000) proclaims:

> Sometimes these 'Sound Art' exhibitions do not make the mistake of including absolutely everything under the sun, but then most often what is selected is simply music or a diverse collection of musics with a new name. This is cowardly. I think we need to question whether or not 'Sound Art' constitutes a new art form. The first question, perhaps, is why we think we need a new name for these things which we already have very good names

[13] A 'sound walk', or 'audio tour' is a public excursion whose purpose is to listen to the environment. It is a form of active participation in the soundscape. Some forms of soundwalks add new sound layers that interact with the environment.

for. Is it because their collection reveals a previously unremarked commonality?

Sound Art and Space

Fine art traditionally does not operate within a time frame, but in the realm of space, and as a result it is a domain of nonlinear artefacts. From this static perspective, sound art within the context of fine art has a clear focus on the connection of sound with space. In the introduction of *Background Noise: Perspectives on Sound Art* Brandon Labelle (2006, p. ix) states:

> It is my view that sound's relational condition can be traced through modes of spatiality, for sound and space in particular have a dynamic relationship. This no doubt stands at the core of the very practice of sound art - the activation of the existing relation between sound and space.
> Thus sound *performs* with and through space; it navigates geographically, reverberates acoustically, and structures socially, for sound amplifies and silences, contorts, distorts, and pushes against architecture.

In 1960s and 1970s art became more and more a "site-specific practice" as illustrated by the location based performances of John Cage and the introduction of 'soundwalks' by artists like Max Neuhaus (LaBelle 2006, p. xiv; p. 147; pp. 151-162). Sound artist Max Neuhaus realised numerous 'sound installations', or 'sound works' outside conventional cultural context[14], many of which have a permanent character (www. max-neuhaus.info 2013). Bernhard Leitner created, what he calls 'sound sculptures' and 'sound spaces', consisting of multi speaker installation that create a strong connection of sound with architecture and public space (Arch Daily 2011).

John Cage, chance, nonlinearity and indeterminism

Kahn (2001, introduction; chapter 6) and LaBelle (2006, p. 3-20) both acknowledge composer John Cage as a key figure in the development of sound art. Apart from his contributions to connecting sound with space, Cage is an

[14] It concerns permanent installations that emit sound signals in public space, such as *Time Piece Stommeln* in Germany (2007, *Eybesfeld* in Austria (2007) and *Time Piece Beacon* in New York (2006) (www. max-neuhaus.info 2013).

important representative of the conceptual art movements that introduced chance and indeterminism as devices for composition, design and performance[15]. His composition *No. 4* (1951) uses the uncertainties from twelve radio receivers together with twenty-four musicians. Randomly mixed recordings structured with the *I-Ching* form the piece *No. 5* (1952) (LaBelle 2006, p. 8). In the documentary *How to Get Out of the Cage* (Scheffer 2012) John Cage explains his cooperation with choreographer Merce Cunningham as follows:

> We learned long ago to work together without stepping on one an others toes. And Merce works as I do within the same structure. Since the early 50s we don't work with a structure with a beginning, a middle and end. We work with a kind of process, just like the weather. And we take a timeline and generally the music is longer, or could be any length, so that it begins when the dance begins. And it stops when the dance stops. No one will listen to music once the dance has stopped. We are not concerned about the relationship between the sound and the dance. We have a faith...we both work with chance operations and we have a faith that each thing that happens is the best thing that could have happened.

While Cage experimented with nonlinearity and indeterminism by using chance and randomness, other conceptual artists used algorithms that are not based on randomness but still lead to an indeterministic output. Visual artist Sol Lewitt used scripted rule-sets for the creation of drawings, that were executed at different locations and every time resulted into a different output (*Sol Lewitt* 2013)[16].

In the animations of Robbie Cornelissen, that are part of the portfolio of this MPhil, sound is not the main focus. In that sense the sound design concerns 'traditional' applied sound design for moving image. Operating within the field of fine art, however, it has clear relationships with traditions in sound art, such as the focus on the relation of sound with space and the nonlinear approach. The application of indeterminism forms the basis for the sound design for the

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[15] The conceptual art movement *Fluxus* organised so called 'happenings' in which randomness was a key element.

[16] The methods of Lewitt are also interesting from the perspective of design for contemporary nonlinear artefacts, such as games, that need scriptable nonlinearity.

exhibition *Studio Vertigo.* The methods of Sol Lewitt were a more important source of inspiration than those of Cage, as scripted indeterminism offers more interesting possibilities than randomness.

The soundscape and sound design of spaces

Besides the sound design for the projects of fine artist Robbie Cornelissen the portfolio of this MPhil includes a project that concerns sound design for public space. The design concept for this assignment combines the knowledge of, and experience with signification by means of sound design for film and other media, with the theory of soundscape study and design. Canadian composer Raymond Murray Schafer used the term 'acoustic ecology' for the study of the acoustic interaction of living species and their environment. For this purpose he initiated the *World Soundscape Project.* Acoustic ecology was already discussed in the sections about sound art and game sound. The term 'soundscape' as introduced by Schafer is the acoustic equivalent of the word 'landscape'. The aim of *World Soundscape Project,* that was founded in the late 1960s, was to transform the negative discussion on noise pollution into positive concepts for 'designing the soundscape', which Schafer mentioned 'the tuning of the world' (1977, title page). Composer and soundscape researcher Barry Truax studied the soundscape from the concept of 'acoustic communication' (Truax 1984). According to Truax sounds are meaningful for a location as long as they are part of, or at least permit, communication on an acoustic level. Sounds that are not functional within the acoustic communication are marked as noise. Good design enables good acoustic communication. Blesser & Salter (2007) map the field of sound and architecture in *Spaces Speak, Are You Listening?* 'We experience spaces not only by seeing but also by listening. We can navigate a room in the dark, and "hear" the emptiness of a house without furniture' (Blesser & Salter 2007, cover). Only one chapter in the book deals with the technical aspects of acoustical engineering. The rest of the content explores hardly before considered subjects such as auditory spatial awareness, navigating space by listening, the social and cultural influence on aural spaces

and the history of designing auditory properties of spaces. In *Acoustic Territories* Brendon LaBelle (2010) 'listens to the contemporary urban soundscape' and discusses 'auditory life' and 'sound culture'. The engineering of acoustics of public space gets full attention in *Urban Sound Environment* (Kang 2007). Topics range from urban noise evaluation and mitigation to acoustic modelling.

There are multiple connections of the portfolio with the concept of acoustic ecology and sound in connection to architecture. The animations by Robbie Cornelissen are in fact wanderings through the mental and physical architecture of his virtual worlds.

Indeterminism, systems and computational nondeterminism

Indeterminism is 'the state of being uncertain or undecided'[17] (Oxford Online Dictionaries 2013). In this chapter, in the section on film sound, we have seen that in the case of nonlinearity there is no one-dimensional chain of cause and effect, but a web of interacting causes and effects, resulting in multi-layered meaning (Macaulay 2009). Meaning, in this case, is not determined by the maker of the artefact. What is presented is a framework for signification, that hands over the responsibility for meaning to the user, in this case, the viewer. In developing nonlinear artefacts the question arises how indeterminism can be designed. One method to organise nonlinearity by means of indeterminism, is by introducing stochastic processes, a technique, among others, explored by John Cage (LaBelle 2006, p. 33, p. 54, p. 60; *How to Get Out of the Cage* (Scheffer 2012)). An alternative method is to design a system, that uses a scripted rule-set, but renders an indeterministic output.

In computer programming the term 'nondeterministic' is used, meaning: 'Non-predictive'. Referring to the inability to objectively predict an outcome of a process due to the lack of knowledge of a cause and effect relationship or the

[17] In philosophy indeterminism is: the doctrine that there are some events, particularly some human actions or decisions that have no cause (Oxford Online Dictionaries 2013).

inability to know the initial condition' (Webster's New Telecom Dictionary Online 2013). A number of sources on the theory of systems and in particular those that have an indeterministic output, were influential for the design of the portfolio. In *The Computational Beauty of Nature* Gary Flake (2000, p. 6) highlights, what he believes, 'the four most interesting computational topics today: fractals, chaos, complex systems and adaptation'. For the context of this MPhil chaos theory is interesting in that it shows that deterministic systems, whose behaviour is based on their initial conditions, with no random elements involved, can produce unpredictable outcomes. 'Prior to the discovery of chaos, determinism and randomness were believed to be mutually exclusive principles. Today, we know that this is not the case' (Flake 2000, p. 221). A system is 'adaptive' when it is self-learning. It does not operate with a fixed rule-set, but can change its rule-set whenever this is required by changing circumstances, a process also known as 'self optimisation' (Flake 2000, p. 254; Kennedy & Eberhart 2001, pp. 35-79). One method to arrange self optimisation, using computers, is to use a feedback loop coupled with evolutionary mechanisms. 'With feedback mechanisms in place between an agent and an environment adaptation can be seen as forming a loop in the cause and effect changes in both agents and environments' (Flake 2000, p. 4). Chapter One in *Swarm Intelligence* (Kennedy & Eberhart 2001, pp. 3-34) is an illuminating introduction to 'models and concepts of life and intelligence'. The book argues that intelligence is a propensity or ability to adapt. Interestingly 'adaptation is almost always a *stochastic* process, meaning that it contains randomness'. Kennedy & Eberhart explain that self optimisation is realised by a loop of 'aiming and guessing' the next best step and subsequently evaluating the outcome for the most rewarding result. The concept of adaptivity is fascinating from the perspective of the MPhil for the reason that it creates the possibility to negotiate meaning within the interaction between computers and humans.

4

A framework for sound design for nonlinear artefacts

"I don't want any more of it. The famous *cogito*[18] stupefies me. Ideas of things are taken for the things themselves. What we understand very slightly is explained by means of words which we don't understand at all—substance, extension, force, matter, and soul. So much abstraction, imagination."

From: *Bouvard and Pécuchet* (Gustav Flaubert, translated edition1904, chapter VIII)

Introduction

In 1881, just after his death in 1880, the first edition of Gustav Flaubert's unfinished novel *Bouvard et Pécuchet* was published in France. The book tells the tragicomic story of two copy clerks that share their interest in science. After one of the two gets a legacy they decide to live in the countryside and to devote themselves fully to truth and knowledge. They fight their way through immense piles of books, covering almost all crafts, sciences and the arts, and try to put the theories into practice. All their efforts fail miserably, but every defeat motivates them to go deeper into the material or to change to a new adjacent discipline. The above citation illustrates how they completely get lost within the difference between the physical reality and its representation in scientific concepts. These are the times of Nietzsche's assertion that we do not know, but invent the world (*Die fröhliche Wissenschaft* 1882, p. 172):

> *Cause and effect.*- "Explanation" is what we call it. but it is "description" that distinguishes us from older stages of knowledge and science. Our descriptions are better - we do not explain any more than our predecessors.

[18] 'Cogito' refers to 'Cogito ergo sum', in translation: 'I think, therefore I am', a proposition by Descartes in *Discours De la Méthode* (1637). The subtitle of the book is: 'Pour bien conduire la raison, et chercher la verité dans les Sciences' , translated: 'Rightly Conducting One's Reason and of Seeking Truth in the Sciences'.

'Nietzsche juxtaposes science and philosophy with a creative knowing; a knowing that realises that one's own definitions are concepts that create a reality rather than reflect it' (van Tongeren 2003, p. 364).[19] In 1879, Flaubert wrote in a letter to Raoul-Duval that 'the subtitle of the book I'm working on could be 'Encyclopaedia of human stupidity"' (Borger 2007, p. 10). The extent and significance of *Bouvard et Pécuchet* were only understood in the course of the next century. Roberto Calasso calls the book 'the prelude to the 20th century' (2006). Almost 100 years after the first publication of Flaubert's novel, Roland Barthes writes in *The Death of the Author* (1977, p. 146):

> 'We know now that a text is not a line of words releasing a single 'theological' meaning (the 'message' of the Author-God) but a multi-dimensional space in which a variety of writings, none of them original, blend and clash. The text is a tissue of quotations drawn from the innumerable centres of culture. Similar to Bouvard and Pecuchet, those eternal copyists, at once sublime and comic and whose profound ridiculousness indicates precisely the truth of writing, the writer can only imitate a gesture that is always anterior, never original.'

Preliminary remarks

The study of existing models and the formulation of new models thereof

This chapter describes the framework that informs the design decisions for the works in the portfolio. It includes concepts, models and strategies for sound design for nonlinear artefacts, with a system of signification, based on existing knowledge of semiotics, perception and systems theory. In order to understand the key elements of sound design for nonlinear artefacts it is first necessary to examine the differences between linear and nonlinear artefacts in general. Although the portfolio does not contain any game sound design, digital games are one of the most widespread forms of nonlinear artefacts that involve sound design. There is a lot of confusion about terminology in this field, so a clear view on the use of definitions is required. Based on the research and teaching on game music and sound, I did over the years, games are used here as a case

[19] In philosophy, the concept that we do not observe, but interpret and invent the world, originated from the ideas of Kant and Nietzsche to Wittgenstein and Heidegger. Putnam, Haberma, Derrida and Rorty led the works of their predecessors into Postmodernism (Bor 2003, pp. 377-383).

study for analysis and from there the theory is extended into a collection of ideas on nonlinear artefacts in general. From there a framework is developed for sound design for nonlinear artefacts. The framework is meant for personal use during design and teaching of design, and as a contribution to the field.

About the usefulness of definitions and models

Definitions, models and frameworks are representations. As such, every definition or model is a reduction of reality. In science it is not the purpose of models to be an expression of truth. As physicist Gershenfield (2012, chapter 29) articulates: 'Making sense of anything means making models that can predict outcomes and accommodate observations. Truth is a model.' The success of a model can be measured by the things that result from its use. The history of philosophy, science and art show that different models lead to different results. Science wants models to explain, predict and control. Since designers are makers, their definitions and models should be useful to make things. They must be supportive to the process of design. The models in this thesis are developed from this perspective of the designer and from the inside of the design process.

Research method

This is a practice based MPhil and the research can be divided into theoretical research and reflection before and after the actual design process, and research through design. In reality this division is artificial because practice and theory mutually influence one another. As a comparison: let us assume that first there was music and from that, music theory was developed. From that moment on the music that was written was not the same as before. The research for this MPhil is both research **for** design and research **through** design. In Chapter 5 the immanence of the design process, and how theory and practice are intertwined are further explained.

The research is divided in the sequence of the following steps:

1. Evaluation of prevailing terminology

The prevailing terminology in the field appears be an obstruction for understanding the questions at hand and to how to deal with them. During the research and design process existing terminology is evaluated and new definitions and models are developed. To keep the flow in the disquisition, the results of this evaluation are not included in the main text. A detailed overview of definitions and basic concepts can be found in Appendix 1.

2. Research on the creation and exchange of information and meaning

An investigation into the way in which meaning is established is approached from the perspective of semiotics and the perspective of neurology.

3. Survey of linear and nonlinear representation

Differences between linear and nonlinear representation are mapped out. Problems and opportunities in relation to sound design are identified. Both sound design for nonlinear artefacts and sound design that results into nonlinear representation are surveyed.

4. Games as a context of nonlinear representation

Digital games are used as a context to evaluate ideas and to further pinpoint the key topics. Music design and sound design for games are compared.

5. Definition of linear and nonlinear representation

The results of earlier research steps are summarised and the key aspects of linear and nonlinear representation are defined. The relation between space and time is placed in the context of linear and nonlinear representation.

6. System design as a method for nonlinear sound design

The possibilities of system design as a method for nonlinear sound design are explored. Both the deployment of systems in order to cope with signification in nonlinear artefacts, as systems to generate nonlinear meaning is examined.

7. Summary

The topics of sound design in relation to nonlinear representation are summarised. Strategies for sound design for nonlinear representation are formulated.

What is a nonlinear artefact?

In appendix 2. the various definitions of the term 'nonlinear', that are relevant to this thesis, are discussed. There, also the reason to make a distinction between 'media' and 'artefacts' is given. Here, the main definition, the relating concepts and how they are to be understood within the frame of this chapter is restated:

A nonlinear artefact is an object or construct of representation, that is not arranged in, or representing a linear trajectory

This definition includes the following considerations:

- An artefact is a man-made object or construction that has been intentionally made for some purpose (Hilpinen 2011).
- An artefact can have a physical or virtual form (in the digital domain).
- Representation is the use of signs that stand in for and take the place of something else (Mitchell 1995, p. 11).
- Representation is the transformation of a concept into a new domain.
- The term 'representation' is used in this thesis as: the rendition of a concept, someone or something, in a medium or domain.
- Examples of nonlinear artefacts in physical form are paintings, drawings, sculpture, photography and in the virtual domain: digital games, augmented and virtual reality, hyperlinked text.
- Examples of linear artefacts are stories, novels, film, plays and music.
- Digital nonlinear artefacts, such as games, must be differentiated from nonlinear 'media', because they are not media, but systems. In digital nonlinear artefacts 'media' (in the traditional sense) are used to represent the system.
- Sound operates simultaneously in the linear domain of time and the nonlinear domain of space.

Design as the creation of meaning

A key element to the reasoning in this chapter is agreement on the definition of the word 'design'. Research on design is done from many different viewpoints. To Heskett (2002, p. 3) 'discussion of design is complicated by an initial problem presented by the word itself.' He indicates that "design' has so many levels of meaning, that it is by itself a source of confusion'. In everyday language design usually refers to a physical, typically industrial, product with certain thought up aesthetical properties. Heskett (2002, p. 2) calls this view 'banal' and places it in the domain of 'snake-oil salesmen of lifestyles'. Many studies on design centre on the practice of design and its methodologies. In his book '*Understanding Design*' Dorst (2003), himself an industrial designer and design studies scholar, gives '150 reflections on being a designer'. The reflections focus on the process of design, varying from applied creativity, problem solving, a learning process, a gradual evolution and a social process to approaching design as a game. Dorst, however, (intentionally) does not specify the context or field of design he addresses and to some design practices a number of his ideas must feel alien.

It is decidedly difficult to connect these ideas to the actual discipline of sound design. According to Heskett (2002, p. 4) 'further confusion is caused by the wide spectrum of design practice and terminology' and 'that it has never cohered into a unified profession, like law, medicine and architecture.' Design practices vary so much among fields that it may be difficult to speak about them in general terms.

Although design 'techniques', and how to guide the general creative process are, on their own, instructive subjects, they are not the main interest of this study. Looking up the noun 'design' in a dictionary, the *Online Oxford Dictionaries of British & World English* (2013) give the following definitions:

> **1** a plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is built or made: *he has just unveiled his design for the new museum*.
> • the art or action of conceiving of and producing such a plan or drawing: *good design can help the reader understand complicated information* | *the cloister is of late-twelfth-century design*.

• an arrangement of lines or shapes created to form a pattern or decoration: *pottery with a lovely blue and white design*.

2 purpose, planning, or intention that exists or is thought to exist behind an action, fact, or material object: *the appearance of design in the universe*.

The fourth edition of *The American Heritage* (2001), gives similar results:

v. tr.
1. a. to conceive or fashion in the mind; invent
   b. To formulate a plan for; devise
2. To plan out in systematic, usually graphic form
3. To create or contrive for a particular purpose effect
4. To have as a goal or purpose; intend
5. To create or execute in an artistic or highly skilled manner

n.
1. a. A drawing or sketch
   b. A graphic representation, especially a detailed plan for construction or manufacture
2. The purposeful or inventive arrangement of parts or details
3. The art or practice of designing or making designs
4. Something designed, especially a decorative or artistic work
5. An ornamental pattern
6. A basic scheme or pattern that affects and controls function or development
7. A plan; a project
8. a. A reasoned purpose; an intent
   b. Deliberate intention
9. A secretive plot or scheme. Often used in the plural

Even the definitions of the noun describe 'design' as the outcome of the process, the arrangement of ideas into a practical solution or tangible commodity, and in many cases in the graphical domain. This is not of much use for the context of sound design. For this reason we delve somewhat deeper, into the etymology of the word, to a time before the concept of design became so fashionable in everyday culture. The second lemma of the definition of 'design' in *Merriam Webster's online Third International Dictionary* (2014) puts the origin of the word in parentheses like this:

'[MF *dessein,* fr, It *disegno,* fr, *disegnare* to mark out]'.

The *Online Etymology Dictionary* (2012) gives a fuller version of the origin of the word as follows:

> design (v.)
> 1540s, from L. designare "mark out, devise, choose, designate, appoint," from de- "out" (see de-) + signare "to mark," from signum "a mark, sign" (see sign (n.)). Originally in English with the meaning now attached to designate; many modern uses of design are metaphoric extensions. As a noun, from 1580s, from M.Fr. desseign.
>
> where 'de-' is explained as:
> de-Latin adverb and preposition of separation in space, meaning "down from, off, away from," and figuratively "concerning, by reason of, according to;" from PIE demonstrative stem *de- (see to).

and 'to' explicated as:

> to
> O.E. *to* "in the direction of"

The prefix 'de-' does not denote[20] removal or reversal, as in many English words, such as 'de-frost' or 'de-activate', but means: 'to' expressing 'motion in the direction of -', or to start with, to begin.[21]
So the origin of the word is: **de** + **sign**, which means, to 'start to' + 'sign', or 'initiate signification', mark out, appoint a meaning[22] to. This is a description that matches the objectives of the sound designer. Indeed, the job of the sound designer for film is to put sound to images, in order to clarify or to link a certain meaning (sign) to them. The applied sounds are supportive to the depicted world in the film, or can play with the meaning of the images. The sound designer signifies by representing an object, situation or concept in the sound domain. In a similar way the film composer (a designer of music), among other things, appoints emotional meaning to a film (Gorbman 1987, p. 79). Music, by itself, being non-narrative and non-representational of objects or facts[23], can induce emotion in the viewer by following the same arcs of tension and release

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[20] In the word de-note, itself, 'de-' has the same meaning of 'to'.

[21] In the same way, the Dutch translation for 'design' is 'ontwerpen', ont + werpen, beginning to throw, to appoint.

[22] The Dutch word for meaning, 'betekenis' comes from 'betekenen', which means 'to put a sign upon', or 'to signify'.

[23] Music can represent an abstract concept or a form principle (Meyer 1956).

that the brain experiences during the development of an emotion (Huron 2006, pp. 305-329; p. 361). Sound design and music design both signify, although each in an other way. Central to this framework is the premise that:

A designer is a creator of meaning and design is the act of signification.

The domain of the sound designer is sound. He or she creates or changes meaning with and through sound.

The mechanics of signification

How does the designer signify? How is meaning conveyed to a user? The designer conveys meaning by means of an artefact. 'An artefact is a man-made object or construction that has been intentionally made for some purpose' (Hilpinen, 2011). The artefact is the vehicle for meaning transfer. The process of meaning transfer is two-fold. It consists of the creation of the artefact by the designer and the perception of this artefact by the user. The mechanisms underlying meaning transfer can be examined from two perspectives: the study of semiotics and the study of perception and cognition, which belong to the field of psychology and neurology.

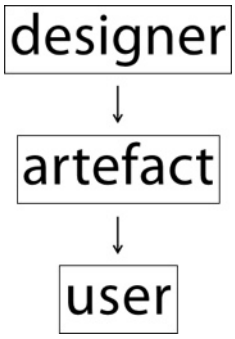

Fig. 1. The artefact as the conveyor of meaning.

Semiotics

Semiotics is the study of signs and symbols and their use or interpretation. Most textbooks place the start of the doctrine at the end of the Nineteenth Century with the work of Ferdinand de Saussure. Saussure mainly studied the

structure and meaning of language. Charles Sander Peirce, who invented the term 'semiotics'[24] broadened the concept from language to many different fields (Hill & Fenner 2010, p.31). In the course of the twentieth century semiotic analysis has been extended to a multitude of disciplines, from language, art, fashion, politics, architecture, to film, social networks and computer games. Today semiotics is branched into many sub doctrines and forms the subject of many, often complicated, formal discussions within media and cultural theory. Here a brief overview of the basic principles of semiotics is presented, with the intention to use them in design models. Based on the introductory writings on the subject by Chandler (2002) and Hill and Fenner (2010) some elementary theory is presented below.

Peirce's definition of a sign is as follows (Peirce 1966, p. 99):

> A sign, or representation, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign or perhaps a more developed sign.

Saussure 'also argues that the sign is the basic unit of exchange' (Hill and Fenner 2010, p. 32). Chandler (2002, pp. 14-17) gives an introduction on Saussure's relational dyadic model of the sign. 'Saussure defined a sign as being composed of a 'signifier' and a 'signified', whereby the signifier is the form the sign takes and the signified the concept to which it refers.' Saussure talks about linguistic signs, such as words, but in contemporary theory the signifier can also be an image, a sound, colour, or musical cadence, in short anything that can be seen as the representation of a person, thing, event or concept.

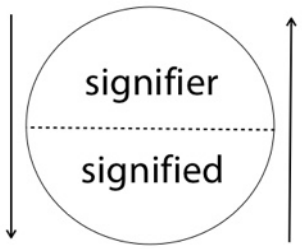

Fig. 2. Saussure's model of the sign (from: Chandler 2002, p. 14)

[24] 'Semion' is Greek for 'sign'.

Peirce presents a triadic model (Chandler 2002, p. 29):

1. The *representamen* (representation)*:* the form which the sign takes (not necessarily material, though usually interpreted as such) – called by some theorists the 'sign vehicle'.
2. An *interpretant:* not an interpreter but rather the *sense* made of the sign.
3. An *object:* something beyond the sign to which it refers (a *referent).*

In this model the sign is 'a unity of what is represented (the object), how it is represented (the representamen) and how it is interpreted (the interpretant)' (Chandler 2002, p. 30):

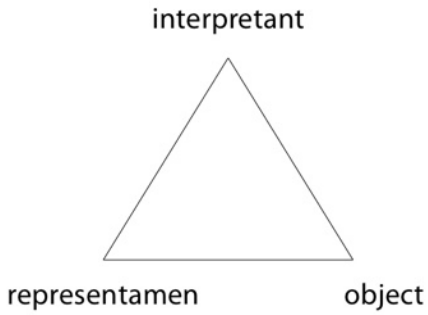

Fig. 3. Peirce's semiotic triangle (from: Chandler 2002, p. 30)

Peirce also offered a typology of signs, that is generally cited in semiotic studies. Chandler (2002, pp. 29-37) defies the often referred classification of 'types of signs' and instead speaks of 'modes of relation' between a representamen and its object or its interpretent. He uses the terms of Saussure 'signifier' and 'signified' to describe the three relational modes (Chandler 2002, pp. 36-37):

1. **Symbol/symbolic:** a mode in which the signifier does *not* resemble the signified but which is fundamentally *arbitrary* or purely *conventional* – so that this relationship must be agreed upon and learned: e.g. language in general (plus specific languages, alphabetical letters, punctuation marks, words, phrases and sentences), numbers, Morse code, traffic lights, national flags.

2. **Icon/iconic:** a mode in which the signifier is perceived as *resembling* or imitating the signified (recognisably looking, sounding, feeling, tasting or smelling like it) – being similar in possessing some of its qualities: e.g. a portrait, a cartoon, a scale-model, onomatopoeia, metaphors, realistic

sounds in 'programme music', sound effects in radio drama, a dubbed film soundtrack, imitative gestures.

3. **Index/indexical:** a mode in which the signifier is *not arbitrary* but is *directly connected* in some way (physically or causally) to the signified (regardless of intention) – this link can be observed or inferred: e.g. 'natural signs' (smoke, thunder, footprints, echoes, non-synthetic odours and flavours), medical symptoms (pain, a rash, pulse-rate), measuring instruments (weathercock, thermometer, clock, spirit-level), 'signals' (a knock on a door, a phone ringing), pointers (a pointing 'index' finger, a directional signpost), recordings (a photograph, a film, video or television shot, an audio-recorded voice), personal 'trademarks' (handwriting, catchphrases).

Chandler recognises (together with Saussure) that the relations between 'signifier' and 'signified' may dynamically change over time or in the exchange of contexts. This semiotic typology has some value for sound design and the categorisation into three modes can be useful for making design decisions. This is addressed later in this text.

Noteworthy is the phenomenon that the dynamic changes of relational modes are becoming faster in this age, where creator and consumer start to overlap (which is the concept of the 'prosumer'). This fast-moving change of mode is a characteristic of digital nonlinear artefacts.

We can now extend our initial definition to:

A designer is a creator of meaning and design is the act of signification. A designer signifies through representation. The product of representation is the artefact. Representation is the reproduction in or transformation of a concept into a new domain.

Meaning as interactive process

The above premise might presume that the designer can place a certain meaning into an artefact and that the user, in turn, simply reads the same meaning from that artefact. But meaning is not simply a straightforward entity

that can be transferred as such. The basics of communication theories explain that this basic model is complicated by the translation or, better stated 'transformation' process into and from the artefact (Oomkes 2000, chapter 1):

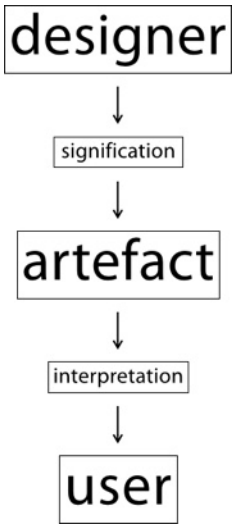

Fig. 4. The basic model of communication (based on Oomkes 2000, chapter 1)[25]

In addition, the word 'meaning' can be problematic if it is interpreted in the sense of 'intention', 'purpose' or 'value', as in 'the meaning of life'. Dutch psychologist Piet Vroon (1976, p.126) simply equates 'meaning' to 'context', which he illustrates effectively with the following image:

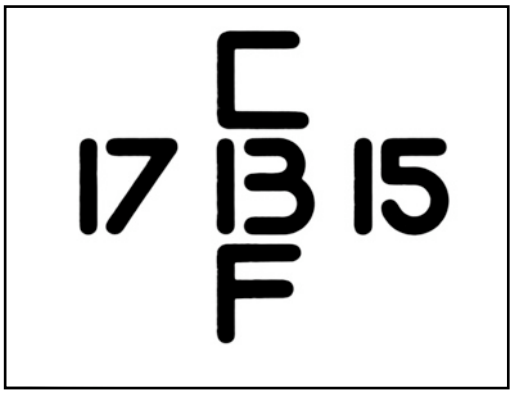

fig. 5. 'Meaning = Context' (Vroon 1976, p.126)

[25] This model corresponds to Peirce's semiotic triangle in fig. 3. and the positions of the designer (offering the representation) and the user (as interpreter) in relation to the artefact.

The meaning of the symbol in the centre depends on the context. From this follows that design, or signification, can also be seen as 'providing a context', a frame for interpretation. In film, the sound designer puts the images in an acoustic context, the music designer provides an emotional context. The supplied context can be seen as a frame for interpretation addressed to the receiver, user or viewer of the artefact. From this follows that:

A designer is a creator of context or frame for interpretation.

Salen & Zimmermann (2004, pp. 39-47) follow a similar path to the etymology of the word 'design' to obtain a workable definition for the design of games. They quote Krippendorf (1995, p. 156) stating 'design is making sense of things', and from there derive their general definition: 'Design is the process by which a *designer* creates a context to be encountered by a *participant*, from which meaning emerges.' [26] The interpretation of the design or signification by the receiver depends on his or her own context. The background of the user, their circumstances, their memories, their taste and environment, are all guiding the perception. The designer has no influence on this interpretation other than hoping that the user will read his/her vocabulary of signification. By using conventions designers can try to augment their chances to convey their intentions to a particular context. As the above illustration by Vroon shows, deliberate ambiguous representation (the figure in the centre) allows for multiple explanations in more than one context. Sound designers for suspense movies gratefully exploit this principle by creating nondescript sound effects to allow for a plurality of interpretations. The *Kuleshov Effect* is a film editing technique that benefits from the phenomenon that viewers will have their own emotional understanding of a sequence of images. Russian filmmaker Lev Kuleshov demonstrated that a single shot of an actor with an ambiguous expression on his face could convey a multitude of very distinct meanings in the mind of the viewer, depending on the nature of the shot immediately preceding it' (Open Culture 2012).

[26] Italics from the original text.

Since the 1950s the recognition of this phenomenon of reinterpretation and the influence of the observer as a part of perception has led to radical changes in thinking about meaning within the disciplines of physics, philosophy, psychology and literary criticism. Philosophical and cultural movements such as structuralism, post-structuralism, post-modernism, and deconstruction challenged the concepts of meaning and the role of the author, designer or artist in creating it. In the pivotal essay '*The Death of the Author*' Barthes (1977, pp. 142-148)[27] claims that it is not writer but the reader of a text that creates the story. In the end it is not the designer but the user that creates meaning.
In the case of film, the viewer is the best filmmaker. In the case of music and sound it is the listener who determines the meaning of what is being heard.
As noted in chapter one, in the past, meaning was for the most part dictated by authorities and passed on tracing a hierarchical path. Today, it is the common viewpoint that everybody participates in the process of signification.
Tech culture journalist Xeni Jardin notes that 'meaning and even facts are becoming more fluid than in the days of our grandfathers' [28] (Jardin 2012, chapter 145). On *Wikipedia* facts and explanations are ever edited. No observation is neutral. 'In our networked mind, the very act of observation changes the story' (Jardin 2012, chapter 145). This dilemma had already been formulated in 1927, in the field of quantum mechanics by Werner Heisenberg. 'No test can be devised to measure the position and speed of the individual electron, for any observation must entail some input of energy which will cause both to change' (Whitfield 2012, chapter 31).
Painter David Hockney puts it like this: 'Do we know what an empty room looks like?'[29] On the internet meaning is negotiated in multiple interrelated networks of discourse. Brian Eno articulates this concept as an 'ecology', the evolution of our thinking from a hierarchy (pyramid) to a network, 'with

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[27] Around the same time as the publication of the book by Vroon (1976).

[28] At the introduction of the first *iPad* in the press it was compared to the stone tablets of Moses with the Ten Commandments, to illustrate the transformation from fixed to fluid meaning.

[29] *David Hockney: A Bigger Picture* (Wolheim 2009).

information running in all directions' and where 'creator and user are co-dependent' (Eno 2012, chapter 125).

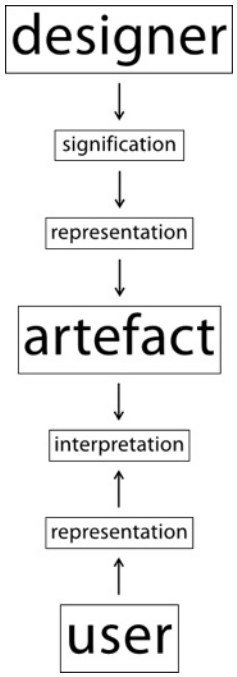

Fig. 6. The two-way process in the creation of meaning.

Neurology, representation and creative perception

Thus, creator and user are equally involved in the creation of meaning. The role of the user is far from passive. The user actively reinterprets the artefact. The artefact, that is the result of a process of signification by the designer, is perceived by the user. This perception involves the development of a mental state or concept in the brain, corresponding to the things perceived. How and where in the brain this process works is the domain of neurology (Greenfield 2012). Research in neurology demonstrates there is no such thing as objective perception. 'We don't see the world as it is' (Greenfield 2012). It is constructed and constantly reconstructed in the brain, based on selective attention, memory, expectation and imagination. 'We guess what is out there, based on memory from past experiences' (Greenfield 2012). Virtually all of the known 32 visual areas send and receive information to and from to other areas. 'So there is an enormous amount of information flowing backwards' (Kosslynn 2012). Just

as with visual perception, 'our perception of the sound-world greatly surpasses the quality of the sensory information available at each instant: it results from mental processing' (McAdams and Bigand 1993, p. 3). The observation that the viewer is the best filmmaker is supported by neurology. Neurologist Susan Greenfield (2012) confirms: 'The power of our imagination is what makes a good horror film so frightening'. The brain tries to construct a coherent interpretation of the world. It connects sensory information with knowledge it already has. The mechanism that is known as 'predictive coding' uses 'the probability of one state or event following another to generate a prediction of what the current state is likely to be' (Clark 2012, chapter 55). In the brain this perceptual principle of connecting new with memorised information operates on many levels. On a lower level the incoming information from the senses is ordered by 'classification'. An example is the perceptual organisation of sound in the brain, as described by Albert Bregman in *Auditory Scene Analysis* (1994). The auditory streams of information are segregated into small units and subsequently ordered into basic groupings, based on rules, called 'schemas'. 'The experiences of the listener are structured by refined knowledge of particular classes of signals, such as speech, music, machine noises and other familiar sounds of the environment' (Bregman 1994, pp. 665-666). 'A fair amount of what you perceive or think you perceive you are actually filling in from memory' (Kosslynn 2012). And, even then, memory itself is a highly selective and interpretive process (Foster 2009, pp. 61-83). 'Our sensory experiences can be thought to have evolved to guide adaptive behaviour, not to report objective truths' (Hoffman 2012, chapter 56). 'The brain plays fast and loose with the information it is taking in. It takes shortcuts and guesses, on what it thinks it discerns, based on past experiences. So, according to neurology, everyone lives in a very personal world' (Greenfield 2012). Each viewer in the cinema sees and hears a very different, personal film, based on personal experiences and context. In the concert hall every listener hears a different violin concerto.

Meaning is, on one end, the act of signification and the study of semiotics is concerned with the way meaning is exchanged in artefacts and culture. Neurology, on the other end studies how the brain perceives, interprets and changes meaning. Meaning is an interactive, creative process. Meaning is fluid.

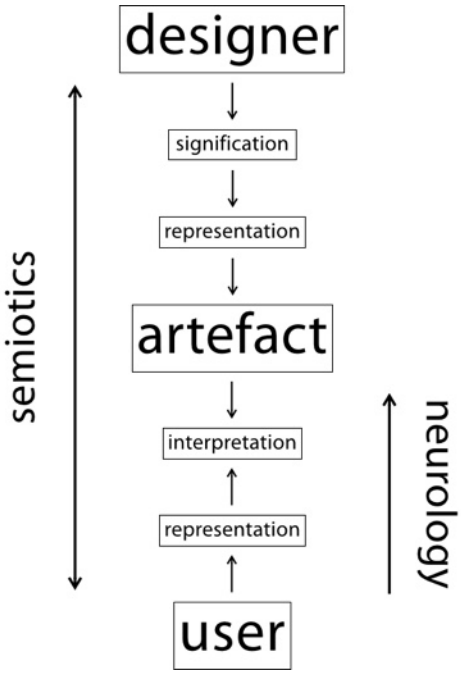

Fig. 7. Designer, artefact and user, semiotics and neurology.

Linear or nonlinear representation

Depending on the artefact the representation can be linear or nonlinear. The structure of the artefact itself can also be linear or nonlinear. Often linear and nonlinear representation are part of the same artefact. In most cases the representation is understood as predominantly linear or predominantly nonlinear.

Semiotics, linear and nonlinear representation

Semiotics started as literary study and an important component of semiotic studies is the structural analysis of texts. In short this concerns how signs are arranged within texts. Chandler (2002, p. 84) summarises the distinction in which 'two structural 'axes' (horizontal as syntagmatic and vertical as paradigmatic) are seen as applicable to all sign systems.' The terms syntagm and paradigm are derived from linguist Roman Jakobson, who, simply put, distinguished the horizontal, syntagmatic, axis of language as the sequence of words, while the vertical axis is offering the type of words that can be chosen:

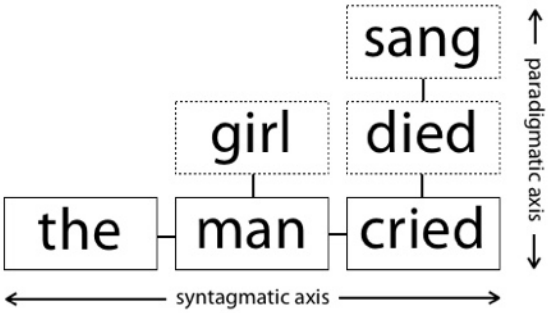

Fig. 8. Syntagmatic and paradigmatic axes (From Chandler 2002, p.84)

The syntagmatic axis, the horizontal organisation, shows which words have actually been chosen within the text, while the paradigmatic axis shows a collection of possible choices. The syntagm is an orderly combination that according to Saussure forms 'a chain' (Chandler 2002, p.85). 'The syntagmatic axis relates to the combination/ accumulation of sign used in a sentence and the paradigmatic axis relates to the selection/substitution of different signs' (Hill and Fenner 2010, p.33). Chandler (2002, p. 85): 'Syntagms are created by the linking of signifiers from paradigm sets which are chosen on the basis of whether they are conventionally regarded as appropriate or may be required by some rule system (e.g. grammar)'.

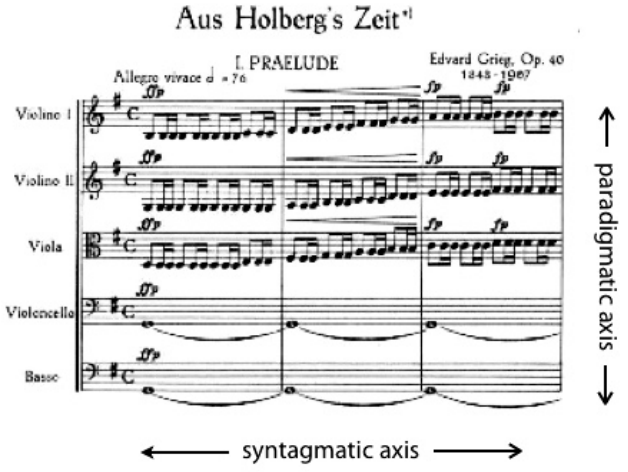

Fig. 9. Horizontal and vertical organisation in music: melody and harmony (score: Grieg 1907, p. 1)

Gradually, the domain of semiotics extended from language to other media, or meaning systems, such as film. Coumans (2002) presents, a more general formulation for the arrangement of information, in relation to what she calls 'new media'[30], as follows:

> A syntagm, because of its relation to time (the sequence of the elements) lends itself best for telling a story. A paradigm, because of its relationship to space (the simultaneity of the elements) is best suited for the construction of a collection.

She continues: 'One medium is, by the way the elements are presented, better suited for a syntagmatic arrangement, another for paradigmatic arrangement.' She argues that film, because of it's horizontal, sequential arrangement, is best suited for storytelling. An extension on this idea is that in film, a linear artefact, the syntagmatic arrangement is explicit, while the paradigmatic organisation is implied. In nonlinear artefacts, such as a picture or digital games, the paradigmatic arrangement of meaning is explicit and the syntagmatic organisation is implied. In the syntagmatic axis the meaning is chosen and fixed, in paradigm meaning is a fluid collection of possibilities. In narrative, the plot is represented through syntagm, while the 'setting' of the story, the story world, is found on the vertical axis of the paradigm. In a game, a nonlinear artefact, the basic structure is a system of rules and/or possibilities, a collection of choices, and thus above all paradigmatic. Other nonlinear artefacts, found in the domain of visual arts - paintings, drawings, sculpture -, photography and architecture are paradigmatic and offer a collection of possibilities for interpretation. Considering that linear and nonlinear artefacts are dissimilar in their construction as to the creation of meaning, each requires a different design practice.

Linearity, nonlinearity and narrative

In the structure of linear artefacts, such as novels and films, linearity is mainly formed by the horizontal thread of narrative. Narratives follow a fixed sequence

[30] Now, in 2014, an outdated term.

of events arranged in a logical order of cause and effect (Cobley 2001, pp. 7-21). Events and facts that are not immediately relevant to the story are left out, resulting in a simplification of reality[31]. From narratives a diversity of linear art forms developed, such as theatre, opera and film, that re-enact an experience. From the beginning music played an important role in these forms of expression, and in a natural way, followed the same linear format. As Barthes (1977, pp. 79-124) argues in his essay *Structural Analysis of Narrative:* 'besides this 'horizontal' structure of the narrative 'thread', there are also vertical correlations, a narrative can be read on many levels.' Barthes reasons that 'in different degrees, everything in it signifies'. (Barthes 1977, p. 89). Even so, linear formats, such as film, in general follow a trajectory in time and have a clear horizontal narrative structure. In many cases the order in which events are presented is not chronological, following the order of time in which they occurred (disjointed narrative). The fixed interrelated sequence is, however, always implied by the plot.

In artefacts with a true nonlinear structure there is no fixed story or plot, but rather a possible or expected development of events, just as in real life. Instead, there is a 'world construct' or model existing of a set of rules that form mutually exclusive choices in particular syntactic roles. Game designers speak of 'rule-sets', 'game mechanics', and 'possibility space' (Salen & Zimmermann 2004, pp. 126-148; Egenfelt-Nielsen et al 2003, p. 82). Music for nonlinear artefacts, such as digital games, poses specific problems for the composer. Dealing with musical form and development in games is particularly challenging, as it is clear **that** some event will happen, but not **when** it will occur. In music for cinema form and development are related to the linear narrative in the film. Accordingly film sound can be helpful with communicating the development of characters and be supportive to the story line. Since nonlinear artefacts, such as digital games have no predefined linear form and do not follow a linear path, a different approach for sound and music design is necessary.

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[31] Through telling stories we 'explain', which means 'make flat'. The Dutch word for 'explain' is 'uitleggen', which means 'lay out' (as in: lay out on the table). In fact when we say 'that explains it!', we say: 'we made it flat'!

In recent times we have seen a changing role for linear narrative within culture and society. Technological developments make dynamic nonlinear representations, instead of fixed linear storytelling, possible. As an alternative to 'simplifying' the world to one-dimensional cause and effect chains, we can now construct systems that make dynamic plural and relative signification possible. In computers, models of the world, or a virtual world, can be created. In the past the only possible representation of events was a linear story. It is fascinating that the procedure for creating dynamic representations is the opposite of storytelling as a 'simplification' of an experience. By typing linear text, in the form of computer code, constantly changing, complex worlds, can be created, that can be experienced in real time.

Nonlinearity, narrative and digital games: a case study

The structure of digital games is used here as an example to analyse the differences between linear and nonlinear representation within one artefact. Key issues are how they are related and how they fit (or do not fit) within the structure of the artefact. Narrative in games is a decisive factor in determining linearity.

Nonlinear formats in the digital domain have evolved from linear ones, regularly resulting in a confusing mixture of old and new structures. Many design practices for digital nonlinear artefacts are inherited from those in film and a long tradition of artefacts before film. Although there, already, exist accepted traditions and genres based on complex blend of the old and new, these do not always render satisfactory results. Moreover, they do not do justice to the important differences between film and nonlinear structures and often exclude the specific possibilities that nonlinear formats could provide. Linear narrative and gameplay are in fact contradictory representation systems.

In the digital domain, games form the ubiquitous examples of nonlinear artefacts. A, seemingly never ending, heated debate between ludologists and

narratologists about the narrative attributes of digital games has been taking place since their inception. The 'story versus gameplay' duality focuses on the fact that stories and games offer entirely different experiences. While stories in traditional media, such as the novel and film, follow a fixed pre-defined linear trajectory, which results in a passive involvement by the user, games are fluid and nonlinear and require active participation. Linear narrative threads are often imposed on the intrinsically nonlinear structure of games. This form of narration in games is called 'embedded' narrative (Egenfelt-Nielsen et al 2003, p. 218). There may be many different reasons to do this. One is the commercial consideration to link the game to a successful movie[32] with the promise that in the game you can play the key role in the film's story. An obvious reason is that many designers of games started working on them, coming from the tradition of traditional media. They started from the established linear models of representation. This compares to the first movies, that were simply registrations of theatre performances. Games with embedded linear narratives have become popular and commercially successful, and to many they remain to be the favoured genres. Some game players simply enjoy stories. Another motive might be that the people who traditionally created the narratives for film wanted to stay employed in the game industry too. Some find it difficult to accept that digital games, being a different kind of artefact than film, are no longer necessarily dependant on a pre-defined linear narrative to be engaging. Game developer Jesse Schnell (2005, pp. 1-14) is convinced that, in order to be entertaining, gameplay, like stories, must follow what he calls pre-defined 'interest curves'. These interest curves that guarantee the alternation between 'focus, empathy and imagination' are in fact the same as a fixed narrative thread. It becomes a scripted experience. Schnell compares game design with the design for Disney's theme parks (in which he has been involved) where the experience for the visitor has been a carefully pre-designed path.
'A castle is placed such that the guests' eyes are immediately drawn to it upon entering the park. Disney was able to control guests to do just what he wanted them to do: move quickly to the centre of Disneyland. Of course, guests are

[32] of which the game publisher is also the intellectual property owner.

seldom aware of this manipulation' (Schnell 2005, p.12). Advocates of the gameplay viewpoint put forward that a linear narrative in games should not be embedded or pre-defined, but should emerge in real time through gameplay. This means that playing a game can by itself be a linear narrative experience. They state that involvement and immersion in games should be the result of the performance of the player instead of the plot of the storyline. This form of dynamic narrative is called 'emergent' narrative (Egenfelt-Nielsen et al 2003, p. 218; Rutter & Bryce 2006, p.87).

In *'Rules of Play'* Salen & Zimmermann (2004, pp. 100-105) discuss the many different forms that games may take. Their framework for the design of games is divided into three primary schemas: 'Rules, Play and Culture'. Rules 'is a *formal* schema that focuses on the intrinsic mathematical structures of games'. Play 'is an *experiential* primary schema emphasising the players interaction with the game and other players'. And the schema Culture 'highlights the cultural *contexts* into which any game is embedded'. The schema for 'Play' offers six angles on gameplay: Games as the Play of Experience, the Play of Pleasure, the Play of Meaning, as Narrative Play, the Play of Simulation and as Social Play. According to Salen & Zimmermann the experience of games as 'narrative play' is, among others, only one of the possibilities for gameplay. The opposite to 'narrative play' then is 'Play of Experience', which Salen & Zimmermann (2004, p. 314) describe as 'participation'. In this context they cite Jesper Juul (2001, p. 379) in support of his view on whether games should be discussed from a traditional narratologists perspective, or from new perspectives, that underscore the unique properties in which games differ from traditional media:

> Using other media as starting points, we may learn many things about the construction of fictive worlds, characters ... but relying too heavily on existing theories will make us forget what makes games games: Such as rules, goals, player activity, the projection of the player's actions into the game world, the way the game defines the possible actions of the player. It is the unique parts that we need to study now.

In his article '*The Semiotics of Time Structure in Ludic Space As a Foundation for Analysis and Design*' Lindley (2005) reconciles the opposing standpoints with

the proposal to view them as a continuum. Lindley states that 'the concept of ludic systems encompasses a family of media forms and experiences involving elements of simulation, game play and narrative or story construction'. He adds to this that 'these three elements can be regarded as different classes of semiotic systems, or systems of meaning, having their own structuring principles and methods of informing experience':

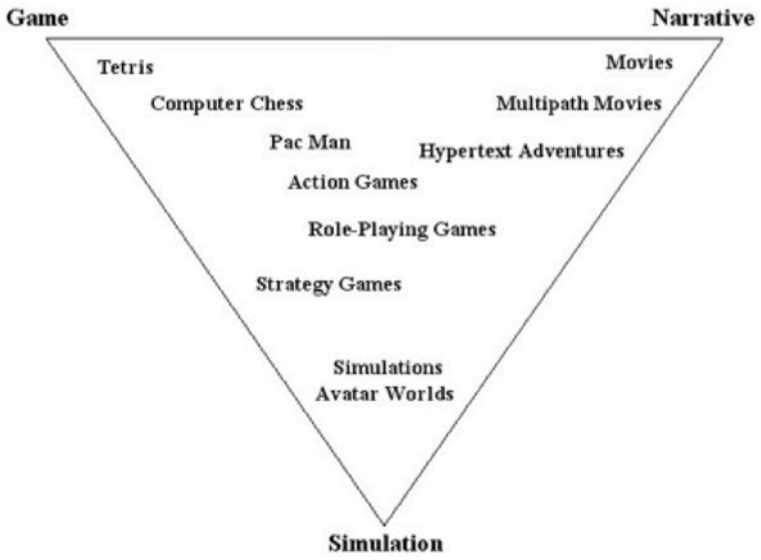

Fig. 10. A classification plane based on time form in ludic systems (Lindley, 2005)

The 'gameplay versus story' controversy is approached by placing the opposing properties at the corners, of a triangle. This results in a continuum, a plane, on which different games can be plotted to show a gradual transition between attributes without abrupt changes or discontinuities. This classification plane makes it possible to plot the complete diversity of game types and rank the ratios of their linear and nonlinear properties. The linear narrative extreme is the territory of film, in which case we can no longer speak of 'games'. In the gameplay extreme we can place a game like *Tetris* that uses completely abstract symbols to represent gameplay. In the simulation corner we'll find, for instance, flight simulators, which have no pre-defined linear narrative and use existing models of the real world to represent the possibility space within which the game operates. To give a better illustration of the 'narrative versus gameplay'

discussion and to be able to more easily combine earlier introduced models, I propose to turn this illustration by 60 degrees as follows:

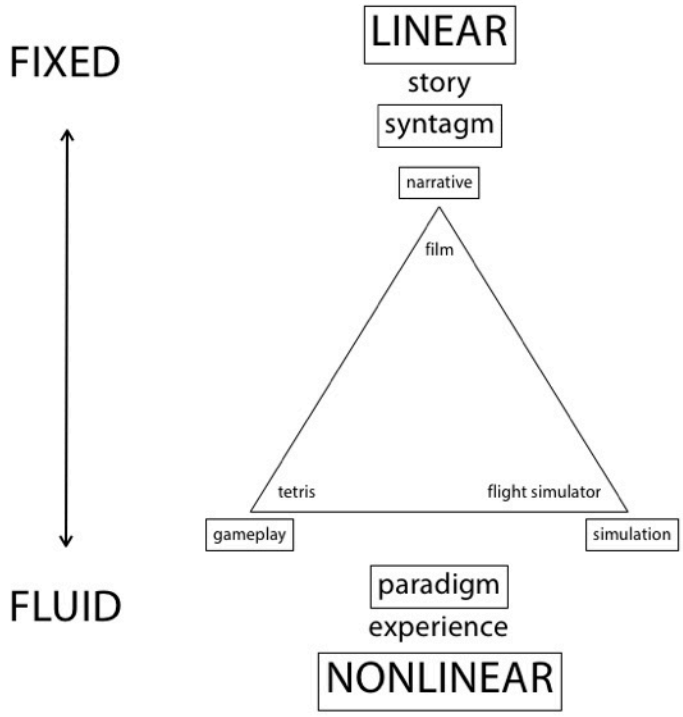

Fig. 11. Linearity versus nonlinearity in digital games and media

With this arrangement it is easier to display the difference between the nonlinear aspects of games and the linear properties of traditional narrative media. Here the top represents the linear extreme, while the bottom appoints the nonlinear extreme. Also the difference between story and experience is added, as well as the difference in syntagmatic versus paradigmatic organisation of the representation. Gameplay and simulation are the two nonlinear aspects in which games differ from linear narrative media. Top and bottom also represent a different principle of construction. Within this model each extreme stands for its own semiotic domain 'having a different tradition, language, variety of methods, problems and solutions' for representation (Lindley 2005). Although Lindley's classification plane can give insight for analysis on how games are being experienced by the user, it can be problematic from the perspective of the actual design and construction of digital games. Linear and

nonlinear artefacts are dissimilar, even opposite, in their construction. As Salen & Zimmermann (2004, p. 50) show, from the perspective of their construction, games are systems: 'Games are intrinsically systemic. All games can be understood as systems.' Artefacts in the narrative extreme require a linear construction with a fixed output, while gameplay and simulation need a nonlinear system with a fluid output. Since in its fundamental construction, a digital game is a system, the narrative elements of a digital game should be considered to be representations of that system.

More than once in 'narrative versus gameplay' discussions the opposing parties seem to be having a dialog of the deaf, because of a loose definition of 'narrative'. What is meant by narrative? The setting and the characters or the plot? The syntagma or the paradigma? In '*Games and Narrative: An Analytical Framework*' game studies scholar James Bizzocchi (2007) discriminates between what he calls 'the narrative arc' and the narrative 'story world'. These definitions correspond to the aforementioned syntagmatic and paradigmatic organisation, in which 'the narrative arc' represents linear narrative thread, while 'story world' represents the nonlinear narrative elements or, setting. Bizzocchi proposes several parameters to include into his narrative framework:

- story-world - what is the environment within which the game unfolds
- character - who are the beings that populate this game world
- emotion - both the emotions shown by the games characters and those elicited in the player
- narrative interface - how are narrative sensibilities instantiated in the appearance and the functionality of the interface design
- micro-narrative - smaller moments of narrative flow and coherence that occur within a broader context of game play

In Bizzocchi's framework the 'narrative arc' is the linear mode of narrative and 'story-world' the nonlinear mode. Based on the above discussion, regarding narrativity, the following distinction between traditional media and digital games, in relation to their construction is proposed:

In novels and films the narrative is the fundamental structure. In digital games the fundamental structure is a system of rules and/or possibilities and narrative is one of the methods of representation of that system.

As a result of this distinction, narrative in games belongs to the game art department, amongst graphics, sound and music. In computing, a 'skin' is the graphical appearance or representation of an interface. Narrative in digital games can be considered to be a skin for the system. Even if you would completely change the narrative, you could still end up with a gameplay that is intrinsically the same. In fact some game developers make a business of just doing that.

Combining two models

The semiotic typology of Peirce, consisting of the three relational modes symbolic, iconic and indexical (Chandler 2002, pp. 36-37) can be combined with the extended classification plane for games by Lindley (2005) above as follows:

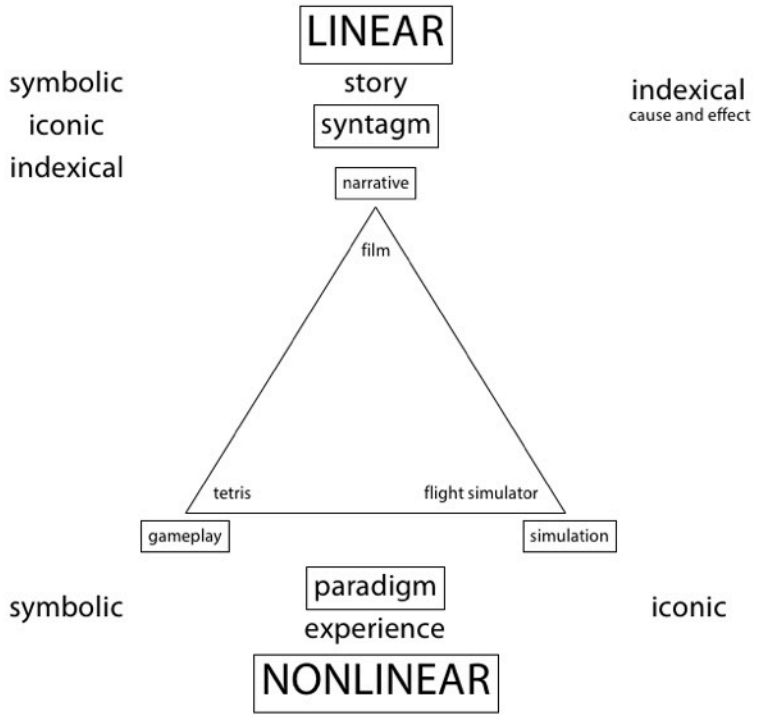

Fig 12. Lindley's classification plane combined with Peirce's typology

Linear story telling traditionally uses all modes of relation and for games this also is the case. But symbolic sounds can suffice in the case of pure paradigmatic gameplay, as with *Tetris.* Indexical representation, with its connection to cause and effect seems less appropriate here. The simulation angle demands mostly iconic sounds. Players of flight simulators want the sound of the plane to resemble the real thing. Whenever simulation moves into the direction of narrative, indexical use of sounds comes into view. The many styles of game design allow to play with the typological relations and to switch modes. The semiotic modes can also be related to the three listening modes as introduced by Michel Chion in *Audio Vision* (1994, pp. 25-35). 'Causal listening' can be connected to the indexical mode, 'semantic listening' to the symbolic mode and 'reduced listening' to the iconic mode. This combined model has some use to analyse and determine which modes are appropriate for a certain application within the game, for a certain design style and to secure consistency. It was used at some moments during the design of the works in the portfolio.

Problems with structure and music in narrative games

As seen above narrative in digital games can be embedded or emergent. In the case of embedded narrative the game is tacked onto a fixed story. An embedded narrative can also be 'disjointed', which means that the story is not told according a fixed sequence. In the event of interactivity the order or the tempo of the disjointed story can be determined by the player, sometimes through the process of branching. In a disjointed narrative the chain of cause and effect remains implicitly fixed. Disjointed embedded narrative is often (erroneously) labeled as 'nonlinear'. In the case of emergent narrative the player experiences the gameplay as a story. One round of gameplay comprises one story, the next round another. Lindley's model above is mainly based on the analysis of games from the perspective of the user and it takes no account of the implications for the actual building of game systems. Both narrative modes pose problems to the

composer of game music. Embedded narrative is in fact a linear semiotic subsystem of the main nonlinear game system. This makes it problematic for music design. Syntagmatic and paradigmatic representation are easily mixed up. This leads to issues with the construction of a music system and also with the type of music that is required. Emergent narrative presents problems because the course of the story is not known and cannot be predicted. The length of musical tension arcs can easily be constructed from the past but not from the future. In practice composers often fall back into their routine of composing the type of linear orchestral music, that is derived from film. Many games use tonal cinematic music. In the case of a war game typical 'war film music' is composed. Because linear music does not fit in the nonlinear construction, most games incorporate a 'nonlinear music system'. Generally, the output of such a system is linear music. There are a number of different solutions, such as vertical re-orchestration, horizontal re-sequencing and generative composition techniques. A detailed explanation of these methods can be found in Appendix 1. An additional problem with using linear cinematic music in games is that it often evokes the wrong emotion. Film music rarely interprets the emotions of the characters, but rather the emotions that the film maker wants the viewer to have to what happens to the characters. A film is viewed from a third person's perspective, a game is played from the perspective of the first person. Do you need the music to tell that you are losing? You already know that. In practice this confusing use of music is regularly found. For the player of a game it seems more appropriate for the music to motivate or stimulate. All this does not seem to matter to the game community. In any event, game music is big business. Since the beginning of this century digital game soundtracks are sold separately from the game and performed in concert by big symphony orchestras (*Distant Worlds* 2010, *Video Games Live* 2013). Compared to film music, the developments in game music have been fairly slow. It took about 15 years, from the first sound movie in 1927, until halfway the 1940s, for composers such as David Raksin and Bernard Herrmann to realise their very specialised music for film (Davis 1999, pp. 47-55). Game music is now some 40 years old. *Pong* was introduced in 1972 and one of the first successful arcade video game with sound. *Gun Fight* (1975) is an early example of a game with *chip-tune* music

(Kent 2000, p. 51). A possibility for game music to develop into music that does justice to the nonlinear character of games is the use of adaptive music systems. Although game music is often referred to as 'adaptive' music', the use of true adaptive systems for music in games is up to now unknown. Adaptive systems are addressed later in this chapter and in Appendix 2.

Sound design for games

Sound design does not display the problems that tonal music has because of its linear tension arcs. It can more easily deal with the multiple semiotic subsystems. Interface sounds even add another category. With sound it is simpler to jump from one semiotic system to another. For sound it is also easier to change and play with Peirce's relational modes, such as alter from symbolic to iconic mode. This is fun to do and in some games this happens almost unnoticed. In games sound plays an important role in shaping the nonlinear game world. Sound design is involved in the creation of spaces and implementing acoustic rules. Traditionally sound design is perfect at representing objects and add to the credibility of the representation, both real and virtual. Iconic sounds, recordings of the real thing, can be used to add realism. Strict synchrony between sound and image assure the workings of 'synchresis'[33], but demand close cooperation between the animation and the audio department (Deutsch 2011, pp. 43-56). For virtual worlds complete symbolic sound-sets can be created. Sometimes indexical and symbolic sounds are used to add tension or atmosphere. So sound works well for both linear and nonlinear aspects of a game. The difference with sound for film is that nonlinearity demands sound to be flexible. For this, all kinds of systems have been developed and many games incorporate a uniquely designed sound engine. These permit scripting the behaviour of sounds and to adjust auditory properties of spaces, in reaction to the changing conditions and states of the game. 'The complexity of the sound-worlds has created a demand for more sophisticated mixing engines' (Deutsch 2011, pp.43-56). 'Procedural audio',

[33]'Synchresis is the spontaneous and irresistable weld produced between a particular auditory phenomenon and visual phenomenon when they occur at the same time ' (Chion 1994, p. 63).

which involves real time sound synthesis and manipulation in software, is becoming the prominent approach.
The idea that the sound world in a game can be considered an 'acoustic ecology' (Grimshaw 2007) is not yet known to have been implemented as a design principle. The consequence of this concept would mean the possibility of communication and interaction on a pure acoustic level. Suppose, in a first person shooter, I would use a gun with a 'big' sound, then the sound alone should make the enemy recoil. In Chapter 3, an overview was presented of current techniques and methods and a number of models that classify game sounds based on their function in the game have been discussed. These models, that are specific for game design, have less significance for nonlinear artefacts in general. It seems that the nonlinear properties of games make sound better suited for games than music. In practice, many players of games switch off the music, because it is too distractive (Huiberts 2010, pp. 108-109).

Linearity and nonlinearity as opposites

Linearity and nonlinearity can be approached as opposites. The discussions in this thesis generate many comparisons that are useful for both linear and nonlinear design. A number of them are summarised in the following table, loosely grouped according the following categories:

- general concepts
- free association
- for the creation of artefacts
- for the creation of games
- for sound and music design

It is important to pay attention to the difference between artefact and representation. Both can be linear or nonlinear. Film is a linear artefact but, as discussed in chapter 3, it uses both linear and nonlinear representations.
A digital game is nonlinear but it can have linear presentational components. Space is at once nonlinear and fixed[34], but we can freely move in space,

[34] At least in Western Culture it is seen as fixed. See the next paragraph about space-time.

although linearly. A plotted story is a fixed linear artefact, but at the same time a recount of a nonlinear experience. This needs to be kept in mind when interpreting the table below. A further discussion on this subject can be found in Appendix 2. Linear and nonlinear are interconnected, just as space and time, which is the subject of the next paragraph. Some examples are obvious and others may seem ambiguous, or so to speak, 'nonlinear'. It is easy to think up more examples and the reader is encouraged to do so.

linear	**nonlinear**
syntagm	paradigm
time	space
event	place
one-dimensional	multi-dimensional
plot	system
story	setting/world
report of the past	experience in real time
descriptive (recount)	prescriptive (rule-set)
cause and effect	web of relations
hierarchic pyramid	network
fixed	fluid
determinate	indeterminate
goal orientation	cyclic orientation
obvious	ambiguous
retrospect	prospect
vector (mathematics)	set (mathematics)
establish	adapt
fact	concept
absolute	relative
reasoning	intuition
certain	uncertain
to go	to be

linear	nonlinear
finished	unfinished
answer	question
embed	emerge
observe	participate
conviction	wonderment
motivation	attitude
identification	anticipation
consume	produce
explain	enable
finite	infinite
goal	method
line	cloud
speech	thought
music	sculpture
melody	harmony
text	diagram
film	game
prose	poetry
3rd person perspective	1st person perspective
protagonist	avatar
embedded narrative	emergent narrative
sequence of events is fixed	sequence of events is fluid
print	hyperlink
bitmap	vector graphics
sampling	MIDI
recorded audio	physical model
DSP (digital signal processing)	procedural audio
Moses' tablets with Ten Commandments	Apple's iPad

Table 1. Linear versus nonlinear

Linearity, nonlinearity and the space-time continuum

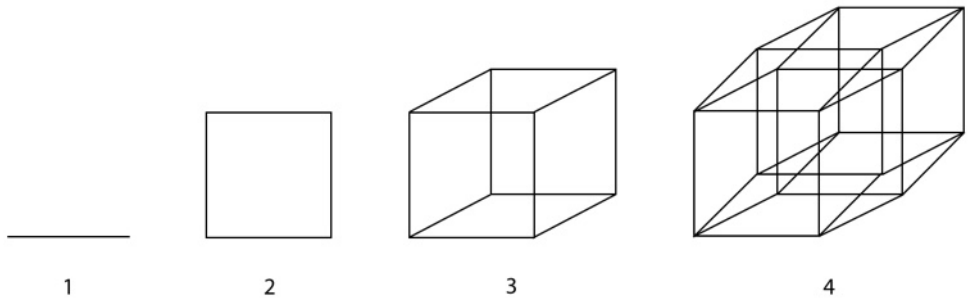

Fig. 13. Graphical representation of one to four dimensions

When we think about space and time they appear to us as two separate entities. Although it is easy to understand that they are interrelated, it is difficult for our brains to imagine them simultaneously in one representation. In Western culture we experience time as linear and space as nonlinear. In 1907 mathematician Hermann Minkowski proposed to represent Einstein's special theory of relativity as one geometric model of four-dimensional space-time. Einstein writes (1920, p. 55): 'The non-mathematician is seized by a mysterious shuddering when he hears of "four-dimensional" things, by a feeling not unlike that awakened by thoughts of the occult. And yet there is no more commonplace statement than that the world[35] in which we live is a four-dimensional space-time continuum.' The mathematically calculated representation of four dimensions in fig.13 is difficult if not impossible for our brains to comprehend as one continuum.

In practice, in the arts, representations are understood as belonging to the time domain (linear) or space domain (nonlinear). Film and music are seen as the linear time-related arts while painting and sculpture, operating in space, are regarded as nonlinear. Still, the actions in films take place in spaces, music is sounding in space, and it takes time to look at a painting. One could say that in the visual arts time is frozen. It takes time to create a painting, then time is frozen in the artefact, and next, time is required to perceive and comprehend it. In the four-dimensional model events are slices of space-time. From the

[35] Minkowski simply referred to all physical phenomena together as 'the world' (Einstein 1920, p. 55).

everyday look at events, time is one-dimensional (line: linear) and space is three-dimensional (nonlinear). Some artefacts emphasise the linear aspects of space-time, others are dependant on the nonlinear features. A plot driven story can only be understood within time relations.[36] Tonal music can only be fully comprehended within time relations[37]. A sculpture cannot be appreciated without considering its spatial relations. Dance is the exception in that it simultaneously emphasises space and time. Artists try to escape the restrictions of the dimensions of their domain. Sometimes composers defy the linear aspects of music by emphasising the spatial properties of music[38]. Brian Eno's objective with *Ambient Music* (1978) was to create music that emphasises a space, a nonlinear ambience, instead of linear development in time. Inspired by new the scientific theories of their time, the art movements *Cubism* and *Futurism* incorporated the linear aspects of time into painting.

In the documentary *David Hockney: A Bigger Picture* (Wolheim 2009) painter David Hockney refers to the Japanese and how they wanted to represent the world in paintings without frames. They did this by painting on rolls. The documentary shows how Hockney paints both space and time in one painting. He manages to do this by painting a landscapes while it is changing over the day, or over a year. So the same painting has elements of what he sees now and of what he saw an hour ago and so forth. It has elements of the morning light and the light of the afternoon. He calls them 'dynamic landscapes'. Hockney explains: 'Time and space are not separate, are they? They used to think they were. It is always now. It is the now that is eternal, actually.'

Space and time are experienced differently in different cultures. In Western culture space is seen as fixed and time is the dynamic dimension. On the other hand, we can move freely in space but not in time. In the radio broadcast *Speaking Freely* (1971) communication theorist Marshall McLuhan asserts that most people think of space as static, as something that is constant, but 'to a preliterate man space has no static properties at all. A person is seen as creating

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[36] What's left when people 'zap' through tv-stations are just unrelated slices of space-time.

[37] It has become a habit to play recorded music without listening to it, in which case tonal music is reduced to its spatial properties, and used as 'atmosphere'.

[38] See appendix 2. under nonlinear music.

his own space and not as being inside space.' Following this reasoning one could say that sound 'creates space'.[39] Time perception is also dependent on culture. 'For the Balinese, for example, temporal processes are not linear, and their music is not linear: it contains rhythmic cycles' (Kramer 1981, p. 540). McLuhan's vision that space is not static and should not be seen as a 'container' was already formulated by mathematician and philosopher Gottfried Leibniz in the 17th Century. Leibniz criticised Isaac Newton, because he maintained the idea of absolute space of Aristotle:

> For Leibniz, space and time are not to be thought of as containers in which bodies are literally located and through which they move, but rather as an abstract structure of relations in which actual (and even possible) bodies might be embedded. Although bodies may be held to stand in spatial and temporal relations to one another, Leibniz claims, space and time themselves must be considered abstractions or idealisations with respect to those relations (McDonough 2008).

Thus, the foundation for Einstein's theory of *relativity* and Heisenberg's *uncertainty principle*[40] was already proposed by Leibniz in the 17th Century.

Nonlinear artefacts as systems

Linear and nonlinear are the structure by which a number of components are organised. Within a linear structure the components are organised along a line, or sequence. Within a nonlinear structure the components are organised as an interrelated network. When the components in a structure are interrelated and also interact, we speak of a 'system'. A system is 'a set of things working together as parts of a mechanism or an interconnecting network, a complex whole' (Oxford Online Dictionaries 2013). Just as both the artefact and the representation within the artefact can be linear or nonlinear, the artefact and the representation can both be organised as a system. A linear representation is a single chain of cause and effect, whereas a nonlinear system can be seen as the

[39] A concept that was used for the design of the portfolio. See Chapter 5.

[40] The uncertainty principle states that the position and momentum of a particle cannot be known simultaneously.

representation of how a complex set of causes and effects are interrelated and interact.

General Systems Theory

During the 1950s biologist Ludwig von Bertalanffy, identified that many kinds of models were used in all fields of science, engineering and enterprise, that were based on what he called 'system thinking' (Bertalanffy 1969, p. xix). He proposed an inter-disciplinary study of systems, that became the 'General Systems Theory' (GST). In 1969 Bertalanffy writes:

> The concept has pervaded all fields of science and penetrated into popular thinking, jargon and mass media. System thinking plays a dominant role in a wide range of fields from industrial enterprise and armaments to esoteric topics of pure science (Bertalanffy 1969, p. 3).

The concept of a system is explained by Bertalanffy, by comparing the manner in which a number of components are classified. 'In dealing with complexes of 'elements' three different kinds of distinctions may be made - 1. according to their *number*; 2. according to their *species;* 3. according to the *relations* of elements.'

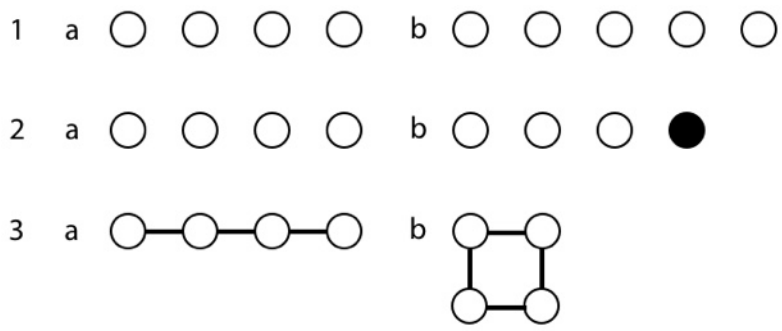

Fig. 14. The system concept (Bertalanffy 1969, p. 54)

In cases 1. and 2. the complex can be understood as the sum of elements considered in isolation. In case 3. not only the elements should be known, but also the relations between them. Bertalanffy calls 1. and 2. *summative* and 3. *constitutive.* Constitutive characteristics are not explainable from the

characteristics of isolated parts. 3a is a linear system and 3b a nonlinear system. Bertalanffy (1969, pp. 28-29) presents an informal survey of main levels in the hierarchy of systems:

	level	description and examples
1	Static structures	atoms, molecules, crystals
2	Clockworks	clocks. conventional machines in general, solar systems
3	Control mechanisms	thermostat, servo mechanisms, homeostatic mechanism in organisms
4	Open systems	flame, cells and organisms in general
5	Lower organisms	'plant like' organisms, 'division of labour' in the organism, distinction of reproduction
6	Animals	increasing importance of traffic in information, receptors, nervous system, learning, beginning of consciousness
7	Man	symbolism, past and future, self and world, self awareness, etc. communication by language
8	Social structures	populations of organisms, symbol determined communities (cultures) in man only
9	Symbolic systems	language, logic, mathematics, sciences, arts, morals, etc.

Table 2. Informal survey of main levels in the hierarchy of systems (Betalanffy 1969, pp. 28-29, adapted)

Adaptive systems

In Bertalannfy's hierarchy starting from open systems and higher there is a form of interaction with other systems in the environment. Whenever systems adapt[41] to their environment they are called adaptive systems. This adaptation happens in real time, as in living organisms, or over a period of time as in evolution. A system is adaptive when it is self-learning. It does not operate with

[41] Adaptive is not the same as 'reacting to'. See Appendix 2. Adaptivity

a fixed rule-set, but can change its rule-set whenever this is required by changing circumstances, a process also known as 'self optimisation' (Flake 2000, Kennedy & Eberhart 2001). In *Swarm Intelligence* Kennedy & Eberhart (2001, pp. 3-34) equate adaptivity to intelligence and intelligence to 'to be alive'. Based on Bertanffy (1969), Flake (2000) and Kennedy & Eberhart (2001) the following properties are required for a system to be adaptive. To be called 'adaptive' the system must meet all criteria.

1. Interaction

Interaction is the mutual action or influence between two systems. Interaction within the environment is fundamental for adaptivity. The environment can be considered as another system. Thus, in the case of interaction with the environment, there is interaction between two systems.

2. Context awareness

The first step to optimise this interaction is to be aware of the context of the environment. In the earlier discussed concept of Vroon (1976) context equates 'meaning'. So context awareness means knowing what things mean for the other system with which a system interacts.

3. History awareness

This adds a time component to the process. With context awareness the interaction can be optimised in the moment, but for a process of (self-)learning the system needs to remember what has happened in the past, and remember which interactions went well and which went wrong.

4. Parallel processing

A system is 'a set of things working together as parts of a mechanism or an interconnecting network, a complex whole' (Oxford Online Dictionaries 2013). To be able adequately to interact with all components, an adaptive system must be able to interact at once with more than one component.

5. Self learning

To main goal of adaptivity, or adaptive behaviour, is to maintain the system, by keeping the connection and interaction with the environment. If the system, through context awareness, detects changes in the environment, it must be able to change its behaviour to keep the connection. Kennedy &

Eberhart (2001, pp. 3-34) describe this process as 'intelligence'. In organisms 'intelligence' is what keeps the system alive. As long as the system interacts with the environment 'it is alive'. Kennedy & Eberhart explain that the basic principle of intelligence is to 'just do something', just anything. Any random choice is as good as another one. When this process, which they call 'aiming and guessing' is performed in a loop of: context awareness - history awareness - evaluating the result for the most rewarding outcome - parallel processing - aim and guess - context awareness etc., the result will be self-optimisation.

Immanuel Kant (Bortoff 1996, p. 995) distinguishes the difference between a machine and an organism as follows:

- In a machine the parts only exist **for** each other, in the sense of supporting each other within a functional whole.
- In an organism the parts also exist **by means of** each other, in the sense of producing each other.

Kant's description of an organism is also a satisfactory general description for an adaptive system.

Adaptive systems and the computation of meaning

In theory adaptive systems can be used for the computation of meaning. Earlier in this chapter meaning has been defined as an interactive exchange of context. As an example an adaptive music system for a digital game should be able to 'aim and guess' what the next step in the development of gameplay is and decide from that what to play. If the system guesses wrong it simply guesses again, until the output matches the circumstances. An adaptive system, created in computer software, can be used as an active participant in the creation or exchange of meaning, because the system and the user are aware of each others context. In my function as lecturer on Sound Design and Composition for Adaptive Systems at the *HKU, University of the Arts Utrecht*, I am involved in

research on the subject. We do research on the use of adaptive systems as a method to build, among others, nonlinear music systems for digital games.

Indeterministic methods and systems

We have seen above that ambiguous or vague representation results into nonlinear meaning. Meaning, in this case, is uncertain, inexact or indefinite for the user. Each user can choose a possible meaning, based on his or her context or accept that the meaning is multi-layered. This type of nonlinearity can also be organised by using a method or system. In Chapter 3. the method, used by John Cage and choreographer Merce Cunningham to organise nonlinearity is described. They deployed chance as a device for composition and performance. In their cooperation they intentionally did not make any arrangements on the relationship and synchronisation between the music and the dance. In combining the two independent representation systems the relations between music and dance were accidental and unforeseen by the creators. With suchlike representation the viewer will try to extract meaning from coincidences (Greenfield 2012) and the resulting meaning is undetermined or nonlinear.

Chaotic systems

An indeterminate output can also be generated without the use of randomness. Chaos theory, a sub division of the study of mathematics, demonstrates that deterministic systems, whose future behaviour is based on their initial conditions, with no random elements involved, can produce unpredictable nonlinear outcomes (Flake 2000, pp. 137-188). A chaotic system with a fixed rule-set has an indeterministic output. Examples of chaotic systems are an economy, a stock market or the weather (BusinessDictionary.com 2013). In comparison: an adaptive system does not operate from a fixed rule-set, but changes its rule-set, through self-optimisation, based on changing conditions. The aim of an adaptive system is to create the most rewarding output based on

indeterminate conditions (Kennedy & Eberhart 2001, pp. 3-34). Adaptive systems are useful to create linear output under nonlinear conditions. Dynamical systems that involve so called 'deterministic chaos' do the opposite in that they develop nonlinear behaviour starting from a fixed rule-set (Flake 2000, p. 138). In 1963 Edward Lorenz, a meteorologist, presented a groundbreaking paper on the subject of chaos theory, *Deterministic Non-periodic Flow* (Lorenz 1963). Lorenz is cited by Danforth (2013) on the website *Mathematics of Planet Earth* with a description of chaos:

> Chaos: When the present determines the future, but the approximate present does not approximately determine the future.

The sensitivity of chaotic systems is expressed in the famous example by Lorenz of the *Butterfly Effect*, by which 'a butterfly flapping its wings can alter global weather patterns' (Flake 2000, p. 155).

Different scientists use different definitions for chaos, but there is agreement on the typical features of chaos (Dito & Munakata 1995, Flake 2000, Miranda 2001):

1. Nonlinearity

Chaotic systems behave in a nonlinear way.

2. Determinism

It has deterministic (rather than probabilistic) underlying rules every future state of the system must follow.

3. Sensitivity to initial conditions

Small changes in its initial state can lead to radically different behaviour in its final state, known as the *Butterfly Effect.*

4. Sustained irregularity in the behaviour of the system

There is a hidden order including a large or infinite number of unstable periodic patterns (or motions).

Chaotic systems as a method for nonlinear design

How can chaotic systems be deployed for nonlinear sound design? This can be done by using an iterative process, a mathematical procedure where each step is applied to the output of the preceding step (Miranda 2001, pp. 83-84):

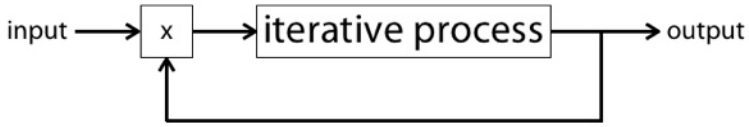

Fig. 15. Iterative process with feedback from output to input (Miranda 2001, p. 83)

Miranda (2001, p. 84) explains that an iterative process may produce three classes of paths:

1. paths tending towards a **stable fixed value**
2. paths tending to **oscillation between specific elements**
3. paths that **fall into chaos**

As soon as the value of the input x is also varied with very small modifications, after a few iterations the system will display chaotic behaviour. Programming such an algorithm can be useful for designing nonlinear output based on fixed rules. A practical example of such an algorithm is a 'self generating patch' on an analogue synthesizer, in which case the feedback loop from the output to the input is essential, just as is a small amount of frequency modulation at the input.[42] Small tweaks on one or more parameters can result into ever evolving nonlinear soundscapes, that can suddenly and chaotically flip into a new state. The most interesting results are obtained when there is a certain balance between repetition and variation, in which case listeners starts to signify the output as 'music'. Experience has shown that the best way to obtain this, is by heuristic tweaking. Patches like this can be programmed in software. The number of parameters dictate the dimensionality of the process. The same

[42] A very time consuming, but very pleasant activity performed by early analog synthesists at the end of the 1970s into the 1980s. *Buchla* synthesizers, in particular, were designed in such a way that they invited a chaotic approach.

patching can be enriched by using subdivisions of values at various inputs. The more complex the patching the more undeterminate the results. An audio example of a chaotic synthesis algorithm can be found on the DVD in the folder labeled 'extra files'.
At several instants in the recording a sudden, seemingly random, change can be heard. This is a cut-out of 3:20 of this, in theory, eternal continuing patch. The recording was started and stopped at random moments.

Adaptive versus chaotic systems

Both adaptive systems and chaotic systems can be useful in the context of sound design and nonlinear representation. Adaptive systems use evolutionary algorithms, which can be useful to fit content in nonlinear structures. Chaotic systems are valuable to generate nonlinear content.

Sound design for nonlinear artefacts or the design of nonlinear sound for artefacts

Summarising we can define strategies for sound design in a nonlinear context. As noted earlier, the combination of sound design and nonlinearity knows two scenarios. First, sound design can be applied to artefacts that are themselves nonlinear in structure. In the second scenario, the representation that is the output of the sound design process is nonlinear. Nonlinear sound representation can be applied to both linear and nonlinear artefacts. An example of the first case is sound design for an art installation in a museum or public space. An example of the second is the application of ambiguous sounds in film, or using sounds with ambiguous meaning for the art installation. The works in the portfolio contain examples of both scenarios. The title of the thesis is based on the initial situation that sound design was required for drawings of visual artist Robbie Cornelissen, which are nonlinear artefacts. In the

transformation of these drawings into animation the objective was to keep the original nonlinear representation of the drawings, as much as possible.
In the following paragraphs, an overview of the material that was covered in this chapter is summarised to define strategies for both scenario's.

Strategies for sound design for nonlinear artefacts

Nonlinear artefacts require a number of strategies for sound design. We must make a distinction between dynamic nonlinear artefacts, such as digital games or computer models, and static nonlinear artefacts, such as paintings and sculptures. Dynamic nonlinear artefacts demand the sound design to address the undetermined states of a disjointed or emergent trajectory. Static nonlinear artefacts, by their inherent structure, do not operate in the time domain and enable sound design that is both linear or nonlinear in its representation.

Requirements and strategies for sound design for dynamic nonlinear artefacts

- The sound design must address the changing states of the artefact.
- In the case of a computer model or simulation this involves the sound design for the paradigmatic world.
- In the case of digital games this involves both the sound design for the paradigmatic world and the sound design for a syntagmatic embedded and/or emergent trajectory.
- The sound design can deal with the changing states by using a scripted play-out system for sampled, or recorded audio. The scripts consist of rule-sets for the 'behaviour' of the audio.
- Real time synthesis and procedural audio offer more flexibility than working with recorded audio samples. It can be difficult to obtain the same realism, in cases that realism is the objective.
- The sound design for paradigmatic world can be enhanced by programming rules for the acoustic behaviour of objects and spaces.

- The sound world thus becomes a an 'acoustic ecology'. In an acoustic ecology participants can communicate with sound and the sound of actions give information to the participants.
- The use of an adaptive system can be useful to anticipate events in disjointed embedded, or nonlinear emergent narrative.

Requirements and strategies for sound design for static nonlinear artefacts

- Sound can underline the spatial properties of the artefact or expand it into the time domain.
- Since a static nonlinear artefact operates in the space domain rather than in the domain of time, its nonlinear properties can be enhanced by representing its spatial properties with sound.
- When the sound design for a nonlinear artefact is linear in its representation, the chance exist that the attention is fully drawn to the sound. As an example, when combining a painting with music, the chances are that the music prevails in the representation.
- The use of an interactive sound system can extend the nonlinear meaning within a nonlinear artefact by facilitating an active role for the user in the process of signification.

Strategies for the design of nonlinear sound

With nonlinear sound, the resulting meaning of the representation is nonlinear.

- One method to design sound with nonlinear properties is to use sounds that are deliberately ambiguous and vague. The listener will determine its own meaning even if there is no intention for meaning by the designer.
- Design for the paradigma and not for the syntagma. Design the sound of spaces and avoid development and vectorization. The sound of spaces will be experienced as atmosphere, which is a nonlinear property.
- Avoid indexical sounds, as they imply a linear trajectory of cause and effect
- Introduce indeterminism. Indeterminism can be organised by the deployment of chance or randomness.

- The use of a chaotic system can be useful to generate indeterminate, nonlinear output based on fixed rules.

5

Application of the framework and the design process

Our ultimate gratitude to art.- If we had not welcomed the arts and invented this kind of cult of the untrue, then the realisation of general untruth and mendaciousness that now comes to us through science -the realisation that delusion and error are conditions of human knowledge and sensation- would be utterly unbearable.

From: Die fröhliche Wissenschaft (Friedrich Nietzsche 1882, p. 163)

Introduction

This chapter is a description of the design processes of the works in the portfolio. The design concepts and methods were influenced by the framework as described in Chapter 4, and the devising of this framework was, in its turn, influenced by the design process of the projects. Some ideas and models, as they appear in Chapter 4, were formulated before I had started on the design. Other concepts were documented afterwards, as they had emerged from working on the projects. There was no set order in which theory and practice succeeded each other. In the alternation between theory and practice, both were mutually influenced. Thought defined action and action defined thought. The method involved both research **for** design and research **through** design.

Models, frameworks and the immanent design process

The design process is immanent, it works within itself, within the motion of the procedure. There is a discrepancy between the academic analysis and the practice of design. Models are like snapshots. Most of the time, during the design process you do not work from an extrinsic framework or model, but from an internalised intuitive position. Many things emerge from the design

action itself. 'If you want to achieve something in business, in writing, in painting or whatever, *you should follow the rules without knowing them*' (Schopenhauer 1851, p. 123-124). Neurologist Ap Dijksterhuis confirms this: 'If all is well, you are, as it were, a vehicle for the things the subconscious invents' (2007, p. 142). 'Stravinsky once proclaimed 'I am the vessel through which the Sacre[43] passed' (Darvas 2001). 'Picasso was one of many, who realised that consciousness should not interfere with the creative process. Perhaps in advance, or afterwards, but not during the creation of art itself' (Dijksterhuis 2007, p. 142).

The design of the works in the portfolio

In the following paragraphs the sound design process of the works in the portfolio is discussed. The account is divided in two parts. Part one describes the cooperation with fine artist Robbie Cornelissen, and involves the sound design for an animation and for installations at an exhibition. Part two is an account of the sound design process for public space, commissioned by Stipo, a 'team for urban strategy and city development'.

Part 1
The design process of the sound for the animations of Robbie Cornelissen

Introduction

Robbie Cornelissen is a visual artist who creates enormous large, black and white drawings in graphite on paper. Recurring themes in his work are architecture, labyrinthine spaces, memory, and the relation between the actual spaces of libraries and the inner space of memory. As an example, in 2011 for the *Gemeente Museum* in The Hague, he presented a drawing with a length of 13 meters, with the title *The Capacious Memory X*. In a review of the exhibition, titled *Wandering through the Drawings of Robbie Cornelissen*, art critic Edzard

[43] *Le Sacre du Printemps.*

Mik writes: 'Looking at his work is like traveling through memories' (Mik 2011, p.18). Mik continues:

> The spaces may seem architectural, but Cornelissen did not draw human figures in them. They do occur in his earlier work, even prominently so, but they would get here in the way. You would get involved with who they are and what keeps them busy, you would look at them and try to place them in a story or anecdote. But it is the intention that you end up in the spaces yourself, and conversely, that the spaces unfold in your mind so that you fill yourself with their breath-taking void (Mik 2011, p. 18).

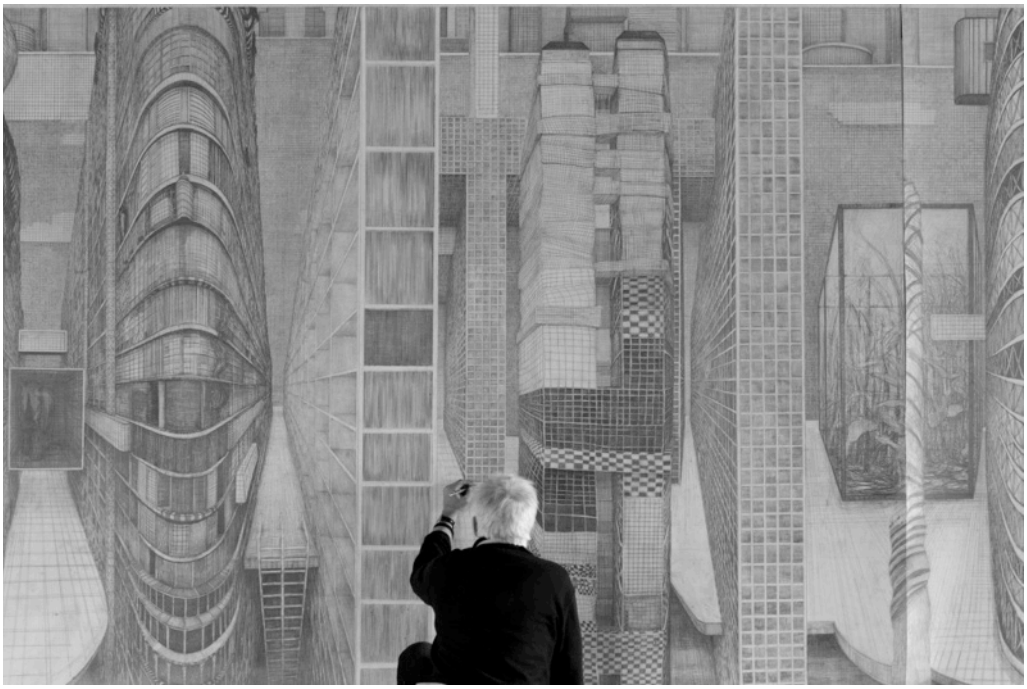

Fig. 16. Robbie Cornelissen working on *The Capacious Memory X* (NRC 2011, p. 18)

The cooperation with Robbie Cornelissen

I met Robbie Cornelissen when he was working on the transformation of his drawings into an animation. He had put music underneath and this caused problems with respect to meaning. He asked my advice, and if I could compose something else that would work. Just as poets, visual artists are noted for their reluctance to talk about the meaning of their work. Why talk about what you can paint? Traditionally, meaning in fine art, as in poetry, is a matter of interpretation and requires the participation of the viewer. In our collaboration, Robbie Cornelissen and I never talk about what the various elements in his drawings and the animations mean. We speak mainly in terms of whether

something works, or whether it feels right or not. I also make suggestions for sounds without linking them to meanings, but rather to an object or element, such as space. I do however think about the themes in the work. Clearly recurring subjects are spaces, libraries, knowledge, memory, and the relation between inner and outer world. The inner world being literally the world within yourself.

Sound design for the animation: *Het Grote Geheugen* (*The Capacious Memory*)

The movie file of this animation can be found on the DVD in the folder labeled '2_extra_files'.

Robbie Cornelissen came to me in 2006 with the first version of *The Capacious Memory,* a computer animation based on his drawings. The temp track[44] he had used was problematic. Not only did the music make the animation too pretentious, it also brought along all kinds of connections that evoked undesirable meanings. When Robbie asked me to think about music for the animation, I was actually doing research on the issues of music and sound with respect to the nonlinear properties of digital games. From this fact, combined with my background in fine art, I immediately recognised the problem. The music steered the animation into a certain direction. Not only did the music have a vectorising[45] effect, it also evoked the wrong emotions. To begin with, I suggested not to use music but sound design.

I saw it as a challenge to preserve the nonlinear character, by means of sound design, despite the fact that the drawings of Robbie had now been transformed into a moving animation. Admittedly, in the animation, you move as a kind of avatar through the world of Cornelissen, but it is not a story. It is just the exploration of that world. So despite the motion there is no driving plot behind it. You are there, you take everything into consideration, you observe certain processes, but nothing really happens. The representation is essentially nonlinear. Just as when viewing a drawing, you can wander through its world, decide how long you want to look at something, and then decide for yourself

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[44] A temp track is an existing piece of music or audio which is used in film production during the editing phase (Sadoff 2006, p. 165).

[45] Vectorisation: sound or music orients the images toward a future, a goal, and creates feelings of imminence and expectation (Chion 1994, pp. 18-20).

what it means. The design process for this animation will be described below, because the design decisions were essential and formed the foundation for the design of the works in the portfolio that followed it.

The design for *Het Grote Geheugen* (*The Capacious Memory)*

The animation has no relation to any genre within the tradition of cinematic animation. As discussed in Chapter 3. most cinematic animation follows a very linear trajectory, which is directed and vectorised by music. This was an animation in the context of fine art. To maintain the nonlinear character, it was obvious that I would focus on the representation of the paradigm, the world. In the design I started with the element of space. Since space and spaces were the most prominent theme in the animation, I suggested to do the production in 5.1 surround sound. Sound would create space. When showing the film, the viewer would right away find himself in the acoustic space of the animation. Next, I started collecting audio recordings of large spaces such as churches, large bank buildings and museums. For this, I made use of sound libraries. For the following animation, *The Labyrinth Runner,* I would go out on the road myself to make my own recordings of empty spaces. In addition to these recordings, I experimented extensively with convolution reverbs[46] to achieve an as intense as possible experience of space. To emphasise the nonlinear aspect of the animation the paradigm, the world had to be emphasised. One method to do that is by supporting the objects in the world by means of sound. This can be done by giving them a clear acoustic texture. By this I mean that one can hear the material of which the objects are made. These are iconic[47] sounds, which reinforce the credibility of the world, because they are placed in synchrony with the picture. In the case of objects that do not exist in the real world, I used symbolic representation. Looking at the animation I designed sounds that, in my opinion, matched in texture with the objects and situations. By the effect of synchresis, achieved by the synchrony between image and sound, this also leads

[46] A convolution reverb is a digital signal processing technique that uses a mathematical convolution operation for the reverberation of the space being modelled.

[47] The terms 'iconic', 'symbolic' and 'indexical' are used here in the semiotic sense as discussed in Chapter 4.

to credibility. One of the sounds that Robbie and I have worked on together, is that of the 'metal grids' (at 04:14 in the movie file). We talked about how we as little boys, when we were bored, would rub along fences with a stick. I for example, during a walk with my parents. And how we would listen to the rhythm of the sounds that this caused. Together we made recordings of such noises and these ended up in the animation. The animation begins with the suggestion of a bodily inside and Robbie suggested to use body sounds, such as bubbling, mumbling and breathing. I made the recordings for this together with Robbie performing. I also used some recordings from sound libraries that I processed to obtain the desired result. The use of these sounds is not synchronous with the image and, although they relate to the inner world they can be interpreted as non-diegetic. There are also some actions in the animation that deliberately have no sound at all, such as the doors at 03:27. This has an alienating effect. Further, there are a lot of half-diegetic sounds, that are somewhere in between music and sound.[48] They are more or less arranged into a soundscape composition. The intention is that this contributes to the atmosphere in the evoked world. And the indeterminate character of the sounds adds to the nonlinearity. I worked long on a vocabulary for these sounds and much discussion went into what worked and what did not. At 09:47 in the animation we look through a monocular and watch a simple animation. This is a world within a world and the soundtrack flips to complete silence. Silence has an association with solemness and it forms a nice contrast to the animation. Taken together, I worked hard to create a sound design that avoids any form of direction or plot. It actually signifies nothing outside the sonic shaping of the virtual world. To underline its nonlinear character the animation was edited in a loop. As a result when it is showed at exhibitions it will have no beginning or end. An encouraging reaction on the animation came from a Belgian art critic. He mentioned that he had been watching the animation in wonderment, to come to the conclusion that it meant nothing, but that it was captivating all the way.

[48] See Appendix 2. for a discussion on music design versus sound design.

Sound design for the animation: '*The Labyrinth Runner*'

The movie file of this animation can be found on the DVD in the folder labeled 'portfolio'.

The next project I did for Robbie Cornelissen was the assignment for the sound design for the animation *The Labyrinth Runner* in 2009. This project was realised in the course of the MPhil and is the first project within the portfolio. During my design for the first animation of Robbie, I had developed a number of concepts, which contributed to the nonlinear character of the final artefact. The artefact itself was linear, but the representation within the artefact was non-linear. As with drawings, which are nonlinear in structure, the animation facilitates optimal participation of the viewer in the creation of meaning. This new project contained a number of elements that broke with the form that was used in the first animation. It contained a number of transformations from one state into another. A transformation is a metamorphosis, a change of form. While the process of transformation is a linear action, each new form is a state, which is nonlinear. The states after each transformation in *The Labyrinth Runner* are by themselves indeterminate in their signification, just as in *The Capacious Memory*. All this meant a new challenge as the animation presented an interplay of linear and nonlinear representation.
Again I started with space. The spaces were even larger than in *The Capacious Memory* and I decided to make my own recordings of spaces this time. As the screening of *The Capacious Memory* with surround sound appeared to lead to problems at certain art galleries, it was decided to do this production in stereo. I recorded the empty interiors of large churches in Rotterdam, Utrecht and Amsterdam. It was interesting to discover again how sound creates space. Literally so, as the sounds from the city outside, which reverberated inside the church, determined the final sound of the space. I discovered I could get a completely different sounding space at different times of the day. Interestingly, the recordings made at moments when there was much traffic gave the best impression of a large empty space. I also recorded a number of impulse responses in every church that I could use for the convolution reverb, during production. The main part of the rest of the sound design was done by means of

sound synthesis. I used a large collection of software synthesizers. I was able to precisely control them within *Logic*, the digital audio workstation.
The way in which I applied synthesis was comparable to how procedural audio is used for game audio. Instead of the scripting you do with procedural audio, I could precisely change the sounds over time with continuous MIDI controllers, which I could draw inside *Logic*.
The animation starts with live action video of the 'labyrinth runner'. The runner is transformed into the (initially digital) world of the animation. I shaped the sound of this transformation partly with granular processing. During the emergence of the 'number wall', as Robbie called it, the breathing of the boy transforms into the breathing of space and the footsteps transform into rhythms that pulsate through the large hall. I managed to make the hall even bigger by adding sounds of wind. I am perfectly happy with the sound of the number wall. It took me quite some time to create it. In my opinion, in the end it perfectly matches the texture of numbers drawn in pencil. At 03:10 in the movie file you can hear a glass falling. This is an indexical sound that suggests there is another person in the room. This may seem inconsistent to the intent to create a nonlinear representation. And that is what it is. It is based on an idea that I learned at art college. If you want to make a painting with a large black area, the black area becomes much larger by placing a little white dot in it. The sound is placed here for contrast. I had to shift it forward and backward a couple of times until it felt to be at the right place. The sound of the reflections of the breaking glass further makes it possible to understand how big the space is.
Next comes descending the stairs. Robbie proposed to make it sound as if you, in some way or other, fall from the stairs. Robbie calls the next space 'the control room'. It shows, what I interpret as, various internal processes of the inner world and I created kind of 'Geräuschmachung'[49] sounds to represent them. This fades into a situation in which we enter a very ambiguous, nonlinear universe. Where time goes forwards and backwards. Where time and space merge. In the soundtrack time is measured by the pulse of the music, but at the same time the sustained chord puts it to a standstill. Spaces unfold and vanish.

[49] 'Geräuschmachung' is German for 'Foley' and in the Netherlands the word has connotations of antique theatre and film sound design.

At 04:32 we see a once repeated sequence of closing doors. During the second time I played the sound of the doors in reverse. Gradually the condition dissolves into an escalator and we enter the second large hall, while the chord dies out. In this space we find a number of previous themes that return in a transformed shape. Moving walkways[50] transport us quickly through the immense hall. Although we have seen the transformation of the runner at the beginning, we travel through the experience in first person perspective. The sound I placed under the first moving walkway (at 06:10) reintroduces the breathing of the runner as an indication of movement. The second time I added the sound of pure noise and the simple increase of volume stands for motion and leads to a climax that turns into darkness. Do we see moving lines or do we go up? Is this an elevator? The clicks you hear might confirm this. Then darkness transforms into light, which in turn transforms into matter that unfolds into a new undefined space-time. Are those moving objects we see or is it time that passes? Musical chords are used as indicators of the nonlinear condition. We can also hear sticks rubbing along fences, a sonic memory from *The Capacious Memory*. A musical modulation lifts us up into the 'shower room', again a name coined by Robbie. The sound of running water has been entirely created by means of synthesis, which enabled a very precise timing of its development. Behind the door at 08:46 we end up in a situation that, for obvious reasons, I will not try to explain. Again time stands still, somewhat as in the monocular scene in *The Capacious Memory.* The transformation happens in one nonlinear moment of contemplation. We hear abstract music played on a piano. Although he was shy about it, I encouraged Robbie to play the notes on the keyboard. I said: 'Anything goes, as long as you play the wrong notes.' So it is actually Robbie's composition. At 09:05 we find ourselves in the spiral, the last transformation. At intervals I worked for two days on the sound of the spiral until it met my idea of the right speed build-up. Here the runner returns in third person perspective and by means of the centrifugal force he ends up in a new virtual configuration. We had some discussion about the sound that was needed to underscore this new world. Eventually we used Robbie's choice.

[50] Also known as 'travellators'.

Part 2

Sound Design for the exhibition: *Studio Vertigo*, Centraal Museum Utrecht

Video and audio files for this section can be found on the DVD in the folder portfolio/ 2 Studio Vertigo

During the production of *The Labyrinth Runner* Robbie and I fantasised about the possibility of actually building a number of situations from the animation as a physical art and sound installation. Eventually this idea became a reality in 2011, when Robbie was given the opportunity to compile an exhibition in a long corridor, four large rooms and one small exhibition room at the *Centraal Museum* in Utrecht. Robbie put together an exposition in which both drawings and projections, and a number of art installations were shown under the name *Studio Vertigo*. In the animations *The Capacious Memory* and *The Labyrinth Runner* the viewer could, in first person perspective, move through the spaces. In the exhibition the visitor would now have the opportunity to literally step into the world of Robbie Cornelissen. Each installation, but also the exhibition as a whole was a nonlinear artefact. What had begun as nonlinear drawings, was first transformed into the linear artefact of animation. This in turn was now transformed not only into a nonlinear artefact, but it allowed real time interaction with it. The installations would be partially based on themes from *The Labyrinth Runner*, but also on new, to be developed, ideas. I was asked to design the sound for the installations. I wanted to develop further and implement the earlier concepts of nonlineair representation. From the idea that creator and user are mutually dependent on each other for signification, it was obvious that my designs would have to be interactive. For budgetary reasons only one installation contained a truly interactive sound system. Additionally, another four static setups were created, which the visitor could physically enter, but it was not possible to interact with them.

The access to the three major exhibition areas consisted of a long corridor. There, Robbie wanted to create an installation, in which the visitor would experience the same transformation as the runner at the start of *The Labyrinth Runner.* This idea was realised by projecting the live video footage of the runner

at the entrance of the corridor and at the end a projection of the 'digitised' runner on the ‘number wall’. I thought about how I could achieve a sonic experience of this transformation for the visitor, during the walk through the corridor. First I thought up a system with sensors, and sound that would follow the visitor. When it turned out there was not enough budget for that, the solution proved to be dead simple. At the entrance of the corridor I placed speakers with the sound of the ‘live video’ runner and at the end speakers with the sound of the runner on the *Number Wall*. Now, when you walked down the corridor the sound would be cross-fading in a natural way from one setting to the other (and also in the right tempo for each visitor). At the end of the corridor one entered the first exhibition room where a projection was shown of the space with the moving cubes from *The Labyrinth Runner* (at 07:15). I edited the original sound from the animation to a loop and adjusted the mix for the acoustics of the location where it was projected. As the walk continued, one came in the first big room, which was set up as the *Number Room*.

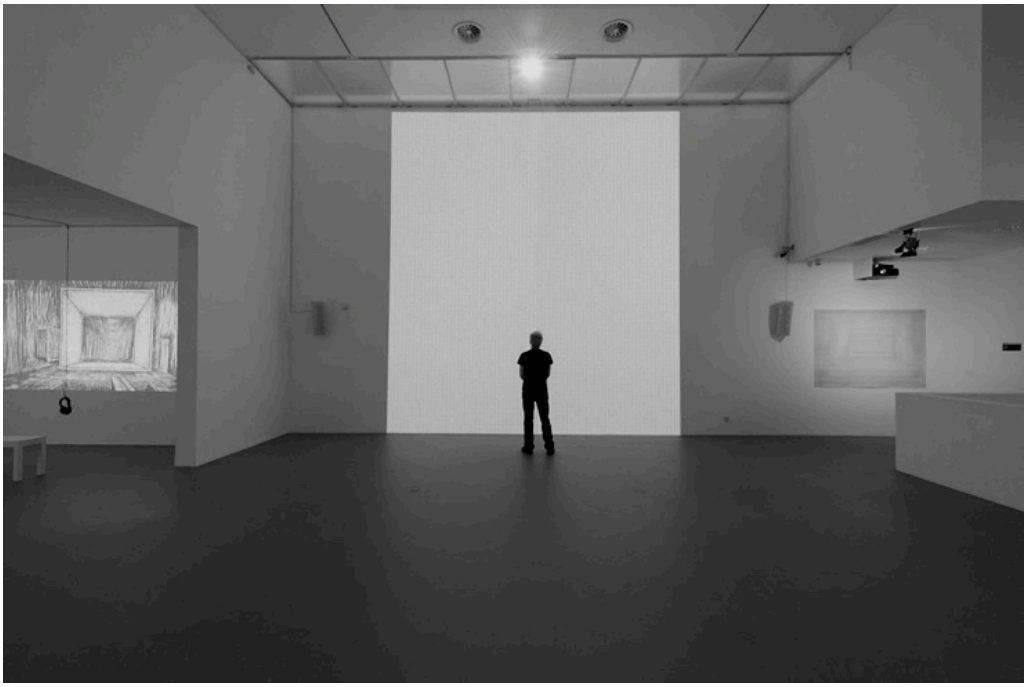

Fig. 17. Robbie Cornelissen in front of the projection of the *Number Wall*

On one of the walls a projection of 5 x 5 meters of the *Number Wall* from *The Labyrinth* Runner was shown. I wanted to make this space acoustically bigger than it was. That is why I opted for a setup with four speakers, one in each

corner of the room. The idea was, as in the animation, to place a recording of an empty church on the four speakers. For this, I made a number of four-channel recordings of the *St. Martin's Cathedral* (or *Dom Church)* in Utrecht. When I played the recordings over the four speakers this proved not to work. The exhibition room had its own reverberation and everything added up to an undefined sonic mush. I ended up making a new four-channel mix of the original sound of the *Number Wall* from the animation. Halfway the looped track, threatening footsteps and heavy breathing loom out of the back speakers, move to the front, and slowly fade out, as they did in the original film. In the end I used a very dry mix, which yielded a very spatial experience.
In the following interspace a number of small drawings were hung on one wall. On the opposite wall one could watch a looped animation of the *Engine Room* (from the *Labyrinth Runner* at 03:29). In order to not disturb the sound coming from the adjacent installations the sound was placed on headphones, for which I made a special mix. Robbie called the next exhibition room the *Zwarte Kamer* or *Black Room*.

In the *Black Room* on one wall a drawing, called *The Execution Room* was shown. In the middle of the room a black cube of 2.7 x 2.7 meters was set up.

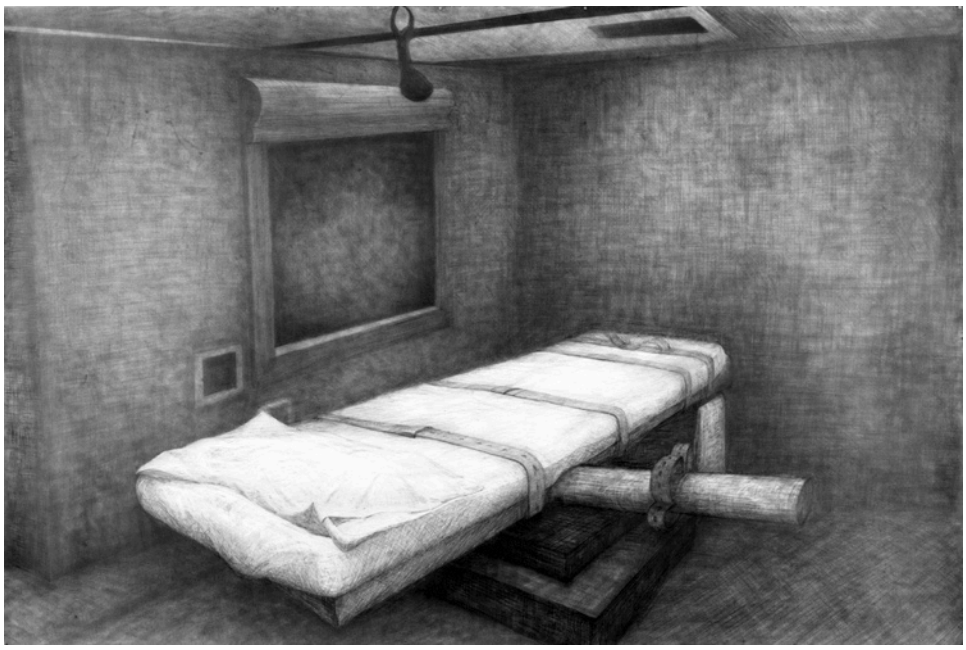

Fig. 18. *The Execution Room* 240 x 364 cm. Graphite on paper. (Robbie Cornelissen 2010)

The cube was made of MDF[51] and covered with paper that which was completely blackened with graphite. It looked like a big three dimensional drawing. Robbie left it up to me to come up with an interactive sound design concept for the cube. Based on his work, I interpreted it as the 'box of all knowledge'. A dangerous object, like *Pandora's Box*, or the *Tree of Knowledg*e from *The Book of Genesis*. A box that contains all knowledge in the universe, condensed in one point (*The Capacious Memory*). To the visitor of the

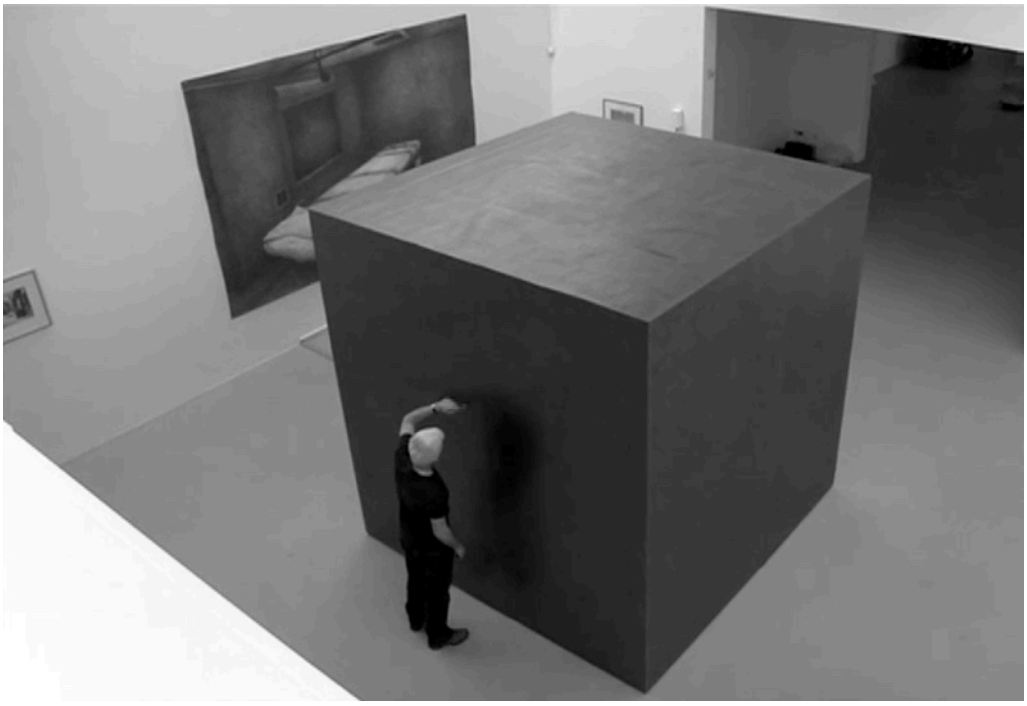

Fig. 19. A Picture of the *Black Room* taken from above

exhibition, the box would be a dangerous but righteous entity, that needed to be approached in a careful manner. Once treated with respect, the box would release its wisdom. I decided to represent this knowledge with the sound of voices, an idea that really appealed to Robbie. The files would be played by an interactive system on a computer. I collected a huge amount of original, historic, sound recordings of quotes and declamations by famous and important scientists, writers, poets, artists, composers and philosophers, mainly from the 1930s to the 1970s. I gathered some 650 recordings, many from the internet, but also from other sources. To give an idea: it included sound clips of a wide

[51] Medium Density Fibreboard.

diversity of prominent personalities, among them, Salvador Dali, Sylvia Plath, Kurt Schwitters, Francis Bacon, Roland Barthes, David Bedford, Cathy Barberian, Joseph Beuys, Michel Foucault, John Cage, Françoise Sagan, Paul Bowles, Christo, Henry Miller, Stephen Hawking, Marshall McLuhan, Albert Einstein, Sol LeWitt, Igor Stravinsky, Alan Ginsberg, Charles Amirkhanian, Ezra Pound, Andy Warhol, Umberto Eco, Samuel Becket, Leonard Bernstein, Oskar Kokoschka, Saul Bellow, Marguerite Duras, Max Planck, Frank Zappa, Jaques Derrida, Max Neuhaus, Bertold Brecht, Delia Derbyshire, James Joyce, Marcel Duchamp, Charles Ives, Wassili Kandinsky and many, many more.
It was a huge amount of work to edit all the recordings into separate quotes, which could only be done by ear. Normalising[52] the files was done by the computer, by batch processing a whole folder of files. So that was the easy part. Besides the audio recordings I also created a folder with a large selection of text files of selected poems, prose and scientific expositions. I intended to have them recited by a speech synthesizer. Another idea was to use news feeds from the internet that also could be read out by a speech synthesizer. A further source of knowledge would be gathered in real time by using bluetooth technology to hunt down the names of the visitors of the exhibition by checking their mobile phones. A software algorithm would recognise the most common brands of phones and process the retrieved data in such a way that only the name of the owner was left and could be put into the memory of computer inside the black box. Taking my own phone as an example it would work as follows. The bluetooth adapter inside the computer would search for other bluetooth devices in the neighbourhood. As soon as I approached the black cube, it would identify my phone as: 'Kees Went's iPhone'. The software would cut of the part '-s iPhone' and keep my name 'Kees Went' in memory. This name would, with some delay, be read out aloud by a speech synthesizer. The visitor would have the perception that the black cube had context awareness. Scary, it even knew your name. Although the content of the black box would not contain audio files with all existing knowledge, this is how far I could go with the given time and budget constraints. But it was close enough for a representation of the concept.

[52]By 'audio peak normalisation' the gain of a sound-file is changed to bring its highest peak to a maximum level. The signal to noise ratio and relative dynamics do not change.

Fig. 20. *The Black Room*. (Robbie Cornelissen 2011)

All of the above ideas for the design were realised in the final version of the installation. This was due, for an important part, to the technical assistance of my colleague, music producer and music technologist, Jeroen van Iterson. Jeroen wrote the software for the play-out system and implemented my system design for interactivity. He has a lot of experience with software play-out systems that are connected to sensors. He has designed such systems for a number of large pop acts and for theatre shows. His specialty is how to transform a recorded music album into a live production, in which the musicians can trigger sampled audio events and start video files in sync with their live performance.

Jeroen also came up with some inspiring ideas of his own, some of which found their way in the final implementation. We decided to create an eight channel play-out system that distributed sound in a matrix over 16 speakers, so that sound would come from all sides and could move along sides. The equipment inside the black cube consisted of a *Apple Mac Mini* computer, a multi channel sound interface, 16 mini speakers, a subwoofer and a number of (actually quite primitive) sensors. First a infra-red sensor hanging outside the cube, at the

entrance of the *Black Room,* counted the number of visitors passing the black cube. An algorithm calculated the average of the number of people that, at a certain moment, was present in the room. The basic rule of the system was that, the less people were in the room, the more knowledge the cube would disclose.

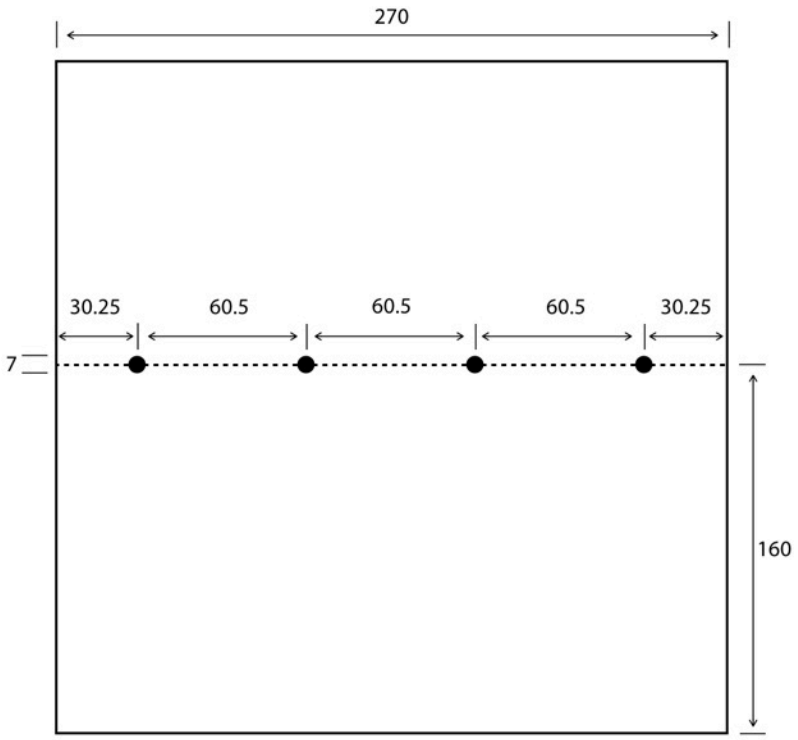

Fig. 21. The speaker configuration on each side of the black cube. Measures are in cm.

A second sensor was mounted inside the cube on one of the four sides. It was meant to measure the proximity of the visitor. If a visitor came too close the system would growl and immediately stop disclosing any more information. We used a very cheap parking sensor to make this work. A parking sensor is a proximity sensor for road vehicles designed to alert the driver to obstacles while parking. Ours was a simple DIY kit that delivered a simple binary on/off trigger to the system.

Fig. 22. Some of the technology inside the cube.

The sound system was programmed in *Max MSP.* The final functional system design consisted of the following elements:

I. **Sound content** (the 'capacious memory' of the system)
The sound content was distributed over four independent layers in the play-out system:

1. **Engine sounds.** The cube represented an entity, a machine with animal-like traits. This was represented with an ever evolving eight-channel soundscape of engine-like sounds that was dynamically mixed, depending on the time of day and the number of people that were in the room.
2. **Long term memory**. This layer contained the spoken original sound samples of famous poets, artists, writers, philosophers and scientists, from 1930s to 1970s. The next samples to play were chosen randomly from a folder with sound files. This knowledge came from long term memory as it was established long ago and the memory was static.
3. **Mid term memory**. News feeds (through a live internet connection) were read by a speech synthesizer. The computer was connected to the internet and collected text clips from news feeds of big papers as *The Times*, *The New York Times, Le Soir, Frankfurter Algemeine* and so forth. A robotic voice reported on current affairs, such as bomb attacks in the Middle East, local accidents, economic news etc. Also some news feeds on other subjects, such as technology news, were used. This knowledge came from mid term memory as it gave an account of occurrences that happened from a few hours to a few days before. This memory was dynamic
4. **Short term memory.** The system recognised mobile phones of visitors by means of bluetooth technology. Phone names are read by the speech synthesizer and immediately after that removed from memory. This knowledge represented a dynamic short term memory.

II. **Context awareness**

The system provided the following mechanisms for context awareness:

1. **Time.** The system inside the cube was aware of time. It slowly started quietly in the morning and went to sleep at night. The attendants in the museum did not need to switch the system on or off. It was completely self-supporting.
2. **Infra-red sensor**. Through the infra-red sensor the system was aware of the number of people that were at any moment in the room. More people resulted in less knowledge that was shared.
3. **Bluetooth sensor.** The bluetooth sensor made the system, to a certain extent, also aware of **who** was in the room. Except for trying to impress people, the system did not act on this awareness.
4. **Proximity sensor.** The system was aware of the proximity of the visitors and pulled back if people got too close.

From the perspective of systems theory, the system complied with the three lowest levels of the requirements[53] for an adaptive system, that is: 1. interactivity, 2. context awareness, 3. history awareness. It connected to the visitors on all three levels. The history awareness of the system was limited to the algorithm that measured the number of people in the room. Based on the number of people that passed the infra-red sensor, it needed statistics to determine the actual number of people that were present. The above discussion on long term, mid term and short term memory, has nothing to do with history awareness, but is both semiotic and practical. The division of the content into these layers means that each layer consisted of a subsystem for play-out. The balance between these layers could be controlled. The system was not aware of the content in these layers. For the system it was just data, that was sent to the output, according to a set of rules. In the hierarchy of systems, as specified by Bertalanffy (on page 82.) the system met the criteria of a level somewhere between level 3. (control mechanisms) and level 4. (open systems). For the visitors it was not always clear what their contribution was to the nonlinear

[53] See Chapter 4. for the requirements for an adaptive system.

representation, although they had a substantial influence on it. The resulting artefact was nonlinear, because it operated in real-time, had no predetermined trajectory and was actively based on the influence of the viewer. The nonlinear representation was partly based on chance (the choice for the next sample of a prominent personality was random) and partly based on fixed rule-sets.

Jeroen van Iterson put much effort into the implementation of the functional system, both technically and conceptually. For the distribution of the sounds over the speakers he developed several interesting algorithms that resulted in a varied sonic output. The quotes of 'prominent personalities' were distributed over the speakers according an asymmetrical bouncing algorithm.[54]

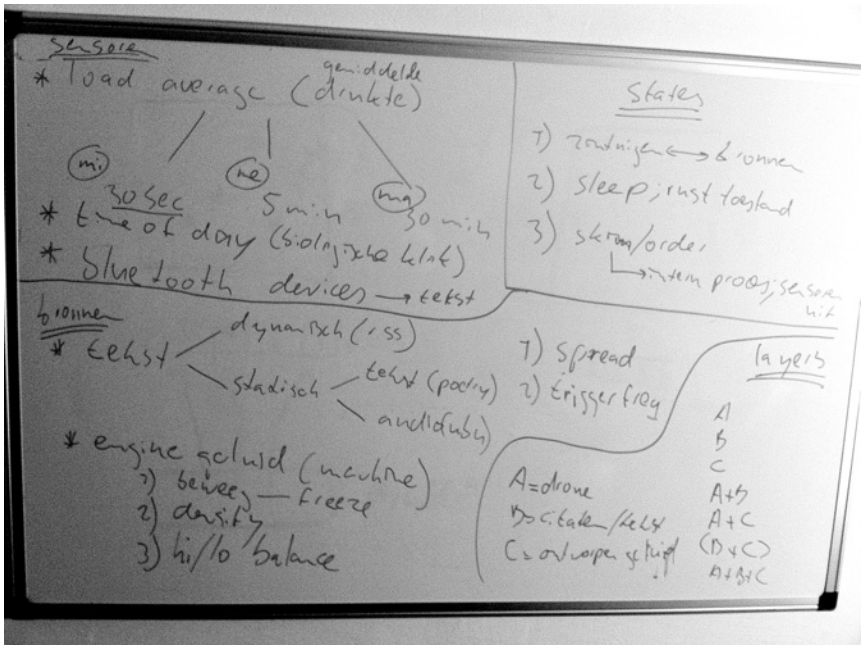

Fig. 23. Jeroen van Iterson's analysis of the sound system on a whiteboard.

A dynamic reverberation algorithm, coupled to a dynamic equaliser made the content sound as if it started from the very depths of the cube and moved from there to the surface, where it sounded intimately close. Once all the technology was built into the cube, the cube was closed, and things could only be remotely operated. Jeroen designed the system in such away that it could even remotely be restarted and that the balance between all layers could be adjusted from

[54] A kind of billiard table with an uneven number of sides.

another physical location. The software tool *Team Viewer* made it possible to do this over the internet. The speakers were mounted behind the blackened paper surface. So the first thing we needed to do was adjust the equalisation to compensate for this. In some occasions during the course of the exhibition I was able to adjust the mix from my home, based on instructions over the telephone from Robbie. The attendants at the exhibition told me how happy they were with this installation. At some other exhibitions a repeating sound installation could really drive them mad after a couple of weeks. The output of this installation was constantly evolving and sounded different all the time.

The next installation at the exhibition was a three-dimensional projection of the shower room. Except for creating a loop from the original sound from the animation I had nothing to do with it. The loop was played in mono on one speaker.

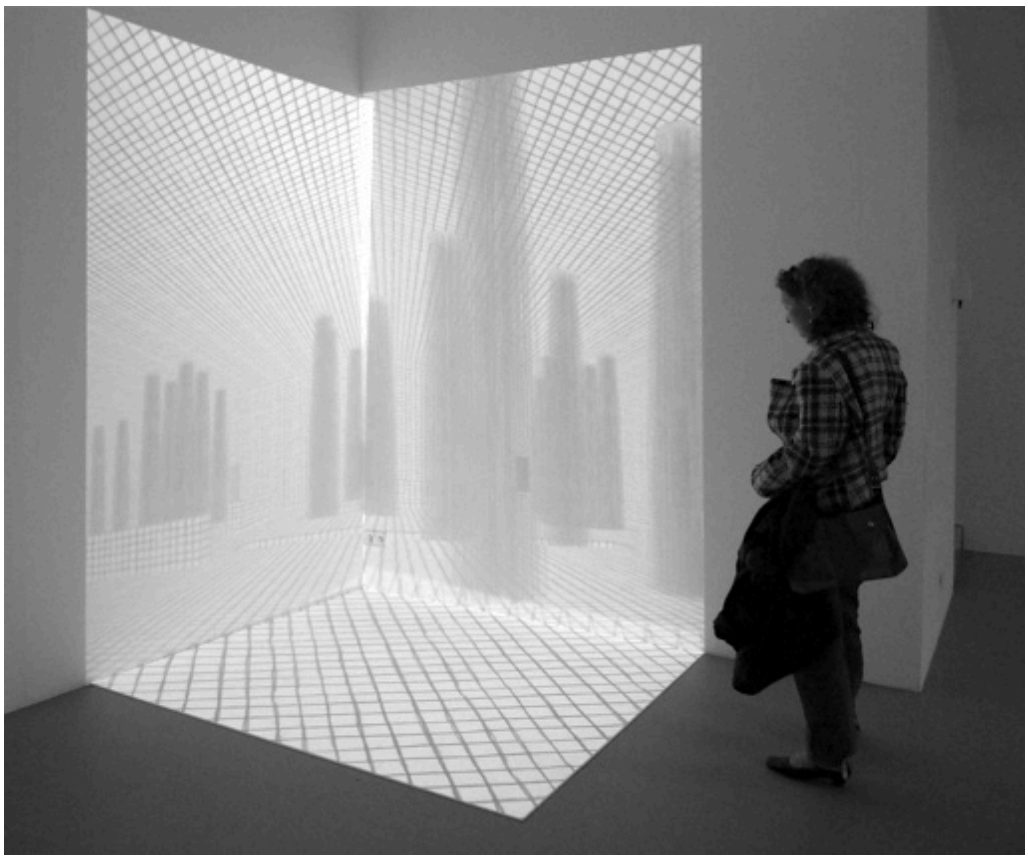

Fig. 24. Three-dimensional projection of the *Shower Room*

The fourth and last exhibition room was reserved for an interactive drawing project. With this work not only was the public involved in the participation of signification, it actually toke part in the physical creation of it. This drawing called *Little boy pissing the Universe* was about drawing straight lines on a piece of paper of 17 x 4,5 meters. Visitors were invited to walk along the paper while holding a graphite pencil. The finished work would be a drawing of hundreds of lines, that together formed a large black plane. I was not involved in this project, but it is interesting to see how it matched the idea of participation of the viewer, and how it was extended.

Fig. 25. *Little Boy pissing at the Universe X*. Visitors participated in the creation of the work.

On the DVD a number of audio and video files can be found in the folder *1_portfolio/2_Studio_Vertigo*. Unfortunately there is no professionally made movie of the exhibition available. The folder contains the following movie files:

- The file *Studio_Vertigo_iPhone_movie.mov* shows the short continuous walk I took along the installations in the exhibition with my iPhone. Although of shaky quality, it gives at least an impression.
- *In_Het_Perspectief_van_Robbie_Cornelissen.mov* is a documentary about Robbie Cornelissen that was made for the local television station of Utrecht. A large part of its content is about the exhibition.
- *Little_Boy_pissing_at_the_Universe_Time_Laps.mp4* shows the creation of this artwork as recorded by a time laps camera.

In the folder *1_portfolio/2_Studio_Vertigo_Audio_Examples* examples of the created audio content for the *Black Room* can be found. It can be understood that these files cannot give a true impression of the sound that could be heard in the exhibition. The soundtrack was generated on the spot, using some prepared raw material, combined with live generated audio based on then current sources on the internet. The folder contains the following files:

- The file *Cube_Drone_8ch_first_15sec.aif* are the first 15 seconds of the one and a half hour 8-track audio file that was used for the engine sounds. This file was interactively mixed on the spot and the output formed a constantly evolving background. The changes were based on changes in context as described earlier in this chapter.
- The folder *Citation_Examples* contains four examples of the audio files of prominent personalities, that formed the second of the four content layers of the sound design for the cube.
- *Audio_Walk_Studio_Vertigo.aif* is an audio recording of a walk through the exhibition from the corridor to the fourth final exhibition room.
- *Cube_Mix_1.aif* and *Cube_Mix_2.aif* are two examples of the possible audio output of the black cube. In the background some visitors are heard. This presence of visitors was necessary because without visitors the cube emerged almost no sound, as discussed earlier in this chapter.

Part 3

Sound design for public space

Introduction

In December 2007, I was asked by *Inspiring Cities*, an international network for cities and culture (www.inspiringcities.org), to give a lecture in Hamburg on sound in public space. It was meant as the introduction to a design workshop for young architects, city planners and urban designers. I had some experience with the subject, in that I had been teaching about urban sound at Utrecht School of The Arts, as part of the sound design course. In my presentation I recommended to view sound in public space as a subject of design instead of a subject of noise control. I also explained that the level of sounds is not as important as their meaning. After the workshop I was interviewed by the Dutch internet magazine *Ruimtevolk* (www.ruimtevolk.nl). This had an unexpected impact. Before I knew it I was interviewed by the Dutch national paper *NRC Handelsblad* (see Appendix 3.), which published an article on the subject. This in turn led to a number interviews on public radio in the Netherlands and Germany. I seemed to have hit the sweet spot with my sound design versus noise abatement discussion.

I started to receive invitations for lectures by diverse institutions, among them the Ministry of Housing, Spatial Planning and the Environment (VROM), the Municipality of the city Breda, *MDRDV*, a global architecture and urbanism office, The National Office for Abatement of Traffic Noise and the Delft University of Technology. For me, this series of lectures became an exploration of the topic, that I funded with the fee, that I received for them. With every new lecture I tried to add a new angle to the discussion, based on the perspective of the target audience. With the writings by Schafer (1977), Truax (1984), Rodaway (1994), LaBelle (2006), and Blesser & Salter (2007) as a starting point and through studying literature on the internet, I started to formulate design principles for sound in public space. Talks with people in the fields of architecture and urban design gave me insight into their goals and their attitude towards sound as a property of design. My objective is not to add a new sound layer, as is the aim of sound art, but to shape the soundscape itself.

Principles of sound design for public space

From my research I learned that a city cannot be designed. It is the result of interaction between many factors and participants. In my framework the urban soundscape is a complex adaptive system. Within my model it is not the level, but the meaning of sound that is most important. As discussed in Chapter 4. meaning is synonymous with context. It depends on the context whether we consider sounds as pleasant or annoying. Too much traffic noise, while we try to sleep, is not wanted. But if we like our neighbours we are inclined to be less irritated by the sounds they produce. It is a common misconception that people prefer silence most of the time. People living in cities accept that they are generally noisy. The soundscape is not a fixed condition but a constantly changing reciprocal process. Within the acoustic community the listener, as a perceptual mediator, is as much responsible for the meaning of sound as its source. My semantic approach does not translate well to current politics that base their success on quantifiable statistics on sound levels. So, my first sound design brief within the field of public space is to create awareness and explain how we interact on an acoustic level. It would go too far to describe my complete framework on sound design for public space here. The main point within the discussion in this chapter is to explain how it relates to the framework in Chapter 4. and how I applied this framework in my design practice.

Sound design proposal for the *Museumplein,* Amsterdam

In 2008 I was invited by *Stipo*, a team for urban strategy and city development[55], to participate in a survey of the Museumplein, the main square in the cultural centre of in Amsterdam. The survey was organised by the *ProjectManagement Bureau (*Project Management Office) of the municipality of Amsterdam. The objective of the evaluation was that it would lead to a strategy document for the possible rearrangement of the square, in accordance with the development plans for the area. My final research extended into halfway the next year, 2009.

[55] Stipo's operating area 'consists of combinations of spatial planning and strategy with economic development, culture, welfare, sport, recreation and tourism' (www.stipo.info 2013).

Fig. 26. The Museumplein as it was in 1971, based on the design of Van Eesteren en Warnau from 1928, but realised in the 1950s.

Sven-Ingvar Andersson's design for the Museumplein

The *Museumplein* (Museum Square) is a public square in the district *Amsterdam-Zuid*, located just below the centre of the city, that owes its name to the *Rijksmuseum* that was opened in 1885. Two other major museums - the *Van Gogh Museum* and the *Stedelijk Museum* - are also located at the square, as is the concert hall *Concertgebouw*. The big lawn is used by the inhabitants of Amsterdam and by tourists for recreation. The open space is also used for many festivities, such as music festivals, demonstrations and dance parties. The pond, when it is frozen in winter, is used for ice-skating. During the history of the square it has been a park and in the 1950s it was even arranged as a freeway (van der Werf 2012). This was in accordance with the zeitgeist that cars in cities should have free rein. The current design by the Swedish landscape architect Sven-Ingvar Andersson was constructed in 1999. It covers underground parking spaces and an underground supermarket. The design was inspired by artists such as Malevich, Christo and Serra (van der Werf 2012). It was Andersson's explicit idea to create a silent space, in which both the town and open spaces could be experienced. All traffic, both cars, cyclists and pedestrians

Fig. 27. The *Museumplein* in 2008, with in the front, the *Rijksmuseum* and in the back the *Concertgebouw*

were were guided along the periphery. Along the Museumpad he wanted to stage different experiences so that each part would have its own atmosphere (van der Werf 2012). Andersson had closely studied how the square was used by its visitors and his design was in fact exactly the right answer to all the design requirements of his assignment. But from the start critics stated that the design had no true metropolitan profile. Less than ten years after its completion, in October 2007, it was decided by the municipality of Amsterdam that the square should again be renewed.

Design brief

With a team of experts in the fields of urban design and planning and city development and representatives of cultural institutions we took walks around

the area, which resulted in an exchange of views. Our assignment involved evaluation, inspiration and idea development for the redevelopment of the square. My contribution consisted of the approach from the perspective of sound and the soundscape.

Soundscape evaluation

The first thing that struck me during my walks with the team of experts was the standout silence on the lawn in the centre of the square. When I pointed this out to the team they were pleasantly surprised. In the weeks after the walks with the team I revisited the square quite a number of times and collected data for analysis. I made a large number of sound recordings, took photographs and made notes to map the behaviour of the visitors of the square. I made use of a special evaluation tool, called *AudioMaps*© that was developed in 2008 in cooperation with my team members at *IAMS*[56]. This tool is a combination of the *iPhone* app *Motion X-GPS*, a tools for tracking routes, and a website designed by Jasja Zuidmeer at *IAMS*. *Motion X-GPS* is a trail tracking tool that records

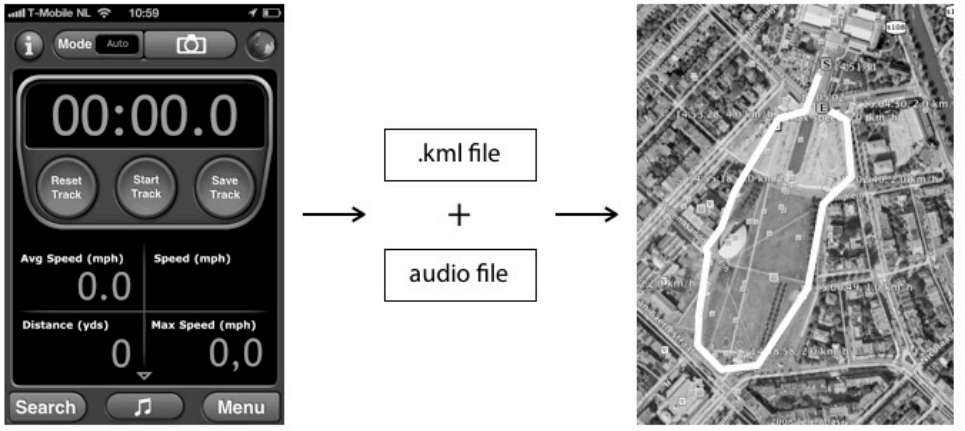

Fig. 28 The *AudioMaps* application, developed at *IAMS*.

[56] IAMS is the *Institute for Adaptive Music and Sound*, a collective that was founded by me and two other members in 2008 to research adaptive systems in connection to music and sound. Because of the large amount work by the team members in other areas the institute is currently suffering a dormant existence.

GPS data and exports the trail of your walk as a .kml file. This .kml file together with an audio recording of the of the same walk is sent to the AudioMaps© website. A Java script, implemented in the website, combines the uploaded tracking data with the uploaded audio file into an animation. The animation shows a cross-hair that follows the trail on Google Maps or Microsoft Virtual Earth, while you can hear the audio track in sync with the crosshair.
With this tool I was able to study the data at home and could profoundly evaluate the sound at all the different locations at the square in relation to their function for the public. An example movie of AudioMaps© can be found on the DVD in the folder 1_portfolio/3_Sound_Design_Museumplein.

Acoustic communication

Sounds are meaningful as long as they fit the context. For my analysis of the soundscape I used the concept of *acoustic communication* as formulated by Barry Truax (1984, pp. xvii-xxvi). According to Truax sounds are meaningful for a location as long as they are part of, or at least permit, communication on an acoustic level. Sounds that are not functional within the acoustic communication in a given context are marked as noise. Good design enables good acoustic communication. According to Truax (1984, p 76) a satisfactory soundscape meets the following three requirements :

- **Variation**. A high quality soundscape has a lot of different sounds and many different types of sounds.
- **Complexity** within the sounds themselves is essential. There must be a complex relation between their levels, and complexity in the amount of information they communicate.
- **Functional acoustic balance** between the spatial, temporal, social and cultural context of the environment. A beautiful building or city area can be spoiled by a bad soundscape, because it cannot fulfil its objective. It makes staying there unattractive or even unbearable.

I compared my recordings and photo's with my notes on the behaviour of the visitors at the square in combination with the development plans.

Fig. 29. I took many photographs, and made many sound-walks and recordings to map how the square was used by visitors.

Findings

My conclusion was that, from the perspective of acoustic communication, Sven-Ingvar Andersson had done a very good job. To begin with, he fully exploited the possibilities to create a wonderful tranquility in the middle of the square. The size and the shape of the square contributes to this. The street plan of the square and its surroundings shows few parallel lines. This is very

Fig. 30. The street plan of the Museumplein and its surroundings shows few parallel lines.

beneficial for the acoustics. The quarter at the east side, around the Johannes Vermeerstraat is a good example. It is exceptionally quiet, even in the middle of the day. By its form the area works as a great absorber and diffusor. The Johannes Vermeerplein has actually a triangular form. And when you close

Fig. 31. The triangular form of the Johannes Vermeerplein

your eyes it is hard to believe you are in a big city, except for the moments when a tram passes. Andersson augmented the advantageous acoustics with the lawn, which further mutes sound. His arrangement presents a great variety of experiences each with its own sound character. Not all locations are quiet.
The Van Baerlestraat, where the *Stedelijk Museum* and the *Concertgebouw* are located, is a very busy street with much traffic noise. But from the perspective of the listener this is consistent with the function of this street. To reach the square at all, you need feeder roads. Whenever the sounds at a location are compatible with its function, whenever they fit the context, they are easier to understand. Along the row of trees on the east side the bicycle path is situated. When you cycle along this path, for a moment you imagine yourself in a park. The restaurants and terraces, with sounds of coffee cups and dishes are a nice addition to the soundscape. When you close your eyes at the edges of the square you hear an interesting mixture at voices in different languages. All in all, in the words of Barry Truax the square has indeed a very good 'functional acoustic balance between the spatial, temporal, social and cultural context of the environment' (Truax 1984, p. 76). There were some problems though in relation to use of music at the square. Sometimes amplified music unnecessarily disrupted the structure of the soundscape.

Shaping of the soundscape

A square cannot be designed. A square is shaped by its layout, but more so by its users. A designer cannot offer more than a framework for signification. As a designer you can invite the user to a certain behaviour by offering possibilities. In 1979 psychologist James Gibson defined his *Theory of Affordances*, a theory that claims that any form or environment permits an individual a certain action (Gibson 1979, pp. 127-143). In the design of digital games this idea is articulated as 'possibility space'. By design some things are possible, others are not. As a sound designer for public space one can promote a spatial arrangement based on the possible effect on the soundscape. One can consider wether the resulting soundscape is meaningful for the participants, in that it matches the context and permits the necessary acoustic communication in this context. Sound design for public space involves analysis of soundscapes and the design of a strategy to incorporate sound properties into the design process of the architect or urban designer.

Report

The research resulted in a report with an analysis and recommendations. It is clear that I fully promoted the silence in the middle of the square. I further suggested to construct a digital infrastructure. This infrastructure can be used to design virtual spaces that can be superimposed as an extra layer on the square. The following text is a section from my original report (Went 2009):

> **The soundscape, an initial analysis**
> An initial exploration of the soundscape of the square and its surroundings makes it clear that it has a number of unique acoustic properties. While the *Museumplein* is the largest city square in Europe, it is astoundingly quiet. In the middle of the lawn, there is even an intimate acoustics: voices sound dry and near, traffic and city noise are far away, much like at the beach, but without the murmur of the sea. It is the ideal spot to read a book in summer. This unique acoustic quality is inspiring and should be cherished and clearly put forward in the promotion of the square. The acoustics is caused by the sound absorption by the grass and the size and shape of the square, but the buildings around the square also contribute to this. The street plan on the east side has almost no parallel lines and therefore sound reflections are muted. As an example, the *Johannes Vermeer Straat* is exceptionally quiet. The scheduled stops of the new North-South line, creating new routes to the museums, will highlight the acoustic properties because visitors are

gradually led from the hubbub of the city into the silence. One of the most remarking sound marks of the square is the carillon of the *Rijksmuseum*, which evokes a typically Dutch atmosphere (clocks can be found everywhere, carillons are a typical phenomenon of the Low Countries). At the periphery of the square one can hear voices in the many languages of the international visitors to the square and the museums. How can these unique acoustic properties be deployed in combination with the many features that the square must fulfil? From the point of view of acoustics, the idea to revive the square by planning catering establishments on the east side could be achieved by placing this activity behind the existing rows of trees. The use of outwardly directed music from these facilities should not be allowed. Music from loudspeakers should be avoided entirely. Live music is recommended, but only as long as it is performed inside the establishments. In contrast terraces provide a lively atmosphere by the chitchat and clinking of dishes etcetera. The radiation of such noises will be limited to the edges of the square.

Virtual digital theatre annex workshop annex concert hall annex art lab
A possibility to exploit the unique acoustic character can consist of the construction of a digital infrastructure, with which one or more virtual layers are added to the square. This provides a setting that can best be used as a virtual digital theatre, or workshop, a virtual concert hall, laboratory. By using a combination of wireless technologies, such as WiFi, FM, GSM, Bluetooth and UMTS, all kinds of events can be programmed. These events may take place in both the physical and virtual domain of the square and without compromising the soundscape. Visitors can participate in these events with their mobile devices (smartphone or laptop[57] with headphones). One can imagine interactive compositions or sound art, but also games. The virtual theatre and workshop thus created may also establish connections with the art institutes around the square. This can be done by providing commissions to composers or artists. Also, events can be programmed that mix the real and virtual world. An exhibition in one of the museums can be expanded to the virtual domain in the square. A concert in the *Concertgebouw* can get a virtual aspect that takes place on the square. These aspects can take place in the audio domain, but also in combination with the visual domain, through the display of the devices from the use or by projection on the square. Traditionally, there are many events organised by the Museum, both in high culture and in low culture. All these events, from major crowd pullers as the *538 Radio Show* to elitist art installations, can make use of the infrastructure. Multiple events can occur simultaneously in different virtual layers. During the summer location based gaming can be programmed in a corner of the square.
Foreign visitors can participate in advance in certain aspects of the virtual settings. At home, using the internet. An advantage of the concept is that the construction can be gradually implemented over time. Experiments can be

[57] Tablet computing was a just emerging phenomenon. Apple introduced their first iPad in April 2010.

started almost immediately. Ultimately, it could become a major international virtual art and media institute with an international appeal.

Fig. 32. The lawn of the *Museumplein* with, in the back, the *Concertgebouw.*

Outcome

In 2009 the *Visie Museumkwartier* (a vision for the museum quarter) was presented. Landscape architect Michael van Gessel together with urban designer Ton Schaap were invited to develop further a master plan for the whole area. On 31 July 2009, national paper *NRC Handelsblad* reports:

> They will modify the existing design of Danish architect Sven-Ingvar Andersson 'with respect' to the needs of the times. 'The main layout of the Museumplein, a large open field, is good,' says Van Gessel. 'It should only be cleaned up and the edges have a lot to win on quality.' Thus, the in the meantime outdated, benches and lanterns will be replaced and the designers duo is working on a style to include paving, kiosks and podiums. In the future the square should be able to match, for example, the Museum Island in Berlin and the Museum Quarter in Vienna. There should be more benches, more bars and more restaurants, so the square provides a vibrant appearance at all hours of the day. And there must be a clear routing between four world-renowned institutions that are located at the Museumplein. 'Now there is no connection between the museums and the Concertgebouw', says Concertgebouw director Simon Reinink. 'That's a missed opportunity.' (Smallenburg 2009)

I was just a small cog in the machine of decision making. According to my contact at Stipo, the City Council has voted for my proposal to protect the silence of the square. He tells me I am to blame for the preservation of the grass.

6
Conclusions

Summary

This document is a treatise on the concepts and methods that were used to create the portfolio that together with this thesis forms the MPhil. It describes the chosen position within the disciplines of art and design. First it follows the path of developments in epistemology since the mid-19th century and supports the now general idea that it is difficult to maintain claims of universal truth. The starting point is that the concept of truth has been exchanged for the notion that every assertion about our existence is a form of representation. We cannot know the world, but are able to communicate and discuss our representations of it. We use our representations to signify. Meaning is not a given, but an ongoing activity. Where, in the past, truths and beliefs were dictated via a linear, hierarchical path, today meaning is negotiated in nonlinear networks based on participation. The artefacts that art and design produce cannot directly convey meaning. At best, works of art and design can provide a context or frame for interpretation. Creator and user are interdependent in a process of signification. This perspective has launched a technology of networks and in return networks have influenced the way we think. In chapter 4 a framework for design is developed that embraces the possibilities that stem from these viewpoints. The works in the portfolio emphatically explore this potential of nonlinear, interactive and participatory signification. This chapter presents the key findings of the research and reflects on the strategies for the design process.

Key findings

In chapter 2 the main research question was formulated as follows:
How does the transformation of artefacts from a linear mode into a nonlinear mode and back influence the sound design for such artefacts?

The main question prompted a number of subquestions on the differences between linear and nonlinear artefacts; on how nonlinearity can be designed; and the role of sound design within nonlinear representation.
The *Critical Review* (chapter 3) provided the first insights into the matter, which were further explored in chapter 4 in which a framework was devised as a guideline for design. Chapter 5 is a description of the actual design process. During the time frame of the MPhil the framework and the design process mutually influenced each other. The framework has been directing the design process and in return the experience that was gained in the design process contributed to the ideas for the framework.
The research resulted in the following key findings in regard to both the framework and its derivative design strategies. The design strategies are evaluated in relation to the key findings to which they are related.

Time-space relations

The fundamental property that distinguishes linearity and nonlinearity from each other is their position in the space-time relation. Since Einstein and Minkowski (Einstein 120, p. 55) the theory is acknowledged that space and time are interrelated in a four-dimensional space-time continuum. In everyday life space and time are imagined as separate entities. In Western culture we experience time as linear and space as nonlinear. The common understanding is that time is the dynamic element, while space is seen as a fixed disposition. Motion and development are looked at as properties of time and space is perceived as a locked arrangement. In the reality of everyday life the opposite is

true. We live our physical existence in real time. In actual life, time can only be dynamically considered in the past or (theoretically) in the future. In reality we are fixed in time and can move freely in space. One could say that in linear representation space is fixed and time is dynamic. In nonlinear representation time is fixed (real time) and space is dynamic.
In art and design, artefacts are understood as belonging to the time domain (linear) or space domain (nonlinear). Film and music are seen as the linear time-related arts while painting and sculpture, operating in space, are regarded as nonlinear. Sound art focuses traditionally on the connection of sound with space. Because space and time mutually define each other a predominantly spatial representation shall always contain some temporal characteristics and vice versa.

In relation to time and space the following scheme can be followed to represent linearity and nonlinearity:

- Stressing the temporal properties sequentiality, motion, length, duration, pace, rate, tension and release, vectorisation, direction, anticipation, development and progress, creates linearity.
- Focus on the spatial elements dimensionality, localisation, room, depth, shape, form, contour, size, mass, density, texture, symmetry and simultaneity produces nonlinear representation.

To render this in the domain of sound a number of strategies can be formulated for design.

Linearity within the time domain can be shaped in the following manners:

- Tonal music underscores linearity with most temporal properties that are described above. 'Tonal music is always in motion toward sonic resolution' (Kramer 1981, p. 539). In film it is used, besides emotional signification, to create or accentuate motion, vectorisation, anticipation, progress and development.

- Within the discipline of sound design any sequential or vectorising gesture will suggest time and linearity. Increase and decrease of amplitude, pitch and spectrum (bandwidth, brightness, filtering) are suitable tools to achieve this. Filter and amplitude envelopes imply progress through buildup and release. Rhythmic sounds and rhythmic development may indicate time.

Nonlinearity in connection to spatiality can be represented like this:

- Cyclic or repetitive music, with little motion or development can lead to standstill. So-called 'ambient music', and the cyclic, recursive patterns of 'minimal music' can express nonlinearity through symmetry and the avoidance of climax.
- Sound design of spatial characteristics starts with the use of reverberation and panning. Simultaneity ('here and now') can be achieved by strict synchrony between image and sound. The effect of synchresis helps to 'materialise' the objects in space. Materialisation and spatialisation of objects can further be realised by the use of sonic metaphors for form, shape and mass. Analogies in the sound domain can imitate or borrow from the sounds of identical real objects. The texture of objects in the image can be complemented by an analogous texture in the sound domain, such as grain, fluidity and consistency.
- The use of multi-speaker systems (surround sound) can reinforce the spatial experience.

Nonlinearity and narrative

In chapter 4 the connection between linearity, nonlinearity and narrative is explained. The semiotic distinction between syntagma and paradigma is used to analyse the linear and nonlinear components of narrative. Syntagma denotes the horizontal narrative 'thread', the chain of cause and effect (in time), and the plot of the story. Paradigma stands for the vertical correlations of possibilities (in space). In practical terms narrative can be divided into the linear story, the sequence of events in time, and the nonlinear space, the story world, in which

the events take place. Cause and effect, progress and goal orientation are the linear elements of narrative. The nonlinear aspects are formed by the spatial setting. In a linear artifact, such as film, in most cases, the priority is given to the plot driven story-line. In nonlinear artifacts, such as digital games, the primary orientation is toward a space of possibilities. In its pure nonlinear form the syntagmatic component in a game would be the nonlinear storyline that emerges (in real time) from this possibility space. As it happens a linear fixed storyline is often superimposed on or 'embedded' in the nonlinear structure of the game system. As explained in the case study in chapter 4 this generates a problematic mix of linear and nonlinear semiotic systems.
It is evident that linearity and nonlinearity in narrative are closely connected to space-time relations as discussed in the previous paragraph. A linear story can only be situated in the past, whereas a nonlinear structure is happening here and now; time is 'real time'. Since the design in the portfolio concentrates on nonlinear representation the thesis does not exemplify methods for the sound design for linear narrative. Although some clues can be derived from the strategies that are mentioned above for temporal representation, this is a very broad topic and beyond the scope of the research. It can be concluded that the sound design for the nonlinear part of narrative resides in the first place within the sonic representation of the story world.

The aforementioned vertical correlation of possibilities in narrative can also be represented by means of ambiguity. Deliberate ambiguity can lead to nonlinear signification. Meaning will be indeterminate and depend on the understanding of the user. The user can choose an interpretation from a number of possibilities.

In relation to narrative the following scheme can be followed to represent linearity and nonlinearity:

- Accentuating the syntagmatic cause and effect chain and producing a logical narrative sequence with a feeling of progress toward a determined, univocal, goal oriented plot will generate a linear representation.

- Focusing on the paradigmatic properties of narrative and concentrating on shaping the story world will result in nonlinear representation.
- Ambiguous representation will create indetermination and nonlinearity.
- Contrary to the inevitable connection between space and time that will show through when presenting the one or the other, in relation to narrative it is possible to construct a completely plotless story world.

To render this scheme in the domain of sound a number of strategies can be formulated for design. There is a clear overlap with the methods for space-time representation. Reference to the mentioned techniques forms a good starting point. Designing the auditory story world involves similar concepts of materialisation and spatialisation. Of course the sound of dialogue in narrative artefacts is to a large extent responsible for shaping of the linear trajectory. The absence or removal of dialogue will immediately focus the attention to the sounds of spaces and the environment. Additional means for nonlinear auditory representation in connection to narrative can be found in avoidance of cause and effect relations and goal orientation. This requires audification of objects rather than events. Many objects, however do not generate sound by themselves. In that case some action (an actual cause and effect chain) must be performed on or towards the respective object. Another exception is that for the realisation of spatial awareness an impulse sound is needed to generate the reflections in the room. In that case a sound **event** may be needed to supplement the general room tone. The room tone is the 'silence' that is recorded at a location when no dialogue is spoken and no events are taking place.

Evaluation of the used design strategies

Years of experience with nonlinear artefacts and teaching music design and sound design for games preceded the cooperation with Robbie Cornelissen. Although the portfolio does not include sound design for games, it was the study on game sound and game music that informed and triggered the

nonlinear approach for the first project, *The Capacious Memory*, in the first place. It formed an essential preparation for the tasks at hand, by mapping initial key issues in working with sound in nonlinear representation.

The strategies and methods described above proved to be succesful for the sound design for *The Capacious Memory* and *The Labyrinth Runner*. Although the artefacts themselves are linear (film), both works are void of storytelling and in fact facilitate the (aimless) possibility to wander through the depicted spaces. In *The Capacious Memory* there is no plot and in art galleries and museums the film is presented in an endless loop to confirm this. The fictive worlds of Robbie Cornelissen are not populated by humans and so there is no dialogue. In *The Labyrinth Runner* there are some hints to a plot in the beginning and end of the work. It is however a vague, ambiguous hint to a process of transformation, which lends it therewith a nonlinear quality. In the sound design vectorisation, progress and development were avoided as much as possible. The main focus was on the design of the paradigma, the world and its spaces. Both projects started with sound recordings of large empty spaces and the sampling of their impulse responses. Most attention went to the sound design for objects, their sonic textures, and with strict synchrony strong synchresis could be realised, which resulted into a credible world construct. Much effort was invested in inventing the right sound textures to go along with the images. A large amount of attention was given to adjust the correct 'size' of the sounds in relation to the size of the rooms and objects. In accordance to the above mentioned technique in *The Labyrinth Runner* there is one instance of a sound event, that proved to be effective in supplementing the room tone of the space. We hear the falling of a glass and the reflections immediately help to define the size of the space. In the animation there are many occurrences of undefined transitions from abstract drawn lines into actual objects and vice versa. The sound design has been effective in underscoring the unclear character of these moments which supported a nonlinear outcome. The sound design for *The Capacious Memory* was produced in 5.1 surround sound which was added to the spatial experience. Unfortunately this happens to be problematic for the actual presentation of the

work in art galleries; in many cases the technical staff finds it too difficult or expensive to organise a surround system.

The positive experience with the first two projects initiated the logical next design step. Whereas as the first two projects were linear artifacts with an in essence nonlinear representation the next project was an invitation to design a nonlinear artefact, a nonlinear system.

Nonlinear presentation by means of systems

Nonlinear artefacts can be fixed or dynamic. Paintings and statues are fixed nonlinear artefacts to the extent that after their creation they do not change over time. Dynamic nonlinear signification can be represented or generated with systems. Digital games are by their construction first and foremost systems. In the present day, we can see more and more systems that enable nonlinear, interactive and participatory signification by the user. The best known example is the internet. These systems are organised as interrelated networks.
Complex adaptive systems are dynamic networks of interactions, that can adapt their behaviour to changing events in their environment with which they interact. This adaptation happens in real time through processes of self-organisation and self-optimisation. Adaptive systems are interesting for art and design as they can deal with unpredictable situations. In digital games adaptivity is important in order to enable anticipation on changing situations during gameplay. An adaptive system, created in computer software, can be used as an active participant in the creation or exchange of meaning.

Another reason to use systems in art and design the opposite: to generate nonlinear, indeterministic signification. In chapter 3 we find the description of two artists who experimented with nonlinearity since the mid-20th century. John Cage realised nonlinear representation by using chance and randomness. At the same time visual artist Sol Lewitt generated nonlinear output by using

scripted, fixed rule-sets for the creation of drawings that were different every time the script was executed. Chaotic systems are complex systems that develop nonlinear behaviour starting from a known, determinate condition or ruleset. Chaotic algorithms produce indeterminate output based on determinate starting conditions.

Adaptive systems use evolutionary algorithms, which can be useful to fit content in nonlinear structures. Chaotic algorithms are useful for the design of nonlinear output based on fixed rules.

The theory of complex adaptive systems informed the realisation of an interactive art installation. It used algorithms that created computated history awareness and context awareness as a design strategy to realise nonlinear, interactive and participatory signification.

For the exhibition *Studio Vertigo*, designed and compiled by Robbie Cornelissen in the *Centraal Museum* in Utrecht, a nonlinear art installation called *The Black Room* was realised. In *The Black Room* a large (270 x 270 x 270 cm) three-dimensional black drawing was placed in the form of a cube. A comprehensive description of the project can be found in chapter 5. For the cube an interactive sound design concept was developed based on the theory of adaptive systems. The system complied with the three lowest levels of the requirements for an adaptive system, that is: 1. interactivity, 2. context awareness, 3. history awareness. It made use of three levels of history awareness and four levels of context awareness. The design facilitated complex interaction that resulted in complex indeterminate output. By interacting with the object the visitors of the exhibition dynamically influenced the emergent signification in real-time.

In general the concept for the installation was interesting and satisfactory. It produced a complex soundscape of voices and engine sounds that was constantly changing and there was no recurrence during the whole course of the exhibition. It was, however, difficult to determine how aware the visitors were of their influence on the output of the system. From informal observations

it was clear that they realised that they had some influence, but it not always exactly how. No extensive research has been done on the experiences of visitors. Such an investigation should not disturb the experience of visitors. It was simply too complex and expensive to organise such a test within the context of the project. This is a problem with many interactive art installations. In the case of computer games the user can gradually discover how the system reacts. Visitors of a museum don't spend enough time at an exhibition to fully explore the possibilities. On the other hand if the interaction is very simple and obvious it can end up being uninteresting. Besides, having no complete control over the process of signification was the very starting point of the concept. The whole idea was to provide a framework, a possibility space for personal signification.

Nonlinearity in artefact or in representation

It turned out to be essential to differentiate between the nonlinearity of an artefact and the nonlinearity of the representation within the artefact. In chapter 3, the *Critical Review*, we have seen that the signification within a linear artefact, such as film, can be nonlinear. At the same time the music in a digital game often turns out to be the linear output of a nonlinear music system.
The sound design within the portfolio endeavors to produce nonlinear representation and signification, independent of the linearity or nonlinearity of the artefact. For example the sound design for the animation *The Labyrinth Runner*, which is a linear artefact, focuses on nonlinear elements in order to stay within the nonlinear domain of fine art, and to allow for nonlinear signification. The sound design for *The Black Room*, which is a nonlinear artifact, is nonlinear and its interactive system is an invitation to participatory signification by the public.
This distinction between artefact and representation proves to be a fundamental contribution to the understanding of the required design structure and architecture with regard to nonlinearity. It happens to be constructive in discussions during cooperations and in education.

Sound design for public space

In addition to the sound design for the works of Robbie Cornelissen the portfolio contains an assignment for a soundscape survey and a sound design proposal for the *Museumplein* in Amsterdam. In combination with outcomes of the research in the two years preceding this project a number of key issues and conclusions can be formulated for the evaluation and design of the urban soundscape:

- Sound in public space should be the subject of design instead of a subject of noise control.
- The soundscape should not be evaluated based on sound levels, but based on the meaning of the sounds for the users of the sound space.
- As is discussed in chapter 4 (p. 56) 'meaning' equates 'context' (Vroon, 1976, p.126). The meaning of sounds in the soundscape is dependent on the context of the sound space. Sounds are meaningful as long as they fit the context.
- A valuable tool for the evaluation of the meaning of sounds is the model of Barry Truax for 'acoustic communication'. A meaningful soundscape meets requirements in regard to variation, complexity and the functional acoustic balance between the spatial, temporal, social and cultural context of the environment (Truax 1984, p. 76)
- A soundscape is a complex adaptive system, a network of interactions, within the acoustic domain, resulting in nonlinear, interactive and participatory signification.
- Principles for sound design for public space should be based on this model of a complex adaptive system. The design of the soundscape thus involves the design of a system for signification.
- A starting point for a system for signification is the design of the 'possibility space.' The possibility space could be demarcated according to Gibson's *Theory of Affordances,* a theory that claims that any form or environment permits an individual a certain action (Gibson 1979, pp. 127-143).

- Within the space-time relations of the soundscape, the space and time elements are of equal importance. A soundscape evaluation only makes sense within a defined time frame.

The excursions into urban sound design (and shaping the sound of the real world) turned out to be helpful for the design of the works with Robbie Cornelissen as it heightened the awareness of how sound works and behaves in the real world. The real soundscape is dynamic and can be very different at different moments. The urban soundscape can change quickly and quite dramatically, even within an area of a few meters.

Definitions and models

The confusion in terminology that was noticed in chapter 3 initiated the need for more general and useful definitions and models. Before, during and after the research definitions and basic concepts for the important themes in this thesis were collected or formulated. They can be found in appendix 1. Together they form a small ontology for music and sound design and research on music and sound, for nonlinear artefacts and nonlinear representation.

Dissemination in education

Many of the concepts were first presented and discussed in the class room before they ended up in this thesis. Currently, the models and concepts of the framework are used extensively in education. The above mentioned definitions and basic concepts have become an indispensable starting point for design. They function as tool for description, a guidance in discussion and peer reviewing and help to avoid confusion. Preventing common mistakes in reasoning about the architecture of nonlinear artefacts results in definitive better and more logically structured designs. The sound design projects for public space inspired to introduce 'sound culture' as a subject for lectures, projects and discourse.

One particular concept proves to be especially liberating for students: because any view on the world is just representation, you can use any model for your sound design. Viewers will accept your model as the reality of the created world , as long as the model has its own inner logic, and as long as its application is consistent throughout the design.

Further research and future projects

At the beginning of this year, Robbie Cornelissen started a new project, where we both have an equal conceptual contribution. For this project, we received a funding from the Mondriaan Fund. After all the technology we had used for the exhibition *Studio Vertigo*, we wanted to see if it is possible to create a nonlinear presentation by using much less technology. Especially the design process itself should be much less technological. This time the animations will not be computer generated. The sequences of images are produced by Robbie by working on one drawing at a time for each sequence. During the creation of the drawing every next step in the process is photographed. Sometimes parts of the drawing are erased in steps. These image sequences are simply compiled into animations using video editing software. Our objective is to create a nonlinear presentation consisting of three animations of different lengths. The movies are not synced and will be shown on three separate screens. The sound will consist of rule based chaotic synthesizer patches. The creation of the sound will be carried out using a heuristic process. The image and sound will be combined according nondeterministic rule-sets.

In partnership with Stipo I formulated a research project for HKU students. The student team consists of a audio programmer, an interaction designer and a 3D- artist. I am the supervisor of the project. In the development tool *Unity* a computer model is created of the *Weesperplein* in Amsterdam. The aim of the model is to use it as a research tool for urban sound design. The model incorporates acoustic rules. The acoustic effects of interventions in the layout of the square and the rearranging of objects can be evaluated. What they are

creating is in fact a virtual acoustic ecology. The same model can also be used as a research tool for digital game design. The acoustic rules can be used for the creation of realistic behaviour of sounds. Adjusting the rules can also result in acoustic behaviour that completely deviates from realism. The possibilities of such fantasy acoustic ecologies can be researched.

Final thoughts

Overall the results of the research and the design have been encouraging.
In most cases the theory could successfully be applied to the practical design process. In other cases the outcome of practical experimentation refined the ideas or generated new concepts for the theoretical framework. The portfolio and the framework explore, facilitate and promote the possibilities of nonlinear, interactive and participatory signification. Hopefully the presented ideas are instructive and inspirational for designers and artists working in the same or adjacent fields.

Appendices

1. Definitions and basic concepts

To demarcate the research field and to ensure consensus on the use of terminology, some definitions and basic concepts, as they are used and developed throughout the thesis, are formulated here for reference.

Linear and Nonlinear

A precise agreement on the usage of the words 'linear' and 'nonlinear' is crucial to the understanding of the subjects of this MPhil and the argumentation in the thesis. Different definitions may be valid and applicable, depending on the subject or the perspective on a subject being discussed.

The general definition of 'linear' according to the online *Oxford Dictionary of British & World English* (2013) is as follows [abridged]:

1. arranged in or extending along a straight or nearly straight line
2. progressing from one stage to another in a single series of steps; sequential: *a linear narrative*

'Nonlinear', being the antonym of 'linear,' is defined as [abridged]:

1. not denoting, involving, or arranged in a straight line
   not linear, sequential or straightforward; random: *Joyce's stream-of-consciousness, nonlinear narrative*
2. of or denoting digital editing whereby a sequence of edits is stored on computer as opposed to videotape, thus facilitating further editing

The different denotations are best illustrated by presenting the various contexts in which the expression 'nonlinear' is used. The following interpretations of the term, that are relevant to this thesis, are proposed:

1. as used in mathematics and physics: nonlinear equation and nonlinear system

The use of equations that are not of the first degree.

The output is not directly proportional to the input.

In algebra nonlinear equations are those whose graphical representation does not form a straight line. An example of a linear equation is: $y = mx + b$, whereas

$y = x^2$ is a basic example of a nonlinear one that results in the graph of a parabola. A nonlinear system, as it is defined in physics and mathematics, is a system whose output is not directly proportional to its input. Most natural systems are nonlinear. Simple changes at the input can result in complex changes at the output. Some elements of the system that determines the weather are a well known example. The reverse is also possible, by which a complex change at the input has the effect of a simple change at the output. This is, for example, the case in systems with a threshold, such as digital logic gates.
A nonlinear system is not random. Nonlinear systems are relevant to our discussion of adaptive systems in Chapter 4.

2. as used in media production: nonlinear editing, nonlinear production

Random access, non destructive processing, random order of decisions or steps.

In media production the word 'nonlinear' is used to indicate an editing system that allows for random access to, and non-destructive editing and processing of source material. A nonlinear editing system, can be designed for editing video (NLVE) or for audio editing, which is called a Digital Audio Workstation (DAW). A word processor is a nonlinear editing system for text. The nonlinear aspect allows for fluid changes in the sequence of the material at any point and moment. The possibility to undo or reverse a editing decision is called 'non-destructive' editing. The final output of nonlinear editing is most of the time a fixed linear artefact. In general, in any creative process, the order of the design decisions and the production steps are often illogical and random. Most design and production processes are nonlinear according to this definition, independent from the linearity or nonlinearity of the resulting artefact.

3. as used in narrative: nonlinear narrative

Non chronological narrative, disjointed or disrupted narrative.

Non chronological storytelling has become common practice in novels and films. In this form of narrative the events of the plot (the storyline) are not presented in chronological order. A well known early example is the movie *Citizen Kane* (Orson Welles 1941), which has a flashback narrative. Although the order of the presentation of the events is not chronological, this order is

always implied in the plot. The construction of the final artefact itself is fixed and linear. It is not possible to change the order once the movie is finished. In digital games that use a single linear narrative plot, the events are sometimes presented in a disjointed manner to allow variation in gameplay. Even though this results in a different order with every instance of gameplay, the implied plot is fixed and linear for every instance. Mouse clicking through a disjointed narrative is immanently still linear. In this thesis instead of 'nonlinear narrative' the term 'disjointed narrative' is used.

4. nonlinear movie: multi-path narrative

Interactive narrative artefacts (on dvd or online) with multiple plots.

Experiments have been done with so called 'interactive movies' or 'multi-path movies', that enable viewers to choose from several plot lines. Because all the alternative plot lines in multi-path live action movies have to be filmed and produced, the number of plots is often restricted. In the case of digitally animated stories 'hundreds of plot alternatives or paths are possible, leading to multiple distinct conclusions, that are influenced by the user' (Wordspy.com, 2012). In other examples the interactivity is restricted to the sequence of the events. According to the above definition under point 3, in such a case, we actually should speak of an 'interactive, disjointed narrative'. Each plot line by itself is again linear. Authoring of multi-path narrative is very laborious as each plot has to be pre-scripted. Automatic generation in software of meaningful plot lines is difficult. Multi-path formats are also used in digital games with narrative threads. In this thesis the term 'multi-path narrative' will be used.

5. nonlinear music

Music is in its construction and manifestation a temporal art form. Music without time is unthinkable. The time that is needed to perform a piece of music can be measured by the clock (ten Holt 1983, pp. 73-83). As a physical phenomenon, music, being made up of sound waves, always follows a trajectory in time. In that sense it is linear. However, music is not always the representation or expression of a linear trajectory. As discussed in the essay *New Temporalities in Music* (Kramer 1981, pp. 539-556) a musical composition can

be the representation of a nonlinear attribute such as space, or tone colour, an ambience, or an abstract static form. Listening to music can be a nonlinear experience, as with Balinese gamelan music or music of Thomas Tallis, Anton Webern, or the ambient music of Brian Eno. Kramer (1981, p. 540) asserts:

> Listening to tonal music has become comfortable to Westerners not only because we have learned a complex skill but also because the linearity of tonality corresponds to many goal-oriented processes in life. But we should not be fooled by the comfort of tonal listening; it *is* learned behaviour.

Kramer (1981, p 540) further states:

> Some of the basic tenets of our civilisation and its music are quite arbitrary. For the Balinese, for example, temporal processes are not linear, and their music is not linear: it contains rhythmic cycles. Balinese music, like Balinese life, is not oriented towards climax. Activities in Bali are understood and appreciated not as means toward goals but rather as inherently satisfying. Thus it is not surprising that Balinese musical performances simply start and stop, having neither beginning gestures nor ultimate final cadences.

'In Victorian England, Tallis was ever-present: in performances of his music, in accounts of his biography, and through his representation in physical monuments' (Cole 2008, cover). Thomas Tallis' composition *Spem in Allium* (1571)[58] was envisioned by the composer as music to coincide with architecture, and sculpting of space rather than as a development in time. This motet was written for 8 groups of 5 singers placed in an octagonal banqueting hall. In the introduction to the full score edited by Philip Legge (2008, p. 2) underlines the historical evidence 'that Tallis incorporated architectural features into his composition: it is conceivable he designed the work to be sung not only in the round, but perhaps with four of the eight choirs singing from the balconies'. Looking at the score (see Appendix 3.) one can clearly see how the music is distributed over the voices forward and backward in circles and travels from the outside to the inside.[59]

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[58] Tonality became fully developed shortly after 1600.

[59] These nonlinear spatial qualities can not be appreciated by listening to this music through a stereo recording. The SACD surround recording of the piece by The Sixteen (2003), although it cannot fully represent the octagonal placement of the voices, gives a wonderful impression of clouds of voices moving through space. Of course its best to hear a live performance.

In the early 20th century the aim for extreme expression in the music of the Second Viennese School led to free atonality. Anton Webern's *Fünf Stücke für Orchester, op. 10* (1913) are not a representation of a linear trajectory but instead an exposition of strong rhythmic musical textures and tone colours (de Ruiter 1993, pp. 50-58). Stripped of a tonal centre to create linear development Webern needed other form devices to create unity. 'There is no longer a traditional syntax in the melodic line and thematic relationships do not occur' (de Ruiter 1993, p. 67). There is no linear trajectory based on a tonal centre that works towards a conclusion in the form of final cadences that solve the buildup of harmonic tension. Instead tone colour to a single pitch or a short series of pitches, and distributed among several different instruments, becomes a essential independent musical element, which Schönberg called 'Klangfarbenmelodik' (de Ruiter 1993, p. 51). The first half of the 20th century is full of examples of musical experiments with new temporalities. Kramer (1981, p. 542) writes about 20th century music:

> There is a body of recent music that is distinctly nonlinear, music that responds more directly to the disintegration of linear thought in Western culture. As this century has found new temporalities to replace linearity, discontinuities have become commonplace. Discontinuity, if carried to a pervasive extreme destroys linearity.

Brian Eno is regarded as the founder of so called 'Ambient Music' which developed in the 1970s (Eno 1978). In the liner notes of the recording *Ambient 1: Music for Airports* Eno (1978, cover) states: 'Over the past three years, I have become interested in the use of music as ambience' and:

> Ambient Music must be able to accommodate many levels of listening attention without enforcing one in particular; it must be as ignorable as it is interesting.

In this thesis it is this interpretation that is used as the definition of 'nonlinear music'. In the discourse on game music the term is often used for music that is the actual linear output of a 'nonlinear music system', which is described below. The proposed definition for the framework in this thesis is as follows:

nonlinear music is music that is not a representation or expression of a linear trajectory.

Nonlinearity is in this case a property of the music itself and not necessarily of the system generating it.

6. nonlinear music system

A nonlinear music system is a software mechanism that allows for real time changes in the structure or performance of music, in reaction or anticipation to the changing states of a nonlinear artefact, such as a digital game. In a digital game these changes are controlled by variables, generated by the game engine, that are either pre-scripted or the result of the developments during gameplay. The output of a nonlinear music system can be both 'linear music' as 'nonlinear music' as described above at point 5.

The prevailing techniques to accomplish this are:

1. vertical re-orchestration of pre-composed and recorded material through mixing;
2. horizontal re-sequencing of pre-composed and recorded material;
3. the use of generative composition algorithms;
4. any combination of vertical re-orchestration, horizontal re-sequencing and generative composition.

Vertical re-orchestration involves a pre-composed and pre-recorded multitrack of a piece of music that is mixed on the spot by cues from game software. The music for different states in a game is sometimes pre-mixed into sub-mixes, or so-called 'stems'. Horizontal re-sequencing is the reordering in time, of small pre-composed and pre-recorded musical audio-fragments. In some systems these fragments are organised in a network of 'cells' that are interconnected according to more or less complex rules. These rules control the flow within the network that determines on a next possible cell to play (van Nispen tot Pannerden 2009, p. 7; p. 26). A disadvantage of vertical re-orchestration and horizontal re-sequencing is that both systems use tracks or fragments of recorded digital audio. The audio is recorded in the form of Pulse-Code Modulation and most often used in a data compressed form, such as mp3 or Ogg Vorbis. This does not allow for changes inside the musical material itself. Only the balance between tracks or the order in which fragments are played can

be altered. This puts restrictions on the possible musical genres or styles that can convincingly be used with these techniques. The application of generative composition algorithms does not entail such limitations, as it concerns real time composition of music. In software, based on sets of composition rules. In theory anything is possible, but with this approach it is difficult to create convincing music in traditional genres. Moreover, with this method it is no easy task to create music that maintains a meaningful relation with the changing states of a game during gameplay.[60] The performance of the music must be generated in real time too, which can be more complex than using perfectly produced audio recordings of music, as is the case with the two other methods. In short, this technique has shown to be useful for certain genres, and not yet for others. Although there is a long tradition in algorithmic composition within the field of electronic art music, it is still a slowly emerging phenomenon within the field of digital games. Combinations of techniques are also possible and are becoming increasingly common. The output of a nonlinear music system can be linear music or nonlinear music (as per the above definition at point 5). In the field of digital game design, the output of a nonlinear music system is alternately called 'adaptive', 'interactive', 'dynamic', 'reactive' or 'nonlinear' music, which is a point of contention. A more detailed view on the drawbacks of this practice is presented below at the definition of 'adaptive' and expanded on in Chapter 3. In this thesis, adaptivity is viewed as a property of life and of systems.

As we have seen, linearity and nonlinearity may or may not refer to a time aspect. The occurrence of nonlinearity is not restricted to the above examples, but only instances relevant for this thesis have been presented. For example the hyperlink can be seen as an example of a nonlinear method of gathering information. The descriptions that are presented above permit a combination of more than one usages of the term 'nonlinear' within one sentence or concept. In Appendix 3. Fig. 42 a proposal for a topology for music systems for nonlinear artefacts is shown, that is based on this terminology. The topology is still under construction.

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[60] A good example is the generative music created by Brian Eno for the game Spore (Will Wright, 2008)

7. nonlinear sound design

'Nonlinear sound design' is as such not a generally accepted term in the fields of sound design for film and digital games. Sound, however, can convey nonlinear concepts and represent nonlinear attributes. Sound designer Skip Lievsay speaks about 'non-linear' sound design in an interview about his work for the film *Barton Fink* (Macaulay 2009). Sound design and nonlinearity is discussed in Chapter 4 and beyond. The current method, which is used in the field of game audio, is 'procedural audio', which refers to sound, that is generated, modulated and processed in software, in real time. This thesis deals with the issues of sound design for nonlinear artefacts, which also implicates the application of 'procedural audio'.

Artefacts not media

Most definitions agree that an *artefact* is a 'work', a 'product' as opposed to an activity. 'An artefact has necessarily a maker or an author; thus *artefact* and *author* can be regarded as correlative concepts' (Hilpinen 2011): 'An object is an artefact if and only if it has an author.' An artefact can also have more than one author. All works of art, including musical and literary works, are called 'artefacts' insofar as they have authors (Hilpinen 2011).

The word 'artefact' is deliberately used in this thesis to create a distinction with the word 'media'. Since the use of computers in the production and consumption of media we have seen a number of descriptions to separate this practice of information exchange from so-called 'traditional media'. Few people still use the term 'new media'. The phrase 'interactive media' is becoming more and more obsolete, because at present an ever increasing amount of media content is consumed in a more or less interactive way, through the universal use of the internet and tablet computing. What, in this case, is meant with 'interactive' in connection with 'media' is that the media are randomly accessed and skimmed through in a disjointed manner. The media themselves are mainly linear. Music, film, stories, articles. Most of the time there is no interaction with the content itself. Digital games, or 'computer' or 'video' games are also

frequently denoted as 'interactive media'. The word 'media', however, is problematic as a descriptor for games. From the perspective of their construction games are systems. A construct in software, consisting of code that generates rule-sets, goals, mechanics and a possibility space. An engine, a construct of possibilities. In the standard textbook on game design *Rules of Play* game design scholars Salen and Zimmerman regard games primarily as systems: 'Games are intrinsically systemic. All games can be understood as systems.' (Salen and Zimmerman 2004, p. 50). Users experience games in the first place as the interaction with an immersive narrative and with the overwhelming media content, consisting of animation, music and sound effects. Games are indeed painstakingly designed to create such an illusion for the user. But from the outlook of the architecture of games all these media are metaphors, and in fact a representation of the system. The implications of this contradistinction can become problematic when you are a creator of games. For this reason digital games are, in this thesis, not called 'nonlinear media', but referred to as 'nonlinear artefacts'. Nonlinear works. It is a more general term that can also be used to address other nonlinear constructs that are not games, such as virtual reality, enhanced reality and augmented reality, as well as sound and music installations and art installations. Moreover, it makes it possible to communicate about the linearity of more traditional, physical, works of art and compare them with digital artefacts.

Representation

In his essay '*Representation*' W. Mitchell gives the following definition for representation: 'Representation is the use of signs that stand in for and take the place of something else' (Mitchell 1995, p. 11). The proposed definition for 'representation' as it is used in this thesis is:

A representation is the rendition of a concept, someone or something, in a medium or domain.

A sound designer creates a representation in the sound domain. A composer creates a representation in the music domain.[61] A novelist represents in the domain of language. Different domains allow for, or are better suited for different representations. It is difficult to impossible to render an object in the domain of music, while this is less difficult in the domain of sound design or painting. If the concept, someone or something already exists in another medium or domain, the technique for rendition can for example be reproduction or transformation.

Nonlinear artefact

Combining the above definitions and reflections, within the context of my work, a nonlinear artefact is understood as follows:

A nonlinear artefact is an object or construct for representation, whose structure is not arranged in a linear trajectory.

So, within the frame of this research, 'artefact' is coupled to representation. This is the general meaning as it is used in the title of the thesis and throughout the text. A nonlinear artefact can use linear or nonlinear media for representation.

Nonlinear representation

In the same manner the following definition for 'nonlinear representation' is proposed:

A nonlinear representation is a rendition of a concept, someone or something, that is not arranged in a linear trajectory.

This is the general meaning as it is used in the title of the thesis and throughout the text. A nonlinear representation can be part of a linear or nonlinear artefact.

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[61] As an example: in her book *Unheard Melodies* Claudia Gorbman (1987, p. 79) provides a comprehensive explanation the channels through which movie music so efficiently conveys meaning.: 'Music appears in classical cinema as a signifier of emotion'.

Linearity in artefact or in representation: device or appearance

As we have seen above there can be a difference between the linearity of the artefact and that of the representation. For reasons of clarity of the discussion, here, I propose to separate the device from the apparent form. In this research the linearity of the structure of the artefact is always distinguished from the linearity of the structure of the representation. This is best illustrated by means of the following table with examples:

example	artefact	structure of the artefact	structure of the representation
Harry Potter	book	nonlinear	linear
Harry Potter	film	linear	linear
Harry Potter	game	nonlinear	linear, disjointed
Beethoven- Symphony #9	music	linear	linear
Anton Webern - Fünf Satzen, op. 5	music	linear	nonlinear
Thomas Tallis- Spem in Allium	music	linear	nonlinear
Rodin - The Thinker	sculpture	nonlinear	nonlinear
The Sims	game	nonlinear	nonlinear
Poetic Documentary	film	linear	nonlinear
Minecraft	game	nonlinear	nonlinear
Rembrandt- Night Watch	painting	nonlinear	nonlinear
Brian Eno- Music for Airports	music	linear	nonlinear
Game world	game	nonlinear	nonlinear
Game with embedded narrative	game	nonlinear	linear
Game with emergent narrative	game	nonlinear	nonlinear
Citizen Kane	film	linear	linear, disjointed
David Lynch - Mulholland Drive	film	linear	nonlinear
World of Warcraft	game	nonlinear	nonlinear
Improvised music	music	nonlinear	linear or nonlinear
From thinking to speech	thought	nonlinear	linear
Nonlinear music system	system	nonlinear	linear or nonlinear

Table 3. Linearity in artefact or representation.

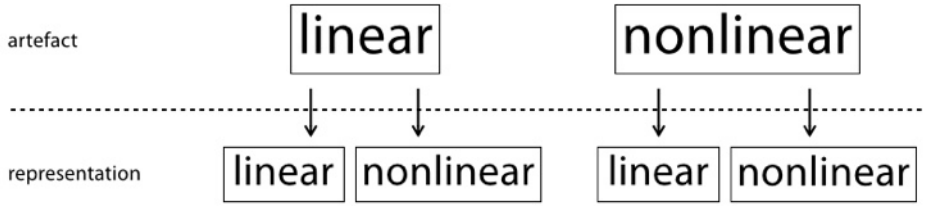

Fig. 33. An artefact can be linear or nonlinear. The representation within both a linear and a nonlinear artefact can again be linear or nonlinear.

It is interesting to compare the different remediations of *Harry Potter*. Also noteworthy is the movie *Mulholland Drive* (David Lynch 2011). It uses all kinds of narrative devices, and in a clever and skilled way follows many conventions of filmmaking. But as well as other films by Lynch, it lacks a clear plot, which makes it poly-interpretable. This means of separation can be further refined by incorporating the method that is used to create the artefact[62]:

example	artefact	method of creation	structure of artefact	structure of representation
Harry Potter	film	nonlinear	linear	linear, disjointed
Ornette Coleman - The Shape of Jazz to Come	music recording	nonlinear	linear	nonlinear
Live performance of Anton Webern String Quartet	music performance	linear	linear	nonlinear

Table 4. Linearity in artefact or representation and method of creation.

[62] The detailed reasoning behind the allocation of types in table 4. for the Free Jazz album 'The Shape of Jazz to Come' (Ornette Coleman, 1959) might go as follows: The album as artefact is an object, an LP or CD, a fixed number of fixed recordings of music. For the listener it is not possible to change the material within the recordings, so the recording is a linear artefact. It is designed to be played linearly in time. The main part of the music itself was created through improvisation, this classifies the method of creation as nonlinear. One might object that this nonlinear improvisation was based on a fixed set of rules and agreements between the musicians. But the rule-set in itself is the receipt for the nonlinear method of improvisation. There was done only a minimum of composition and there were no rehearsals in advance. The result, based on this improvisation, is harmonically nonlinear music as it is not based on a linear chord progression or a linear series of harmonies. Each section holds a brief melody, followed by minutes of free improvisation. Both the LP version and the CD allow for random playback order of the pieces, or disjointed listening of the album. But the order of songs is implied by the way it was published.

The assigned types in the tables are, off course, open to discussion, and this proposal for classification presents the possibility to do so. It is interesting to note that in most cases the method of creation is nonlinear. Even roads and railway tracks are, in most cases, not built linearly from A to B.

Digital Games

Games that are created and played in the digital domain are most often referred to as 'computer games' or 'video games'. Since their appearance in the 1970s we have seen a multitude of platforms to play games on: from our black & white TV to the personal computer, and from there to consoles designed exclusively for gameplay, and now cellphones. Furthermore, an increasing amount of games are being developed that use different means of representation than video[63]. Audio games have been created that solely use sound as interface and for their representation. There are 'location based games' that even use the real world for representation and reserve the role of digital techniques to enhance and alter this reality, or to add virtual layers to it. For this reason video games, computer games, electronic games, games for computer platforms, game consoles, handheld game devices, PDAs or cellphones, as well as 'location based games' are collectively referred to in this thesis as: 'digital games'. A term borrowed from the book *Rules of Play* by Salen & Zimmermann (2004, p.86).

Adaptivity

In everyday speech to 'adapt' means: to adjust to changing circumstances. As such the adjective 'adaptive' was adopted by digital game designers to denote music that exhibits changes in parallel with altering conditions during gameplay. Thus, 'adaptive music' is a commonly used expression for such music. In games, the underlying device to attain this fluidity is designed as a fixed set of rules, and anchored in a software algorithm.

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[63] A video game is an electronic game that involves human interaction with a user interface to generate visual feedback on a video device.

In science, adaptivety is seen as the basic principle of life. It forms the basis for the theory of evolution and is, in a way, congruent with intelligence (Kennedy & Eberhart, 2001, pp. 3-34). Adaptive behaviour is not just the application of fixed rules, but the ability to change the rules themselves in response to changing circumstances. Adaptive behaviour is a strategy of living organisms to survive in the interaction with their environment. It is characterised by a process of self learning and self optimisation. Systems can also be adaptive. 'The universe is full of systems, weather systems, immune systems, social systems etcetera, and these systems are complex and constantly adapting to their environment' (Fryer, 2012). According to the interpretation of the term, as it is used in science, music in itself cannot be self learning or adaptive. A possible system that generates music indeed can. In this thesis the adjective 'adaptive' is exclusively reserved for organisms and systems. Linear and nonlinear music could possibly be the output of an adaptive system. Separating the system from the output makes it clearer to understand the underlying principles. The application of a self learning system in music engines for digital games is, so far, an unknown practice to the author of this thesis.[64] The exploration of adaptive systems is a part of the proposed framework in Chapter 4.

Narrative

In an attempt to give meaning to our existence, stories are a way to represent and communicate the world. Narratives follow a fixed sequence of events arranged in a logical order of cause and effect. 'The act of selecting what is depicted is also crucial to the process of narrative' (Cobley 2001, p. 6). Events and facts that are not immediately relevant to the story are left out, resulting in a simplification or reduction of reality. The selection is done by the author of the narrative. Cobley (2001, p. 4) differentiates between 'narrative', 'story' and 'plot' as follows: Stories are about events. All events, that are selected for representation, together form the 'story'. The 'plot' is the chain of causality and how the events and characters are interconnected. 'Narrative' is the chosen form

[64] Not much information is disclosed on the actual design and systems used by developers. Intellectual property arguments dictate secrecy.

of representation of the events and causalities. The 'narrative mode' is the way the story is told. Some events may be described from the third person perspective of the narrator, other events and causations may be deducted from the dialog between characters. As another example, the chronological order of the presentation of the events, that was discussed in a section above is also part of the narrative mode.

It is important to note that stories are recounts of events that happened in the past. Even science fiction stories that are placed in the future are in fact told from a retrospective angle. A story can only be told from the overview of the selected events, and with knowledge[65] of the causal interrelations. The meaning of narrative emerges from its linear chain of interconnected events. Other forms of representation, such as pictorial arts, do not display this time aspect. They 'realise their meaning through their existence as an isolated whole' (Cobley, 2001, p. 7). Representational forms such as comic books, film, television and digital games combine these characteristics. Also important is that 'a narrative has a beginning and an ending, a fact that distinguishes it from the rest of the world and opposes it to the "real" world' (Metz, 1968, p. 17).

Some theories of narratology claim that all instances of meaning and all forms of interconnected significations are to be considered as narrative. This 'meta-view' on narrative in fact completely annex the concept of meaning. In her book '*Wired For Story*' Cron (2012, p. 2) states that 'when given the choice, people prefer fiction to nonfiction'. Basing her assertion, among others, on the writings of Damasio (*The Self Comes To Mind*, 2010) she affirms that 'our neural circuitry is designed to crave story'. Branigan (1992, xi-xv), on the other hand, considers narrative as one of many ways of organising data in the world around us and presents a long list of non narrative ways of assembling and understanding data, from poetry to pie charts. In this thesis narrative is considered as one of the forms of representation apart from others. The sequential attribute of narrative is important in the discussion on linearity.

[65] 'Narration' stems from the Latin word 'gnarus', which means 'knowing'.

Sound or audio

The following definitions for sound and audio are used:
'Sound' is the perception of vibrations that travel through the air or another medium. 'Audio' is 'produced sound' that has been generated, recorded, transmitted or reproduced. The equipment that is used to perform these tasks is called audio equipment. The sound that is generated by digital games is called: game audio. The attribute 'auditory' is used as a general adjective or adverb expressing: 'related to hearing', as in 'auditory perception', or 'auditory scene analysis'.

Fine Art

The works in the portfolio include applied sound design for artworks that are exhibited in museums, art exhibitions and art galleries. Wikipedia translates the Dutch expression 'Beeldende Kunst' as 'Visual Arts' (Wikipedia, 2011). The Dutch concept 'Beeldende Kunst' differs in important parts from the English term 'visual arts'. Other English sources use the term 'Fine Art'. This term is applied by The Royal College of Art in London, which incorporates the 'School of Fine Art', as can be found on their website (Royal College of Art, 2012). The description of 'Fine Art' as found at the English version of Wikipedia (Wikipedia, 2011) differs again from the one employed by the Royal College. During the 20th Century the general notion of what can be considered 'art' blurred. Here the expression 'Fine Art' is used and in cases of a possible misunderstanding it is further explained in the text.

2. Music design versus sound design

Sound in film and digital games comprises both music composition and sound design. There is, however, an overlap between the two disciplines. An unambiguous definition for music can be difficult. Not just in the field of applied composition and sound design for film or games. During the 20th century the definition of music has been broadened substantially. Composer Edgar Varèse was inspired by the sounds of machinery and industry, which he transmuted into orchestral 'sound mass' compositions (de Ruiter, 1993, pp. 116-124). His definition of music was 'organised sound' (de Ruiter, 1993, p. 116), which might fit just as well for sound design. So, just as for the concept of 'art', there is no general consensus on a definition. One might say that everything is 'music', that is considered or accepted as 'music' by a listener. A general accepted view, both for 'art' and 'music', is that must be produced by humans.[66] In that sense an animal or random event cannot create music or art. In the case of computer generated music, the composition algorithms are designed by humans and can thus be considered as art. Composers Pierre Schaeffer, and later, John Cage were famous for stretching the definition of music to everyday sounds. In the same way that *Dada* artists, such as Duchamp, extended the definition of art to everyday objects. Cage suggests that we can hear the combination of everyday sounds in the environment as music, because this very conduct of classification is a human activity that can be seen as composition. In practice, in the context of film, there is a broad area of transition between music and sound design.

The discipline of sound design for film or digital games involves more than just the acoustic representation of sound sources, such as dialog, objects or (linear) events. The representation of (nonlinear) states, or conditions also falls within the domain of sound design. In film sound theory there is a distinction between diegetic and nondiegetic sound. 'Diegetic' means being a part of the 'diegesis', or the 'narrative plot'. Which means that all the sounds that the characters within the story would be able to hear are considered to be diegetic. In that sense

[66] See also: Hilpinen 2011

music in film can also be diegetic, which is the case whenever the music is played within the depicted world of the story, such as musicians in a bar, or music playing on a radio. All sounds that are not part of the world within the story are called 'nondiegetic'. So in most cases underscored music for film is nondiegetic. But sound can also be nondiegetic.

'Music appears in classical cinema as a signifier of emotion'. (Gorbman 1987, p. 79). But music is just as well used to exemplify the narrative plot. To complicate things: nondiegetic sound and music can both signify or represent emotion. Sometimes sounds can be called, 'semi-diegetic', which means that the sound could actually be part of the diegetic world but has added, frequently emotional, connotations. When you see a woman wake up in a movie, the sound of children's voices in the background might signify that she wakes up in a cosy family home. But as soon as the sounds of children are substituted by distant trains and whistles, the impression is that the woman is much lonelier. There is a convention to use train sounds to represent distress in films (as is done in a famous scene in '*The Godfather*' [Coppola, 1972; part 1 at 01:25:10]), which is - also through convention - subconsciously read as such by the viewer.

In the 1970s Canadian composer Raymond Murray Schafer (1977) coined the term 'soundscape' as the acoustic equivalent of 'landscape' to indicate the total acoustic impression of a certain physical location. Composers using abstract or everyday sounds as content for their compositions also embraced this term. Another term, used by cognitive scientists, for 'soundscape' in the sense of Schafer's definition is 'auditory scene', which would be a better descriptor to differentiate between the two. In the context of film and game sound, the confusing term 'atmospheres' is interchangeably used for both definitions, as is the word 'ambience'. A sound designer operates in both fields. One of the tasks of the sound designer is to acoustically represent the actual locations or scenes that are part of the diegesis. Abstract sound compositions (also called 'soundscapes') might both be part of the job of the sound designer as of the job of the composer. But as soon as notes, beats and chords are involved we certainly enter the territory of the composer.

There is a difference in the perception in the brain of music and nonmusical sounds as well. Psychological and neurological research indicate that the cognition of music involves complex pattern recognition and memory functions. Cognition and evaluation of musical properties is divided over many different parts of the brain (Huron, 2006; Levitin, 2007; Sachs, 2008). Nonmusical auditory information is being processed in other ways that will be described later in this chapter.

In everyday practice of the design of film sound, composers are involved where the conventions of generally accepted music styles, such as tonal music, are required. The design or composition of this music demands special skills within the conventions of genres.

As opposed to the design of the 'auditory scene', nondiegetic musical 'soundscape composition' can be done both by the sound designer and the composer since this is within the previously mentioned transitional area between music composition and sound design. There is no indication of a sound source and most of the time this type of composition has the function of emotional signifier.

3. Additional illustrations

Preface

Fig. 34. Tubes placed on the surface of the road to evaluate traffic streams.

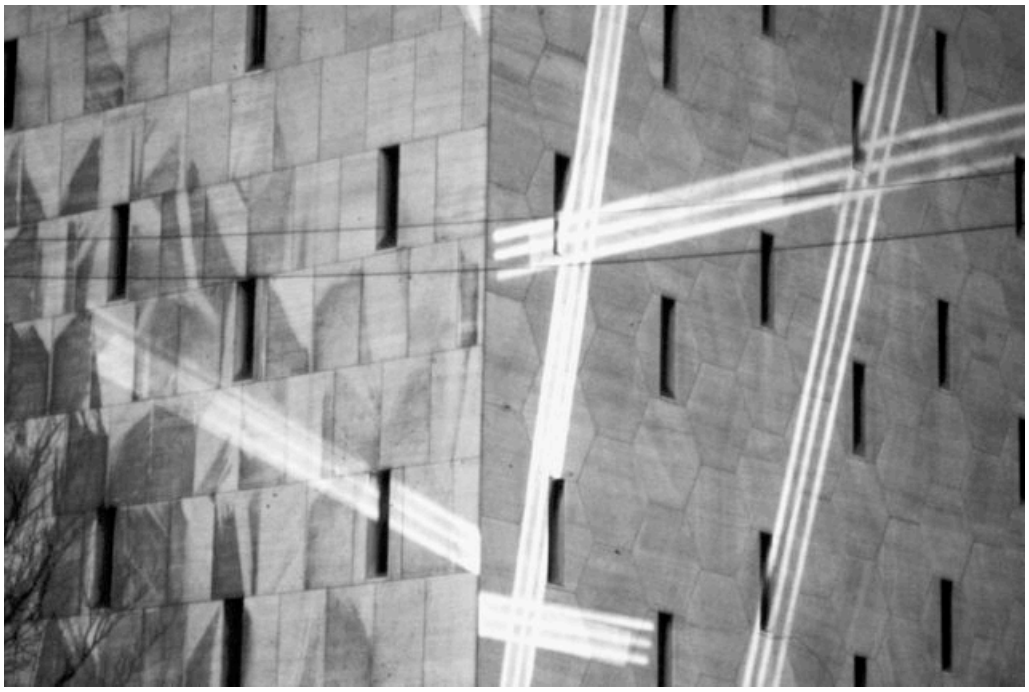


Fig. 35. Light projections on the *Bijenkorf* building in Rotterdam in 1982.

Fig. 36. . More light projections on the *Bijenkorf* building.

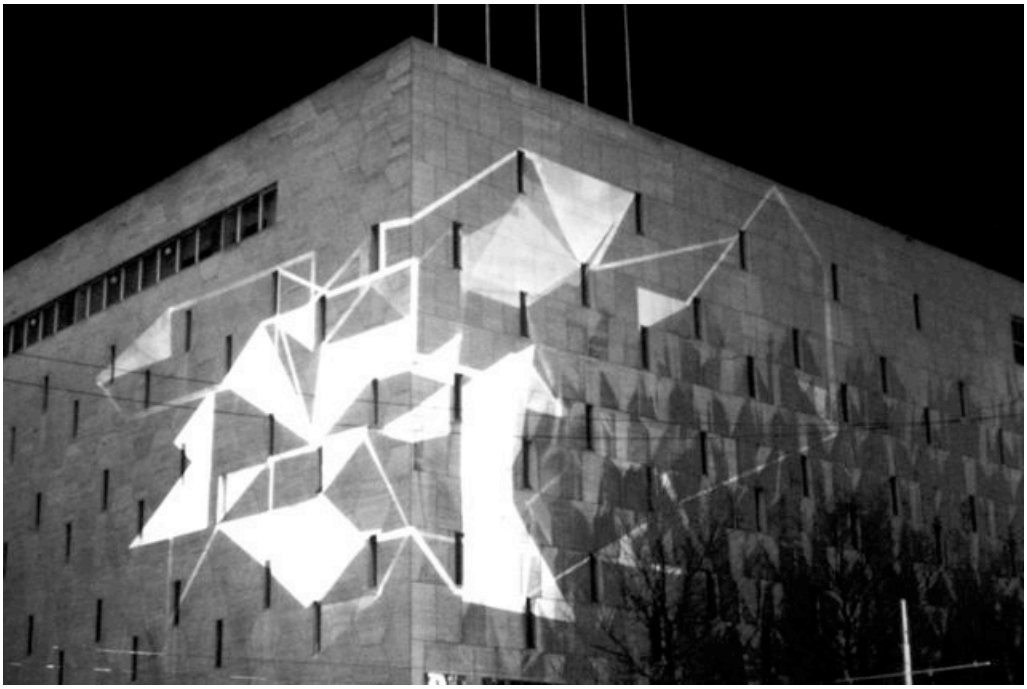


Fig. 3. Another picture of light projections on the *Bijenkorf* building.

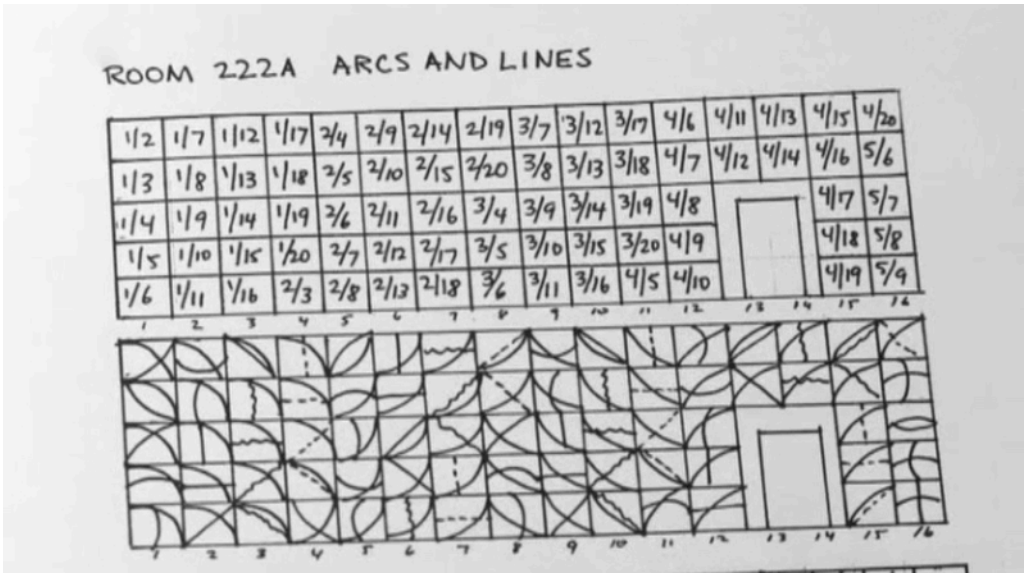


Fig. 38. A rule-set for a wall painting by Sol LeWitt (still from the documentary *Soll LeWitt* 2013)

Fig. 39 An instance of a resulting painting (still from the documentary *Soll LeWitt* 2013)

Welke stad klinkt het mooist?

Architecten denken niet na of een plein aangenaam klinkt, zegt sounddesigner Kees Went. Hij lanceerde onlangs een site met geluiden uit o.a. Amsterdam, Rotterdam en Utrecht.

Door TIJS VAN DEN BOOMEN

Reisgidsen staan vol plaatjes. Ook in architectuurboeken is het beeld allesoverheersend: driedimensionale animaties, modellen, schetsen en natuurlijk heel veel foto's. Alleen de ogen worden bediend, de andere zintuigen waarmee we steden ervaren komen er bekaaid af. Alsof de haven van Marseille zonder haar zilte geur zou kunnen, alsof de straten van Lissabon hetzelfde zouden zijn zonder de handgehakte keitjes waar je leren schoenzolen overheen glijden. Om maar te zwijgen van het geluid van de stad: wat zou Amsterdam zijn zonder trams „die de hoek om gillen of ze katten staan te villen" (Tol Hansse).

Volgens Kees Went, sounddesigner en docent aan de Utrechtse Hogeschool voor de Kunsten, verdiepen architecten en stedenbouwers zich ten onrechte niet in geluid: „Elke filmmaker weet hoe belangrijk geluid is voor de beleving, maar architecten kijken alleen naar het mooie plaatje. Ze denken niet na of een plein bijvoorbeeld ook aangenaam klinkt."

Rotterdam is volgens Went, die er geboren en getogen is, een voorbeeld van een stad die beroerd klinkt. Dat komt door de hoge gebouwen, het gebrek aan functies op de begane grond, de brede autowegen dwars door de stad en de vele gebroken ruimtes. Went borduurt voort op het werk van de Canadese musicoloog R. Murray Schafer, die in de jaren zestig van de vorige eeuw het begrip soundscape muntte. Elke omgeving heeft volgens Schafer een keynote, voor steden wordt deze grondtoon gevormd door het verkeer. Daarnaast zijn er karakteristieke geluiden, de soundmarks, een soort auditieve landmarks. Bij Rotterdam denk ik meteen aan heimachines, bij Amsterdam schieten me behalve de trams van Tol Hansse draaiorgels te binnen.

De proef op de som biedt de site met audiomaps die Kees Went deze week lanceerde. Hierop staan wandelingen van een uur die je niet alleen kunt beluisteren, maar op Virtual Earth ook precies kunt volgen. De wandeling van Rotterdam-Noord naar -Zuid begint op het Hofplein hoopvol met een klaterende fontein en een bellende tram. Even verder op het Coolsingel hoor je zelfs een draaiorgel, maar al snel wordt het geluid lelijker: het suizen en razen van auto's, het knetteren van brommers, het dreunen van de wind die vrij spel heeft. Maar geen heimachines. De soundmark van Rotterdam blijkt afkomstig van de rateltikkers die blinden bij verkeerslichten waarschuwen dat ze kunnen oversteken. Een typisch geluid van een autostad dus.

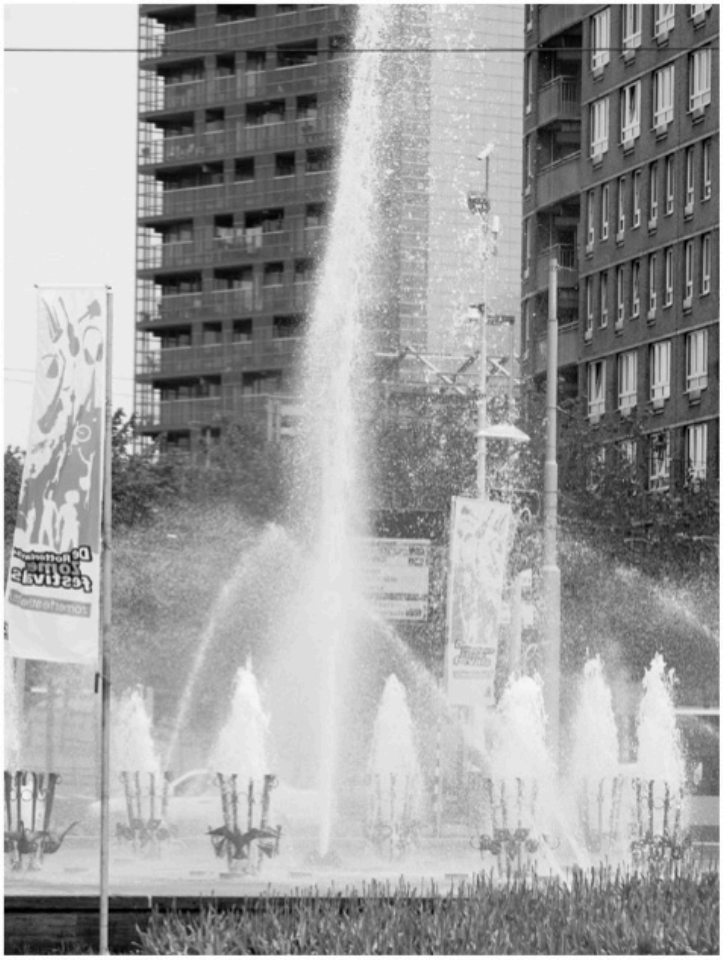
De Amsterdamse wandeling voert van het Vondelpark naar het IJ, dwars door het centrum. Ook hier trams – alhoewel ze niet gillen – en auto's, maar opvallend is dat je veel meer mensen hoort praten en vogels hoort fluiten. Het geluid is kleinschaliger en gearticuleerder, je kunt verschillende frequenties onderscheiden en er is een verschil tussen voorgrond en achtergrond. Als de wandeling door de Oudemanhuispoort voert, hoor je zelfs een fraaie echo van voetstappen: dit komt in de buurt van wat Schafer een hifi soundscape noemt. Het draaiorgel blijkt ondertussen ingeruild voor een valse klarinet en de nieuwe soundmark van Amsterdam is de rinkelende ketting waarmee fietsen aan palen of bruggen worden vastgezet, je hoort het op de hele route.

De kans is groot dat zulke specifieke stadsgeluiden ten onder gaan in een steeds sterkere orkaan van geluid. Elk jaar stijgt het geluidsniveau in de stad met 1 decibel, dat betekent een verdubbeling van de geluidsbelasting in tien jaar. Een van de oorzaken is de toenemende mechanisering, zelfs bladeren opruimen kan niet meer zonder apparaat. De black-and-decker-isation noemt Kees Went dit.

Hij pleit voor de inzet van bomen om geluid te dempen en de inzet van fonteinen om mooie, gevarieerde geluiden toe te voegen. Ook kerkklokken dragen volgens Went bij aan een positieve beleving van de stad: ze verruimen de horizon en benadrukken gemeenschapszin. Maar dat geldt voor de gebedsoproep vanaf een minaret natuurlijk net zo goed, alhoewel Wildersstemmers daar wellicht anders over denken.

Geluid blijft een persoonlijke aangelegenheid, maar een objectief vereiste is dat je de geluiden van elkaar moet kunnen onderscheiden, anders wordt de stad een monotoon loeiende stofzuiger. Leve de bezem.

Kijk en luister vooral:
www.adaptivemusicandsound.org



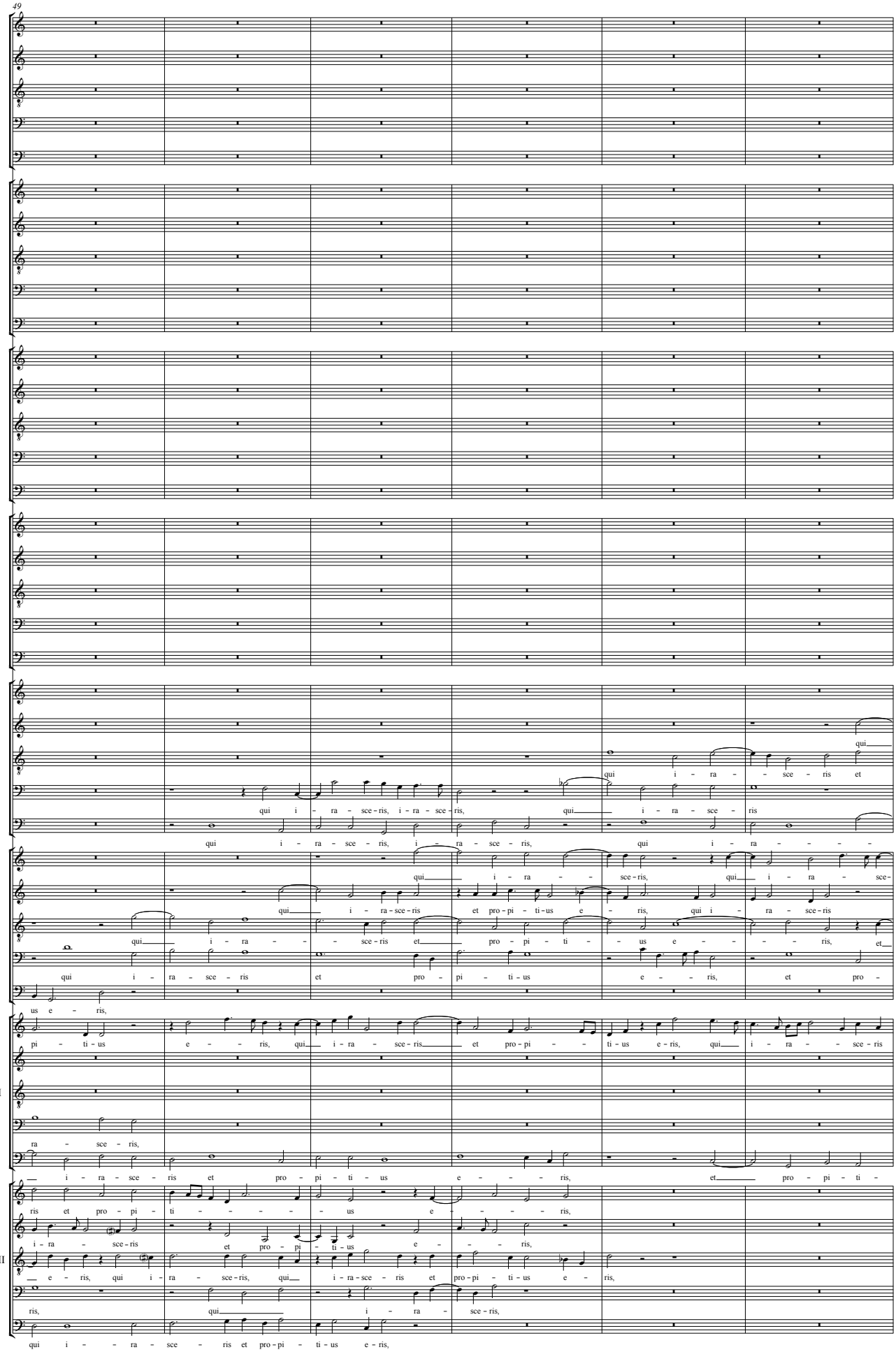
De audiowandeling in Rotterdam begint bij de Hofpleinfontein. Foto Leo van Velzen

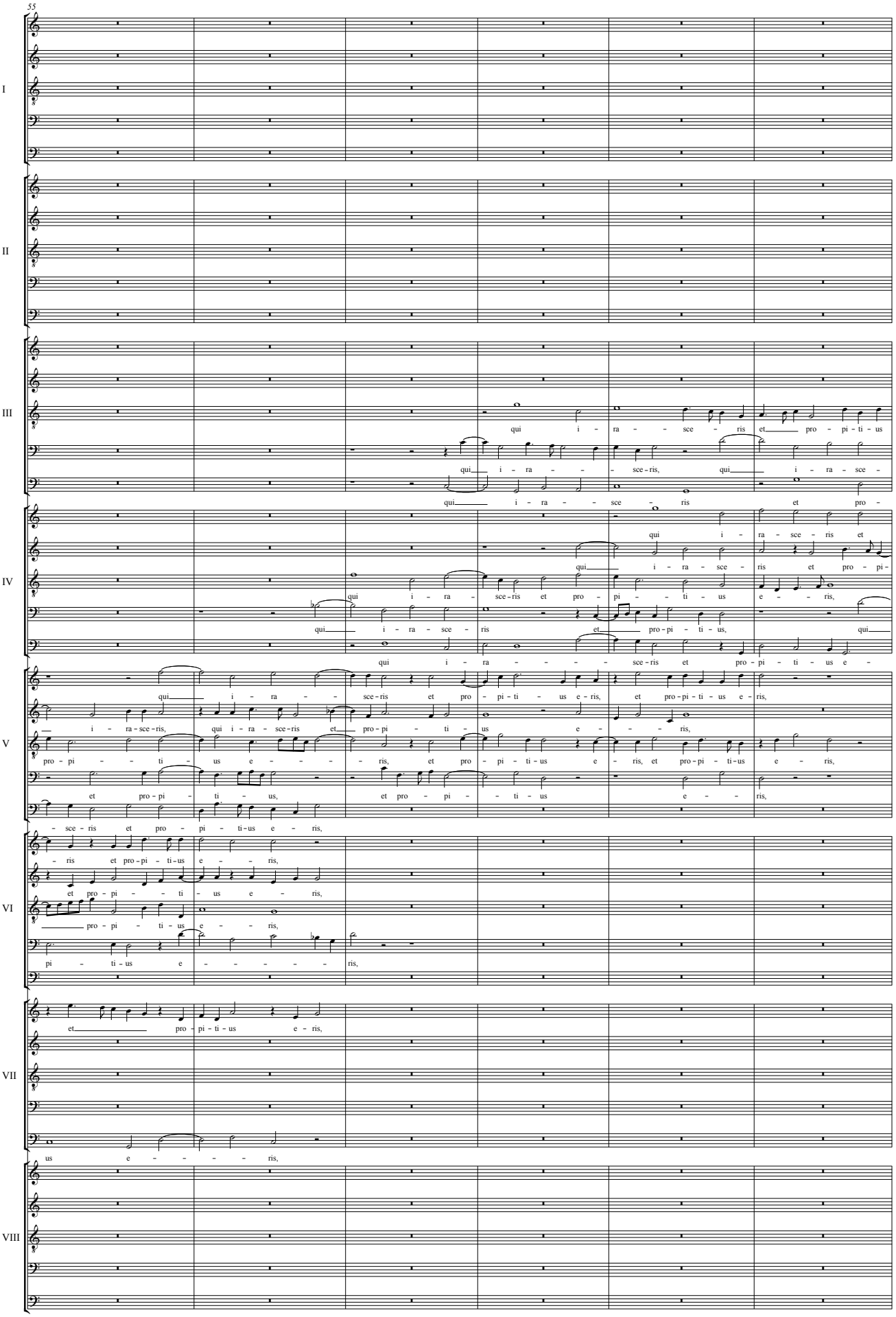
Fig. 40. Article on urban sound in *NRC Handelsblad*, 15 May 2008.

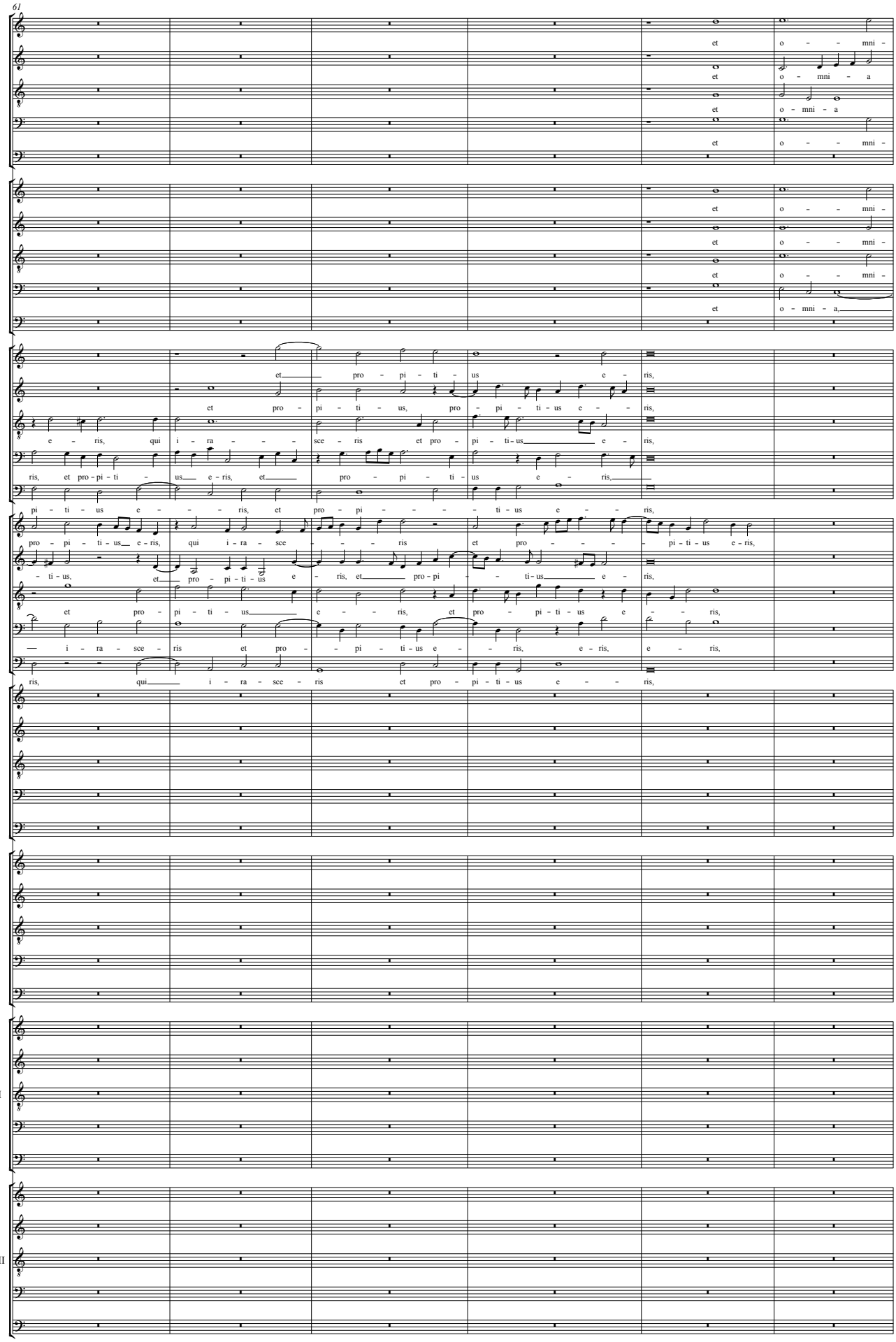
Appendix 1.

The following three pages contain page 9-11 of the score of Thomas Tallis - *Spem in Alium*.

Fig. 41. Page 9-11 of the score of Thomas Tallis - *Spem in Alium* (Legge 2008):


49
I
II
III
IV
V
VI
VII
VIII
qui i – ra – sce – ris, i – ra – sce – ris, qui i – ra – sce – ris
qui i – ra – sce – ris, i – ra – sce – ris, qui i – ra – sce – ris
qui i – ra – sce – ris et
qui i – ra – sce – ris, qui i – ra – sce –
qui i – ra – sce – ris et pro – pi – ti – us e – ris, qui i – ra – sce – ris
qui i – ra – sce – ris et pro – pi – ti – us e – ris, et
qui i – ra – sce – ris et pro – pi – ti – us e – ris, et pro –
us e – ris,
pi – ti – us e – ris, qui i – ra – sce – ris et pro – pi – ti – us e – ris, qui i – ra – sce – ris
ra – sce – ris,
i – ra – sce – ris et pro – pi – ti – us e – ris, et pro – pi – ti –
ris et pro – pi – ti – us e – ris,
i – ra – sce – ris et pro – pi – ti – us e – ris,
e – ris, qui i – ra – sce – ris, qui i – ra – sce – ris et pro – pi – ti – us e – ris,
ris, qui i – ra – sce – ris,
qui i – ra – sce – ris et pro – pi – ti – us e – ris,


55
I
II
III
qui i - ra - - sce - ris et pro - pi - ti - us
qui i - ra - - sce - ris, qui i - ra - sce -
qui i - ra - - sce ris et pro -
IV
qui i - ra - sce - ris et
qui i - ra - sce - ris et pro - pi -
qui i - ra - sce - ris et pro - pi - ti - us e - - ris,
qui i - ra - sce ris et pro - pi - ti - us, qui
qui i - ra - - - sce - ris et pro - pi - ti - us e -
V
qui i - ra - - sce - ris et pro - pi - ti - us e - ris, et pro - pi - ti - us e - ris,
i - ra - sce - ris, qui i - ra - sce - ris et pro - pi - ti - us e - - ris,
pro - pi - - ti - us e - - - ris, et pro - pi - ti - us e - ris, et pro - pi - ti - us e - ris,
et pro - pi - ti - us, et pro - pi - - ti - us e - - ris,
- sce - ris et pro - pi - ti - us e - ris,
VI
- ris et pro - pi - ti - us e - - ris,
et pro - pi - - ti - us e - ris,
pro - pi - ti - us e - - ris,
pi - ti - us e - - - - - ris,
VII
et pro - pi - ti - us e - ris,
us e - - - - - ris,
VIII


61
I
et o – – – mni –
et o – mni – a
et o – mni – a
et o – – – mni –
II
et o – – – mni –
et o – – – mni –
et o – – – mni –
et o – mni – a,
III
et pro – pi – ti – us e – ris,
et pro – pi – ti – us, pro – pi – ti – us e – – ris,
e – ris, qui i – ra – – – sce – ris et pro – pi – ti – us e – ris,
ris, et pro – pi – ti – us e – ris, et pro – pi – ti – us e – ris,
pi – ti – us e – – – ris, et pro – pi – – – – ti – us e – – ris,
IV
pro – pi – ti – us e – ris, qui i – ra – sce – – – – ris et pro – – – – pi – ti – us e – ris,
– ti – us, et pro – pi – ti – us e – ris, et pro – pi – – – ti – us e – ris,
et pro – pi – ti – us e – – ris, et pro – pi – ti – us e – – ris,
– i – ra – sce – ris et pro – – pi – ti – us e – – ris, e – ris, e – ris,
ris, qui i – ra – sce – ris et pro – pi – ti – us e – – ris,
V
VI
VII
VIII

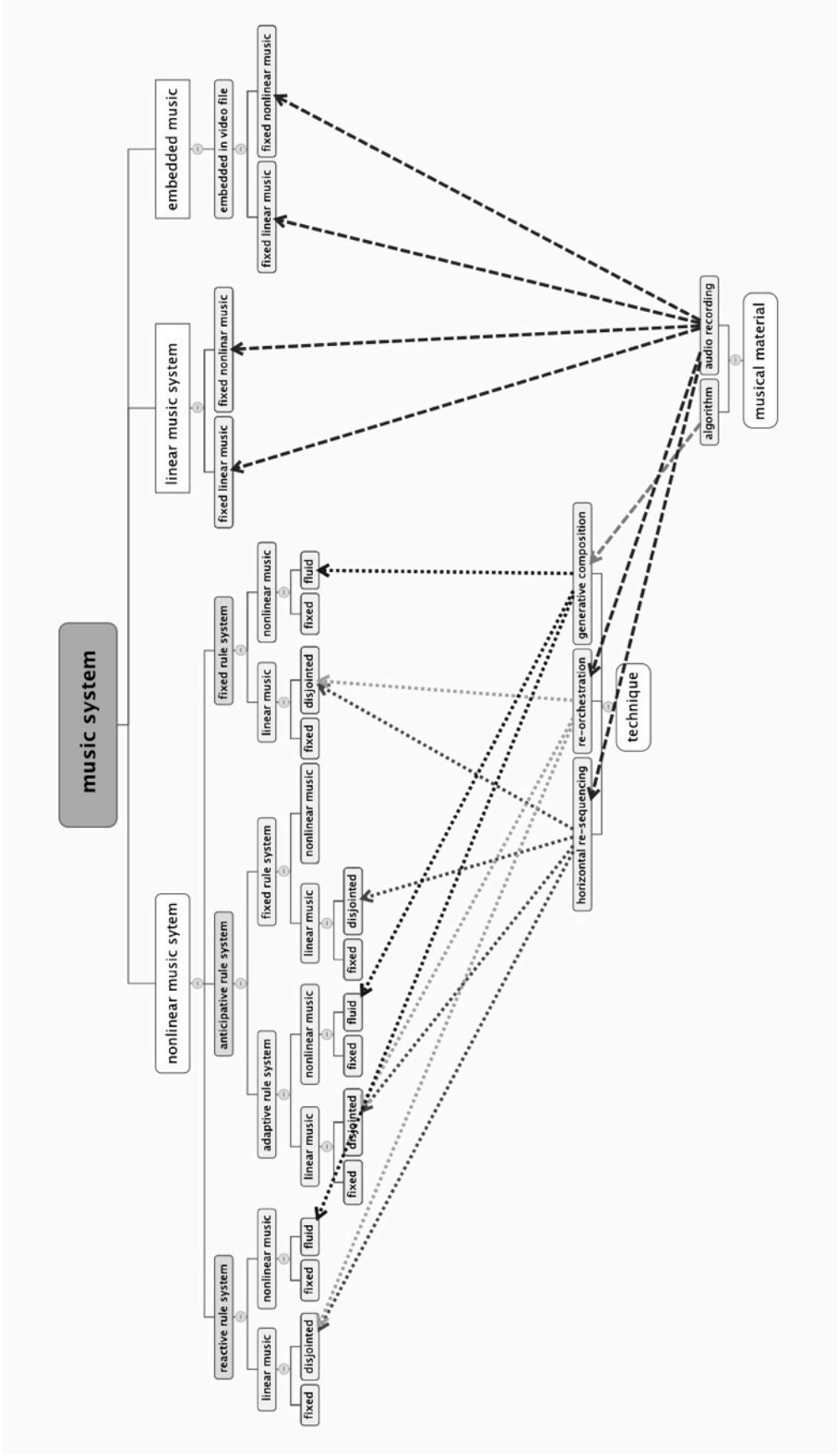


Fig. 42. Proposal for a topology for music systems for nonlinear artefacts.

4. The contents of the Data DVD

The DVD includes a PDF version of this thesis. This file contains interactive links to the movies and other files on the DVD, which will work in *Adobe Reader* version10.1.10 or higher, which can be downloaded from www.adobe.com. The interactive links are recognizable by the blue rectangle around the filename. The interactive links may not work in other PDF readers.

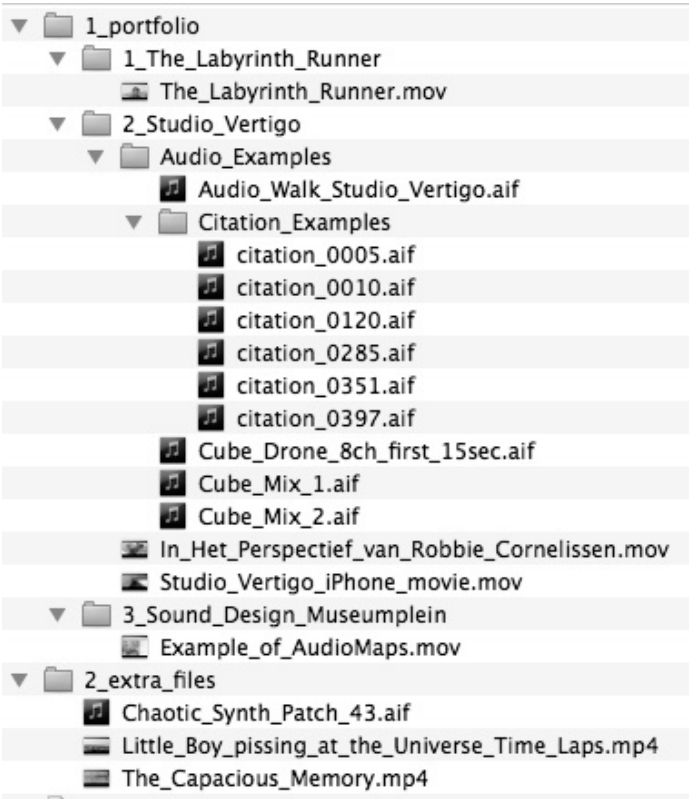


Fig. 43 The folder structure of the DVD

Folder 1_portfolio

1_ The_Labyrinth_Runner.mov

This is the the animation *The Labyrinth Runner*

Folder 2_Studio_Vertigo

Audio_examples

This folder contains audio examples of the sound files used for the installation *The Black Room*

In_Het_Perspectief_van_Robbie_Cornelissen.mov

This is a documentary about Robbie Cornelissen that was made for the local television station of Utrecht. A large part of its content is about the exhibition.

Studio_Vertigo_iPhone_movie.mov

shows the short continuous walk I toke along the installations in the exhibition with my iPhone.

Folder 3_Sound_Design_Museumplein

Example_of_AudiMaps.mov

This a demonstration of the *AudioMaps* Tool

Folder 2_Extra_Files

The_Capacious_Memory.mp4

The animation *The Capacious Memory*

Chaotic_Synth_Patch_43

An example of a chaotic synthesizer algorithm

Little_Boy_pissing_at_the_Universe_Time_Laps.mp4

shows the creation of this artwork, that was part of the exhibition *Studio Vertigo* as recorded by a time laps camera. This movie contains no audio.

References

Aarseth, Espen & Smetstad, Solveigh Marie & Sunnanâ, Lise, 2003. *A Multidimensional Typology of Games*. Utrecht: Utrecht University

Arch Daily, 2011. *Bernhard Leitner: Sound Spaces.* Available at: http://www.archdaily.com/168979/ [Accessed 12 December 2012}

A Serious Man, 2009. Film. Directed by Joel and Ethan Coen. USA: Focus Features

Altman, Rick Ed., 1992. *Sound Theory/Sound Practice.* New York: Routledge

Balio, Tino (Ed), 1985. *The American Film Industry.* London: The University of Wisconson Press, Ltd.

Barnes, Randall, 2007. *Barton Fink: Atmospheric Sounds of the Creative Mind.* In: Offscreen, Volume 11, issue 8-9. Available at: http;//www.offscreen.com/index.php/pages essay/barnes_bartonfink [Assessed 2 November 2013]

Barthes, Roland, 1977. *The Death of the Author.* In: *Image - Music - Text.* New York: Hill and Wang

Barthes, Roland, 1977. *Introduction to the Structural Analysis of Narratives.* In: *Image - Music - Text.* New York: Hill and Wang

Barton Fink, 1991. Film. Directed by Joel and Ethan Coen. USA: 20th Century Fox

Bendik, Stang et all., 2006. *The Book of Games Vol. 1*. McLean: GameXplore NA Inc.

Ben Minto on Game Sound Design, 2011. Available at: http://www.waves.com/ben-minto-on-game-sound-design [Assessed 29 November 2013]

Berndt, Axel, 2011. *Diegetic Music: New Interactive Experiences.* In: Grimshaw, Mark, Ed. *Game Sound Technology and Player Interaction: Concepts and developments*. Hershey - New York: IGI Global

Bernus, Volker & Kemper, Peter & Oehler, Regina, 2006. *Der Aufstand des Ohrs- die neue Lust am Hören*. Göttingen: Vandenhoeck & Ruprecht

Berry, Wallace, 1987. *Structural Functions in Music*. Mineola: Dover Publications Inc.

Bertalanffy, Ludwig von, 1969. *General System Theory*. New York: George Braziller, Inc.

Bijsterveld, Karin, 2008. *Mechanical Sound - Technology, Culture and Problems of Noise in the Twentieth Century.* Cambridge, MA: The MIT Press

Bizzocchi, Jim, 2007. *Games and Narrative: An Analytical Framework*, published in Loading - the Journal of the Canadian Game Studies Association, Vol., No 1. Available at: http://journals.sfu.ca/loading/index.php/loading/article/download/1/1 [Accessed: 18 October, 2010]

Blesser, Barry & Salter, Linda-Ruth, 2007. *Spaces Speak, Are You Listening - Experiencing Aural Architecture.* Cambridge, MA: The MIT Press

Bolter, Jay David & Grusin, Richard, 2000. *Remediation - Understanding New Media.* Cambridge, MA: The MIT Press

Bor, Jan, Ed. , 2003. *25 Eeuwen Westerse Filosofie.* Amsterdam: Boom

Bordwell, D & Thompson, K, 2010, *Film Art: An Introduction*. New York: McGraw-Hill

Borger, Edu, 2007. *Woord vooraf.* In: *Bouvard en Pécuchet* (Dutch translation), Flaubert, Gustav. Amsterdam: Arbeiderspers

Bortoff, Henri, 1996. *The Wholeness of Nature*. US: Lindesfarne Books

Brandon, Alexander, 2005. *Audio for Games* - Planning, Process, and Production. Berkeley: New Riders

Brandon, Alexander, 2009. *Adaptive Audio... what is it?*. Interactive Audio Special Interest Group. Available from: http://www.iasig.org/pubs/features/adaptaudio/adaptiveaudio.shtml [Accessed 18 November 2009]

Branigan, Edward, 1992. *Narrative Comprehension in Film*. New York: Routledge

Bregman, Albert S., 1994. *Auditory Scene Analysis - The Perceptual Organization of Sound.* Cambridge, MA: The MIT Press

Bugler, Justus,1966. *Logic as Semiotic: The Theory of Signs in Philosophical Writings of Peirce.* New York Dover Publications

Burt, George, 1994. *The Art of Film Music*. Boston: Boston University Press

Business Dictionary.com, 201 . *Chaotic System,* Definition. Available at: *http:// www.businessdictionary.com/definition/chaotic-system.html* [Accessed 12 December 2013]

Buskin, Richard, 1998. *Sounding out The Simpsons.* in; Studio Sound, Februari 1998. Available at: http:// www.filmsound.org/studiosound/pp_simpsons.html [Accessed 28 November 2013]

Calasso, Roberto, translation Els van der Pluijm (2006). *Prelude op de 20e eeuw (Bouvard et Pécouchet van Gustav Flaubert)* in: Raster #114. Available from: http://tijdschriftraster.nl/roberto-calasso/prelude-op-de-twintigste-eeuw-bouvard-en-pecuchet-van-gustave-flaubert/ [Accessed 12 November 2010]

Chandler, Daniel, 2002. Semiotics; The Basics. New York: Routledge

Chion, Michel, 1994. *Audio Vision - Sound on Screen.* New York: Columbia University Press

Chion, Michel, 2003. *Film, a Sound Art.* New York: Colombia University Press

Cipriani, A. & Giri, M. edition 2013. *Electronic Music & Sound Design: Theory and Practice with Max and MSP.* Rome: ContempoNet

Clark, Andrew, 2007. *Defining Adaptive Music*. Gamasutra. Available from: http://www.gamasutra.com/ view/feature/1567/defining_adaptive_music.php [Accessed 3 April 2008].

Clark, A., 2012. *Predictive coding.* In: Brockman, J., ed. *This Will Make You Smarter.* New York: HarperCollins Publishers

Cobley, Paul, 2001. *Narrative.* New York: Routledge

Cole, Suzanne, 2008. *Thomas Tallis and his Music in Victorian England.* Woodbridge, Suffolk: Boydell Press

Collins, Karen, 2007 *An Introduction to the Participatory and Non-linear Aspects of Video Games Audio.* Eds. Stan Hawkins and John Richardson. Essays on Sound and Vision. Helsinki: Helsinki University Press. pp. 263-298

Collins, Karin, 2008. *Game Sound - An Introduction to the History, Theory, and Practice of Video Game Music.* Cambridge, Massachusetts: The MIT Press

Collins, Karin (Ed.), 2008. *From Pac-Man To Pop Music. Interactive Audio in Games and New Media*. Burlington: Ashgate Publishing Company

Cook, Nicholas, 1998. *Analysing Musical Multimedia.* Oxford, New York: Oxford University Press

Coumans, Anke. 2002. *Het verhaal van de nieuwe media*, in E-view 2002. Available at: http://comcom.uvt.nl/e-view/02-2/coumans.pdf [Accessed 16 October 2010]

Curtis, Scott, 1992. *The Sound of Early Warner Bros. Cartoons.* In: Altman, Rick Ed. *Sound Theory/Sound Practice.* New York: Routledge

Damasio, Antonio (Dutch Translation: Stoltenkamp, Marjolijn), 2010. *Self Comes to Mind* (*Het Zelf wordt zich Bewus*t). Amsterdam: Uitgeverij Wereld Bibliotheek bv

Danforth, Christopher M, 2013. *Chaos in an Atmosphere Hanging on the Wall* In: *Mathematics of Planet Earth 2013*. Available at: http://mpe2013.org/2013/03/17/chaos-in-an-atmosphere-hanging-on-a-wall [Accessed 12 December 2013]

David Hockney: A Bigger Picture, 2009. Documentary, Directed by Wollheim, Bruno. USA: First Run Features

Davis, Richard, 1999. *The Complete Guide to Film Scoring.* Boston: Berklee Press

Descartes, René, edition 2008. *Discourse On the Method of Rightly Conducting the Reason, and Seeking Truth in the Sciences.* E-pub version. Available at: http://www.gutenberg.org/ebooks/59 [Accessed 11 september 2010]

Deutsch, Stephen, 2011. *From Battlezone to Battlefield: Immersion, Sound and Computer Games: An Interview with Ben MInto.* In: The New Soundtrack., Vol. 1, March 2011. Edinburgh: Edinburgh University Press

Dijksterhuis, Ap, 2007. *Het slimme onbewuste*; *Denken met Gevoel*. Amsterdam: Uitgeverij Bert Bakker

Dinkla, S., 1994. *The History of the Interface in Interactive Art***.** Available from: http://www.kenfeingold.com/dinkla_history.html [Accessed 21 Januari 2012]

Distant Worlds: Music from Final Fantasy. Available at: http://web.archive.org/web/20100923033415/http://ffdistantworlds.com/index.php?option=com_eventlist&view=categoryevents&id=1&Itemid=59 [Accessed 18 December 2011]

Ditto, William & Munakata, Toshinori. 1995. *Principles of Chaotic Systems.* In: Communications of the ACM, November 1995/Vol 38, No.11. Available at: http://cis.csuohio.edu/~munakata/publs/pdf/cacm95ch.pdf

Doob, J.L., Edition 1990. *Stochastic Processes.* Hoboken, NJ: Wiley-Blackwell

Dorst, K., 2nd ed. 2003. *Understanding design: 150 reflections on being a designer*. Amsterdam: BIS Publishers.

Egenfeldt-Nielsen, S., Heide Smith, J., Pajares Tosca, S., Second Edition 2003. *Understanding Video Games: The Essential Introduction.* New York: Routledge

Einstein, Albert, 1920 edition 1983. *Relativity: The Special and the General Theory - A popular Exposition by Albert Einstein.* London: Methuen & Co Ltd

Eno, Brian, 1978. *Ambient 1: Music for Airports.* UK: Polydor

Eno, B., 2012. *Ecology*. In: Brockman, J., ed. *This Will Make You Smarter*. New York: HarperCollins Publishers

Farnell, Andy, 2010. *Designing Sound. C*ambridge, MA: The MIT Press

Fay, Todd M. and Selfon, Scott and Fay, Todor J., 2004. *DirectX Audio Exposed - Interactive Audio Development*. Plano Texas: Wordware Publishing, Inc

Finding Nemo, 2003. Directed by Stanton, Andrew & Unkrich, Lee. Animation Film. USA: Walt Disney Pictures/Pixar Animation Studios

Flake, Gary W., edition 2000. *The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems and Adaptation.* Cambridge, MA: The MIT Press

Flaubert, G., 1904. *Bouvard and Pécuche*t- *A Tragi-Comic Novel of Bourgeois Life, in English translation.* London: M. Walter Dunne. E-pub version. Available at: http://www.gutenberg.org/ebooks/14157 [Accessed 11 september 2010]

Foster, J., 2009. *Memory*. *A Very Short Introduction*. Oxford, New York: Oxford University Press

Geisler, Michael, 1999. *Whap! Zing and a Holler: Animation Sound Design*. In: Animation World Magazine - Issue 4.1. Available from: http://www.awn.com/mag/issue4.01/4.01pages/geislersound.php3 [Accessed 18 november 2013]

Gershenfield, N., 2012. *Truth is a Model*. In: Brockman, J., ed. *This Will Make You Smarter*. New York: HarperCollins Publishers

Gibson, James J. 1979. *The Theory of Affordances* (pp. 127-143) In: Shaw, Robert & Bransford, John (Eds.) *Perceiving, Acting and Knowing*. Hillsdale: Lawrence Erlbaum Associates, Inc.

Gorbman, Claudia, 1987. *Unheard Melodies; Narrative Film Musi*c. London: The British Film Institute

Greenfield, Susan, 2012. Editor and presenter in*: Brain story*, Episode 3:*The Minds Eye*, BBC Broadcast - DVD version

Grieg, E, 1907. *Aus Holberg Zeit/ Holberg Suite*. London: Ernst Eulenberg Ltd.

Grimshaw, Mark, 2007. *The Acoustic Ecology Of The First Person Shooter*. PhD Thesis: University of Waikato

Grimshaw, Mark (Ed), 2011. *Game Sound Technology and Player Interaction: Concepts and developments*. Hershey - New York: IGI Global

Gronow, Pekka & Saunio, Ilpo, 1998. *An International History of the Recording Industry*. London: Cassell Academic

Halo, 2001-2013. X-box game developed by Bungie, Inc. USA: Microsoft Studios

Hawkins, Jeff with Blakeslee, Sandra, 2005. *On Intelligence*. New York: Times Books/Henry Holt and Company

Heskett, John, (2002). *Design: A Very Short Introduction*. Oxford: University Press

Hill, Stephen & Fenner, Bevis, 2010. *Media and Cultural Theory*. Frederiksberg: Ventus Publishing ApS

Hilpinen, R., 2011. *Artifact*. In: The Stanford Encyclopedia of Philosophy (Winter 2011 Edition, Edward N. Zalta (ed.). Available from: http;//plato.stanford.edu/archives/win2011/entries/artifact/ [Assesed 14 Januari 2012]

Hoffman, D., 2012. *Our sensory Desktop.* In: Brockman, J., ed. *This Will Make You Smarter.* New York: HarperCollins Publishers

Holman, Tomlinson, edition 2002. *Sound for Film and Television*. Waltham, MA: Focal Press

Holt, Simeon ten, 1983. *Wat is Tijd?: Tijd en Ruimte in de muziek (pp. 73-83).* Rotterdam: Rotterdamse Kunststichting Uitgeverij

How to Get Out of the Cage: A Year with John Cage., 2012. Documentary Film by Scheffer, Frank. Germany: EuroArts

Huiberts, S. & van Tol, R.. 2008: *IEZA: A Framework For Game Audio.* Available at: http://www.gamasutra.com/view/feature/3509/ieza_a_framework_for_game_audio.php [Accessed 12 Februari 2008]

Huiberts, S., 2010. *Captivating Sound. The Role Of Audio For Immersion in Computer Games*. Thesis submitted in fulfilment of the requirements for the degree of PhD at the Utrecht School of the Arts (HKU)

Huron, David, 2006. *Sweet Anticipation - Music and the Psychology of Expectation.* Cambridge, MA: The MIT Press

Igor Stravinski: Composer. Documentary, 2001. Directed by János Darvas. Munich: Metropolitan

In Het Perspectief van Robbie Cornelissen. Documentary, 2012. Directed by Jan van den Berg. Utrecht: drsFilm

Indeterminsm. Online Oxford Dictionaries, Dictionary of British and World English. available from: *www.oxforddictionarries.com* [Accessed 18 November 2013].

Jardin, X., 2012. *Ambient Memory and the Myth of Neutral Observation.* In: Brockman, J., ed. *This Will Make You Smarter.* New York: HarperCollins Publishers

Jennett, Charlene Ianthe, 2010, *Is Game Immersion Just Another Form of Selective Attention?* PhD Thesis: UCL Interaction Centre, Department of Psychology

Jørgtenson, Kristine, 2011. *Time for New Terminology? Diegetic and Non-Diegetic Sounds in Computer Games Revisited.* In: Grimshaw, Mark, Ed. *Game Sound Technology and Player Interaction: Concepts and developments*. Hershey - New York: IGI Global

Juslin, Patrick N. & Sloboda, John A., 2001. *Music and Emotion*. Oxford, New York: Oxford University Press

Juul, Jesper., 2001. *Games Telling Stories? A brief note on Games and Narratives. Gamestudies*, In: *The International Journal of Computer Research, Volume 1, issue 1, July 2001*. Available at: http://www.gamestudies.org/0101/juul-gts/ [Accessed 23 July 2012]

Kaae, Jasper, 2008. *Theoretical approaches to composing dynamic music for video games.* In: Collins, Karin (Ed.), 2008. *From Pac-Man To Pop Music. Interactive Audio in Games and New Media*. Burlington: Ashgate Publishing Company

Kahn, Douglas, 2001. *Noise, Water, Meat: A History of Sound in the Arts*. Cambridge: MIT Press

Kalinak, Kathryn, 2010. *Film Music, A Very Short Introduction.* Oxford, New York: Oxford University Press

Kang, Jian, 2007. *Urban Sound Environment.* London: Taylor & Francis

Kant, Immanuel, 1787- edition 2007. *Critique of Pure Reason.* London: Penguin Books Ltd.

Kay, Alan C., 1989. *Predicting the Future*. Article: Stanford Engineering, Volume 1, Autumn 1989, pp. 1-6

Kennedy, James & Eberhart, Russell C., 2001. Swarm Intelligence. San Francisco: Morgan Kaufmann

Kent, Steven L., 2000. *The First Quarter: A 25-Year History of Video Games.* Bothwell, WA: BWD Press

Kosslyn, S., 2012. Interview in *Brain story*, Episode 3:*The Minds Eye*, BBC Broadcast - DVD version

Kramer, Gregory, 1994. *Auditory Display; Sonification, Audification and Auditory Interfaces*. Reading, MA: Addison-Wesley Publishing Company

Kramer, Jonathan D., 1981. *New Temporalities in Music*. In: *Critical Inquiry*. Chigaco: University of Chicago

Krippendorff, Klaus, 1995 p.156-86. *On the Essential Contexts of Artifacts or On the Proposition that 'Design is Making Sense (of Things).* In *The Idea of Design: A Design Issue Reader*, ed. Victor Margolin and Richard Buchanan. Cambridge, Massachusetts: The MIT Press

Kusek, David & Leonard, Gerd, 2005. *The Future of Music*. Boston: Berklee Press

LaBelle, Brandon, 2006. *Background Noise - Perspectives on Sound Art.* New York: The Continuum International Publishing Group Inc.

Labelle, Brandon, 2010. *Acoustic Territorities; Soundculture and Everyday Life.* New York: The Continuum International Publishing Group Inc.

Lai, Ying-Chen & Grebogi, Celso & Kurths, Jürgen, 1998. *Modeling of chaotic systems.* Available at http://chaos1.la.asu.edu/~yclai/papers/PRE_99_LGK.pdf [Accessed 12 December 2013].

Lamme, Victor, 2010. *De Vrij Wil Bestaat Niet. Amsterdam*: Uitgeverij Bert Bakker

Legge, Philip (Ed.), 2008. *Notes to the score of 'Spem in alium nunquam habui' by Thomas Tallis*. Melbourne: Choral Public Domain Library

Levitin, Daniel, 2007. *This Is Your Brain On Music*. London: Atlantic Books

Lindley, Graig A., The Semiotics of Time Structure in Ludic Space As A Foundation for Analysis and Design. Gamestudies, The International Journal of Computer Research, Volume 5, issue 1, October 2005. Retrieved March 27, 2009: http://gamestudies.org/0501/lindley/

Lorenz, Edward N., 1963. *Deterministic Nonperiodic Flow.* In: *Journal of the Atmospheric Sciences.* Available from: http://www.astro.puc.cl/~rparra/tools/PAPERS/lorenz1962.pdf [Accessed 12 December 2013]

Macaulay, Scott, 2009. *Serious Sounds: Skip Lievsay on Sound Design*. Focus Features. Available from: http://www.filminfocus.com/article/_em_serious__em__sounds__skip_lievsay_on_sound_design [Accessed 18 december 2009]

Macpherson, Stewart, 1907. *Form in Music.* London: Stainer & Bell Limited

Marks, Aaron, 2001. *The Complete Guide to Game Audio - For Composers, Musicians, Sound Designers, and Game Developers.* Berkeley: CMP Books

Max Neuhaus/Soundworks. Available at *http://www.max-neuhaus.info/soundworks/soundart/SoundArt.htm* [Accessed 28 november 2013]

McAdams, Stephen and Bigand, Emmanual, 1993. *Thinking in Sound -The Cognitive Psychology of Human Audition.* New York: Oxford University Press

McDonough, Jeffrey K., 2008. *Leibniz's Philosophy of Physics*, In: *The Stanford Encyclopedia of Philosophy* (Fall 2008 Edition), Edward N. Zalta (ed.). Available at: http://plato.stanford.edu/archives/fall2008/entries/leibniz-physics/> [Accessed 28 November 2012]

McLuhan, Marshall, 1964. *Understanding Media.* London: Routledge and Kegan Paul

McLuhan, Marshall, 1967, edition2008. *The Medium is the Massage.* London: Penguin Group

Metz, Christian, 1968. *Film Language. A semiotics of the Cinema.* Chicago: Oxford University Press

Meyer, Leonard B., 1956. *Emotion and Meaning in Music*. Chicago: The University of Chicago Press

Mik. Edzard, 2011. *Wandering through the Drawings of Robbie Cornelissen*. In: *NRC Handelsblad*, 4 March 2011, page 18.

Mitchell, W. 1995, *Representation*, in F Lentricchia & T McLaughlin (eds), *Critical Terms for Literary Study*, 2nd edn, University of Chicago Press, Chicago

Monod, Jaques, 1972.*Chance and Necessity: Essay on the Natural Philosophy of Modern Biology*. New York: HarperCollins Publishers

More, Charles, 2000, *Understanding the Industrial Revolution*, London: Routledge

Mulholland Drive, 2001. Film. Directed by David Lynch. USA: Universal Pictures

Murch W.. 1998. *Dense clarity - Clear density.* Available at: http://facultynh.syr.edu/dhquin/Newhouse_Fall2011/Newhouse_Fall2011/Courses_Fall_2011/TRF456_Fall/Resources/Murch02.pdf [Accessed 28 November 2013]

Neuhaus, Max, 2000. *Soundart?* Available at http://www.max-neuhaus.info/soundworks/soundart/SoundArt.htm [Accessed 28 november 2013]

Nietszche, Friedrich, 1882. *Die fröhliche Wissenschaft*. Chemnitz: Verlag von Ernst Schmelzer

Nispen tot Pannerden, Than van, 2009, *Non-lineaire Muziek Strategieën.* Thesis (MA) Utrecht School of the Arts

Non-deterministic. Webster's New Online Telecom Dictionary. vailable from: *www.your* dictionary.com/non-deterministics.com [Accessed 18 November 2013]

NTR Podium, 2011. *Een interview met componist John Cage n.a.v. muziek uit schelpen en planten (13-06-1978).* Available at: http://nachtklassiek.ntr.nl/2011/10/07/interview-met-componist-john-cage-n-a-v-"muziek-uit-schelpen-en-planten"-13-06-1978/ [Accessed 25 October 2011]

Online Etymology Dictionary. Available from: http://www.etymonline.com/index.php?search=design&searchmode=none [Accessed 3 Januari 2012]

Oomkes, Frank R.,2000. *Communicatieleer: een inleiding.* Den Haag: Boom Lemma uitgevers

Open Culture, 2012. *Alfred Hitchcock on the Filmmaker's Essential Tool: 'The Kuleshov Effect'.* Available at: http://www.openculture.com/2012/05/alfred_hitchcock_on_the_essential_filmmakers_tool_the_great_kuleshov_effect.html [Accessed 12 September 2012]

Oxford Online Dictionaries, *Dictionary of British and World English.* available from: www.oxforddictionarries.com [Accessed from December 2009 to December 2013].

Parkinson, G.H.R. et all, 1968. *The Theory of Meaning*. Oxford, New York: Oxford University Press

Procedural audio. Website. available at: *http://www.procedural-audio.com* [Accessed 12 december 2012]

Rabbit Fire, 1951. Selzer, Edward. Animation Film. USA: Warner Bros. Pictures

Rodaway, Paul, 1994 *Sensuous Geographies.* London: Routledge

Rorty, Richard, 1979. *Philosophy and the Mirror of Nature*. Princeton: Princeton University Press

Ruiter, Wim de, 1993. *Compositietechnieken inde 20e eeuw.* Haarlem: De Toorts

Russell, Bertrand, 1921. *The Analysis of MInd.* Digital edition 2008. South Dakota: Nuvision Publications

Rutter, Jason & Bryce, Jo, 2006. Understanding Digital Games. London: Sage Publications Ltd.

Sachs, Oliver, 2008. Musicophilia; Tales of Music and The Brain. New York: Vintage Books

Sadoff, Ronald. H, 2006. *The role of the music editor and the 'temp track' as blueprint for the score, source music, and source music for films.* In: *Popular Music* (2006) Volume 25/2. Cambridge: Cambridge University press.

Salen, Katie & Zimmermann, Eric, 2004. *Rules of Play - Game Design Fundamentals.* Cambridge, Massachusetts: The MIT Press

Sausure, F. de, 1879 *Mémoire sur le système primitif des voyelles dans les langues indo-européennes.* Leipsick: B.G. Teubner

Schaeffer, Piere, 1952. *À la recherche d'une musique concrète.* Paris: Le Seuil

Schafer, R. Murray, 1977/1994. *The Soundscape - Our Sonic Environment and The Tuning of the World.* New York: Knopf

Schnell, Jesse, 2005. *Understanding Entertainment: Story and Gameplay Are One*. ACM Computers in Entertainment, Vol. 3, No. 1, January 2005. New York, NY: ACM

Schopenhauer, A. 1851, edition 1970. *Essays and Aphormisms*. London: Penguin

Smallenburg, Sandra, 2009. *Museumplein wordt omgebouwd naar voorbeeld Berlijn*. In: *NRC Handelsblad* 31 July 2009. Available at: *http://vorige.nrc.nl/kunst/article2316050.ece/Museumplein_wordt_omgebouwd_naar_voorbeeld_Berlijn* [Accessed 12 December 2013]

Sol Lewitt, 2013. Documentary film directed by Chris Teerink. The Netherlands: Doc Eye Film & The Avro

Sonnenschein, David, 2001. *Sound Design - The Expressive Power of Music, Voice, and Sound Effects in Cinema.* Studio City, CA: Michael Wiese Production

Speaking Freely - Marshall McLuhan. 1971. Public Broadcasting/N.E.T. Available from: http://huffduffer.com/eflclassroom/33610 [Accessed 14 December 2009]

Spem in alium, 2003. Super Audio CD recording by The Sixteen. UK: Coro

Steamboat Willy, 1928. Walt Disney. Animation Film. USA: Walt Disney Studios

Stuart Little, 1999. Minkoff, Rob. Animation Film. USA: Columbia Pictures

Swaab, Dick, 2010. *Wij Zijn Ons Brein*. Amsterdam: Uitgeverij Contact

Tallis, Thomas, 1571. *Spem in alium.* Motet for 40 voices.

The Godfather Part 1 - DVD version, 1972. Directed by Coppola, Francis Ford, 1972. Hollywood: Paramount

Thompson, Kristin & Bordwell, David (2003). *Film History: An Introduction*. New York: McGraw-Hill

Truax, Barry, 1984. *Acoustic Communication*. Norwood, H.J.: Ablex Publishing Cooperation

Van Dulken, Stephen, 2000. *Inventing the 20th Century: 100 Inventions That Shaped the World*. London: British Library Publishing Devision

van Tongeren, P., 2003. *Nietzsche*. In: Bor, Jan, Ed. *25 Eeuwen Westerse Filosofie.* Amsterdam: Boom

Video Games Live. Website. Available from: http://www.videogameslive.com/index.php?s=home [Accessed 28 November 2013]

Viers, Ric, 2008. *The Sound Effects Bible - How to Create Hollywood Style Sound Effects.* Studio City, CA: Michael Wiese Production

Viers, Ric, 2012. *The Location Sound Bible - How to Record Professional Dialogue for Film and TV.* Studio City, CA: Michael Wiese Production

Vroon, Piet, 1976. *Bewustzijn, hersenen en gedrag.* Baarn: Uitgeverij Ambo bv

Wang, DeLiang and Brown, Guy J., 2006. *Computational Auditory Scene Analysis - Principles, Algorithms, and Applications*. Hoboken, N.J.: John Wiley & Sons Inc.

Weiss, Elisabeth & Belton, John, 1985. *Film Sound: Theory and Practice*. New York: Columbia University Press

Went, Kees, 2009. *De Soundscape van het Museumplein*. Internal report.

Werf, Jouke van der, 2012. *Plein, park of veld?: Cultuurhistorische Verkenning Museumplein en omgeving*. Amsterdam: Gemeente Amsterdam. Available at: http://www.amsterdam.nl/kunst-cultuur-sport/monumenten/monumenten-0/gebouwen-gebieden/openbare-ruimte/rapporten/museumplein/ [Accessed 12 December 2012]

Whitfield, Peter, 2012 E-book. *The history of Science.* Hong Kong: Naxos Books

Wikipedia, 2013. *Copyright*. Wikipedia. Available from: http://http://en.wikipedia.org/wiki/Copyright [Accessed 25 November 2013].

Wilde, Martin D., 2004. *Audio Programming for Interactive Games*. Burlington, MA: Focal Press

Wilhemsson, Ulf & Wallen, Jacob, 2011. *A combined Model for Structuring of Computer Game Audio.* In: *Game Sound Technology and Player Interaction: Concepts and developments*. Hershey - New York: IGI Global

Windows Phone 8 adds DirectX, native development, easier app porting, 2012. The Verge. *Available from:* http://www.theverge.com/2012/6/20/3095150/microsoft-windows-phone-8-common-platform-directx [Accessed 28 November 2013]

Worm Blast, 2002-2011. Puzzle/action game. Developed by Team 17. USA: Ubisoftic

Wyatt, Hilary & Ameys, Tim, edition 2006. *Audio Post Production for Television and Film*. Waltham, MA: Focal Pres