UNIVERSITY OF SOUTHAMPTON

FACULTY OF HUMANITIES

Sounds perfect: the evolution of recording technology and music's social future

by

William Richard Lingard

Thesis for the degree of Doctor of Philosophy

March 2013

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF HUMANITIES

Department of Music

Doctor of Philosophy

SOUNDS PERFECT: THE EVOLUTION OF RECORDING TECHNOLOGY AND MUSIC'S SOCIAL FUTURE

by William Richard Lingard

The effect of technology on music has been indisputably profound. As a cultural descendant of the traditions first established by notation and printing, recorded music technology has transformed our understanding and use of music in all sorts of ways. Whether or not different technologies have had a positive or negative effect, however, is a subject of much debate.

Traditional histories of recorded music technology demonstrate a tendency either to treat each new platform as truly revolutionary, or to elide the differences between them to such an extent that significant socio-cultural and socio-economic transformations become occluded. Revisiting this history with an open mind—and a degree of cultural and temporal distance—permits a perspective of progression, from which the ramifications of recorded music technologies become more accurately discernible. This thesis highlights six characteristics of recorded music, all of which have been affected at various times and in various ways by the evolution of recording technology. Without exception, every new platform for recorded music has improved upon at least one of these six characteristics, although not necessarily without detriment to one of the others.

It is in the scope of these improvements that digital music files, as a platform, are fundamentally different to any of their predecessors. Far from simply continuing or exaggerating the trend that forms the customary narrative of the traditional histories of recorded music, digital music files have completely reengineered our relationship with and understanding of the production, distribution, and consumption of music in a very profound way. The thesis explores these changes, and offers some frank yet ultimately encouraging insights as to what the social future of music may hold.

Contents

List of tables and illustrations

Chapter 5

Declaration of authorship

I,

declare that the thesis entitled *Sounds perfect: the evolution of recording technology and music's social future* and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission.

Signed:

Date:

Acknowledgements

A project such as this is never undertaken in isolation, even though it feels that way sometimes. Many people have made many contributions; sometimes knowingly, sometimes not.

I am indebted to the staff at the University of Southampton and my colleagues there. Those who have had the dubious pleasure of being involved in my PhD have been supportive and stimulating. Sadly, neither my memory nor my word count will allow me to enumerate them all here, so I say thank you en masse to everyone. There are a few people, however, whom I would like to thank more directly.

My supervisor, Andrew Pinnock. Your guidance during the last four years (and beyond) has been invaluable, and equipped me to do something I never thought I could.

My good friends Jaime Ashworth, Andy Fisher, Stephen Groves, and David Steynor. Your conversation, distraction, and camaraderie have been a constant source of pleasure and relaxation throughout a time when despair and frustration threatened to reign supreme.

My brothers, Tom and Harry. You not only ignited my interest in music, but you have also been feeding it and sharing it for over 20 years, encouraging me to broaden my musical horizons and to change the CD once in a while . . .

Lastly and loudly, Mum and Dad. Your generosity, patience, support, and understanding have been infinite; that I am writing this at all is testament to just how freely you offer them. I cannot thank you enough.

Abbreviations and definitions

ATRAC: Adaptive Transform Acoustic Coding

AAC: Advanced Audio Coding

ARPANET: Advanced Research Projects Agency Network

AEG: Allgemeine Elektricitäts-Gesellschaft [General Electric Company]

A&R: Artists and Repertoire

AIFF: Audio Interchange File Format

BASF: Badische Anilin- und Soda-Fabrik [Baden Aniline and Soda Factory]

BPI: British Phonographic Industry

CBS: Columbia Broadcasting System

CD: Compact Disc

CD-I: Compact Disc-Interactive

CD-R: Compact Disc-Recordable

CD-ROM: Compact Disc-Read Only Memory

CD-RW: Compact Disc-Re-Writable

CDDA: Compact Disc Digital Audio

Codec: Coder-decoder, compressor-decompressor

CPI: Consumer Price Index

dB: Decibel

DAD: Digital Audio Disc

DAT: Digital Audio Tape

DCC: Digital Compact Cassette

DRM: Digital Rights Management

DVD: Digital Versatile Disc

EMI: Electrical and Musical Industries

CERN: Centre Européen pour la Recherche Nucléaire [European Organization for Nuclear Research]

EB: Exobyte

EP: Extended play

FACT: Federation Against Copyright Theft

FLAC: Free Lossless Audio Codec

GB: Gigabyte

GRM: Groupe de Recherche Musicales [Musical Research Group]

Hz: Hertz

IEC: International Electrotechnical Commission

IFPI: International Federation of the Phonographic Industry

IP: Internet protocol

ISP: Internet service provider

kbps: Kilobits per second

kB: Kilobyte

kHz: Kilohertz

LPCM: Linear pulse code modulation

LP: Long play record

M4P: File extension for Advanced Audio Coding (AAC)

MB: Megabyte

MHz: Megahertz

MILNET: Military Network

MPEG: Moving Picture Experts Group

MP3: MPEG-1 Audio Layer III, MPEG-2 Audio Layer III

MCA: Music Corporation of America

NBC: National Broadcasting Corporation

NHK: Nippon Hōsō Kyōkai [Japanese Broadcasting Corporation]

NRZI: Non-return-to-zero, inverted

P2P: Peer-to-peer

PEAQ: Perceptual Evaluation of Audio Quality

PRS: Performing Rights Society

PB: Petabyte

POP: Post Office protocol

PCM: Pulse code modulation

RCA: Radio Corporation of America

ITU-R: Radiocommunication sector of the International Telecommunication Union

RDN: Radiodiffusion Nationale [National Broadcasting]

RIAA: Recording Industry Association of America

rpm: Revolutions per minute

SMTP: Simple mail transfer protocol

SACD: Super Audio Compact Disc

TB: Terabyte

UNESCO: United Nations Educational, Scientific and Cultural Organization

USB: Universal Serial Bus

UWI: Unskilled Wage Index

VHS: Video Home System

WAV: Waveform Audio File Format

WMA: Windows Media Audio

The machine is neither a god nor a devil.

(Hans Stuckenschmidt, 1924: 8)

1 Introduction

On Tuesday 19th February 1878, the United States Patent Office granted Thomas A. Edison the patent for a "phonograph or speaking machine". The purpose of Edison's invention was to "record in permanent characters the human voice and other sounds, from which characters such sounds may be reproduced and rendered audible again at a future time" (Edison, 1878a: 1). Edison was aware of the potential versatility of the phonograph and, in an article published in June of the same year, he provided a list of ten possible uses for it. The first three are letter writing and dictation, creating books for blind people, and the teaching of elocution. The fourth item on the list—and also the shortest of any of the entries—is "reproduction of music" (Edison, 1878b: 531).

In retrospect, it is baffling to think that elocution lessons might be of greater concern to the inventor and his contemporaries than the preservation of music. Contemporary public reaction, however, suggests that people initially saw the phonograph as a means of augmenting existing traditions of reading and writing, rather than the key to entirely new practices (Gitelman, 2006: 25). Through no fault of his own it seems that Edison, like many other pioneers, was "blind to the full significance of [his] discovery" (Coleman, 2005: 12).[1] In fact, it was not until the middle of the 1890s that Edison realized the phonograph's primary use would be music and entertainment (Dew et al., 2004: 77).

It is clear, more than 130 years later, that like almost all media technologies, sound recording has been, and continues to be, pivotal in "the (re-)configuration of social and cultural practices and formations" (van Loon, 2008: xii). But Edison could scarcely have known that

[1] Edison even described the phonograph as "a mere toy" with "no commercial value" (Sanjek and Sanjek, 1988 [volume 2]: 365).

recorded sound was so "fully pregnant with possibilities" (Dew et al., 2004: 76). Nor could he have known that some of these possibilities would profoundly shape human interaction with music and, ultimately, spark a chain of technological innovations that would lead to a fundamental reconstruction of music's historically accepted social function.

1.1 The prophecies of Jacques Attali

Nearly a century after Edison's patent was granted (and with the benefit of commensurate hindsight) the French economist, scholar, and government advisor Jacques Attali wrote *Noise: the political economy of music* (Attali, 1977). In *Noise*, Attali proposed that the technology of recorded sound had begun to affect the social function of music in profound and radical ways, and would continue to do so, ultimately to the detriment of music.

His analysis rests on the assumption that the history of music can be divided into distinct stages, each corresponding to a particular era with attendant technological and cultural practices.[2] The first stage, 'sacrificing', encompasses the entire history of music before the beginning of the sixteenth century, during which time music existed almost entirely as an oral tradition. The next stage, 'representing', picks up where sacrificing leaves off and runs until the late nineteenth century, starting with the development of printed music and ending more or less with the beginnings of music's mass distribution.

[2] The names given by Attali to each stage stem from his application to music of René Girard's anthropological theories of sacrifice and violence as the foundation of organized religion. Attali perceives noise as violence and music as giving structure to that noise: "Music is a channelization of noise and a simulacrum of sacrifice, a sublimation to create order and political integration. Therefore music is ritual murder" (Attali, 1977: 26). For expansion on this, and a concise outline of Attali's theories, see Gracyk (2002).

'Repeating' corresponds to the age of broadcasting and recorded music onward.[3] Attali theorized about a fourth stage that he called 'composing'—often referred to later by scholars as 'post-repeating'—that focuses particularly on digital music files, electronic music and promising new methods of composition such as sampling and mixing.[4]

Putting aside some of Attali's more contrived and occasionally unconvincing rhetoric, the first two stages provide a useful interpretation of the technological and cultural interplay that has affected music from its inception right through to the first sound recordings.[5] The third and fourth stages focus more specifically on the effect of recording and broadcast technology on music and contain a number of predictions about what the future might hold for music. Although some of the predictions—particularly those contained in the then-embryonic fourth stage—have proved to be a little wide of the

[3] In this context, the terms 'recorded music' and 'recorded sound' deserve clarification. Early musical devices like the player piano should be considered as examples of recorded music complete with playing equipment, rather than just instruments; they are really mechanical contraptions through which a set of pre-ordained notes permanently sculpted on a transferable medium can be played. The player piano is the turntable, as it were, and the piano roll serves as the vinyl disc. Recorded sound implies the capturing of sound waves—the propagation through air of fluctuations in pressure—either by mechanical or electrical means.

[4] 'Digital music files' refers to a broad swathe of file formats—such as Advanced Audio Coding (AAC), Ogg, and Free Lossless Audio Codec (FLAC), to name just a few—which are often misleadingly referred to as 'MP3s'. The term 'MP3' has become synonymous, particularly in the popular press, with any sound file that can be created, stored, or reproduced on a computer, portable music player, or mobile phone. It is crucial, for this thesis and the sake of accuracy, that distinctions be drawn between one file type and the next; the very earliest manifestations are dramatically different to the latest. When referring to music stored on a computer or similar device, therefore, the term 'digital music files' will be used.

[5] The concepts contained within *Noise* are powerful and appear to have withstood a great deal of intellectual scrutiny. However, as James Wierzbicki points out, Attali's tendency to traffic in "hyperbole, exhortation, and slogan" often renders his prose "as 'noisy' as the modern world that is the focus of his attention" (Wierzbicki, 1985: paragraph 7).

mark, Attali clearly recognizes the unique and constantly evolving nature of music's relationship with technology; a relationship that Robert Friedel describes as "a pattern of constant change" (Friedel, 2007: 518).

Attali's understanding of this relationship seems remarkably accurate (notwithstanding some of his eccentric predictions). On the one hand, he appreciates the potential socio-cultural benefits afforded to music by early and subsequent recording technologies: "Reproduction, then, emerges as a tremendous advance, each day giving more people access to works created for representation—formerly reserved for those who financed the composition of the work—than at any other time since man's creation" (Attali, 1977: 89). On the other hand, he is very aware of the potential damage that the misapplication of technology could inflict on our notions of music, suggesting that reproduction "constitutes, moreover, a massive deviation from the initial idea of the men who invented recording; they intended it as a surface for the preservation of representation, in other words, a protector of the preceding mode of organization" (Attali, 1977: 89). The hostile part of Attali's attitude to recorded music and its associated technologies derives from a concern that it has somehow corrupted the function of music. Like many other music scholars, Attali considers the advent of recording technology to be vastly and somehow innately different to the advent of notation. He implies that recording was intended as some kind of documentary medium, but outgrew its original purpose and has become "a technology imposing a new social system, completing the de-ritualization of music and heralding a new network, a new economy, and a new politics—in music as in other social relations" (Attali, 1977: 89). If this is an indictment of sound recording, it can be directed at musical notation just as easily. As a form of recording, notation served to capture the fruits of oral traditions that were under threat of extinction or occlusion. Over time, notation outgrew its original 'intended' role, becoming more than just a tool for documenting that which already existed. It was soon inextricably (and some might argue inevitably) bound to the processes of composition and performance. Any suggestion that music might somehow have suffered because of this would seem misguided. Despite this obvious discomfort with the effect of technology on music, Attali acknowledges notation's ability to render music "an autonomous art, independent of its religious and political usage" (Attali, 1977: 88). By distancing itself from its previous affiliations to church and state, music became:

> . . . no longer sufficient either to meet the demands of the new solvent consumers of the middle classes or to fulfill the economic requirements of accumulation: in order to accumulate profit, it becomes necessary to sell stockpileable sign production, not simply its spectacle.
>
> (Attali, 1977: 88)

The increasing inability of music to satisfy consumers without the creation of at least some kind of economic value system virtually *required* a new technology: "Once music became an object of exchange and consumption, it hit against a limit to accumulation that only recording would make it possible to exceed" (Attali, 1977: 88–89). Thus the ties between economic and aesthetic value in music became ever more conspicuous:

> For with the appearance of the phonograph record, the relation between music and money starts to be flaunted, it ceases to be ambiguous and shameful. More than ever, music becomes a monologue. It becomes a material object of exchange and profit, without having to go through the long and complex detour of the score and performance any more. Capitalism has a frank and abstract interest in it; it no longer hides behind the mask of the music publisher or entertainment entrepreneur.
>
> (Attali, 1977: 88)

According to Attali, the increasing emphasis on the economic wholesaling of what was once an individual, crafted artifact, signals the death of the original: "In mass production, the mould has almost no importance or value in itself" (Attali, 1977: 89). He goes further, arguing that music's ability to exist as a saleable commodity would eventually supplant aesthetic value as its *raison d'être*: "The growth of exchange is accompanied by the almost total disappearance of the initial usage of the exchanged" (Attali, 1977: 89).

Attali's concerns, then, were focused on the advancement of technology and how this advancement would affect the social function of music: by rendering the modes and rituals surrounding the production, consumption, and distribution of music so different as to "profoundly transform every individual's relation to music" (Attali, 1977: 88). He anticipated that music would cease to function as a social mirror, becoming instead "a solitary listening, the stockpiling of sociality" (Attali, 1977: 88). From this position, Attali portrays repetition as a dystopian age where surplus production and hoarding of recorded music render obsolete music's once immutable social function. It is not just the future of repetition that spells doom for music; for Attali in 1977, it had already begun:

> Music became an industry, and its consumption ceased to be collective. The hit parade, show business, the star system invade our daily lives and completely transform the status of musicians. Music announces . . . the conditions for the shattering of representation.
>
> (Attali, 1977: 88)

1.2 Limitations of Attali's theories

Writing in 1977, Attali could never have foreseen the extent to which technology would evolve in the succeeding three decades. The idea that almost every household in the developed world would have a computer that was small enough to sit on a desktop would have seemed a little far-fetched to all but the most prescient minds. Moreover, the idea of an 'Internet' that would not only provide near instant connection between these computers across the globe, but also act as a conduit for sharing music and culture in general, would have seemed ludicrous.[6]

Whilst Attali was writing *Noise*, what we now know as the Internet was in its infancy. Networks connecting military and research institutions did exist, but they were experimental and "still part of the 'closed world' of military contracting" (Aspray and Ceruzzi, 2008: 21).[7] Even if such networks were known of beyond the confines of the military sphere, it is unlikely that they had any kind of grip on the popular or even academic conscience as a techno-cultural force or subject of study. As an intellectual with strong affiliations to the political and academic establishment, Attali was probably aware of the military and scientific developments and the possibility of their eventual mutation into a larger, more popular network. He is unlikely to

---

[6] Even if the technological possibilities that lay ahead were in some way divinable, Attali and his contemporaries would have been forgiven for not putting a great deal of faith in them at the time: "The beginning of the 1970s saw a remarkable confluence of forces that collectively cast into doubt the once ascendant culture of improvement. The cessation of manned lunar exploration, the grinding to a halt of the expansion of nuclear power, the increasing challenge to technological projects, both small and large, on the grounds of environmental damage or hazards, all gave evidence of widespread questioning in the West of the consensus on what constituted improvement" (Friedel, 2007: 537).

[7] Janet Abbate argues that, despite their relatively basic nature and limited pool of users, these demonstrations of network capability "confirmed the feasibility of the Internet scheme" (Abbate, 2000: 131).

have foreseen, however, the development of the World Wide Web in the early 1990s.[8]

Although the two terms are often used interchangeably, the Internet and the World Wide Web (or the Web, for short) are two distinct entities. The Internet is a conglomeration of many different data transfer networks, connecting vast numbers of computers and other devices across the world.[9] Once connected, these computers and devices can send and receive information transmitted by a number of different protocols. The Web is just one of the many protocols available for the transmission of data across the Internet and is usually rendered using a browser, such as Google's Chrome or Microsoft's Internet Explorer (Comer, 2007: 8). In contrast, emails are sent using the Internet but via different protocols such as simple mail transfer protocol (SMTP) or Post Office protocol (POP).[10]

Tim Berners-Lee first conceived of the Web in 1980, but his ideas did not come to fruition until a decade or so later (Berners-Lee, 1996). It was the flexibility and relative user-friendliness of the Web—compared to systems like the Military Network (MILNET) and the Advanced Research Projects Agency Network (ARPANET)—that would eventually make the Internet not just a popular technological innovation but, for many people, an indispensable and integral part of everyday life. William Aspray notes that until 1991 "there was no commercial use of the Internet, and only limited personal use" (Aspray, 2008: 458). On 30th April 1993, the European Organization for Nuclear

[8] The creators of the Internet had one purpose in mind: connecting geographically distant computers to one another in order to share experimental and sensitive data. But, in a distinct echo of Edison's early adventures in sound recording, this agenda was soon hijacked: "In this unstructured environment, a range of uses sprang up, including electronic mail and bulletin boards—uses never envisioned by the original network designers (much less by those footing the bills)" (Friedel, 2007: 523–524).

[9] See Frischmann (2001).

[10] For further explanation of Internet protocols and their applications see Clark (2003).

Research (more commonly known as CERN) issued a statement announcing that "a little known piece of software" called the World Wide Web would be placed in the public domain, free to anyone who wanted to use it, and in doing so CERN "opened the floodgates to Web development around the World" (CERN, 2003).[11] Initial efforts were restricted to personal use, but the rules were soon relaxed and other entities began to take advantage of the opportunities afforded by the Web.

Amongst these was a variety of record companies, artists, and radio stations that "experimented with using the Internet to publicize and distribute music" (Aspray, 2008: 458). Some websites, such as MP3.com, allowed consumers to legitimately download music—usually uploaded to the site by unsigned artists—at no cost. These tended to be more popular with independent musicians who saw the opportunity to promote themselves without the backing of a record label or publishing company. By contrast, services like Napster (a centralized peer-to-peer file-sharing service) were used primarily for the illegal sharing of copyrighted files: invariably songs already released by acts with an existing revenue stream, which piracy threatened to disrupt. The centralized nature of services like Napster (and its successors) provided obvious targets for litigators, and most such services have at least been involved in legal disputes, if not forced to shut down. Other protocols for file-sharing have emerged and, courtesy of some innovative design measures, the most recent generation appears to be far more resilient to the application of legal force, continuing to be used daily by millions of people to share music and other types of data.[12]

The impact of file-sharing on music is vast and few would seek to deny its importance. It is, however, by no means the only phenomenon

[11] A copy of the first World Wide Web page, created by Berners-Lee, is still available (Berners-Lee, 1992).

[12] On 15th November 2008, popular BitTorrent hosting site The Pirate Bay announced that over 25 million individual users had been tracked (The Pirate Bay, 2008).

to emerge at the confluence of music and the Internet: online shopping, new forms of interaction between artists and fans, a proliferation of websites, charts, and forums for niche musics have all played a part in the recent evolution of music, and the list continues to grow. There are also technological developments other than the Internet and the Web that have had peculiar significance for music, even though their ramifications may be less widely felt. As is almost always the case, none of these technologies evolved in isolation; in fact, many of them have been dependent upon the Internet, the Web, and even each other for their continued adoption, improvement, and success. Until the 1980s, most if not all of the technology surrounding the production, distribution, and consumption of music was analogue. However, a combination of several innovations "changed the situation entirely, creating a serious problem for the record companies in the form of digital reproduction" (Aspray, 2008: 453–454). To list all of these would be a lengthy and painstaking task, and potentially not a very useful one. Highlighting the most significant, however, provides a general trajectory, and Aspray cites the development of the following as being of particular importance: the Internet as a distribution channel for music files; the MPEG-1 and MPEG-2 Audio Layer III (MP3) compression standard that gave users the means to compress audio files without a significant subjective loss of quality; equipment and software that allowed consumers to make their own digital music files; sufficiently powerful processors for personal computers for digital audio files to be decompressed in real time; bigger and cheaper hard drives for computers giving more usable and cost effective storage for personal and commercial music libraries; fast external interfaces such as Universal Serial Bus (USB) and FireWire (Apple's proprietary high speed serial bus) to facilitate quick transfer of data from one hard drive to another; and high-speed and high-bandwidth commercial and domestic broadband connections, promoting increased interaction and exchange of data between users (Aspray, 2008: 454–456).

Recorded music was once a world of analogue, offline interactions and transactions, but a unique combination of technological forces has created a world whose shape is increasingly determined by digital and online practices. Transformations of this sort are not new to music: notation, the printing press, and electronic instruments have all challenged the received understandings of what music is and how we engage with it.

1.3 Six characteristics of recorded music platforms

Crucial to this thesis, then, is an appreciation of the fundamental differences between digital music files and every other platform of recorded music that has preceded them.[13] The fourth chapter is particularly important in this respect; it identifies six separate characteristics of recorded music, all of which have been affected at various times and in various ways by the evolution of recording technology. These are capacity, compatibility, cost, durability, editability, and fidelity. Without exception, every new platform for recorded music has in some way made room for improvement[14] in at

[13] The term 'platform' will be used in order to avoid confusion when discussing the various 'formats' for encoding and compression within the 'platform' of digital music files. It should be noted that the term 'platform shifting' will be used to denote the activity of transferring recorded music from one platform to another (usually from a physical platform such as a CD to digital files stored on a computer); a practice often known, particularly in the field of copyright law, as 'format shifting'.

[14] What constitutes improvement, and for whom, is to a certain extent a matter of opinion. In order to prevent technical discussions becoming bogged down in philosophical debates of value—however relevant they may be—this thesis works on the following sorts of assumptions: cheaper is better than more expensive; more editable is better than less editable; infinitely replaceable is better than irreplaceable; and so on. It should be noted, however, that there are some consumers who consider any digital recording platform to be inherently inferior to analogue media. The vinyl record is a striking example of this; many of its followers are adamant that the quality of CDs and digital music files is inferior to that of the '45'. These arguments, however, are based largely

least one of these six characteristics, although not necessarily without detriment to one of the others.[15]

It is in the scope of these improvements that digital music files, as a platform, are fundamentally different to any of their predecessors. For the first time in the history of recorded sound, technology has achieved (or is not far from achieving) the theoretical perfection of all of these characteristics. Explanation and justification of this claim follow in the succeeding chapters, but the pivotal point is this: far from simply continuing or exaggerating the trend that forms the customary narrative of the traditional histories of recorded music, digital music files have completely reengineered our relationship with and the economics of the production, distribution, and consumption of music in a very profound way. So profound, in fact, that present-day scholarship and commentary cannot fully fathom it.

1.4 Summary of chapters

This dissertation, therefore, is designed to serve two purposes. In the first instance, it re-examines the history of recorded music platforms in order to elucidate the fundamental similarities between recording technologies that are traditionally construed as radically different. It then analyzes the specific technological attributes of the modern digital music file that mark it out as a comprehensive departure from its forebears. This prepares the ground for the second task; to establish a better understanding of the extent to which digital music files have transformed music's social function. Although predictions about the

---

on aural perception. Consequently, they invariably suffer from the opacity of the language used to describe sound, and are thus inherently subjective and often irresolvable. This is discussed in greater detail in Chapter 4.

[15] CD technology was generally considered to be a marked improvement on tape technology in terms of fidelity but, for the majority of domestic consumers, it was nothing like as editable.

future of music's relationship with technology are not without limitations, some thoughts are offered on how recorded music and its production, distribution, and consumption are likely to evolve.

The dissertation begins with a chapter surveying the history of recorded music (Chapter 2). In such a short space it is inevitable that such a survey will be cursory at best. The intention, however, is not to compete in terms of detail with other, more elaborate histories of specific platforms, but instead to give sufficient context for a re-reading of recorded music's history. This will allow an uninhibited exploration of the possible future and impact of recorded music later in the dissertation. Moreover, few (if any) of the existing histories treat the most recent developments surrounding digital music files as part of the same picture as older technologies, a perspective that is crucial to this thesis. These traditional histories, however, will not be ignored. Lisa Gitelman demonstrates that they can, despite their shortcomings, teach us "some interesting lessons about the emergence of new media and about media as the subjects of history" (Gitelman, 2006: 56).

Chapter 3 examines the evolution of technology in general, in order to provide a theoretical grounding for Chapter 4. Specific consideration is given to the process of exaptation, in which a feature of an existing technology is co-opted for a new technology (Dew et al., 2004: 70). Exaptation is rife throughout the history of recorded music, and an appreciation of both its potential and its unpredictability provides a clearer understanding of the forces that guide the evolution of recorded music platforms.

Chapter 4 explores the fundamental technological differences and similarities between digital music files and their predecessors. Particular attention is paid to the ways in which digital music files have become paragons of audio technology: theoretically infinite durability courtesy of the robust nature of digital code, global compatibility across a huge range of devices and formats, and so on. Such an exploration permits a better appreciation of not only how digital music files have perfected (or nearly perfected) the six characteristics mentioned previously, but also how they can be produced, distributed, and consumed in fundamentally different ways to previous platforms of recorded music, such as the CD or vinyl record. This allows a sharper contrast to be drawn between the traditional, historically accepted social function of music and its modern, culturally enacted correlate.

Chapter 5 comprises two parts. The first part is a review of the rituals and socio-cultural economics surrounding the production, distribution, and consumption of music prior to the advent of digital music files. It is here that the thesis truly departs from traditional histories of recorded music. In addition to not being extended to include digital music files, such histories invariably portray each of the technological advancements outlined in the first chapter as catalysts for dramatic change in the rituals of production, consumption, and distribution. The narrative of each successive platform shift upsetting the music industry's apple cart and depriving established musical institutions of their income is a familiar one. This chapter provides evidence that, on the contrary, the rituals and economics of the music industry have, until recently, changed little since their inception. Each new breed of music technology has been assimilated into the existing rituals, and consumers have had to adapt surprisingly little in order to preserve tradition.

The second part of Chapter 5 examines the rituals and economics that have sprung up in response to digital music technology. In doing so it brings two things to light. First, and as a counterpoint to Chapter 4, it is only with the advent of digital music files that the production, distribution, and consumption of music have been thoroughly reconstructed. Second, the evidence suggests that many of these rituals have been created or reconstructed because the social function of music was in jeopardy. It seems that, even when consumers and the music industry at large are faced with a technology that could remove the social function of music entirely, the response is to devise rituals and economic systems in which the social aspect can be conserved where it survives, and buoyed where it has foundered.

Chapter 6 offers both conclusions and thoughts for the future. The objective is not to predict the future, or even to offer the final word on the current relationship between music and recording technology. Instead, the intention is to add nuance and specificity to a debate that, though lively, tends to hyperbole and generality. In order to do so, a response is required to Gitelman's plea that histories of new media technologies "be sought amid uses and users, rather than simply amid descriptions of product development, product placement, business models, or calculations of market share" (Gitelman, 2006: 59). This allows familiar assumptions about media technologies to be questioned and, in doing so, draws attention to "a range of different futures than those that seem to be prefigured by theories relying upon a certain sense of inevitability in their prognoses" (van Loon, 2008: xii).

Attali clearly understood and anticipated the potential threat posed by technological innovation to music's traditional social function. Unfortunately his tendency to favour such 'inevitable prognoses' prevented him from making a fair appraisal of the likely outcome. As this dissertation demonstrates, it seems that the social and socializing aspect of music is of sufficient importance that, where technology has threatened to render music as isolated and individual, users have found new ways of rendering it sociable and shared.

The mercurial nature of technology's development, application, and effect is largely attributable to users of the technology in question, who invariably "respond selectively . . . embracing those aspects that they find appealing or useful, and rejecting those that they do not" (Ensmerger, 2008: 351). The meaning and purpose of any new technological medium is not necessarily derived from its inherent utility but rather from its contexts and public participation (Gitelman, 2006: 44). That the Internet, file-sharing, digital music, and their associated phenomena are revolutionary in their scope and impact is already clear. However, the technologies that spawned them (and the technologies they have spawned in return) are still being explored by consumers, and are by no means fully matured. We have only to consider the example of Edison's phonograph to see that the hype surrounding such innovations is inevitably accompanied by "the failure of the 'beta' device unveiled to public acclaim to presage anything like the functions that subsequent, related devices eventually serve" (Gitelman, 2006: 56). For Gitelman there is no doubt that "the social meanings of new media are not technologically determined in any broad sense" (Gitelman, 2006: 56). Friedel agrees, reminding us that the social consequences of new media technologies have been as "remarkably resistant to successful prediction" as the eventual application of the technologies themselves (Friedel, 2007: 517).

Like any other, this dissertation has been written within the boundaries of a specific cultural and temporal context. For studies whose subjects are rooted more firmly in the past, this context is often removed by a significant period of time: an advantage when it comes to delineating the terms of study and viewing the subject in a more objective light. It is more problematic when the subject being researched is still evolving, and its full impact has yet to be perceived. As such, this dissertation does not make any grand and unguarded prognostications about the future of music in the hands of digital technology. Instead, it provides an optimistic reality to counter Attali's pessimistic prophecy: organization where he saw disorder, music where he predicted Noise.

One cannot go to a museum to see a piece of music, or erect a piece of music in the town square, or sit down and read a good piece of music—unless one has the rare gift to 'hear' music by looking at a score . . . Because of this, music has been less aware of its history than any other art.

(Charles Hamm et al., 1975: 261)

2 Rehearsing history

Recorded music has for a long time been the bread and butter of the music industry. It hardly needs to be said that technological developments over the last 20 years have transformed the industry, forcing a reconsideration of long-held economic assumptions and trusted business models. At the heart of this challenge to the orthodox notions of how and why consumers listen to music is the question of what social function music serves, if any, in the modern world.

In order to understand fully the fundamental changes in the relationship between music and technology and the social consequences of such changes, it is imperative to consider the history of recording: the first instances of recorded sound, how the methods for storing recordings have changed since then, the drivers behind these changes, the development of digital music files, and, ultimately, any similarities or macrocosmic patterns of progress that can be identified within such a history. Histories of recorded music that provide greater detail do exist, and this is not an attempt to compete with them.[1] Instead, this chapter seeks to give sufficient context for a rereading of recorded music's history and to allow an uninhibited exploration of the possible future of recorded music later in the dissertation. In addition, few existing histories treat the most recent developments surrounding digital music files as part of the same picture as older technologies, a perspective that is crucial to this thesis.

[1] For two good examples, see Millard (1995) and Sterne (2003). Chanan's *Repeated Takes* (1995) comes the closest to providing a fully rounded history of recording technology's effect on music. When Chanan was writing, however, digital music files had yet to become established and thus the work is now—inevitably—limited in scope.

2.1 Proto-recording

An early example of what might be termed 'replayable' rather than recorded music is an automated flute player that existed around 875 AD (Farmer, 1931: 14). Pins on a rotating barrel caused levers to open holes on the flute and the wind required to make the flute sound was produced hydraulically. Although the design takes its inspiration from a collection of ancient Greek texts this was the first example of a truly "programmable machine" (Koetsier, 2001: 590).[2]

Sometime in the early fourteenth century, similar technology was used in Flanders to automate bell-ringing, using bells instead of flutes and hammers instead of wind (Westcott, 1998: chapter 3; and Koetsier, 2001: 592). By 1780, manufacturing techniques had evolved sufficiently for the Jaquet-Droz brothers to produce a 'singing' mechanical bird, which used a similar mechanism but was small enough to fit in a snuff box (Rosheim, 1994: 23). In about 1796, a Swiss clockmaker named Antoine Favre reworked the design with tuned metal combs instead of bells, and pins attached to a rotating disc instead of a barrel (Nijsen, 1984a: 169). This became what we know today as the music box, or 'carillon à musique', and the first commercial production of music boxes began in Sainte-Croix, Switzerland in 1812 (Favre, 1865: 13–14). They became hugely popular, particularly among those who could not play an instrument. However, each box only played one tune and people soon tired of hearing the same thing over and over again. Music boxes with interchangeable barrels did exist, but they were expensive to produce and few people could afford them. The demand for versatility at a reasonable price led to the development of cheaper music boxes that played interchangeable discs such as the Symphonium, developed by Paul Lochmann in Leipzig in 1886 (McElhone, 2004: 9–10).

[2] The device was named *Banū Mūsā* after three brothers (from what is now Iraq) who translated the Greek texts (Rosheim, 1994: 9).

2.2 Early acoustic recording

In 1877, having invented a carbon transmitter for Alexander Graham Bell's telephone and made a tidy profit from it, Thomas Edison set about inventing a device that would capture a spoken message sent down a telegraph line; an aural counterpart to the written messages already being sent as telegraphs (Gelatt, 1977: 18–19). The steps taken by Edison from here to the invention of the phonograph are well documented (see Gelatt, 1977), but it is worth noting that this was the first instance of a device that could acoustically reproduce *recorded* sound, as opposed to the physically crafted sound of devices like the Banū Mūsā (Edison, 1878a).[3]

Between 1881 and 1885, with Edison having deserted his work on sound recording to focus on the incandescent lamp, Bell and his colleague Charles Tainter took over development (Dowd, 2002a: 116). They made the stylus apparatus more sensitive and, having experimented with discs, replaced Edison's recording medium of tin foil with wax-coated cardboard cylinders. The quality of sound was vastly superior to Edison's phonograph, and in 1886 they patented the 'graphophone' (Bell et al., 1886).

Emile Berliner—a German-born American inventor—had also realized that Edison's design would benefit from some modifications. He believed that not only would it be difficult to reproduce cylindrical recording media cheaply, but also that discs would take up a lot less space than cylinders. So, in 1887 Berliner was granted a patent (Berliner, 1887) for his 'gramophone', which used discs instead of cylinders, and horizontal stylus movement instead of vertical (Frayne, 1985: 263). It was not until the founding of his eponymous Berliner

[3] The first device that could record sound was invented by Édouard-Léon Scott de Martinville in 1857. His 'phonautograph' transcribed sound visibly, but could not replay the recorded data (Scott de Martinville, 1857).

Gramophone record label in 1894—later to become Deutsche Grammophon—that discs really took off as a medium for listening to music.

On 8th July 1899, an engineer at the Copenhagen Telephone Company in Denmark named Valdemar Poulsen filed a submission to the United States Patent Office for "certain new and useful Improvements entitled an Apparatus for Effecting the Storing Up of Speech or Signals by Magnetically Influencing Magnetizable Bodies" (Poulsen, 1899: 1). The most commonly used of these "bodies" was metal wire, and it was used to record fluctuations in electrical signal as stored magnetic fluctuations. Several years later Poulsen was granted a patent for his telegraphone, the first device to use magnetic sound recording (Poulsen, 1906). Poulsen was not, however, the first person to think of using magnetizable materials as a means of storing data. Oberlin Smith, an engineer based in Cincinnati, wrote an article in 1888 that described a magnetic recorder very similar to Poulsen's (Smith, 1888). These ideas would have ramifications well beyond the realm of sound recording: computer floppy disks, hard drives, credit cards, and train tickets all function on the same principles of electromagnetism. This is a rare example of what was intended primarily to be a sound recording technology becoming the cornerstone for other, largely unrelated technologies. In the majority of cases the roles are reversed; the sound recording industry seems to adopt technologies developed initially in unrelated fields. (This process of co-opting technologies into other domains, known as 'exaptation', is discussed in Chapter 3).

The 1900s witnessed not only marked improvements in gramophone technology but also the deployment of several clever marketing strategies by the Victor Talking Machine Company (founded in 1901). The consequent improvement in sound quality and change in public perception of the gramophone was sufficient to persuade major artists to release their records on gramophone discs, broadening the consumer demographic. Initially, the richer, more elite members of society were reluctant to acknowledge the merits of the gramophone, but carefully targeted advertising soon dispelled the scepticism and by 1914 over a third of British households owned a gramophone (Martland, 2013: xviii).

By this time, disc and cylinder technologies had been competing for the market for approximately two decades. However, Edison's adoption of Berliner's flat disc in 1912 (Frayne, 1985: 263) and the expiry towards the end of the 1910s of many patents controlling the methods for producing disc records[4] resulted in the market becoming flooded with discs from numerous manufacturers, and the cylinder began to lose the first of many 'platform wars'.[5]

2.3 Electrical recording

With the market having settled on discs rather than cylinders, the Western Electric Company spent the early 1920s improving Edison's and Berliner's technologies to give louder, clearer recordings. Coupled with the advent of the Roaring Twenties and the accompanying taste for jazz and dance music, this increase in quality and reproducibility led to a burgeoning recorded music industry. It would not flourish unchallenged for long though. The industry perceived the onset of radio broadcasting in 1921 to be a serious threat; by 1922 sales of records had begun to drop, and the handful of companies producing records began "looking around for some salvation" (Frayne, 1985: 263).

Following the invention of the condenser microphone by Edward Wente and other developments in the fields of amplifier and

[4] For an example, see Jones (1901).
[5] At the time, United States patents expired 14 years after being issued, although utility and plant patents granted after 8th June 1995 are enforced for 20 years (United States Patent and Trademark Office, 2012).

microphone design by Western Electric and others, the Columbia Phonograph Company began to experiment with electrical rather than acoustic recording equipment (Wente, 1917: 40).[6] Rather than directly carving physical grooves into various media using a stylus attached to a mechanical diaphragm, Columbia engineers Joseph Maxfield and Henry Harrison used a microphone as an electrical sound transducer, creating an electrical analogue of the fluctuations in sound pressure levels. Having been amplified, this signal was then used to drive an electromechanical recording cutter, thereby making a physical copy of the input signal (Millard, 1995: 141).

Despite being generally hailed as an improvement on acoustic recordings, the first electric recordings were often described as sounding "harsh and artificial" (Read and Welch, 1959: 373). This was due in part to the limitations of the microphones used to capture the original sound, which offered quite a limited frequency response (Maxfield and Harrison, 1926: 493).[7] Wente, writing in *Physical Review* in 1922, describes his latest model of condenser microphone as having "an over-all sensitivity which is practically uniform from 25 to 8,000 cycles [Hertz]" (Wente, 1922: 501). This was approximately "four times the range of acoustically recorded sound" (Malsky, 2003: 244) and a variety of "definition and details previously missing, such as vocal

[6] See Egerton (1917).

[7] Frequency response is the range of frequencies—usually measured in cycles per second (Hertz or Hz)—that a recording device is able to capture or that a playback device is able to produce, and the characteristic emphasis or emphases that such devices place on particular parts of the frequency spectrum. For example, the Shure SM58 vocal microphone (the industry standard for live performance) has a frequency response of 50 Hz to 15 kHz (Shure, 2013). Although the human ear has a frequency response of approximately 20 Hz to 20 kHz, the microphone is an input device and it is unlikely that any singer would produce notes below 50 Hz (approximately G_1 where C_4 is middle C) or above 15 kHz (approximately Bb_9 where C_4 is middle C.). Apple's iPod Classic, on the other hand, has an advertised frequency response of 20 Hz to 20 kHz (Apple, 2012b), covering the average maximum range of human hearing. This response may, however, be coloured by the choice of headphones or speakers to which an iPod or similar device is connected.

sibilants, were now recordable for the first time" (Gelatt, 1954: 223). However, given that the frequency response of the average human ear is roughly 20 Hz to 20 kHz, it is perhaps unsurprising that the quality of sound was considered to be lacking.

Nonetheless, improvements continued to be made. In 1931, by building on the work on electrical sound transmission at Western Electric and by redesigning the shape of the acoustic horn used for playback, engineers at Bell Laboratories were able to record an orchestra "in fidelity comparable with the original sound" (Fox, 1981: 908). This electrical recording was "a revelation to listeners accustomed to acoustic reproduction: the dramatic increase in volume, the clear sibilants, and most of all, the amazing reproduction of bass notes" (Millard, 1995: 143).

On 17th September of the same year, the first 33 revolutions-per-minute (rpm) disc records—developed by RCA Victor—had their first outing at a press conference at the Savoy-Plaza Hotel (Gelatt, 1977: 253). Slowing down the speed of rotation and increasing the number of grooves per inch allowed RCA to manufacture discs that were capable of reproducing up to 14 minutes of music from each side (enough for listeners to be able to enjoy most symphony movements without having to change disc). The majority of the 33-rpm record's predecessors had only been able to cope with four minutes per side. In addition, the new records were pressed from a vinyl plastic-based material that was less brittle than 78-rpm records and thus more resistant to breakage. Unfortunately for RCA, the demonstration was not well received. The public was unimpressed with RCA's decision to eschew a wide range of new recordings in favour of simply transferring their existing catalogue of 4-minute recordings onto the new discs. Reporters were critical of this secondhand sound quality: "The recording is conspicuously lacking in colour, brilliancy, and character; it is thin, flabby, faded, and lusterless; the music is all there, but it is pale and weak and lacks the life of the original" (anonymous critic quoted in Gelatt, 1977: 253). And although the flexibility of vinyl rendered it safer in transport, it also made the records more susceptible to wear and tear from everyday playing and handling. Crucially, RCA failed to anticipate the reluctance among consumers to abandon their collections of 78-rpm records. Instead of offering cheap turntables that would play at both speeds, RCA released a range of radio-phonographs, which at the time cost between $247.50 and $995 (Gelatt, 1977: 254).[8] 33-rpm discs were discontinued, but would later be resurrected amid more favourable economic climates and supported by more elegant marketing strategies.[9]

2.4 Magnetic tape recording

By the early 1930s, wire technology had been adopted by a small number of studios—including those of the British, Canadian, and German broadcasting corporations—but it failed to attract much commercial success. In the preceding decade, German scientist Fritz Pfleumer extended the work of Smith and Poulsen, devising a process for creating magnetically coated paper tape (Gelatt, 1977: 286). In fact,

[8] The conversion of such figures to modern monetary values is likely to be approximate at best. By using two indices to project the current equivalent of such an outlay—the Consumer Price Index and the Unskilled Wage Index—it is possible to provide a broad range of prices that conveys some sense of the relative cost of such an item. Using the CPI, the range equates to roughly £2,000–£9,000. Using the UWI, the same figures translate to modern prices in the region of £6,500–£26,000 (figures converted from United States dollars using exchange rates provided by www.xe.com). The imprecision of such conversions is immediately apparent, but the figures suggest that such record players are likely to have been prohibitively expensive for the majority of consumers.

[9] Despite the market resistance with which they were met, vinyl records offered a significant advantage over their shellac predecessors: "Because vinyl contains no abrasives, like those found in shellac, vinyl enabled the use of a permanent jeweled stylus with a synthetic sapphire or diamond. The lightness of this stylus and the use of piezo-electric crystal pickups doubled the signal-to-noise ratio of these records" (Funk, 2007: 10).

Oberlin Smith had already theorized about the possibilities of a recording medium that used a non-magnetic base material combined in some way with magnetizable particles (Thiele, 1988: 396).

The Second World War saw "the first generation of independent inventor/entrepreneurs . . . replaced by the organized research of large companies" (Millard, 1995: 197), and in 1932 German industrial giants AEG bought all the patents and rights that had been awarded to Pfleumer (Thiele, 1988: 401). Along with firms like I.G. Farben (now known as BASF), AEG set their laboratories to work on improving the technology even further. They introduced plastic tape and experimented with a variety of magnetizable coatings such as iron oxide and steel. These improvements were incorporated into the AEG Magnetophon; a machine that offered fast playback, portability, and a clarity of sound to rival the gramophone (Millard, 1995: 198). Crucially, in the theatres of war, it had the advantage of being able to make longer recordings and to record despite the presence of vibrations. As the war continued, Magnetophons were captured by Allied engineers and taken back to Britain and the United States. This swelled the interest in magnetic technology and the 1940s saw the arrival of the first consumer magnetic recorders.

Magnetic tape recording soon supplanted wire recording entirely, save for a handful of outdoor and military applications. Although it had comparable sound quality to its disc competitors (Millard, 1995: 198), it was considered superior in two ways: it was much cheaper per minute of audio and, crucially, it was editable. Reels of tape could be cut, spliced, faded, and manipulated in a variety of ways that were simply impractical with wire or disc recordings. Not only did this allow technicians to create previously unheard sounds and effects (such as tape delay and chorus), but it also meant that whole radio shows could be compiled from sections of prerecorded material and broadcast without any live intervention.

2.5 Stereo sound and multi-tracking

The market for disc records, however, had far from disappeared. In the 63 years since Edison invented the phonograph, the fidelity of recorded music had improved dramatically. But, by 1940, consumers had been offered very little by way of realistic aural imaging.[10] Almost all commercial recordings up to that point had been monophonic and were usually listened to through a single speaker. In the first half of the 1930s, Bell Laboratories engineer Arthur Keller developed a method for producing and listening to stereophonic disc records, but it was far from perfect. Recorded by cutting a groove for each sound channel, one starting at the outside of the record, and one halfway through, the disc had to be played on a gramophone "with two pick-up arms, each capable of tracking its own hill-and-dale groove in perfect synchronism" (Fox, 1981: 910–911).

Around the same time, EMI engineer Adam Blumlein showed that it was possible to achieve stereo recordings that could be read through a single stylus by storing two channels of information in a single groove (Blumlein, 1931).[11] Traditional monophonic sound was produced by transduction and amplification of vertical vibrations in the stylus, created as the 'hills and dales' of the disc passed underneath it. Emile Berliner had advocated the use of horizontal motion (Fox, 1981: 909) but by 1931 the hill-and-dale approach was widely accepted to be superior. Blumlein's idea was to move the stylus in two different directions simultaneously. His first experiments relied on a combination of his and Berliner's preferred techniques; vertical

[10] Clément Ader had demonstrated a basic form of binaural stereo sound transmission at the 1881 Paris Electrical Exhibition, but it was only possible on a large scale and not economically viable for domestic use (Fox, 1981: 908).
[11] According to Fox, this patent was "arguably the most extensive audio patent ever filed, covering not only the foundation of all modern stereo disc recording and reproduction but today's stereo film sound as well" (Fox, 1981: 908).

movement for one channel and horizontal movement for the other. However, Blumlein soon realized that by recording both channels of sound at 45 degrees to the surface of the disc (but still at 90 degrees to each other) he could create a system that was superior to its vertical-horizontal counterpart in two ways. First, the 45-degree arrangement avoided the inherent problems with gravitational bias towards the vertical channel over the horizontal. Second, and more crucially, it was backwards- and forwards-compatible. A stereophonic record played through a monophonic stylus cartridge would produce an equal mix of the left and right channels, as would a monophonic record played through a stereophonic cartridge.[12] Frustrated with his double armature method, Keller—unbeknownst to Blumlein—had arrived at a similar conclusion (Keller and Rafuse, 1938). At the time, neither knew of the other's work: "I'd never heard of him [Blumlein] until the 1950s and I'm sure he'd never heard of me. My first exposure to the Blumlein matter was in 1958 when the system was reinvented" (Keller quoted in Fox, 1981: 910).

As Keller notes, the stereo revival did not take place until much later. Due to wartime exigencies and economic depression, the efforts of Blumlein, Keller, and their contemporaries went largely unnoticed until 1957 when, prompted by alleged developments in Britain and Germany, Westrex resurrected Blumlein and Keller's earlier work (Frayne, 1985: 269). In 1958, the Recording Industry Association of America (RIAA) endorsed the 45-degree system as the standard for stereo recording (Fox, 1981: 910), and consumer enthusiasm grew rapidly.

Blumlein's 1935 experiments with stereo sound on film—recording and playing back two independent signals alongside each other on the same stretch of film—gave rise to similar ventures on magnetic tape and, before long, 'multi-tracking' had arrived. This was a

[12] This mono compatibility occurs because "lateral movement of a mono pick-up stylus produces a signal that is the sum of the left and right channels" (Fox, 1981: 910).

huge leap forward in recording technology and had enormous musical impact. It allowed for one recording to be laid 'on top' of another, and for these separately recorded sources to be combined into a single output signal at the point of playback. At the time, perhaps the most impressive and ingenious use of multi-tracking culminated in the release of Pyotr Tchaikovsky's 1812 overture on Mercury Records in 1956. In one of the first truly 'produced' records, Mercury tried to fully realize Tchaikovsky's vision for the piece:

> Mercury's producers began by recording the strictly musical parts of the score in Minneapolis's Northrup Auditorium, using the Minneapolis Symphony Orchestra and the University of Minnesota Brass Band under the direction of Antal Dorati. Then they moved their recording truck to New Haven to put the bells of Harkness Memorial Tower on tape. Finally, they moved on to West Point and prevailed on the authorities to fire off a 1761 brass cannon for the benefit of their microphones. Back in the New York studio, the engineers superimposed these various tapings onto a final master tape, employing whatever electronic trickery seemed in order.
>
> (Gelatt, 1977: 312–313)

The mastering and conversion to disc took place without any compression and although "not every needle could track the final measures without sometimes popping out of its groove", the record produced "a tremendous, soul-satisfying noise" and soon topped the charts (Gelatt, 1977: 313). But consumers were not easily sold on the new technology. Although by September 1958 almost every record company had stereo discs on their catalogues, the average consumer "had adopted a wait-and-see attitude"; figures for December of that year show stereo records as constituting only six per cent of the total sales (Gelatt, 1977: 317).

2.6 Cassettes

The birth of stereo recording dramatically affected both the evolution of magnetic tape technology and public perception of the medium itself. Companies like Ampex and RCA Victor had offered consumer-orientated stereo tape players and recorders from the early 1950s, but the performance of this otherwise "flexible and easily edited format" was marred by "difficulties of handling": open-reel tape required deft threading of the tape through the player heads, attachment to reels, and correct orientation of the reels themselves (Millard, 1995: 315). Although endless-loop tapes and reel-to-reel cartridges (such as the RCA 'Casino') were developed in the late 1950s, these attempts to overcome the problems of handling were commercially unsuccessful. RCA's cartridge was cumbersome—about the size of VHS cassette—and endless-loop tapes, whilst reducing the frequency with which reels had to be changed, made selection of a specific track very difficult, and rewinding them was impossible. It was not until cassettes were developed that tape became as easy to use as disc records and began to establish a position in the market. Throughout the 1960s, a plethora of tape platforms and associated cassette types were released: four-track tapes, eight-track tapes, micro-cassettes, and mini-cassettes, to name only a handful. The one that had the most impact, however, was the 'compact cassette'. This was also known as the 'audio cassette', 'cassette tape', 'cassette' and later, thanks to its eventual dominance, simply 'tape'.

Philips started development on the compact cassette in 1962 (Millard, 1995: 316), reducing the width of the tape from RCA Victor's standard 0.25 inch (in) to 0.15 in, and reducing the playback speed to 1.875 in per second from the 3.75 in favoured on home tape recorders (Camras, 1988: 410). The reduced tape width allowed for a plastic case to enclose the moving parts, the slower tape speed allowed more music to be stored on a given length (albeit with lower fidelity) and it was first introduced at the Berlin Radio Show in August 1963 (Chandler, 1967: 6). It was durable, lightweight, compact, easy to use, and some cassettes could store up to 120 minutes of audio data. This put audio cassettes in direct competition with the thriving vinyl industry. In terms of pre-recorded music, Mercury Records released a catalogue of 49 'musicassettes' in 1966 (Billboard, 1966: 69) and by 1970 more than 6,000 prerecorded titles were available (Robertshaw, 1982: 3). The hardware required to play them was selling well too. In the first five years following their release roughly 2.5 million tape recorders had been sold, and by 1982 markets were seeing "hardware penetration over 100 per cent"; that is, more than one for every household (Robertshaw, 1982: 3).

Nonetheless, there were still enough problems with tape technology to ensure that many people continued to buy vinyl records. As an unavoidable artefact of analogue recording on magnetic media, the 'hiss' audible when playing a tape cannot be removed from even the most carefully produced master; it is present even on blank tapes. Each new analogue recording from one tape to another will produce the combined hiss of the blank tape and the hiss inherited from the original. Hiss will also increase with the age of a tape, as once-magnetized particles (i.e., the very substance in which the data are stored) become demagnetized. In addition, listeners must also contend with the phenomena of 'wow' and 'flutter'. These are two types of the same sonic distortion, caused by non-uniform motion of the tape past either the recording or playback heads. Both result in a modulation of the 'intended' frequency: "A frequency modulation of ½ to 5 Hertz per second is a wow, while above this is a flutter" (Olson, 1972: 164). In terms of listening, fluctuations below 0.1 Hz might manifest themselves aurally as "slight departures from perfect musical pitch by musically trained listeners", 1–10 Hz as "sour notes", and those from 20–50 Hz as "a warble" (Camras, 1988: 337).[13] Although these are partially

[13] This is surprising given that, as Camras notes, "a vibrato purposefully and artistically applied by the performer to violin and vocal music at

surmountable with precision-engineered audio equipment (and less of a problem with more modern tape decks) "even the best tape drives give imperfections in the steadiness of tape motion" (Camras, 1988: 334). Finally, the frequency response of compact cassettes was not as wide, nor as consistent as that of contemporary vinyl discs. The frequency response of magnetic tape media is not flat, and depends on both the speed of playback and the track width. Even in the late 1970s, a typical portable tape player had a frequency response of only approximately 100 Hz to 8 kHz (Olson, 1972: 317). These distortions, "built-in to the very heart of every analogue tape recorder" (Baert et al., 1995: 7), did little to charm hi-fidelity enthusiasts, many of whom remained steadfastly devoted to vinyl records.

2.7 Optical and multi-phonic platforms

The 1950s and 1960s saw the beginning of a battle between tape and vinyl that would continue for the next 20 to 30 years. At the same, time David Gregg—yet another Westrex engineer—was developing the technology that would eventually displace both tape and vinyl as the consumer's first choice for recorded music and video: the optical disc.[14] The term 'optical' refers to the way in which data stored on the disc are read. The data are recorded onto the disc in much the same way as sound is recorded onto vinyl disc (i.e., physical indentations of varying shapes and sizes) but, unlike vinyl, the data stored on an optical disc are read by shining a narrow, focused beam of light (usually a laser) on the rotating disc and inferring the shape and relative positions of the indentations from the light that is reflected.

about 8 Hz enriches the music and is very pleasing" (Camras, 1988: 337).

[14] Although Gregg was the first to develop *optical* disc storage of visual data, Scottish inventor John Logie Baird successfully recorded video images in the 1920s using his 'Phonovision'. Interestingly, this multi-stylus technique predates the work of Blumlein and Keller by approximately five years.

Following the foundation of their company Gauss Electrophysics in 1965, Gregg and co-founder Keith Johnson filed various patents relating to optical disc technology (Gregg, 1967, 1969, and 1970). In 1968, both Gauss and the rights to the technology were bought out by MCA, the company that would later become Universal Music Group, and the first videodisc players were released to consumers by MCA in 1976. After a series of business mergers and acquisitions Pioneer Electronics bought the rights to the technology and rebranded it as the ultimate in home video technology: LaserDisc. It was still an analogue platform, but it was the first optical data storage platform for video—as opposed to magnetic tape platforms like VHS and Betamax—and, as such, it provided significantly higher picture quality than its rivals. However, LaserDisc players were expensive and consumers could choose only from a limited selection of prerecorded releases; at the time, home recording equipment was not commercially available. Despite reasonable commercial success in Japan and southeast Asia, LaserDisc did not take hold in Europe or the United States save for among videophiles (Monaco, 1999: 148). The Gauss technology would, however, provide the foundation for the CD and Digital Versatile Disc (DVD) technologies that would dominate the 1980s and 1990s.

The early 1970s witnessed the release of several quadrophonic platforms that used four or more speakers instead of the customary two employed for stereo listening. In modern parlance, these systems would be referred to as 4.0 stereo. As per '5.1 surround sound', the digit before the decimal point indicates the number of 'tweeters' (speakers that are assigned to treble or upper frequencies) and the digit following denotes the number of 'sub-woofers' (speakers that deal with bass or lower frequencies). These quadrophonic platforms offered aural imaging that was more refined, but were largely unsuccessful due to issues of incompatibility, lack of standardization, and a need for more speakers and technical equipment than most consumers possessed or were willing to acquire (Millard, 1995: 352 and Monaco, 1999: 22, 83, and 206).

2.8 Personal stereo and boom box

By the beginning of the 1980s, the compact cassette had become a formidable market opponent to vinyl, despite its allegedly inferior sound quality. This almost certainly would not have happened without the development of the personal stereo. Andreas Pavel invented the first device of this kind, the Stereobelt, in 1977, but his attempts at commercialization proved unsuccessful.[15] After taking up Pavel's idea in 1978, Sony released their first Walkman (known then as the Soundabout) to the public the following year and other manufacturers quickly followed suit (Thompson, 2006: 124). The problems of low fidelity associated with tape recording and playback had not been overcome but the portability, low cost, and battery power of personal stereos meant that the majority of consumers were happy to sacrifice hi-fidelity audio in favour of being able to listen to whatever they liked, wherever they liked. Sales of personal stereos were strong to start with, and continued to rise as the devices became smaller, cheaper, and more power efficient. Sony alone sold 25 million Walkmans in the United States in the first ten years (Millard, 1995: 325), 186 million worldwide by the Walkman's twentieth anniversary (Sony, 1999), and in 2004 reported global sales of 330 million (Evangelista, 2004: 1). These are formidable sales figures for any platform, but even more so when extrapolated to include the unit sales from market rivals like Panasonic, Aiwa, Toshiba, and Sharp.

In addition to the rise of personal stereos, the 1970s and 1980s saw the increasing popularity of another tape device: the boom box. Even though it was bigger than the personal stereo (typically carried like a briefcase or on a shoulder) the boom box's size, battery power, sound quality and the "sheer volume of noise [it] could generate" made it very popular with urban youth, particularly in poorer, inner-city

[15] Pavel filed his patent on 24th March 1977 but legal disputes between Pavel and Sony started shortly afterwards and continued for nearly two decades, delaying the granting of the patent to Pavel (Schofield, 2005).

areas (Morton, 2004: 169). Almost predictably, just as audio tape was gaining a foothold in the market and tending towards ubiquity, another technology was being born that would threaten tape's place in the market, and ultimately succeed it as the consumer's first choice for recorded music media.

2.9 Compact Discs

In 1977, at the Tokyo Audio Fair (Pohlmann, 1989: 10) Sony, Mitsubishi, and Hitachi each demonstrated their own 'digital audio disc' (DAD) systems (Baert et al., 1995: 14). In 1979 Philips introduced an independently developed equivalent (only 11.5 cm in diameter, less than half the diameter of its rivals) and shortly afterwards began a collaboration with Sony that would result in the commercial release of the first prerecorded audio CDs in October 1982.

The CD was developed through the efforts of numerous companies, using the optical disc technology invented by David Gregg two decades earlier. The crucial difference between CDs and Gregg's initial efforts was that the former stored audio data in digital rather than analogue form. This was the first commercially exploited digital audio platform, and the impact that it would have on both consumers and subsequent platforms cannot be over-emphasized.[16] For the purposes of later comparisons between CD-quality audio and digital music files, it is beneficial to discuss here the fundamental differences between digital and analogue data and how CD technology works.

The grooves carved into a vinyl disc are a direct physical analogy of the sound waves that they represent. A loud, high-pitched sound is represented by wide oscillations at a high frequency, a soft, low-pitched

[16] Pulse code modulated digital audio recording was first demonstrated to the public in May 1967 by NHK, a Japanese broadcasting corporation (Baert et al., 1995: 7).

sound is represented by narrow oscillations at a low frequency. The same is true of magnetic tape recording, except that the physicality lies in the relative position and alignment of magnetic particles rather than indentations upon a surface. In order for audio data to be stored digitally, however, the input signal (i.e., the fluctuations in sound pressure level picked up by the recording device) must be converted from a continuous stream of data into separate chunks. These can then be assigned an appropriate digital value. Recording the instantaneous value of the analogue signal at given intervals of time provides a set of discrete, digital data. Once stored, this recorded data can then be used to reconstruct the original analogue signal.

This technique is known as sampling. Sampling is used in all sorts of applications to produce digital representations of analogue data: "Just as the discrete frames of a movie create moving pictures, so the samples of a digital audio recording create time-varying music" (Pohlmann, 1989: 19–20). These audio samples are, in essence, records of the amplitude of the sound signal at a given time. The sampling rate of a system is the frequency with which samples are taken (expressed in Hz). The higher the sampling rate, the more accurate the reproduction of the original signal. Sampling rate varies from system to system, depending on the nature of the data being sampled. Most traditional video cameras, for example, have a sampling rate of 24 Hz (i.e., 24 frames per second). CD-quality audio is typically sampled at 44.1 kHz, and with good reason. In 1928, Swedish engineer Harry Nyquist delivered a paper on telegraph transmission theory at the American Institute of Electrical Engineers convention in New York (Nyquist, 1928). During the paper, he demonstrated that if samples are taken with a sampling rate at least two times greater than the highest frequency recorded, "complete reconstruction [of the original signal] can be accomplished" (Pohlmann, 1989: 16). If the accepted upper limit of human hearing is approximately 20 kHz, then in order to satisfy the Nyquist theorem, a sampling rate of at least 40 kHz must be used to ensure that complete reconstruction is possible. Using a lower sampling rate can produce an effect called aliasing, where the sampling rate is insufficiently frequent to describe the input signal:

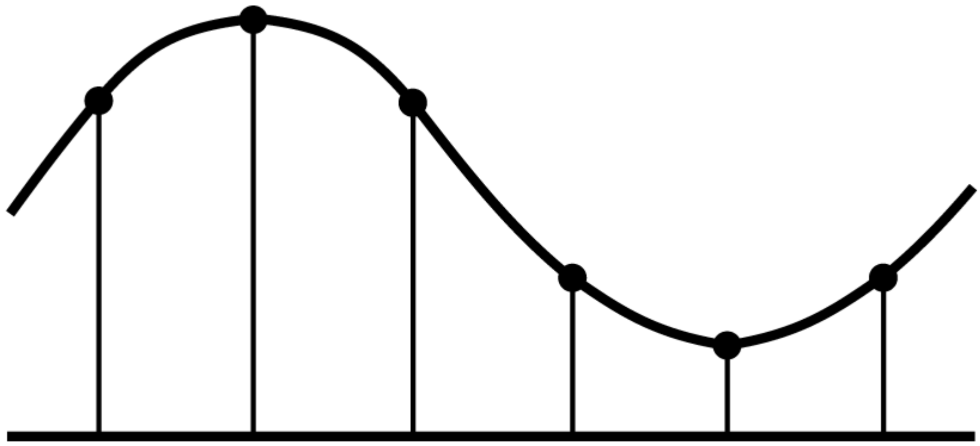

Figure 2.1 (a) *Input signal and sampling above Nyquist frequency*

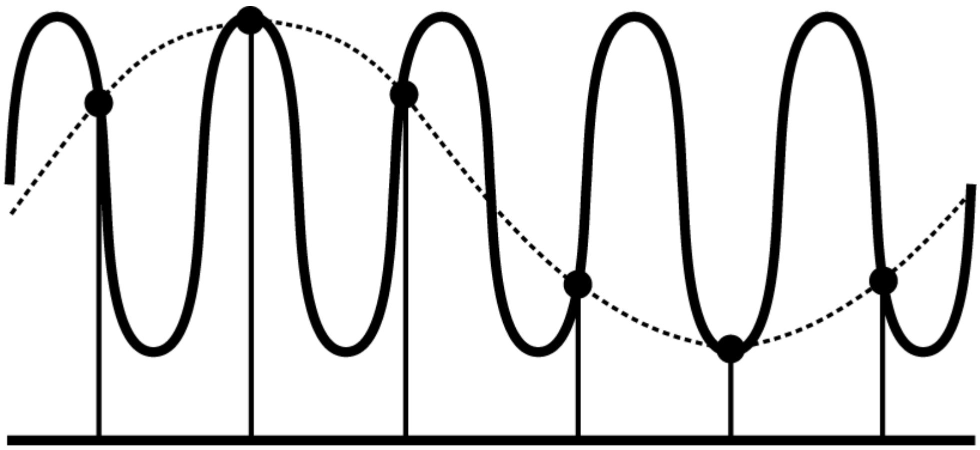

Figure 2.1 (b) *Input signal, sampling below Nyquist frequency, and aliased output signal*

In (a) the sampling rate is sufficiently high to accurately capture, and later reproduce, the waveform. In (b) the sampling rate does not satisfy the Nyquist theorem and the reconstructed signal (dashed line) would be an inaccurate 'alias' of the input signal (solid line). Aliasing can never be completely avoided, but CD-quality sound is sampled at a rate of 44.1 kHz—a process known as 'oversampling'—in order to allow 'room' for low-pass, anti-aliasing input filters that keep aliasing to a minimum (Watkinson, 2001: 202).[17]

The values obtained by sampling are converted into digital 1s and 0s, known as binary 'bits'. Digital values are inherently discrete, and recording an analogue signal as a digital value often requires the recorded value to be rounded to the nearest discrete level, or 'quantized', so that it can be represented in binary form. Quantization is the process of "approximating an analog amplitude to form a discrete number" and is a necessary step in the compression of sound data. Analogue waveforms such as those created by sound have "an infinite number of amplitude values" (Pohlmann, 1989: 30) and recording such a range is, by virtue of its infinity, impossible. By choosing from a finite number of discrete values the storage of data is not only made possible, but also relatively efficient. However, this comes at a price: "There will always be an error associated with quantization because the limited number of amplitude choices contained in the binary word can never completely map an infinite number of analog possibilities" (Pohlmann, 1989: 30). For data storage on CD, then, a balance must be struck between efficiency of storage and minimization of quantization error. A higher bitrate will offer more accuracy derived from longer binary words (the binary representation of the sampled amplitude will take up more space on a CD) whereas a lower bitrate will offer shorter binary words (requiring less space on a CD) but reduced accuracy (there will be higher quantization error).[18]

---

[17] Aliasing is not unique to the aural world. John Watkinson describes a common example of visual aliasing: "With a frame rate of 24 Hz, a film camera will alias on any object changing at more than 12 Hz. Such objects include the spokes of stagecoach wheels. When the spoke-passing frequency reaches 24 Hz the wheels appear to stop" (Watkinson, 2001: 201–202). Although in audio applications, aliasing is kept to a minimum, the same principles are exploited to great effect in devices like the zoetrope and stroboscope. For a more detailed explanation of aliasing see Pohlmann (1989: 20–26) and Watkinson (2001: 198–204).

[18] The term 'bitrate' is the number of bits that can be transmitted via a digital network in one second.

When stored on a CD, these strings of 1s and 0s are represented by raised areas, known as 'lands', and the depressions between them, known as 'pits'. The length of the regions and the frequency with which they alternate from one to the other correspond to the digital representation of the original analogue signal.[19] These are recorded on a spiral track that runs from the centre of the CD to the outside (the opposite direction to vinyl records) because the edges of discs are more prone to manufacturing defects and damage from handling. This track is approximately 0.0001 mm wide, whereas the groove on a vinyl disc is roughly 0.05 mm wide, about the width of a human hair (Pohlmann, 1989: 7). The track pitch, "the distance between successive tracks" (Pohlmann, 1989: 52), is 0.0016 mm, allowing approximately 625 adjacent tracks per mm. The precision engineering of the CD, as much as the way in which data are stored on it, gives it a much higher data storage density than its vinyl counterpart.

In order for the data to be read, the track is passed under a fixed laser beam by rotating the disc. A typical audio player will need to read the same amount of data per second in order to produce uninterrupted sound, and this requires the spiral track to pass under the laser beam at a continuous linear velocity—usually specified as 1.4 metres per second (m/s) for CDs with a playback time of less than 60 minutes, and 1.2 m/s for those with a longer playback time (Pohlmann, 1989: 53). As the track works its way out towards the edge of the CD from the centre, each rotation offers a greater length of track, since diameter varies proportionally with radius. In order to compensate for this, the CD player does not provide a constant angular velocity, but instead varies the number of revolutions per minute from around 500 at the inside edge to approximately 200 at the outside edge.

[19] Contrary to popular belief, it is not true that pits represent 1s and lands represent 0s, or vice versa. Instead, "each pit *edge* . . . is a 1 and all areas in between, whether inside or outside a pit, are 0s" (Pohlmann, 1989: 56). In conjunction with a decoding process known as 'non-return-to-zero, inverted' (NRZI) this method of storing binary values is "a much more efficient storage technique than coding the binary bits directly with pits" (Pohlmann, 1989: 56).

Many of these specifications were established early on in the development of the audio CD, and have changed very little since the earliest prototypes. The only substantial difference between such prototypes and the product released commercially in 1982 was the length of playing time. Sony's 1978 prototype held 150 minutes of audio data, and the first product of the Sony and Philips collaboration stored 60 minutes. The two companies eventually compromised, settling on 74 minutes. The decision to find a way of increasing the playback time is often traced back to conductor Herbert von Karajan, who suggested increasing the amount of data storable to 74 minutes so that Wilhelm Furtwängler's celebrated recording of Beethoven's ninth symphony from the 1951 Bayreuth Festival would fit on a single disc. In fact, there was more to the issue than satisfying the demands of a world-renowned conductor; there were serious market implications for both manufacturers. At the time, Philips owned Polygram—one of the biggest music distribution outfits then in existence. Having encouraged Polygram to set up a factory in Germany to press their own discs, Philips were keen for Sony to acquiesce. Sony's adoption of the 115 mm disc would secure Philips a hefty share of the market that was soon to emerge. Sony wanted to convince Philips that a different-sized disc would be needed and, perhaps using von Karajan's idea as ballast, insisted on the 74-minute format, necessitating the 120 mm disc that has since become the standard.[20]

Such disagreement amongst developers prompted the instigation of an industry-wide standard for audio CDs (officially referred to as Compact Disc Digital Audio, or CD-DA, to distinguish them from other CD formats such as CD-ROM and CD-I). In 1980 the first edition of the

[20] Stories about the negotiations surrounding the parameters of the Compact Disc standard abound and are often shrouded in hearsay. Quoting senior employees, Kees Immink suggests that the decision was made by Philips, who wanted the new platform to be of a similar size to tapes: "'Compact Cassette was a great success', they said, 'we don't think CD should be much larger'" (Immink, 1998: 2). The now familiar 12 cm diameter of CDs is, in fact, only 0.5 cm larger than the longest dimension—corner to opposite corner—of a compact cassette.

now-famous 'Red Book' technical specifications was published by Sony and Philips.[21] In 1981 it was approved by the DAD Committee and ratified by the International Electrotechnical Commission as directive 60908 (IEC, 1981).[22]

The standardization of the CD was a crucial step in avoiding the complications of compatibility that had plagued platforms such as quadraphonic sound. The resulting uniformity secured CDs a place in the market and contributed to their remarkable success. By 1988, sales revenue of CDs had outstripped that of vinyl discs in the United States (Baddeley, 1989: 19) and in 1992, a total of 1.15 billion CDs were sold worldwide (Laing, 1993: 302). It is easy to see why they were so popular: they produced arguably the highest fidelity audio available, allowed users to select tracks easily, had considerably longer archive life than tapes, and were more resistant to everyday wear and tear than vinyl. Simply *playing* a vinyl record will cause a certain degree of degradation to the physical medium, resulting in loss or distortion of the original data.

For the first decade or so after CDs were introduced, however, home users were unable to edit, copy, or create their own. In this respect, CDs were comparable to vinyl. Vinyl would continue to be the platform of choice for urban music DJs—its facility for scratching and artistic mixing has only recently been rivalled by CD and software mixers.[23] The threat posed to vinyl by the introduction of the CD was

[21] This standard, officially available only to manufacturers of CDs and related equipment, derives its name from the colour of one of the books in which the original handwritten specifications were contained. The technical specifications of CD-ROMs, for example, are governed by a document known as the 'Yellow Book' (Maes, 1996: 3).
[22] IEC 60908 is available as a PDF download at the International Electrotechnical Commission website for a fee of $260 and is generally purchased only by manufacturers of CDs or associated equipment. The salient details are summarized, however, in several books on the Compact Disc and audio engineering (see for example, Pohlmann, 1989: 49).
[23] Software like Final Scratch provides “exactly the same controls you’d have on a turntable when playing MP3, WAV and AIFF files from a hard

compounded by the increasing popularity of tapes and personal stereos, and soon heralded the demise of vinyl's market dominance. Although CDs did not outsell vinyl until 1988 (Immink, 1998: 3) sales of vinyl records in the preceding decade fell by almost 80 per cent (Millard, 1995: 355). The decline in sales did not, however, continue at the same rate. Today, vinyl records still have "an enthusiastic and loyal following among 40-something collectors and 20-something hip-hop, techno and punk fans" (Chivers-Yochim and Biddinger, 2008: 183), with many audiophiles maintaining that, as a holistic platform for recorded music, vinyl is still superior to CD.[24] There are some, however, who disagree: "We must accept that vinyl is inadequate to itself, that it has been superseded by the CD. This in turn means that we must no longer treat it (in mourning) as a romanticized or fetishized object imbued with levels of fidelity and advantages that in fact it never had—as many audiophiles still do" (Hainge, 2007: paragraph 35).

2.10 MiniDisc

If there were consumer frustrations with CD technology, Sony hoped they would be assuaged by the arrival of MiniDisc, released to the public in late 1992 (Sony, 2011a). It was developed as a sort of spiritual successor to compact cassettes, allowing tracks to be easily recorded, edited, split, combined, moved or deleted, unlike its purely optical predecessors. Each MiniDisc took the form of a magneto-optical disc housed in a cartridge—similar to the kind that had been used for computer floppy discs—with a plastic casing and a sliding window allowing appropriate devices to access to the disc inside. MiniDisc also had significant advantages over traditional magnetic platforms such as

drive", allowing DJs to "stop hauling crates full of vinyl from gig to gig" (Rolling Stone, 2003: 36).

[24] Audiophiles, according to Pinch and Bijsterveld (2004), are "listeners (mainly white, middle-class men) who invest large sums of money in purchasing dedicated audio equipment for extreme hi-fi listening to recorded music" (Pinch and Bijsterveld, 2004: 644).

the compact cassette. First, it avoided the problems associated with magnetic recording systems such as reduced quality and inherent noise. There was no tape hiss, wow, or flutter, and the fidelity was similar to CD. Second, each MiniDisc was capable of being played or recorded one million times before it would begin to suffer any deterioration. In contrast, each time a section of magnetic tape passes under a player head, some of the stored data are damaged.[25] Third, MiniDiscs are random-access media, which means that songs, for example, do not have to be stored as complete, discrete units. A single continuous song can be replayed by accessing chunks of data from locations spread across the whole disc. This allowed for faster accessing of data, in contrast to the fast-forward and rewind of tapes.

Sony also introduced an anti-bump system for MiniDisc players that would later become standard on almost all portable music devices. Instead of having the player's laser read data from the disc and send them directly to the decoding and amplifying circuits, the anti-bump technology allowed a given amount of upcoming audio data to be stored in a buffer system several seconds in advance (the precise buffering time varies from player to player). Thus, the system had enough leeway to provide uninterrupted audio signal even if the laser had been jogged out of place and its position had to be reset. This made portable players a much more practical and attractive option for consumers.

An audio CD can hold approximately 80 minutes of 16-bit, stereo audio. In order to make their new platform compatible and competitive, Sony strived to ensure that MiniDisc was capable of storing an amount of audio data comparable to that contained on a CD. Maintaining audio fidelity as far as possible was paramount; consumers had by this point become accustomed to the relatively high quality sound offered by CDs. If MiniDisc was to stand a chance of commercial success it needed to be of similar fidelity to CD.

[25] On the official website, Sony claims that the PRMD-74 blank MiniDisc offers an "extremely low error rate unaffected by one million erase/read/write cycles" (Sony, 2011b).

In order to achieve this feat, Sony developed an audio compression technology called Adaptive Transform Acoustic Coding (ATRAC).[26] The purpose of the compression was to reduce the amount of data required to be stored in order to produce a subjectively acceptable reproduction of an original sound signal. Audio compression technologies such as ATRAC work on the assumption that within the original signal there is a certain amount of information that is redundant because the human auditory system simply does not process it. The eventual audio compression is achieved in three ways: by not recording the unnecessary data in the first place, by transforming them into other sounds, or by eliminating them after recording. The sound data that are ignored, transformed, or removed are present at the sound source, but cannot be discerned by the human ear. As such, their absence at the point of listening goes unnoticed.

To ascertain which sound data in any given signal were expendable, Sony looked to the principles of psychoacoustics, the science of the human perception of sounds. Two of these principles are not only essential to theories of perceptual audio encoding, but will also form the basis for discussions throughout this dissertation and thus are explored here in some detail.

First, the human ear does not have a flat frequency response. Figure 2.2 is a graph of Fletcher-Munson equal loudness contours, showing "the intensity at which a sine wave must be presented, as a function of frequency, in order to sound equally loud as sine waves at other frequencies on the same curve" (Cook, 1999: 72).

[26] ATRAC is what is often described as a 'codec': a contraction of two terms (compression and decompression) used to denote a method or protocol for both compressing audio for storage, and decompressing it for playback. It should be noted, however, the word compression is "often used for this kind of action, although the meaning in this application is not totally the same as in a computer environment" (Maes, 1996: 65).

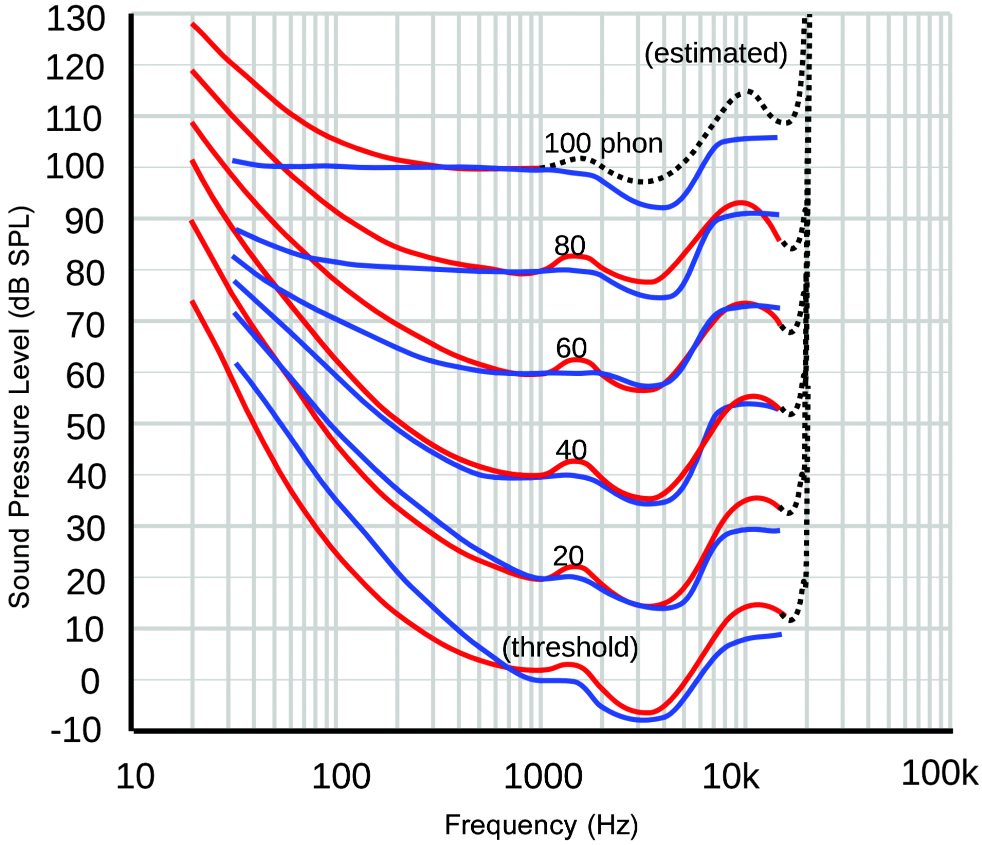

Figure 2.2 *Fletcher-Munson equal loudness curves (blue lines) and International Standards Organization (ISO) revisions from Standard 226: 2003 (red lines)*

The graph shows that some frequencies will be more easily heard than others, and that "a sound at a given frequency must have a minimum level in order to be perceived" (Maes, 1996: 61). For example, when presented at a sound pressure level of less than 10 decibels (dB), the A below middle C on a keyboard (220 Hz) will be inaudible.[27] This minimum level of hearing is represented by the lowest curve on the graph and is known as the threshold of audibility. The A lying just over two octaves below middle C (55 Hz), will be more or less inaudible below a sound pressure level of 40 decibels (dB). This may seem a little far-fetched; playing this low A on a piano will certainly produce an

[27] The decibel is a logarithmic unit used to indicate power ratios in a wide variety of scientific and engineering applications. In acoustics, the decibel indicates the ratio of a sound pressure level to a specific reference pressure level of 0 dB, defined as 2 x 10^{-4} microbars, which is the generally accepted lower limit of human hearing.

audible note, even with gentle pressure applied to the key. However, the note produced by the piano will not be a pure sine wave—as is the case for sounds on the graph above—but will instead be rich in harmonics (multiples of the fundamental frequency) that add loudness to the sound and have lower thresholds themselves.

As the graph suggests, the relation between frequency and loudness is a complex one. It is complicated even further by the fact that each human ear is not only different, but also subject to change. As people get older, their sensitivity to high frequency sound decreases, and prolonged exposure to sound pressure levels above 100 dB can permanently damage hearing. Nonetheless, it is possible to remove from recorded audio data some or all of the frequencies that sit under the threshold of hearing curve without altering the perceived sound on playback for the majority of listeners.

The second principle of psychoacoustics exploited by Sony's ATRAC codec is the phenomenon of 'masking', which refers to the occlusion of one frequency in the spectrum by another (usually adjacent) frequency. Figure 2.3 shows a graphical representation of simultaneous masking. The masking signal (green bar) creates an upward and downward 'spread' of masking, represented by the asymmetric red lines. This spread of masking is frequency and loudness specific; in order for a sound not to be masked, it must be of a certain frequency *and* loudness, relative to the masking signal. Signal A and Signal B are both of equal loudness, but Signal B is audible because it is composed of higher frequencies. Conversely, imagine a Signal C that was of the same frequency as Signal A but twice as loud. This Signal C would penetrate the downward spread of masking and thus be audible. (The graph also includes a line to represent the natural threshold of hearing, as per the Fletcher-Munson equal loudness curves in Figure 2.2):

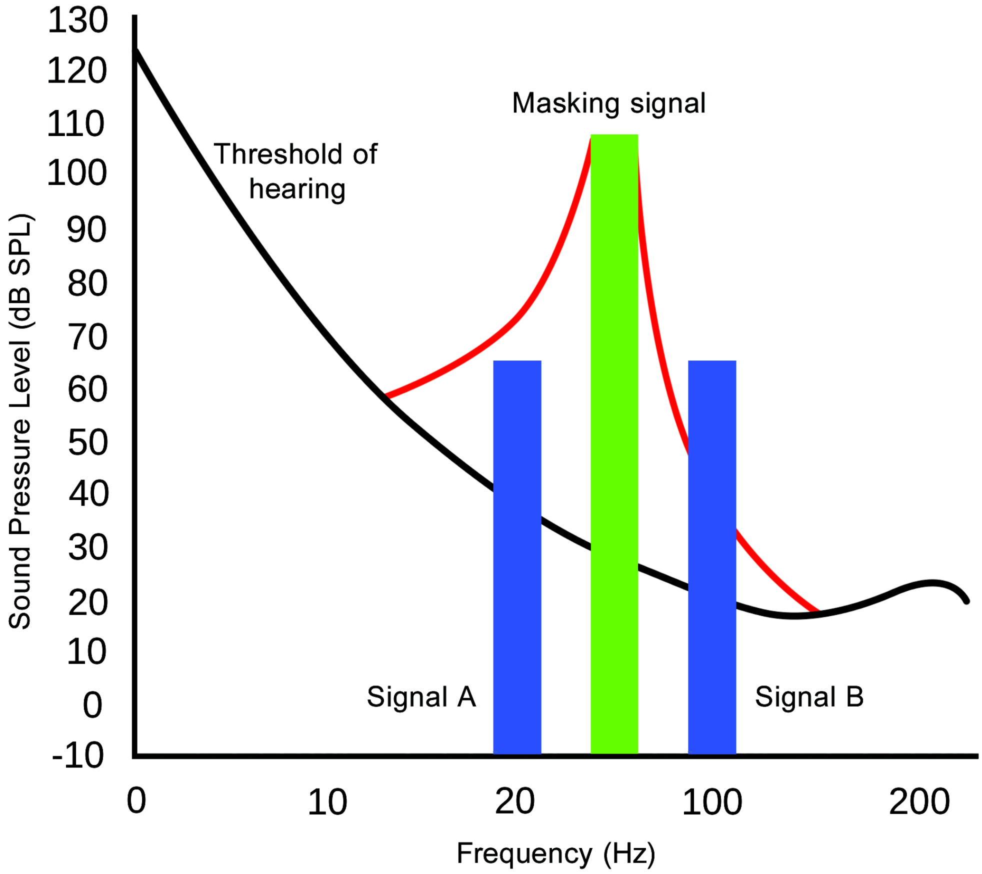

Figure 2.3 *Simultaneous auditory masking of lower frequency, quieter signal by higher frequency, louder signal*

By way of an analogous explanation, imagine standing in a room, whispering very quietly whilst a person standing close by is shouting loudly. If the difference in loudness is sufficient, a person at the other end of the room will not hear the whispering, even though it is creating sound waves that would be audible to them were it not for the person shouting. This is an example of simultaneous masking.

Temporal masking occurs when one frequency occludes another that sounds shortly after or even *before* it. Again, by way of analogy, imagine clicking your fingers a fraction of a second before someone else fires a gun. A person situated at the other end of the room is likely to have only heard the sound of the gunshot, the click having been retroactively obscured by the sheer loudness of the gunshot. Deconstruction of complex sound signals into individual frequencies with specific levels (using Fourier analysis) allows data to be removed according to the principles of masking without altering the perceived playback.

Since its first incarnation as the algorithm behind MiniDisc-based audio compression, ATRAC has evolved through several generations, including ATRAC 3 and ATRAC 3 Plus. Their different compression capabilities relative to CD quality audio are shown below:

	CD	ATRAC	ATRAC 3	ATRAC 3 Plus
Bitrate (kbps)	1411	292	132	64
Data size of 4 minutes compressed audio (megabytes)	42.33	8.77	3.97	1.94
Number of 4-minute tracks per audio CD	16	79	176	360

Figure 2.4 *Compression capabilities of Sony's ATRAC formats compared to the linear pulse code modulation used in Red Book CD audio*

Linear pulse code modulation (LPCM) is a form of encoding used for storing audio data on CDs. It involves sampling both the left and right stereo channels approximately 44100 times each second (44.1 kHz). The sampled waveform amplitudes are converted into 16-bit binary words, which are then strung together and recorded onto the disc. One minute of music, encoded in this manner, will create nearly 10 megabytes of data, allowing a typical CD to store approximately 74 minutes of audio data. This equates to approximately 16 four-minute tracks. Encoding with the ATRAC 3 Plus compression algorithm, however, allows approximately 360 tracks to be stored on a single CD. Crucially, each generation of ATRAC compression algorithms should, according to Sony, provide the listener with a listening experience that is indistinguishable in terms of subjective audio quality from that of its predecessors (Sony, 2011c).[28]

Even though it demonstrated comparable audio quality, MiniDisc never really posed a serious commercial threat to CDs. The cost and availability of the first MiniDisc players discouraged many consumers from adding them to their domestic hi-fi setups.[29] The robustness and compactness of the portable players made them ideal for portable audio recording, but they were mainly used for fieldwork and as personal stereos that could play compilations. Prerecorded MiniDiscs were available from major retailers, complete with album artwork and liner notes. However, the nature of the music industry in the late 1980s and early 1990s was such that many electronics companies bought, or attempted to buy, the rights to the music catalogues of record companies or even the companies themselves (hence the current union of Sony BMG). Doing so allowed the electronics companies to release a range of commercially popular music on the platform of their choice that would in turn drive sales of their latest hardware. Unfortunately for Sony, their acquisition of CBS Records was met with resistance from other major labels, and the launch of MiniDisc suffered a heavy blow (Tom Hutchison et al., 2010: 405). The result was a limited offering of popular releases that were considerably more expensive than their CD

---

[28] The most recent addition to the family is ATRAC Advanced Lossless encoding. This format boasts the ability to reduce CD-quality music (i.e., 44.1 kHz sampling rate) to half its original size without affecting the perceived sound quality.

[29] Only portable, Walkman-style players were introduced at first, with stationary units becoming available later. The first generation of portable players retailed at approximately $650, and models capable of *recording* to MiniDisc (not just playing them) cost upwards of $800 (Ratazzi, 2004: 8).

counterparts. Despite MiniDisc's inability to penetrate the consumer audio market, ATRAC laid the foundations on which several digital music platforms would be built in the years following its release.[30]

2.11 Digital music files

In 1985, Apple Computers—in conjunction with programmers at Electronic Arts, a computer games company founded in 1982—developed the first digital music file format, AIFF (Audio Interchange File Format). This allowed audio to be stored on computers as streams

[30] Digital Audio Tape (DAT), Digital Compact Cassette (DCC), DVD-Audio, and Super-Audio CD, are just a handful. Like MiniDisc, however, the majority of them failed to become serious contenders for a place in the recorded music market (despite being used extensively elsewhere in more niche applications) and are becoming less commonplace or disappearing altogether. The DualDisc platform, for example, was released in 2004 and offers an audio CD-type medium on one side, and a DVD-compatible medium on the other. It was developed and introduced by a consortium of record companies and provided the opportunity for inclusion of extra DVD content (such as live concert footage and interviews) to accompany the traditional audio material. At the time, label bosses such as Sony's Thomas Hesse hoped the visual media would be harder to pirate and that DualDiscs would therefore "drive people back to the store and away from taking a friend's purchased disc and just ripping it or going to the Web and stealing it" (Hesse quoted in Breznican, 2005: paragraph 15). Commercial supporters also hoped that in time it would lead to the adoption of DualDisc as the preferred choice for physical recorded music products (Billboard, 2005) and a number of major artists went so far as to release material *only* on DualDisc. But the platform has enjoyed only limited success. At the time of writing, leading music retailer Amazon lists only 980 music releases available on DualDisc, compared to 3,059,907 music CD releases (results taken from Amazon.co.uk search conducted on 10th August 2012). A small proportion of both figures will be duplicates, but it gives a reasonable indication of the current relative market share of each platform. Funk notes that DAT and DCC did not accrue "a critical mass of users" and, as a result, were unable to "overcome the demand-based economies of scale that exist with CDs" (Funk, 2007: 13). As will be discussed in Chapter 4, the adoption and success of a new platform depends on the switching costs that potential consumers are likely to incur.

of pulse code modulation (PCM)—much like CDs.[31] The non-compressed nature of AIFF files makes them ideal for fast transfer from computer hard disk to whichever application might be using the data, especially in situations where multiple audio files are being used simultaneously, such as digital mixing. Compressed files stored on the hard disk have to be decompressed before they can be used by applications, reducing the speed of transfer from hard drive to application.

AIFF was followed in 1992 by WAV (Waveform Audio File Format), an equivalent developed by Microsoft and IBM. Both are still in use today, and their superior sound quality and uncompressed nature makes them particularly suitable for high-end audio applications—such as sound archiving, broadcasting, and music studios—where audio quality is paramount and data storage limitations are rarely an issue. By the same token, such files are invariably quite large, usually amounting to approximately 10 MB of data per minute of audio. In the early 1990s, the emergence of the Internet and improvements in desktop computing facilitated (and to a certain extent encouraged) the transfer of digital audio files from one computer to another, whether between supercomputers in the same lab or between home computers on opposite sides of the world. Unfortunately, the speed at which files could be copied or downloaded was greatly restricted by the physical infrastructure underpinning such transfers, and large files were often problematic to transfer. Although academic and military computer networks were served by dedicated, state-of-the-art hardware, most early domestic Internet data transfer took place through the existing network of telephone lines. These were colloquially known as 'dial-up'

[31] The relationship between music and computers goes back much further than the late 1980s; synthesizers have been in commercial and professional use since the 1960s and were succeeded in many applications by MIDI technology at the start of the 1980s. Even as early as 1951, performances of 'Baa baa black sheep' and 'In the mood' were recorded on a Ferranti Mark I computer at the University of Manchester (Fildes, 2008). Nevertheless, this section is primarily concerned with sound recorded or transferred onto a computer, rather than music composed by a computer.

connections, capable of delivering data at a rate of 56 kilobits—56000 digital 1s and 0s—per second (kbps). Because decimal *kilobits* (used to measure data transfer speed) and binary *kilobytes* (kB, used to measure the data themselves) are different, a connection offering a speed of 56 kbps actually equates to a theoretical transfer speed of 7 kB of data per second. Three minutes of audio—approximate to a pop song—stored as a 44.1 kHz, 16-bit, stereo WAV file would create a file of approximately 30 MB in size, or 30,720 kB. At 7 kB per second, such a file would take over 70 minutes to download. However, Internet transfer speeds are rarely, if ever, as fast as theory would predict; real-world speeds are often 50 to 80 per cent of the theoretical or advertised maximum (Kang, 2009). This could increase the time taken to download a 30 MB WAV file to nearly 3 hours.[32]

Building on previously unconnected research into psychoacoustics and audio compression[33], the Moving Picture Experts Group (MPEG)—in conjunction with engineers at the Fraunhofer Institute in Erlangen, Germany—set out to create a compression standardization that would reduce the gargantuan amount of visual and audio data that constitute a film to files of a manageable size, such that they could be quickly and easily stored on and shared between computers (Katz, 2004: 161). The result was the audio standard MPEG-1 Layer 3, or MP3, as it is commonly known. Although one of many digital audio file formats, MP3 has in many circles become synonymous with almost all types of digital audio file formats: a catch-all term often used by consumers, businesses, journalists, and so on to refer to any digital audio file format, regardless of the compression algorithms involved.[34]

---

[32] Even in 1996, this author remembers a 3 MB digital music file taking more than 6 hours to download.

[33] See Ehmer (1959), Krasner (1979), Mayer (1894), Schroeder et al. (1979), and Terhardt et al. (1982).

[34] There two other types of compression standard very closely related to MP3: MPEG-1 Layer 1 and MPEG-1 Layer 2. The difference between these layers stems from the different psychoacoustic models used for encoding. For example, the psychoacoustic model used by Layer 1 is

In an echo of Edison's naïveté regarding the potential applications for the phonograph, it had not occurred to the members of MPEG or the Fraunhofer engineers that this would be employed for compressing digital music files. "Nobody, I promise you," said Leonardo Chiariglione, president of MPEG, "had any idea of what this would mean to music" (Mann, 2000: 53).

MP3 compression is based on the same psychoacoustic theories as Sony's ATRAC standards. It uses the limitations of human hearing to identify and remove redundant data from the input signal whilst preserving a subjectively similar output signal. As well as exploiting the finite frequency response of the human ear and the phenomenon of auditory masking discussed earlier, MP3 compression capitalizes on the inability of the human ear to spatially resolve stereo signals at very low or very high frequencies (Breebaart et al., 2005). Converting stereo signals at these frequency extremes into mono signals further reduces the information required to convincingly reconstruct the sound.[35]

For the engineers in the MPEG and at the Fraunhofer Institute, the difficulty lay in finding an algorithm that would carry out this destructive compression in an effective way. Destructive compression loses information during the compression process that cannot be retrieved. (It also became known retrospectively as 'lossy' compression, in comparison to lossless compression, its non-destructive counterpart). The destruction or loss of data is not problematic when all that is required upon decoding is to faithfully reproduce the sound to the human ear. But where editing, mixing, processing or archiving with no loss of sound quality is concerned, lossy compression often does not

---

much less complex than that used for Layer 3, and consequently, a much higher bitrate is needed for transparent encoding (Fogg, 1996). Due to the size of files they produce, Layers 1 and 2 are used mainly on state of the art technology (akin to AIFF and WAV) and Layer 3 on more modest systems, i.e., where data storage is at a premium.

[35] Although different encoders work in different ways, it is common practice to leave the midrange frequencies (1 kHz–4 kHz) unaltered, as this is where the human auditory system is most sensitive (see Fletcher-Munson equal loudness contours in Figure 2.2).

suffice. For such purposes, lossless compression is necessary. Because lossless compression preserves every element of the input signal it will not reduce the size of a given file by the same factor as a lossy compression format such as MP3, but significant compression can be achieved nonetheless.

The algorithms used in MP3 compression are sufficiently complex to prevent a full exploration of them here but the general principles are quite easily summarized. First, filters are used to split the audio signal into 32 frequency sub-bands, each of which the human ear hears separately. Second, the psychoacoustic model of the ear determines the amount of masking caused by adjacent bands that is tolerated for each individual band. Third, frequencies in any band where the power level is below that of the masking threshold, are discarded. Fourth, if the frequencies in any band are of sufficient power, the algorithm determines the number of bits required to represent them. Finally, these bit representations are formatted as a bitstream, i.e., a binary string of Is and 0s constituting a digital signal.

After these operations have been performed, the bitstream itself is then compressed using a coding procedure devised by mathematician David Huffman in 1952. Like the algorithm mentioned above, Huffman encoding is incredibly complex. In essence, it employs a method for selecting the representation of each character to be encoded that results in a prefix-free code, subsequently reducing the file size by optimizing the data code for the most often used signals (Huffman, 1952).[36]

Another algorithm is then employed to decompress the bitstream in order to play the file back. After decompression, the output signal sounds so similar to the uncompressed input signal that, in theory, the

---

[36] This form of encoding has been mathematically proven to be the most efficient compression process; no other procedure produces a smaller average output whilst maintaining the same fidelity. For a full explanation see Huffman (1952).

human ear cannot perceive any difference. Crucially though, the destructive nature of MP3 compression means that the process is not reversible; the original waveform can never be retrieved in its entirety from the compressed output. Attempts to convert an MP3 file into a WAV file will result in noticeable blots on the sonic landscape: missing information cannot be reintroduced faithfully, and distortion of the original signal necessarily occurs.

The tremendous popularity of MP3s amongst Internet users in the latter half of the 1990s—particularly those acquiring or distributing music through peer-to-peer file-sharing services such as Napster—gave rise to a proliferation of digital audio file formats. MP3's immediate successor, Advanced Audio Coding (AAC), was the product of extensive collaboration between the Fraunhofer Institute, audio engineering firms Dolby and Sony, and telecommunication giants Nokia and AT&T (Aspray, 2008: 459). AAC encoded files are theoretically superior to those created using MP3 algorithms, providing higher quality and transparency[37] at the same bitrate. Following the general release of AAC, MP3 continued to dominate the market despite its inferior sound quality, simply by virtue of having already become the encoder of choice for so many users, companies, and institutions. Since then though, AAC has gained some ground over MP3, largely as a result of its adoption by Apple as the standard format for the iTunes Store and a number of mobile phone companies (Aspray, 2008: 460).

At the outset of the digital audio file era, compression was paramount. Personal computer hard drives were relatively small and uncompressed music files were impractically large. It was certainly possible to store a handful of uncompressed tracks on a hard drive, but it would have been impossible to create any kind of substitute for a typical music collection of CDs, tapes, or records. Consequently, compression formats such as AAC enjoyed tremendous market success.

---

[37] Transparency refers to the ability of an encoding system to render the compressed output perceptually indistinguishable from the uncompressed input. This is discussed in greater detail in Chapter 4.

By the start of the new millennium, however, two important changes had taken place. First, digital data storage had become cheaper and more capacious. There was room for higher quality digital music files, because it was now possible to store increasingly large numbers of them on a single, relatively inexpensive hard drive. Second, as the first digital audio file formats emerged, many consumers were happy to eschew CD quality audio in favour of being able to get the music they wanted from free file-sharing services or being able to take thousands of songs with them on their iPod. As the novelty of digital music files (and all the things that consumers were able to do with them) wore off, people started once again to focus on audio fidelity.

This change in focus hastened the arrival of a new breed of digital audio: lossless encoded file formats. In recent years, these lossless digital audio files have come to almost entirely overshadow their predecessors, in terms of both their ubiquity and their often controversial role in the modern music industry. The next two chapters reveal *why* this is the case, examining the fundamental ways in which digital music files differ from every recorded music platform that has come before them, and providing evidence to support the argument that they have become (or are about to become) paragons of consumer audio in every respect.

All progress is based upon a universal innate desire on the part of every organism to live beyond its income.

(Samuel Butler in Price, 1912: 22)

3 On the origin of CDs

In 1923, American anthropologist Alfred L. Kroeber published *Anthropology*, a title that would subsequently become required reading for social science classes at many universities in the United States (Kroeber, 1923). The book contains two sketches by Kroeber, designed to illuminate the difference between living things and made things:

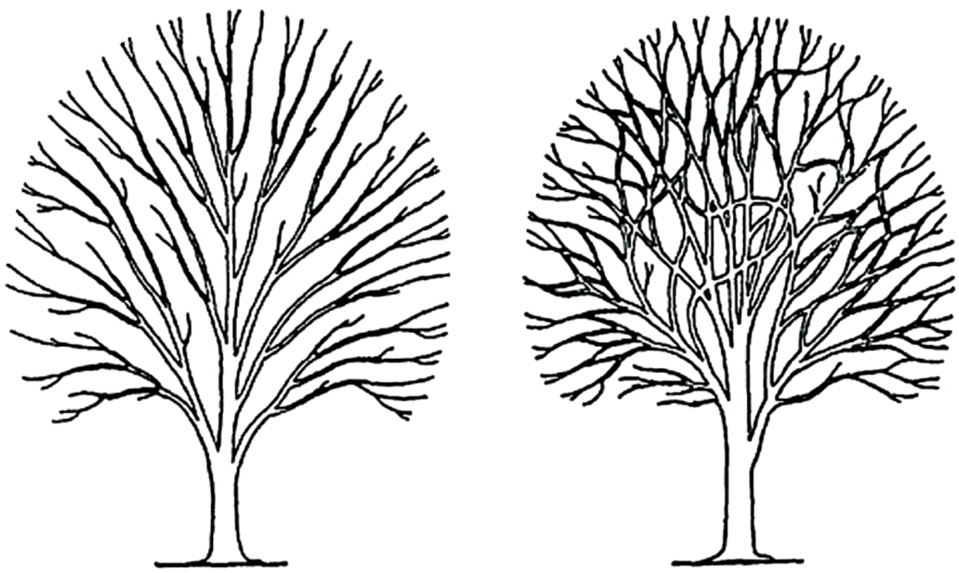

Figure 3.1 *Tree of organic life (left) and tree of cultural artifacts (right)*

Kroeber's 'living' tree of organic life is much like an ordinary tree. It comprises separate branches, emanating from a central trunk, and bifurcating repeatedly. No branch fuses with any of its neighbours, and the result is a entropic tendency toward a greater number of thinner branches, each directly traceable back to the trunk by one route only. Conversely, the artifactual tree is a little less straightforward. Different branches fuse with one another to produce unusual connections, and these often merge again with yet another branch, resulting in complex routes between the tip of the branch and the trunk. George Basalla cites a readily accessible example of complex and reticulate inter-branch productivity: "The internal combustion engine branch was joined with that of the bicycle and horse-drawn carriage to create the automobile branch, which in turn merged with the dray wagon to produce the motor truck" (Basalla, 1989: 138).

Although it is unlikely that any one tree diagram could capture the complexity of modern technological evolution at large (or even of recorded music technology, more specifically), the intention is to provide a visual understanding of how such technologies interact, and in doing so to highlight an important distinction for the purposes of this study. Many researchers and studies consider recorded music technology to have progressed along some sort of single linear track, moving neatly from one platform to the next, like branches on Kroeber's 'living' tree. Few consider the extent to which recorded music technology owes its existence to other, often wholly unrelated technologies, like the tip of a branch on the 'artifactual' tree.

Why is this debt to unrelated technologies so often overlooked? Basalla suggests there is an "excess of technological novelty and consequently not a close fit between invention and wants or needs" (Basalla, 1989: 135). As a result, individual users and consumers as a whole must choose between various technologies, selecting those that are useful and discarding those that are not. Those selected are woven into the fabric of technological life, relied upon, and replicated in various different forms. Those that do not pass muster are discarded and generally forgotten about unless a conscious decision is made by an individual or, more likely, a group of individuals to "bring them back into the stream" (Basalla, 1989: 135). Moreover, this selection process is not necessary a straightforward question of cost-benefit analysis. It involves uncertainty and risk, resting upon "an act of faith and the judgment that an invention will prove useful to some segment of the public and that it can be developed into a reliable device" (Basalla, 1998: 143). Understandably, successful selections flourish, become part of life for those who use them, and history remembers them accordingly: "We tend to hear about the times when that act was vindicated, when an Edison or a Ford brushed aside doubts and criticisms to bring us the electric light bulb or the Model T" (Basalla, 1989: 143). The failures, on the other hand, are consigned to the waste-paper basket of technological evolution. This is often due to public dissatisfaction, technical obstacles in the manufacture or production of such a technology, or simply a hostile economic climate. As a result, tales of technological evolution tend to cherry-pick those successes that suit the narrative being drawn and ignore those that do not, as if to distance themselves from—or try to comprehend—the random nature of such evolution. In doing so, the idea of deliberate, paradigmatic technological progression along an orderly trajectory is reinforced, sometimes excessively and misleadingly so.

This risk and uncertainty goes some way to explaining why the emergence of a new platform for recorded music rarely occurs in a precise or orderly fashion. The application of new technologies to recorded music platforms can be entirely unforeseen, and the alacrity with which they are adopted depends on a great many reciprocal and unpredictable factors: "Rather like ugly ducklings, some technologies have a propensity to be transformed . . . into white swans" (Dew et al., 2004: 83). What seems to happen, according to the evidence of the preceding chapters, is that once a platform such as vinyl or tape is established within the market, various entities (record labels, engineering firms, home enthusiasts) set about trying to improve it as far as possible. Sooner or later, and with little or no regard to whether or not the previous technology has been exploited to its fullest extent, a new platform emerges with the help of technology from a more or less unrelated domain.

The successful co-option of technology into other use-domains suggests that, in accordance with Gitelman's theories, technology derives at least some of its meaning from usage, rather than entirely from inherent aspects of its design. The extent and type of usage depends on the particular technology's suitability for the task at hand, yet the task in question is often determined to a greater or lesser extent by the technology available. In other words, invention can sometimes be the mother of necessity.

3.1 Knowledge-push and market-pull

Basalla argues that inventions “are fusions of an intellectual past with a socio-economic, functional future" (Basalla, 1989: 113). He distinguishes between two types of situations that give rise to inventions. On the one hand, there are situations in which the undirected acquisition and synthesis of knowledge permit the creation of inventions at leisure, i.e., 'knowledge-push'. On the other hand, there those situations that hurry inventions into existence through economic, cultural or social pressure, even if the necessary knowledge is not present to start with, i.e., 'market-pull' inventions. The latter category is obviously more closely allied to an economic understanding of technological innovation; market forces provide stimulus for inventors as well as research and development departments to invest time and money pursuing "certain lines of enquiry" (Basalla, 1989: 143) in order to produce a commercially exploitable product. This is obviously and understandably true in many cases: more efficient turbine engines, wireless Internet, and bagless vacuum cleaners, to name but a few. However, the market-pull theory cannot explain everything, and is discredited by situations where the market has always exerted a pull, but the invention does not appear until well after the knowledge could have been available. A 1973 report from the Battelle Research Institute concludes that, amongst innovations such as hybrid grains, "recognition of the need for the innovation preceded the availability of means to satisfy that need" (Battelle, 1973: 6). Nathan Rosenberg refutes this assertion, arguing that it is "empty of meaning . . . Can one seriously maintain that the 'need' for high-yield grains, oral contraceptives, or a heart pacemaker has been unrecognized for the past centuries?" (Rosenberg, 1982: 214).

In other instances, the market was not exerting any pull, but the invention happened anyway and the market later embraced it. The motor car is a shining example of such inventiveness begetting necessity, i.e., a knowledge-push invention. Though not much more than a century old, the motor car has become an indispensable part of many people's lives but, as Basalla points out:

> The automobile was not developed in response to some grave international horse crisis or horse shortage. National leaders, influential thinkers, and editorial writers were not calling for the replacement of the horse, nor were ordinary citizens anxiously hoping that some inventors would soon fill a serious societal and personal need for motor transportation. In fact, during the first decade of existence, 1895–1905, the automobile was a toy, a plaything for those who could afford to buy one.
>
> (Basalla, 1989: 6–7)

The phonograph, tape recorder, CD player—and virtually every other platform of recorded music—fall into the same category. It would be hard to argue that they came about in order to satisfy a pre-existing want or need for a particular type of recorded music platform: "When these machines appeared on the scene, neither the technologists nor the public knew what to do with them" (Basalla, 1989: 141). The same is true of the compression technology underpinning digital music files; it was designed for use in the film industry but found an application in the music industry for which it is now perhaps better remembered.

3.2 Exaptation and recorded music technology

Accidental acquisition of technologies for particular tasks in unrelated fields is not, however, a new thing. There is evidence to suggest that many millennia ago, early hominids used fractured stones produced as a result of throwing rocks while hunting as sharp tools fit for processing animal carcasses (Schick and Toth, 1993: 143–146). This phenomenon is known as exaptation.[1]

According to Dew et al., exaptations are "features of a technology co-opted for its present role from some other origin" (Dew et al., 2004: 70). The history of technology is littered with exaptations (Mokyr, 2000) and, far from being peripheral, they are "a central and pervasive phenomenon in the development of technology over time and, as such, are an important phenomenon in any theory of economic change" (Dew et al., 2004: 70).[2] Dew argues that "a strong focus on the adaption of technology products and processes to user needs and efficiency criteria has generally obscured the phenomenon of exaptation, which points to the *non*-adaptive origins of many technologies, and the process by which they are later co-opted for other roles" (Dew et al., 2004: 70).

A logical but nonetheless striking understanding that emerges from the notion of exaptation is that, if technologies can be exapted for completely unforeseen circumstances, then they are, on the whole and in the first instance, used for only a fraction of their potential applications. Dew et al. argue "no finite limit exists for the exaptive potential of a given technology" (Dew et al., 2004: 71). If this is true, it is

---

[1] One study demonstrated that, of all basic scientific discoveries and inventions, 41 per cent had no immediate use. It took approximately 25 years—on average—for them to be usefully applied (Comroe, 1977).

[2] Mokyr (2000) argues that exaptation is probably more common in technological history than in natural history. Most pioneering inventions of the modern age, he suggests, emerged from technology employed in applications that were quite different from what eventually turned out to be the invention's primary domain.

unsurprising that so much of the technology governing the industry of recorded music is exapted from other areas. It becomes even more understandable when one considers how reluctant the record industry has been to invest in new technologies. The technologies central to recorded music platforms are invariably a product of both knowledge-push and market-pull. Although the transfer of application of the technology is often knowledge-push, the final shape of the technology is usually determined by market-pull, i.e., commercial interests, rather than purely utilitarian or ergonomic motives. In some cases the market does not 'pull' at all. Quite the opposite, in fact. Some commercial entities have actively tried to prevent new technologies entering the marketplace in order to protect their financial interests: "In the 1980s, record companies were at first reluctant to adopt the CD as a platform to release music and to agree on a standard, unless the major electronic manufacturers agreed to keep CD-recording equipment at prices too expensive for domestic consumers—or even off the market, for at least ten years" (Patokos, 2008: 233–234). But it is not only the potential or intended *users* of a particular technology who resist exaptation; the *inventors* of technologies sometimes do, too. The seriousness with which Edison viewed his work on the phonograph was sufficient for him to resist the application of it to domains of use that he deemed trivial (Dew et al., 2004: 76).

Some might argue that exaptations are merely unintended consequences. For example, being able to remove a beer bottle top with a plastic cigarette lighter, even though the lighter was never designed to do such a thing. This perspective, however, ignores two things. First, exaptation "thrives on acts such as connecting a technology with a new domain of use—in other words, on technology-domain combinations, not on technology-technology combinations" (Dew et al., 2004: 73). Exapting a technology from one domain to another requires a conscious and deliberate recognition and assessment of the potential of that technology in the new domain. Second, such an approach overlooks the fact that "the act of exapting a technology normally requires deliberate leveraging of effects of a technology that would otherwise have been dormant or perhaps gone unnoticed" (Dew et al., 2004: 74). Laser technology was exapted for storing and playing video data but not by simply pointing a laser at a VHS cassette. Great effort, research, and money went into rendering it usable in the domain to which it had been exapted.[3]

More pertinently, perhaps, "the exaptation [of the phonograph] was the primitive jukebox", an exaptation that was "in retrospect obvious" (Dew et al., 2004: 76). For all its wisdom, this retrospectiveness does not assist with spotting the next exaptation, mainly because exaptations are always context-dependent. The defining features of such contexts can be technological, social, cultural, financial even legal, and the unique set of conditions that give rise to a particular exaptation are virtually impossible to predict.[4] If future contexts elude prediction, then the list of possible exaptations for any given technology is even more incalculable. This uncertainty is amplified when many technologies that one might refer to as single entity are, in fact, combinations of many other technologies, and any one of these components might be exapted on its own. The result, suggests Rosenberg, is a "listing of failures to anticipate future uses and larger markets for new technologies [that] could be expanded almost without limit" (Rosenberg, 1996: 95).

---

[3] Rosenberg describes the extent of the laser's exaptation as "still surely in the early stages of its trajectory of development" and its range of unforeseen uses as "truly breathtaking" (Rosenberg, 1996: 336).

[4] That socio-cultural factors play a significant part in how various technological innovations are adapted is demonstrated quite neatly by three renaissance inventions: the printing press, gunpowder, and the magnetic compass. All three were products of Chinese civilization but the full extent of their impact was felt in the West, not in China. This suggests that the cultural influences at play in East and West were sufficiently different to have a radical effect on how these technologies were dispersed and adopted (Basalla, 1989: 169–170).

3.3 Technological perfection and ideality

What becomes of these exaptations, improvements, refinements, risks, uncertainties, selections, and uses? Can technology improve indefinitely? Will technology ever reach a point where it can 'go no further'? There is a tendency in this kind of discussion to deal in vague ideas of technological improvement and ill-defined terminology. Julian and Codrin Blosiu sought to create a road map of technology development in order to provide benchmarks against which forecasted technology evolution could be measured. In order to clarify such notions as state-of-the-art, they gave useful and important definitions of technology perfection performance and ideal performance (Blosiu and Blosiu, 2000). This distinction is central to the discussions that follow and, as such, is quoted at length below:

> The notion of 'perfection' and the notion of 'ideal' have in fact a similar but different connotation. 'Perfection' is defined as the state of performance of being entirely without fault or defect as per initially specified functional requirements, and where all predetermined performance requirements are being satisfied. 'Ideal' is defined as an ultimate objective or aim of performance endeavour that is reaching an ultimate goal of a mental image that exists only in fantasy or imagination. All engineering systems have the natural development tendency of approaching the imaginary ideal system. For that reason, perfection is a practical and obtainable performance characteristic of a technology at a given state-of-the-art level, where the ideal is the ultimate imaginary state of the unreachable perfection. In the real world of creative technology development and improvement, there is a continuous tendency towards proximity to perfection, as well as a perfection proximity towards ideal.
>
> (Blosiu and Blosiu, 2000: 322)

Using the evolution of clock technology as a simplified example, the graph below provides a visual example of this distinction between perfection and ideality:

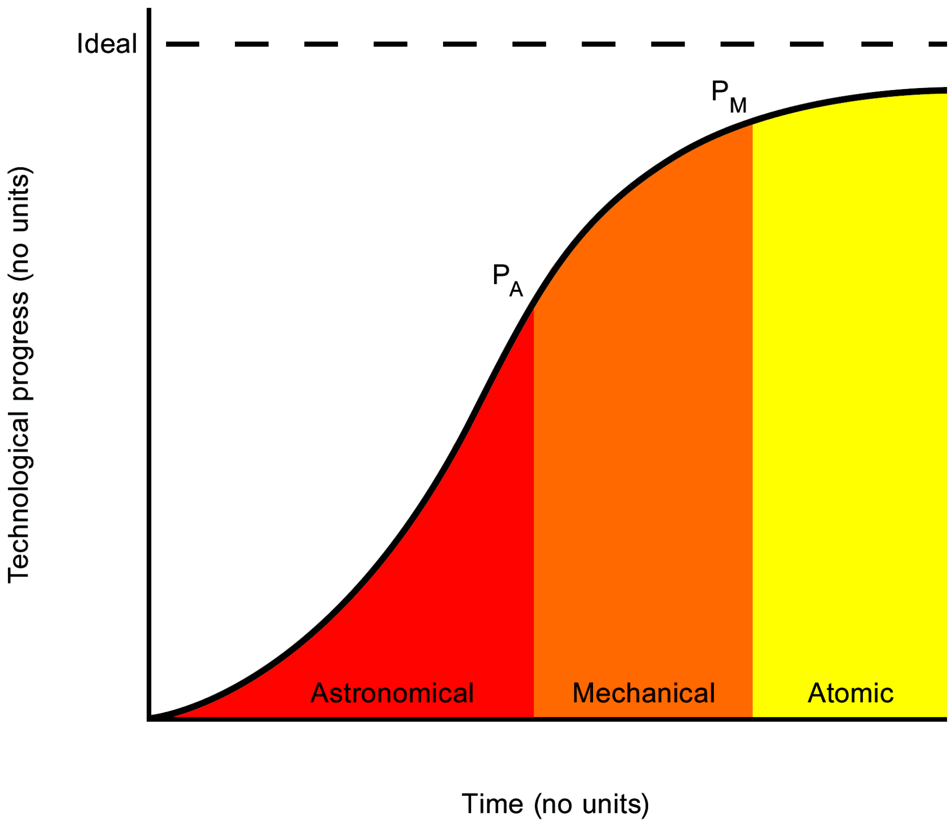

Figure 3.2 *Evolution, perfection, and ideality of clock technology*

The coloured sections of the graph represent three broad categories or sub-sections of timekeeping: astronomical, mechanical, and atomic. Astronomical would include methods like lunar and solar calculations, mechanical would include devices such as pendulum clocks and wristwatches, and atomic would include the more advanced caesium fountain and quantum clocks. The dashed line represents the technological 'ideal'; the imaginary and, for Blosiu and Blosiu, unachievable point toward which the proponents of each specific technology are aiming. In the case of timekeeping, this ideal is the ability to keep perfect time over an infinite timespan. The curved black line describing the upper edge of the coloured sections represents the evolution or progress of timekeeping technology as a whole, comprising the cumulative progress of each individual type of technology. This line tends toward the ideal, without ever quite reaching it, but the sub-sections within it each reach their own stage of perfection (the points P_A and P_M denote the perfection of astronomical and mechanical technologies respectively).

Platforms of recorded music follow in a similar although perhaps less ordered fashion. Those involved in the development of the earliest platforms were concerned primarily with fidelity, striving for ever greater frequency response and realism in reproduction. Many improvements were made, but the sticking point was ultimately the sonic sensitivity and limitations of needle-and-groove technology. Progress along and up the 'curve of evolution' happened relatively swiftly, and although small improvements have been made since, it is conceivable that, in traditional vinyl disc technology, perfection has been achieved, even though ideality has not.

The minds behind tape technology were likewise concerned with fidelity; namely, matching and improving upon the standard set by vinyl. Out of tape technology, however, sprang a previously unprecedented level of editability: a characteristic with which developers of earlier platforms had scarcely concerned themselves. Once the technology became cheap enough to market to the public, tape allowed the average consumer to edit and reproduce recorded music relatively easily.

So, technological progress, particularly with respect to recorded music platforms, is more complicated than it might seem. The next chapter explores the six characteristics of recorded music that have been variously improved upon with the advent and perfection of each platform, and the proximity of digital music files to the imaginary state of ideality.

Any sufficiently advanced technology is indistinguishable from magic.

(Arthur C. Clarke, 1961: 36)

4 Perfect in every way?

Crucial to this thesis is an appreciation of the fundamental differences between digital music files and every other platform of recorded music that has preceded them. This chapter identifies six separate characteristics of recorded music, all of which have been affected at various times and in various ways by the evolution of recording technology. Without exception, each new platform for recorded music has in some way made room for improvement in at least one of these six characteristics, although not necessarily without detriment to one or more of the others.

It is in the scope of these improvements that digital music files, as a platform, are fundamentally different to any of their predecessors. For the first time in the history of recorded sound, technology has achieved (or could foreseeably achieve) the theoretical perfection of all of these characteristics. Explanation and justification of this claim follow, but the pivotal point is this: far from simply continuing or exaggerating the trend that forms the customary narrative of the traditional histories of recorded music, digital music files have completely reengineered our relationship with and understanding of the production, distribution, and consumption of music in a very profound way.

Particular attention is paid to the ways in which digital music files have become paragons of consumer audio: zero loss of quality from one copy to the next, theoretically infinite durability courtesy of the robust nature of digital code, global compatibility across a huge range of devices and formats, and so on. Such an exploration leads to a "robust understanding of the technological and aesthetic dimensions" of digital music files (Sterne, 2006: 827). Consequently, it provides a more appropriate context for discussions of how digital music files can be produced, distributed, and consumed in fundamentally different ways to previous platforms of recorded music.[1] This, in turn, allows a sharper contrast to be drawn between the traditional, historically accepted social function of music and its modern, culturally enacted correlate.

Following the explorations of the preceding chapters, we are now able to scrutinize these six characteristics within a broader context of perfection performance and ideal performance. Each characteristic has its own trajectory of sorts, along which it reaches several stages of perfection (usually once within each platform) whilst tending to ideality.[2]

For Blosiu and Blosiu, such trajectories will continue to tend toward ideality without ever achieving it; ideality will always be a mental construct rather than an achievable state (Blosiu and Blosiu, 2000). The fantastic or imaginary nature of ideality stems from a collective tendency to base notions of the 'ideal' on our collective capabilities at the time. As the capabilities advance, so the notions of 'ideal' are reconstructed. With major contemporary technological progressions like stereo sound, the mental possibilities entertained by consumers, inventors, designers, and manufacturers jump forward as well, leaving technologists chasing the shadows in front of them.

The re-examination in Chapter 2 of recorded music's history demonstrates that without exception, every new platform—from the phonograph to CDs—has improved in some way on the platforms that had come before it. This author has identified six 'characteristics' applicable to every recorded music platform that serve as the primary

---

[1] Sterne is, in fact, surprised by "how little of the common sense of technology studies has been applied to MP3s" (Sterne, 2006: 826).

[2] Funk describes the performance trajectories of platforms as a whole as having progressed through various technologies, "from electromagnetic and mass production ones in the late-nineteenth and early-twentieth century, to vacuum tubes from the 1920s, transistors, integrated circuits, magnetic tape, and plastics from the 1960s, and a variety of ones in the 1990s" (Funk, 2007: 5).

sites of improvement from one platform to the next. These six characteristics are, in alphabetical order:

1. Capacity
2. Compatibility
3. Durability
4. Economic viability
5. Editability
6. Fidelity

Although the concept of this distinct group of six characteristics and their perfection is the author's original work, two other facets of recorded music platforms are mentioned in associated literature: portability and separability. These have been excluded from the present discussion on reasonable grounds. Although Sterne considers the portability of recordings to be "as important a feature of their history as the nature of their reproduction" (Sterne, 2006: 837), portability is primarily a function of capacity combined with compatibility, compounded by an appreciation unique to each consumer of the sacrifices they are willing to make for portability, i.e., what equipment and media can they physically carry around and how much music the given media is able to store.[3] It is hard to conceive of a way in which the portability of a particular platform could be measured (or in any way quantified) that did not come under the auspices of capacity. It is even harder to imagine a method for charting the trajectory of portability's progress across platforms.

Separability warrants consideration for inclusion in the list of six characteristics, primarily for its effect on consumption habits, i.e., the ability to allow consumers the option of buying individual tracks rather than albums (Bockstedt et al., 2006: 6). It could be argued that such separation comes under the banner of editability, but there is more to it

---

[3] Consideration must also be given to the power requirements or battery life of any equipment.

than that. Separability is a convenient by-product of digital music files (and, to a lesser extent, tape and CD) but it is not something to which the creators and manufacturers of older recorded music platform ever aspired. It would be ludicrous to deny that the physicality of older platforms did not affect things like the running time of an album (and vice versa) but it stands apart from the trajectories of improvement and evolution inherent in the other six characteristics.

Each new platform has not necessarily improved upon all of these characteristics, nor have the improvements always been dramatic. Some improvements have been negligible and, in many cases, enhancement in one characteristic has been to the detriment of another. Nonetheless, it is the "cumulative nature of the improvements along these trajectories that drive technical progress in the industry" (Funk, 2007: 1).

It is in the scope of these enhancements that digital music files are fundamentally different to any of their predecessors. Technology has achieved the theoretical perfection of some of these characteristics, and is very close to perfecting the rest. Digital music files may soon represent the culmination of a struggle that began over a century ago—albeit unwittingly—to perfect the recorded music medium.

Considering each characteristic in turn permits an understanding of how digital music files can be produced, distributed, and consumed in fundamentally different ways to previous platforms of recorded music, such as the CD or vinyl record. Such an understanding is crucial if we are to better comprehend the social and cultural effects of digital music files in contrast to previous platforms. The six characteristics are explored below, each accompanied by a context-relevant definition.

4.1 Capacity

How much audio data can be stored on a given media 'unit' of the platform.

Digital audio files clearly exist in some tangible sense—they are not floating round in a massless ether—but they have, to a certain extent, been abstracted from the physical constraints of older platforms. Thomas Mock sees this as "liberating music from the last link to Edison's era; the dependence on physical, recorded media that has long confined it" (Mock, 2004: 1). A similarly fundamental change occurred the first time music was stored as *digital* data on a medium (Rothenbuhler and Peters, 1997: 245–246). A CD, for example, contains no music. It contains an array of numbers whose character and arrangement are correlated to the music in some way, but it is only in their interpretation according to given conventions (software decoding of the original signal) that the music comes into being once again. This is in stark contrast to a phonograph record, whose very surface is etched with the physical indentation of the music it represents.[1] Philip Sherburne argues this trend toward 'aphysicality', led in many ways by digital music files, epitomises "the ongoing dematerialization of music (or perhaps a better term would be 'micromaterialization' since even MP3s live in silicon, invisible as they may seem)" (Sherburne, 2003: 46). Sterne follows on from Sherburne, insisting that because of this micromaterialization, consumers are able to handle digital music files in a very different way to their 'macromaterialized' predecessors (Sterne, 2006: 832).[2] As a result of this micromaterialization, there is

1 "The phonograph inscribes not the spirit of music but its body, its acoustic being in time. Phonography captures not the code but the act, not the script but the voice, not the score but the performance" (Rothenbuhler and Peters, 1997: 243).

2 Sterne also points out that, despite this micromaterialization, most consumers of digital music files will still "talk about MP3s as if they are physical objects" (Sterne, 2006: 832).

no standard-issue unit of media for digital music files. Thanks to their extraordinary compatibility they can be easily and conveniently stored on or in a variety of media.[3] Consequently, the storage capacity of digital music files as a platform is completely reliant on the storage facilities at hand. Invariably these facilities take the form of magnetic, optical, magneto-optical, or solid-state data storage.

Even though magnetic and optical data storage predate the arrival of modern home computers by many decades, they are still the type most commonly found in the hard drives of desktop and laptop computers. Solid-state data storage (often erroneously synonymised with 'flash memory', which is one type of solid-state storage) has its origins in 1950s vacuum tube computing and has become increasingly popular in recent years. It has no moving parts, and is typically exists either as data cards for devices like digital cameras and mobile phones (such as the Secure Digital (SD) and Extreme Digital (xD) cards) or as small portable USB devices generally referred to as 'pen' or 'thumb' drives. The first of these drives came to market in 2000, with IBM's initial device offering 8 MB of storage. This was more than four times as much storage offered by the primary portable data storage medium of the day: 3.5-inch floppy disks, capable of storing 1.8 MB each. At the time of writing, data storage company Kingston were offering the DataTraveler USB drive with a capacity of 256 gigabytes (GB)—the equivalent of more than 140,000 floppy disks' worth of data storage—in almost exactly the same physical volume as a single floppy disk.[4] Consider the following infographic showing the evolution of recorded music media capacity:

[3] Media that, interestingly, can be used to store all sorts of other digital data. The first hint of this cross-media data storage came with audio cassettes which, in the late 1980s, were used as vehicles for computer games. It gradually became common to store other, non-audio data on CDs, such as software applications and photographs.

[4] A standard 3.5 inch floppy disk measures approximately 90 millimetres (mm) wide, 94 mm long, and 3.3 mm deep, with a total volume of approximately 27.918 cubic centimetres (cm^3). The Kingston DataTraveler HyperX 3.0 measures approximately 75 mm long, 23 mm wide, and 16 mm high, with a total volume of 27.769 cm^3.

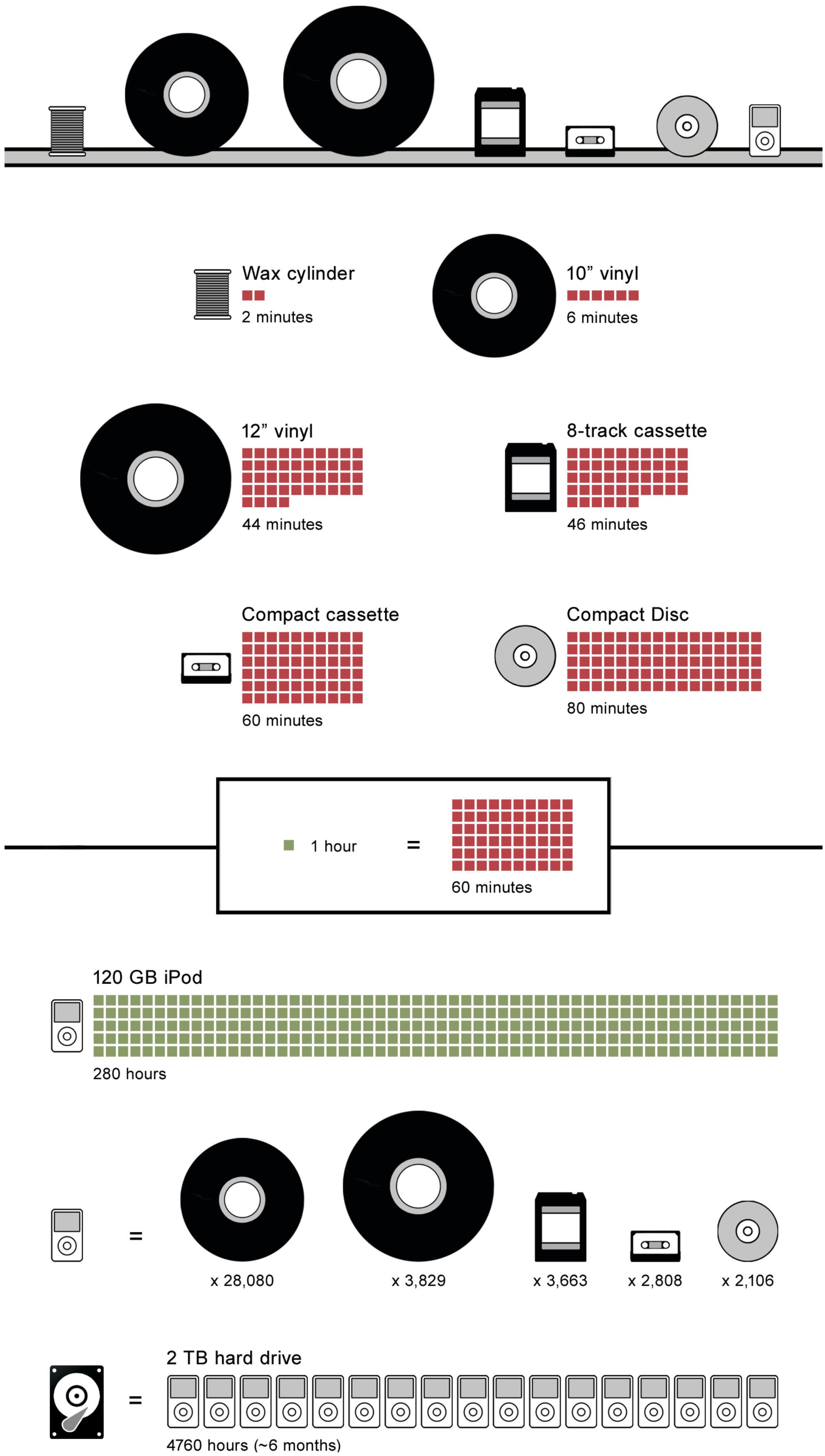

Figure 4.1 Evolution of recorded music media capacity

Not only is the capacity of storage devices increasing more or less exponentially, the devices themselves are getting cheaper, relatively speaking. Consider the following graph, which shows the cost of data storage (per GB) on hard drives, over the last three decades:

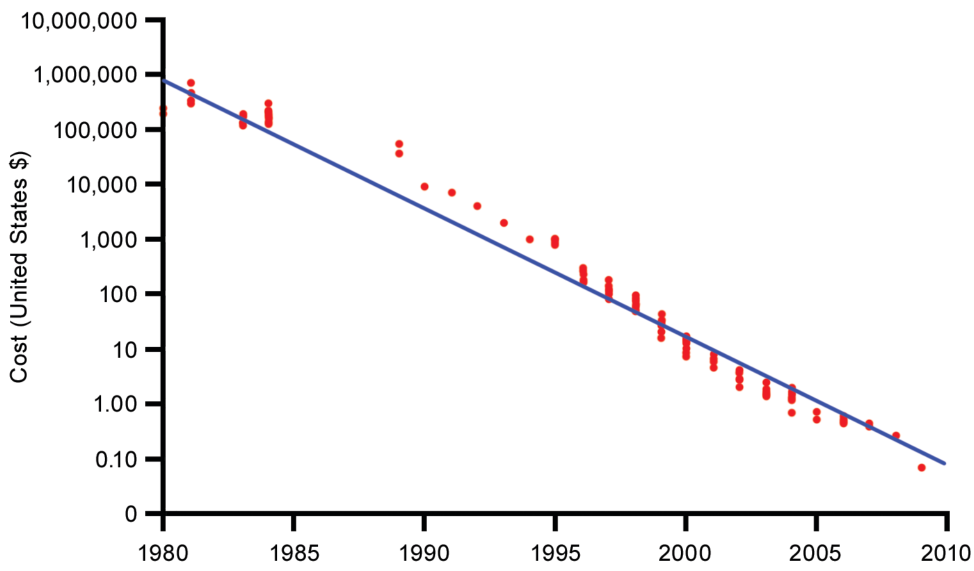

Figure 4.2 Cost per GB of data storage from 1980–2009[5]

It is important to note that the scale of the y-axis is exponential rather than linear. Thus, although the line on the graph is straight, it actually represents an almost uniform exponential reduction in cost over nearly 30 years. Clearly, the real-term cost reduction will be less and less each year if the actual cost continues to tend to zero. Nonetheless, it is likely that data storage capacity will increase year on year in a similar fashion, in accordance with Moore's law.

Much has been written about Moore's Law but, for the purposes of this discussion, a brief summary will suffice. Moore's Law states that the number of transistors that can be housed on a given integrated circuit will double every two years.[6] Data storage may not continue to

[5] The data used to construct this graph is provided in Appendix 1.
[6] This timeframe is often given as 18 months, but this refers to the time taken for *performance* to double, which equates to a shorter period

obey the same law indefinitely; there are theoretical limits to the semiconductor technology currently underpinning data storage methods.[7] However, holographic data storage has the potential to allow a similar trend to continue, offering as it does the ability to store this kind of information in three dimensions.[8]

It is tempting to make predictions for the next 20 years, but they are of limited use here. Although the rates of increase and decrease may diverge from Moore's Law—or even fail to constitute any kind of pattern—it is fair to assume that, for the foreseeable future, data storage capacity will continue to increase, the relative cost of data storage will decrease, and the size of data storage and the devices containing it will also decrease.[9]

Now to some examples of what this phenomenal data storage capacity means for housing what could loosely be called a 'modern music collection'. The Kingston DataTraveler HyperX 3.0 USB drive (mentioned earlier) is 75 mm long, 23 mm wide, and 16 mm high. This equates to a total volume of approximately 27.8 cm^3. It is capable of storing 256 GB of data. One gigabyte of storage on any medium or device will hold approximately 32768 seconds or 546 minutes of CD-quality music. This equates to just over nine hours of music. Multiplying by 256 (for the DataTraveler) gives 139,776 minutes of music, or approximately 2,330 hours. This gives a 'music density' (amount of music in hours / physical size of medium in cm^3) of 83

---

because of the combination of a greater number of processors and improved performance of said processors (Intel, 2011).

7 Funk thinks it likely that "continued improvements in semiconductor memory will have a large impact on competition between iPod-type devices and mobile phones in the playing of music and may cause the mobile phone to eventually become the dominant product class for portable music players" (Funk, 2007: 14).

8 See Coufal et al. (2000) and Bekenstein (2003) for an in-depth examination of holographic data storage.

9 In early 2012, IBM announced that they had managed to 'get ahead' of the progress curve described by Moore's Law. Following five years of research and testing, a single bit of data was reliably stored on just 12 atoms, compared to the 1 million previously required (Mearian, 2012).

hours and 48 minutes of music per cm^3. Compare this to a 45-rpm vinyl long-player record (LP), which has a volume of 141.4 cm^3 and can hold, at most, 60 minutes. This gives a music density of 0.007 hours of music per cm^3, or 25 seconds per cm^3. The music density of the USB drive is, therefore, approximately 12,000 greater than that of vinyl.[10] Assuming 15 tracks per CD, at 3.5 minutes per track, the 83 hours and 48 minutes stored on a Kingston DataTraveler would equate to 96 CDs. Stored in their cases, these would have a combined volume of 17,040 cm^3. The calculations can be performed with a variety of media, and though the answers vary from one platform to another, two things are abundantly clear. First, digital data storage allows digital music files to be stored at densities *many* orders of magnitude higher than previous recorded music media. Second, the trend is set to continue; although the average digital music file is increasing in size (from approximately 3 MB in 1998 to approximately 10 MB in 2012) the storage capabilities are far outstripping this increase.[11]

All this has obvious implications not only for portability—it is possible to carry with you in your pocket more music than you could feasibly listen to in a year—but also for how consumers select which music to store and which music to listen to. The catalogue of music made available by the free streaming service Spotify contains over 20 million tracks and grows by approximately 20,000 tracks per day (Spotify, 2013). Even as one music repository among many, this represents an astonishing collection of music. If one were to listen to Spotify for eight hours per day, five days per week, it would take approximately 480 years to listen to all the music currently available (assuming a conservative 3 minutes per track). By the time those 480 years were up, however, over 3.5 billion more tracks could have been added—according to Spotify's prognosis. These calculations are cartoonish, but they elicit important questions of musical democracy. At

---

[10] Assuming a diameter of 30 cm (12 in) and a thickness of 0.2 cm.
[11] This has an obvious overlap with cost. If two formats are of similar size and hold similar amounts of data, the cheaper is likely to be more preferable.

a time when records were expensive, and the available catalogue was limited, it behoved all but the wealthiest of consumers to spend their money wisely. Many people would not have been able to afford the records they dearly wanted, let alone to buy music they were unfamiliar with on the off-chance that it would be to their liking. For many years, the gatekeepers of the recorded music industry—record labels, publishers, promoters, retailers, and so on—have done their best to influence this decision-making process, in order to maximize their own financial gain. Consumers became accustomed, however unwittingly, to buying the music that was put in front of them. Users now have the luxury of being able to preview, in part or in whole, almost all the recorded music in the world before parting with any money for it.

As data storage increases and becomes cheaper, as computer processors become more powerful, and as Internet bandwidths and speeds get wider and faster, it seems likely that compression will become less important, and online music services will tend to offer music for download in increasingly high quality formats.

4.2 Compatibility

The extent to which a platform can co-operate with existing or future platforms.

With the emergence of every new recorded music platform, compatibility has become increasingly important. Not long after Edison invented his phonograph and wax cylinders, Emile Berliner offered an alternative in the form of the gramophone and the flat disc. The two were not compatible and consumers were faced with questions that have since presented themselves repeatedly: Which platform is better? What do I already own? Is it worth replacing my existing music collection? Are the new machine and its attendant media better than my current set-up? Are they sufficiently better to warrant repurchasing or converting what I already own? These questions are the result of the "intense ferment triggered by competence-destroying technical change" that invariably follows the emergence of any successful new technology (Anderson and Tushman, 1990: 625).

As the first half of the twentieth century gave way to the second, manufacturers of recorded music technology began to realize that compatibility was a serious issue, and one they could not afford to overlook. The first notable instance of compatibility being deliberately engineered was the design of stereo vinyl records and playback equipment. This was both 'forward' and 'backward' compatible in terms of machine *and* media; a stereo turntable would play mono records just as easily as stereo records, and a mono turntable could play stereo records in mono.[1] Many modern platforms are engineered in a similar way. SuperAudio CDs (SACDs) fit in the same hardware as normal CDs, and some are engineered to be easily transferrable to and

[1] Most stereo records did, however, carry a warning urging listeners to use a 'compatible' stereo cartridge, to avoid spoiling the disc.

from other platforms (CD onto computer, vinyl onto tape etc.). The money and effort required to ensure compatibility with other platforms is often prohibitive for manufacturers. On the one hand, they stand to gain financial benefits and market share by making a desirable platform that is incompatible with any other. If a sufficient majority of consumers adopt their new platform (for its superior sound quality or convenience, for example), the manufacturer will have a monopoly over the market, and can then exercise a degree of control over the price of media and machines. Such widespread usage and monopoly also translates into patent-based revenue streams, assuming that the new platform incorporates new and protected technology that will be licensed to other manufacturers. On the other hand, however, a complete lack of compatibility might amount to asking consumers to abandon and replace or convert their existing collection in favour of the new platform. If the incentive for consumers to do this is insufficient and as a result they are unwilling to replace or convert, the new, incompatible platform is likely to suffer.

Compatibility clearly overlaps with issues of economic viability and, more bluntly, profit. As a result, compatibility became even more important in the later stages of the twentieth century as developments in recorded music moved away from privately funded inventors like Bell and Edison (who gave little or no thought to how their inventions would cooperate with existing interests or to the financial rewards and costs of doing so) towards corporations like Sony, Philips, and Pioneer. As highlighted by the discussion in Chapter 2 of the development of the CD, companies such as these often have commercial interest in pushing product development one way or another to maximize or capitalize upon their existing portfolio, be it a range of audio equipment or a back catalogue.

The phenomenal success of digital music files as a compatible platform can be attributed to two things. Practically, they cannot be easily separated, but they are worth teasing apart here. First, digital music files demonstrate near-global compatibility across a huge range of devices. Desktop computers, laptops, portable music players, mobile phones, Internet tablets (like the Apple iPad), hi-fi systems, car stereos—these are all capable of playing digital music files of one sort or another. There are, of course, still certain compatibility issues, particularly with proprietary and protected formats such as Apple's M4P downloads and FairPlay software. Nonetheless, these are fairly limited (and often surmountable) examples of incompatibility amongst a 'sea of compatibility'.[2]

The second element of the success of digital music files is due to the abundance and ubiquity of the devices with which digital music files are compatible. A huge proportion of consumers already owned or had access to a home or work computer before digital music files really took off, and the same people—and more besides—will have continued to purchase and upgrade their computers for purposes other than listening to music, i.e., word processing, surfing the Internet, graphic design, and communicating with friends, family, and colleagues. The net result is that a vast proportion of music consumers will continue to find themselves with the necessary equipment to play digital music files, even if playing digital music files was not their primary reason for purchasing the equipment. Contrast this with the gramophone, which served no other practical purpose than to play music.

4.2.1 Network externalities

Compatibility within the recorded music industry (along with many others) is often pursued and avoided with equal vigour. Carmen Matutes and Pierre Regibeau contend that "in industries where

[2] A 1995 United States government White Paper likens this ubiquity of easily accessible music to a 'celestial jukebox': "a technology-packed satellite orbiting thousands of miles above Earth, awaiting a subscriber's order" (Goldstein, 2003: 187).

consumers can assemble their own systems, firms must decide whether to make their components compatible with those of their rivals" (Matutes and Regibeau, 1988: 221). Central to this decision must be an understanding of the costs and benefits of industry-wide compatibility, both of which revolve around the network of relationships that exist between the platform on one hand and its users and associated products on the other, as well as the relationships between one user and another.

Consider the following simple example. Purchasing a 3D Blu-Ray player will be of substantially more use (and therefore, in theory, value) to a user if all their friends have one. Assuming a certain level of trust and generosity, the user would be able to access their friends' libraries of films as *well* as their own. In contrast, if they are the only person in the country with such a piece of equipment, they are likely to find their options more limited. Michael Katz and Carl Shapiro offer a more precise and rigorous interpretation: "The benefit that a consumer derives from the use of a good often is an increasing function of the number of other consumers purchasing compatible items" (Katz and Shapiro, 1986: 146).

The effects of such relationships on the perceived value of the platform in question are known as network externalities. The diagrams below illustrate the increasing benefits of network externalities in a series of increasingly user-loaded telephone networks[3]:

Figure 4.3 (a) *Two-node network with one connection*

[3] The same can be applied, in theory, to more modern networks such as social media websites and facilities such as Twitter and Facebook.

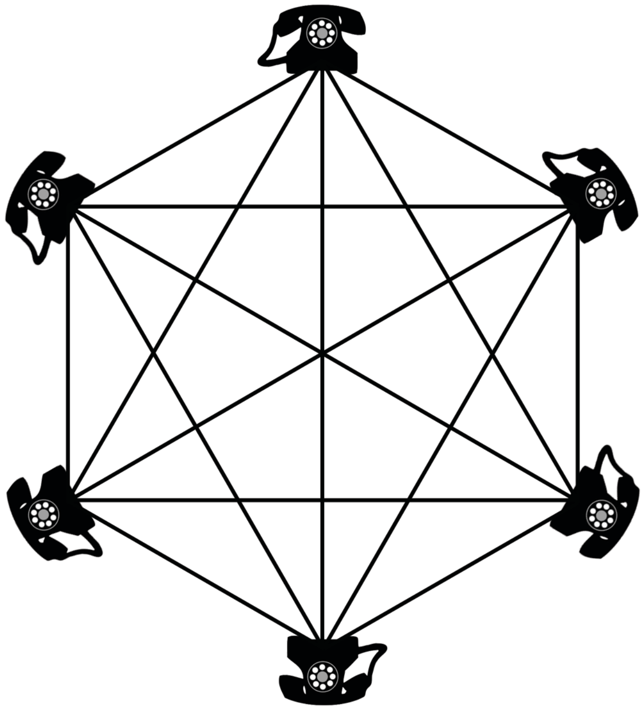

Figure 4.3 (b) *Six-node network with 15 connections*

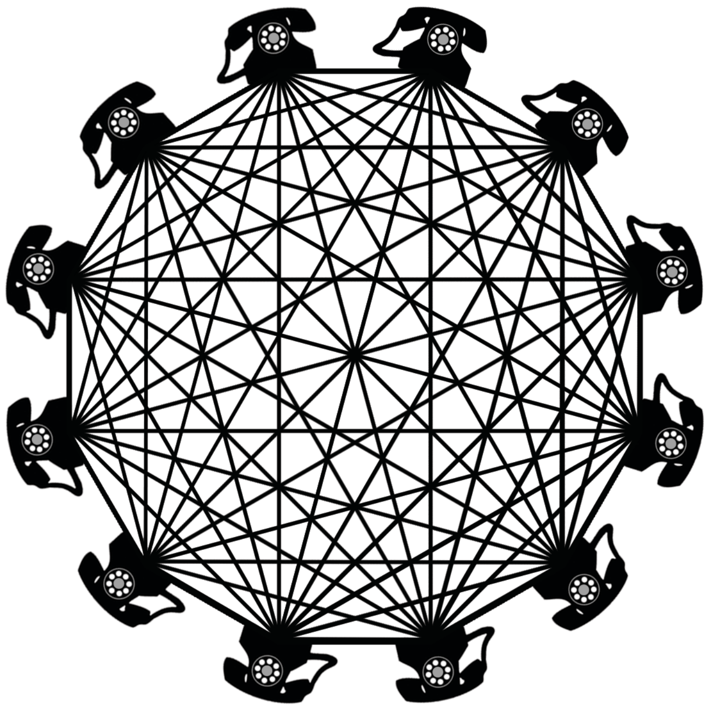

Figure 4.3 (c) *12-node network with 66 connections*

A single telephone, not connected to any other, is of zero use to a user. The greater the number of people who purchase telephones and connect to each other via the same network, the greater the number of people any one user can call and the greater the number of people who can call that user. As a result, the user's telephone—which has zero value when not connected to any other user—begins to represent better value for the user as a result of the *external* decisions made by other users. An expanded, numerical version of the information contained in Figure 4.3 is shown below:

Number of nodes (n)	**Number of connections (c)**	**Increase in connections (c) relative to next smallest network**
1	0	–
2	1	1
3	3	2
4	6	3
5	10	4
6	15	5
7	21	6
8	28	7
9	36	8
10	45	9
11	55	10
12	66	11

Figure 4.4 *Connections in networks of 1–12 nodes*

As can be seen from the right hand column in Figure 4.4, the greater the number of users already connected to the network, the greater value each additional user will represent. In the case of a network with three existing users, the addition of one more user creates an additional three possible connections. In the case of a network with 11 existing users, the addition of one more user creates an additional 11 possible connections. Accordingly, when dealing with networks on the scale of, for example, the Internet, the theoretical benefit provided by the addition of each user is of a much higher order of magnitude.

In bare economic terms, the increased value afforded by positive network externalities makes such a network more attractive to potential users. In theory, this causes more users to join the network, creating yet more positive externalities, making the network more attractive, and so on. This snowball effect often leads to a 'tipping point', after which a network is likely to achieve near-universal usage (Gladwell, 2000; Rohlfs, 2001).[4]

Despite the subconscious association of network externalities with physical phenomena, they are still "significant in many important industries where there are no physical networks" (Katz and Shapiro, 1986: 146). These can be explained in terms of hardware and software, where hardware equates to a durable good and software denotes a complementary service or good. Katz and Shapiro use the example of computing: "For instance, computers and programs must be used together to produce computing services and the greater the sales of hardware, the more surplus the consumer is likely to enjoy in the software market due to increased entry" (Katz and Shapiro, 1986: 146). So, the positive network externality is created when the availability of software increases with the volume of hardware sold.

[4] In this context, universal should be taken to mean all those users who were likely to use the network in the first place. Where users are given a choice between two networks, the network that reaches the tipping point first is likely to recruit all users, whether or not they already belong to another network.

4.2.2 Increasing importance of compatibility

As the recorded music market has matured over the last century, so the issues of compatibility have become more and more pressing for manufacturers and consumers alike. This is due partly to an ever-growing audience for recorded music, as well as the gargantuan volume of recorded music to which consumers are now able to listen, assuming they have the appropriate equipment.

The financial implications of success or failure (or somewhere in between) for manufacturers of audio equipment and recording media are now correspondingly large. A business strategy common in recent decades has been integration into the music industry by firms traditionally preoccupied with traditional consumer electronics. David Sadler suggests, quite rightly, that this process is "intimately associated with the changing form of information storage and retrieval devices, and the competitive struggle between producers of these different formats" (Sadler, 1997: 1932).

Once these companies had established an interest (vested or otherwise) in the music industry and the media on which it released its products, each new platform became "embroiled in a complex debate", the purpose of which was, in theory, to establish an "agreed set of specifications" that would promote compatibility, but was seldom resolved other than through "gradual adoption of the best-selling format", i.e., *de facto* standardization (Sadler, 1997: 1932).

Competition between their respective hardware systems brought electronics firms such as Pioneer and Sony closer and closer to the music industry, eventually resulting in unapologetic mergers with (or acquisitions of) traditional record companies, such as Sony's $2 billion purchase of CBS Records in 1988. In this way:

> competition between different consumer electronics firms became closely embroiled with the ownership and control of rights to commercially recorded music and film. Successive format disputes in the audiovisual consumer electronics industry involved a shifting combination of collaboration and competition between hardware companies.
>
> (Sadler, 1997: 1933)

Sony's MiniDisc and Philips' Digital Compact Cassette (DCC) were released onto the market in the early 1990s, each 'backed' by a different corner of the traditional music industry. MiniDisc was supported by Warner and EMI, and DCC by MCA. But this was not an isolated incident; by that time, five of the 'Big Six' record companies had substantial interests in the consumer electronics arena (Sadler, 1997: 1925).

This represents a thorough application of what Anirudh Dhebar calls "a structured approach to understanding and managing product change"; a necessary tactic for any such firms wishing to remain competitive in the recorded music platform marketplace (Dhebar, 1995: 136).

4.2.3 Complementarities

Dhebar theorizes such an approach by focusing on the three primary 'interrelationships' in which any such product—here, a recorded music platform—would be involved (Dhebar, 1995: 136). Using various examples such as branded fizzy drinks, personal computers, cameras, games consoles, and personal audio equipment, Dhebar argues that:

> In each case, there are strong *complementarities*, or interrelationships, of (1) the product and the user; (2) the product and the other products with which it is typically used; and/or (3) the product and databases that are created and repeatedly modified with its help.
>
> (Dhebar, 1995: 138)

These three types of complementarity are known respectively as 'product-user', 'product-product', and 'product-database'.[5] The way in which they differ will be explored below, but Dhebar urges us to consider the common feature that they share: "They define the context in which a product is used" (Dhebar, 1995: 138). Given this context-defining role, it is reasonable to assume, as Dhebar does, that effective use of any such product requires "*compatibility* between the product and its *complements*" [original emphases] (Dhebar, 1995: 138).

Minor interruptions or disturbances of these complementarities —such as an incremental upgrade of computer software from, say, version '10.5.9.1' of an operating system to '10.5.9.2'—can generally be absorbed by the user with no lasting detriment to the complementarities already extant. Dhebar invites us to consider the introduction of a discontinuous product: one that causes substantial and permanent disruption of one or more complementarities, resulting in the new product being incompatible with its predecessor. This type of change constitutes "a break with the past", and usually results in a 'switching cost' for the consumer (Dhebar, 1995: 136–139). A switching cost is not necessarily financial: it takes the form of time, effort, or money (or a combination of all three) that the consumer must expend in order to re-establish complementarities disrupted by the

[5] Dhebar's notion of complementarities expands on more traditional ideas of 'complements', such as expressed by William Baumol: "bread and butter . . . are complements—for many consumers they are better together and hence an increase in the availability of one tends to stimulate the demand for the other" (Baumol, 1977: 212).

introduction of a new platform (Dhebar, 1995: 136). The financial cost can vary enormously: "A minor consideration for a small-ticket consumable product [can be] a major concern for a big-ticket durable product that has not exhausted its useful life when a new version is introduced" (Dhebar, 1995: 139).

Switching costs will be discussed in greater detail later in this section, but for now let us examine the ways in which the three different types of complementarity (product-user, product-product, and product-database) might be disrupted.

4.2.4 Disruption of product-user complementarity

The product-user interface (in the broadest sense of the term) is often multi-faceted. According to Dhebar, the first 'facet' to consider is the tactile elements of product such as "the taste of a beverage, the smell of a perfume, the styling of a car, the handling of a camera, and so on" (Dhebar, 1995: 139). These hold importance not only because they are "vital to a product's basic functioning", but also because they are often "defining traits" that separate one product from its competitors, e.g., Pepsi versus Coke (Dhebar, 1995: 139).

The second facet is the method or methods by which information about the product is fed back to the user, such as a battery level indicator on a phone, or a graphic equalizer on an audio system. Although this is arguably less potent than the primary tactility of a product, familiarity with these feedback systems "is not always easy to attain, nor is it easily forgotten, and it is this familiarity that is sometimes disrupted in the course of product change" (Dhebar, 1995: 139).

The third and final facet concerns the very tangible ways in which a user might control or operate a particular product. The example provided by Dhebar and many others in this literature is that of the QWERTY arrangement of keys on a typewriter or computer keyboard. This relates to the issue of familiarity mentioned just above but, more pertinently, it characterizes the type of switching cost created by disruption of product-user complementarities:

> Not only does the user make a substantial investment in learning how to operate these interfaces, once operational skills are internalized they are difficult to unlearn. The difficulty-of-unlearning is noteworthy for at least two reasons. First, some unlearning may be necessary if the world is to move to more efficient, effective, and intuitive controls . . . Second, the unlearning may be so difficult as to adversely impact the experienced user's ability to interact with the [new] product—a factor to be borne in mind as more and more product functions are automated.
>
> (Dhebar, 1995: 140)

Through Katz and Shapiro, it is possible to relate this familiarity to the positive network externalities of 'training', with such training (learning to touch-type on a QWERTY keyboard, for example) holding greater value if the associated technology is more widely adopted (Katz and Shapiro, 1986: 146).

These three facets translate to a complex of switching costs that vary from user to user: "If a new software release includes significant changes to the user interface, consumers must weigh the potential benefits of any new features against the time and effort involved in relearning the interface" (Dhebar, 1995: 136). Each user is likely to derive different potential benefits from the new software, and each user is likely to 'relearn' the interface at different rates and with different amounts of effort.

4.2.5 Disruption of product-product complementarity

A traditional hi-fi system, made up of physically separable units —usually an amplifier, plus one or more of a tuner, CD player, MiniDisc player, or turntable—can be classed as a 'multi-component' system. For the 'separates' to function as a whole hi-fi system, a certain degree of compatibility must exist between the components. Even though the CD player will not accept MiniDisc cartridges, the two can both communicate sound signals to the speakers (via the amplifier) if common connections are present on both. Such connections usually take the form of phono connectors (left and right channels) that take the output from one component and feed it to the input of another. This compatibility is no accident. Competing manufacturers of hi-fi equipment are well aware of the potential positive network externalities arising from such compatibility and go to great lengths to capitalize on them. Katz and Shapiro highlight two different ways in which such network externalities can be fully exploited:

> For some products (e.g., video cassette recorders), the competing technologies may be inherently incompatible. In such cases, the only way to enjoy the full benefits of network externalities is to achieve de facto standardization by having all consumers purchase the same technology . . . The second way of exploiting network benefits to their fullest is to design products utilizing different technologies to work with one another. This type of technical compatibility might be thought of as creating a 'standardized interface'. By this we mean that each firm continues to produce according to its own technology, but the products of

the two firms use the same software or may communicate directly with one another.

(Katz and Shapiro, 1986: 147)

Katz and Shapiro point to the dominance of the QWERTY keyboard format as an example of de facto standardization. Different keyboard formats were incompatible with each other (even among computer users communicating with a Latin alphabet). Gradually, as positive network externalities grew, subscribers to the QWERTY format reached a tipping point, and the subsequent adoption of QWERTY as a standard became almost universal (David, 1985).

The most profound disruption in product-product complementarity is one that causes two or more components to lose physical compatibility (Dhebar, 1995: 141). If your new DVD player has no way of connecting physically (or wirelessly) to your television or screen, the two are incompatible and the usefulness of the DVD player is severely limited unless an appropriate interface can be found.[6] Standardized interfaces are particularly common amongst manufacturers of personal computer hardware. Different brands of external hard drives (for example) can deliver data to different brands of laptop computers using, for example USB connections. The laptops can then send this information to printers from different manufacturers, via a standardized wireless protocol. Thus, designers and manufacturers are free to pit their products against each other (allowing the user to decide which product offers them the most benefit in terms of features or price) as long as they are capable of communicating via the standard interfaces.

The switching cost incurred by consumers through disruption of a product-product complementarity is usually a fairly straightforward

[6] For further discussion on issues of functional compatibility see Dhebar (1995: 141).

financial outlay to replace equipment or obtain interfaces that will allow otherwise incompatible components to communicate effectively (as opposed to the user having to learn or unlearn any skills). Katz and Shapiro emphasize the potentially high cost of achieving compatibility through the design and manufacture of interfaces or deliberately compatible equipment, but they concede that "in many markets, this may be done at a reasonable cost" (Katz and Shapiro, 1986: 147). Clearly, any significant costs incurred by the manufacturer in ensuring the compatibility of their products with those of another firm are likely to be passed on to consumers in the form of higher retail prices.

4.2.6 Disruption of product-database complementarity

Dhebar notes that product-database complementarity is, in fact, a special case of product-product complementarity, treated separately in order to highlight "the user's investment in building the databases" (Dhebar, 1995: 138). Within the realm of computing, these databases are understood to be the myriad files written by a particular program or application ('software' and 'hardware' respectively, according to the definitions given earlier).

More appositely for recorded music, database connotes an "installed base" of, for example, related media (Dhebar, 1995: 141). In simple terms, a user's collection of music CDs could constitute a database. If the user purchases a new CD player, it is unlikely that any of the CDs will be incompatible with it, and so the product-database complementarities remain intact. If the user were to dispose of the CD player and replace it with a MiniDisc player, the database would now be physically incompatible with the new product and the product-database complementarities *would* be disrupted. This is a crude example, and perhaps more often than not users are faced with questions of forward and backward compatibility.

The terms 'forward-compatible' and 'backward-compatible' are perhaps most commonly used with regard to computer software such as Microsoft's Office package where, for example, files created by an earlier version of the word-processing program Word are able to be opened, read and edited by later versions of the same software. In a situation such as this, the later version of the software is said to be backward-compatible.

Given the unpredictability imposed upon technological evolution by exaptations and economic uncertainties, few platforms are designed *at the time* to be forward-compatible. It would be very hard to foresee what such compatibility would require. In the example above, it could be argued that, by implication, the word-processed file from an earlier version is forward-compatible. However, in reality, the efforts toward compatibility will have been made when writing the later version of the software in such a way as to be au fait with files created by older versions, rather than the other way round.

4.2.7 Switching costs

Within the study of recorded music, the earliest issues of forward-compatibility emerge amongst the earliest platforms. In 1908, consumers buying a record made by one company "were lucky if it played on the machine of another" (Millard, 1995: 125). The competition between Edison's cylinders and Berliner's lateral-cut discs has been documented earlier in this thesis. The compatibility (or lack thereof) between them, however, warrants further analysis. It was easy enough to see the advantages of discs over cylinders in terms of storage. As a medium they required substantially less space to store the same amount of data. Given this, many assume that Edison's decision to stand by his cylinders was foolish and stubborn. It was, however, a little more calculated. For the needle on a disc player to track the groove of a lateral-cut record at a consistent speed, the rate at which the disc rotated had to be reduced as the needle approached the centre of the disc. Edison's company remained faithful to the cylinder because they thought that the benefits afforded to consumers by the lateral-cut disc would be eclipsed by the cost of the variable speed motors passed on in the form of increased retail prices for players (Read and Welch, 1976: 113).[7]

When Edison finally relented and introduced a disc player in 1913, he opted for a vertical-cut format (akin to the cylinders he was so fond of) rather than the lateral-cut favoured originally by Berliner, but now also by most of the music-buying public (Funk 2007: 9). The result was that Edison's machines would not play the great swathes of lateral-cut pre-recorded music that already existed and that many people already owned. This complete lack of backward-compatibility would push Edison's machines out of the market, giving us yet another example of de facto standardization.

Time and time again, the desire to preserve a proprietary platform has backfired on all but the luckiest of recording technology companies. The most successful platforms have, on the whole, been those whose creators licensed their use to competitors, thus ensuring wide and deep market penetration. By the time Columbia Records introduced their vinyl records in 1948, the recording density of their shellac predecessors had been improved upon greatly. Columbia's records boasted 224–260 grooves per inch, substantially more than the 80–100 grooves per inch found on shellac records (Millard, 1995: 204). This allowed them to squeeze more music onto each side of a disc, and provided better sound quality. However, as will be discussed later in this section, improvements in performance alone are not always sufficient to guarantee a platform a meaningful place in the market.

---

[7] Bell and Tainter were promoting the idea of variable speed motors that would allow the needle to track the grooves more slowly at the outside of the record, as a means of storing more sound data on a given disc (Read and Welch, 1976: 23)

There were, as Funk points out, two other factors upon which the success of Columbia's new offering hinged (Funk, 2007: 10–11). First, by developing a relatively inexpensive aftermarket attachment, Columbia ensured that their new records were compatible with existing phonograph players. For $9.95 consumers were able to enjoy all the benefits of the new discs, without having to abandon the investment in their existing players. Columbia's second canny move was to license the necessary technology to competing record makers (Langlois and Robertson, 1992: 301). This interchangeability of record players and records ensured that the new discs were widely taken up across the market by consumers and manufacturers alike.

It has been established that when complementarities are disturbed switching costs arise. These costs usually fall into one of four groups:

1. Unlearning how to use the old version of the product and learning how to use the new version
2. Adapting existing complementary products or acquiring new ones so that they are compatible with the new version of the product
3 Modifying, translating, or recreating databases, spreadsheets, documents, recordings, and so on
4. Redeveloping the interfaces between the new version of the product and its various complements

(Dhebar, 1995: 139)

Dhebar also includes an acknowledgement of the elusive, intangible cost he calls "emotional energy" (Dhebar, 1995: 139). It is interpreted here as a sense of psychological inertia: a reluctance to change and an attachment to the status quo, even when faced with a set of switching costs and benefits that would present a rational *homo oeconomicus* with a 'no-brainer'. Trying to quantify (or even construct) the value of such inertia is likely to be difficult at best, and certainly beyond the scope of this chapter.

It is reasonable to assume, however, that in most compatibility-dependent situations, costs outlined in the four categories above (plus a degree of influence from emotional factors) will combine to create an overall switching cost. All other things being equal, the higher the switching cost the less likely consumers are to swap from one platform to another, and thus the less likely the platform is to succeed in the marketplace.

Crucially though, not all consumers are the same. Therefore, switching costs may be very different for different consumers. Switching costs can be imagined as a negative balance, capable of being countered by positive balances in the form of switching benefits. In the context of recorded music platforms, these benefits usually take the form of enhanced performance aspects (e.g., higher quality audio, better editability), improved convenience (e.g., smaller media, lighter equipment), or stronger or more numerous complementarities (e.g., more compatible with your existing equipment, or more of your friends and fellow consumers have the same kit so you are better able to share media and other consumables).

By weighing switching benefits against switching costs, consumers should be able to make an informed decision about whether or not to adopt a new platform. Everett Rogers argues that consumer understanding about the relative merits of a particular innovation has a profound effect on the eventual adoption and diffusion of a technological innovation (Rogers, 2003).[8] At a theoretical level, this

---

[8] Over the course of several works, Martin Fishbein and Icek Ajzen (1975; 1980; 1985; 1991; 2010) have developed and refined their theory of planned behaviour and the theory of reasoned action. Together, these theories provide an understanding of how (in the context of recorded music) beliefs about behavioural outcomes—i.e. the advantages and disadvantages of adopting a platform—affect attitudes

understanding explains the chequered success of, for example, Sony's MiniDisc platform. MiniDisc was tremendously popular amongst field-recording enthusiasts, for whom the complementarities associated with portable tape recorders were worth disrupting in order to avail themselves of the convenience, quality, and editability offered by MiniDisc.[9] By the time MiniDisc had been launched, however, *average* music consumers (i.e., those not making recordings on-the-go), had established a 'critical mass' of complementarities with commercially released CDs. Many had purchased CD-playing and CD-compatible equipment, the vinyl collections of many had been supplanted by CDs, and many were used to the wide selections of pre-recorded CDs available at retailers, with which MiniDisc could not feasibly compete. For these sorts of consumers—who probably constituted the majority—the benefits of changing allegiance to MiniDisc were invariably minimal, and the switching costs were often large.

All this begs a question. Is it in the interest of consumer electronics companies to engineer compatibility with rival products? If so, how far should they go? Matutes and Regibeau confirm that corporate incentives to compatibility:

> . . . have been shown to depend on the firms' relative size and on how compatibility can be enforced. If compatibility can only be achieved with the agreement of all firms (adoption of a common standard), privately profitable industry-wide standards are socially desirable, but some socially desirable standardization will be rejected. If, on the other hand, standardization can be enforced unilaterally (by building an adaptor) and firms differ greatly in sizes, private incentives to standardize may be excessive.
>
> (Matutes and Regibeau, 1988: 222)

---

towards that behaviour, and how, in turn, these affect our behavioural intentions and eventual behaviour.

9 CD recorders did exist but they were too cumbersome, expensive, and delicate to be considered for use in the field.

Within the perimeters of this dissertation, an attempt to answer this question any more expansively makes little sense. The marketplace is emphatically dynamic, and any questions of compatibility incentives must be understood in terms of the product being developed, the rival products, the size of the firms producing the rival products, the existing market share of each product, and the complementarities exhibited between each product and the wider world.[10]

Nevertheless, the discussion thus far permits a far sharper consideration of how digital music files have brought about an unprecedented level of compatibility, both with themselves and with other platforms. As mentioned above, the astonishing market success of digital music files as a whole can be attributed to two primary conditions: the ubiquity of equipment on which digital music files will operate and the extensive interoperability of such equipment.

Digital music files allow consumers to use the same media (or lack thereof) on multiple and differing playback devices. A single digital music file might be played on a desktop computer, a laptop, a mobile phone, an iPod, a tablet, a television, a games console, and more besides. Thanks to standardized interfaces and the software provided with most modern personal computers, almost all older platforms are rendered forward-compatible. Any player (record, CD, Minidisc) with an auxiliary output—such as headphone or phono sockets—can be used to feed the recording input on a computer, converting music from older platforms into digital files stored on a computer or similar device. They are also backward-compatible, able to be burned to audio or data CD, recorded onto MiniDisc, and copied to cassette tape. The sheer versatility of digital music files makes them arguably "music's first universal format" (Bockstedt et al., 2006: 8).

---

[10] Using game theory, Matutes and Regibeau (1988) provide a detailed stochastic analysis of whether firms should make their systems compatible with rivals. They conclude that compatibility results in higher prices for consumers than incompatibility, but that it also increases the number of compatible products on offer, thus leaving some consumers better off.

This would not be so remarkable were it not for the fact that the great majority of consumers will already own one of these devices, or will be incentivized to buy one for other reasons as well. Most modern phones are capable of playing music, but few people will buy a phone for that reason alone. For most music consumers—particularly those in the developed world—a mobile phone is an indispensable part of everyday life. Thus, those interested in persuading consumers to buy digital music of one format or another usually avoid the challenge of persuading consumers to adopt or convert to a proprietary piece of equipment for music listening as well (unlike Edison and Berliner). In the context of the complementarities discussed earlier, this greatly reduces the switching costs, allowing the consumer to focus on and enjoy a whole host of switching benefits.

Similarly, most consumers will already own or have access to a computer of some description. By tailoring their services to the equipment that consumers already have, music providers (like Spotify, Last.fm, the iTunes music store, and many others) make it very easy for consumers to tap into their products without having to spend any extra money or time in ensuring compatibility. Services like Apple's iCloud—a proprietary form of 'cloud computing'—will even store all consumers' purchased music online, and 'push' it to their wirelessly-enabled mobile Apple devices (such as the iPod Touch, iPhone, and iPad).[11] As cloud computing becomes more prevalent, and as the trend towards global compatibility between the devices mentioned above becomes more pronounced, the 'celestial jukebox' will become less a fantasy and more a reality.

Further to this device-centric level of compatibility, there has been an unprecedented amount of compatibility-orientated 'engineering' to make online music services available on a wide array of devices. Services like Spotify can be accessed through computers,

---

11 For a useful introduction to cloud computing see Antonopoulos and Gillam (2010).

phones, and tablets, allowing users access to almost any *music*, almost any*where*. Proprietary interests have dominated in the past; companies like Apple and Sony, for example, continue to restrict users of their audio hardware players to mainly proprietary formats. This, however, has its own perils. In 2004, Sony released its answer to Apple's iPod: the NW-HD1. Despite being billed as an 'MP3 player', the Sony offering could only store files in ATRAC3 format, Sony's proprietary audio compression algorithm that debuted with the MiniDisc Player in 1992. Users with an existing collection of MP3s or other common audio files such as WMA were required to convert them to ATRAC3 before they could be loaded onto the player. Sony were "widely and bitterly criticized" for their choice of compression compatibility, and the NW-HD1 (along with its successors) failed to take any substantial market share from Apple's iPod (Mock, 2004: 2). Many producers of digital music file formats have realized that absolute incompatibility is ultimately going to threaten their market share, and have started to relax their grip on proprietary interests as a result.

The audio format Ogg Vorbis (Ogg) is a case in point. According to its creators—the Xiph.Org Foundation—Ogg is "a completely open, patent-free, professional audio encoding and streaming technology with all the benefits of Open Source" (Xiph, 2008). It is a widely respected container format, capable of combining a number of distinct audio and video streams (as well as metadata and text such as subtitles). It is patent-free and distributed under an Open Source agreement. As a result, programmers and developers do not have to pay to use it and it has enjoyed widespread adoption, particularly in the video games sector.

Some proprietary interests still exist. Tracks bought and downloaded from the iTunes Store cannot be loaded onto an iPod that is synced through Spotify, for example. However, the digital rights management (DRM) software embedded into these tracks can be circumvented by copying them to an audio CD and re-importing them from the audio CD to a computer. This is one small example that highlights the enormous power—often underestimated by music and electronics firms and those corporations and bodies with a vested interest in selling copyrighted material—of developers and programmers who are willing to work for nothing, and the (online) communities they inhabit. These groups and individuals often provide the necessary tools to overcome any obstacles that incompatibility (whether deliberate or inadvertent) might interpose between consumers and their music, even if not all of the methods are entirely legitimate.

As the case of Ogg demonstrates, hardware remains an issue nonetheless. Despite its many merits, Ogg has failed to compete substantially with MP3—and other major formats like AAC and Windows Media Audio (WMA)—because it has not reached the 'tipping point' of positive network externalities that would allow it to snowball into the most popular format. Why? Because, although they do exist, there are very few audio hardware players that are Ogg-compatible (Hollender, 2004: 1). The control exercised over hardware production will, for the time being at least, give companies like Apple—who have fingers in most of (if not all) the digital music pies—the bargaining power to dictate their terms of engagement with the rest of the music industry. Apple is a particularly salient example given the 'brand community' it has built, and the highly emotional attachment to its products that many of its devotees demonstrate (Thompson and Sinha, 2008).

Though never masterminded by one single company or individual, the master-stroke behind the success of digital music files is the re-engineering of traditional complementarities. It is easy to see that digital music files are much less likely than their predecessors to cause any disruption to product-user, product-product, or product-database complementarities.

Product-user complementarities are likely to remain intact because, although many different digital music players exist (iTunes, WinAmp, Windows Media Player, etc.), the programmers of such software will invariably tailor their designs to make them as user-friendly as possible, incorporating features, layouts, menus, commands, and visualizations common to other programs. This increases the familiarity of consumers with a new music-playing program, often reducing the amount of 'relearning' required to operate the new software effectively.

Product-product complementarities are also more secure, thanks to the existence of multiple versions of software for different operating systems, allowing them to be used on a multitude of branded and non-branded computers, phones and other devices. Because iTunes can be installed on computers running Microsoft operating systems as well as computers running Apple operating systems, users need not abandon iTunes as their music player of choice, even if they substitute their Windows laptop with a Mac laptop.

Product-database complementarities are a bit more complex when it comes to digital music libraries. Spotify will not allow users to import lossless encoded audio files directly but there are often methods of converting files that are free even if they are not quick. These, though sometimes time-consuming, are undeniably cheaper and undeniably more convenient than repurchasing an entire music collection on a new platform. Spotify also allows users to import playlists from iTunes, further reducing the disruption of product-database complementarities.

4.3 Durability

The ability of a platform to resist the loss or corruption of data caused either by normal use (e.g., wearing out of vinyl records), benign neglect (e.g., de-magnetization of tape) or by extraordinary damage (e.g., unanticipated physical trauma).

The definition provided above for the characteristic of durability is noticeably longer than the definitions provided for any of the other characteristics. The length of the definition attests to the many and varied interpretations of 'durability'. On the one hand, there is the durability of the physical media upon which given data are stored; how resistant is the physical object to the stress and strain, the impact and neglect (deliberate or otherwise) that it might encounter? On the other hand, there is a more abstract element to durability; what is the potential longevity of the data stored on such a medium?

This distinction warrants further explanation. Suppose that, today, a section of speech is recorded via analogue means onto a vertical-cut cylinder. Suppose also that the same speech is recorded via digital technology onto a flash-based USB drive. Both will, eventually, be subject to physical degradation or decay, and will cease to function as storage media. In an attempt to perpetuate the life of the stored data, one might conceivably copy the data from one cylinder to another before the previous cylinder disintegrated or rusted or otherwise failed. When that second cylinder threatened extinction, the process could be repeated. Crucially though, because of its analogue nature, the information stored on a cylinder cannot be physically conveyed to another cylinder without introducing a degree of distortion to the original signal, no matter how refined or precise the equipment being used. As this process is repeated ad infinitum, the original signal will become increasingly occluded by the noise and the interference introduced by the process of transferral until eventually it is no longer discernable. Though likely to suffer deterioration sooner, the data stored on the flash drive can be replicated perfectly again and again, even using domestic computer equipment. Thus, the data on the flash drive has a longevity that outstrips the durability of the media on which it resides.

That some media are damaged by the simple act of being played complicates matters further. Even as a by-product of what Sterne calls "loving use" (Sterne, 2009: 60), dragging a fragile shellac disc under a needle erodes the very fluctuations in the surface that are being read. Playing an audiocassette subjects the tape inside to magnetic fields that, ultimately, will demagnetize the information stored on the tape. The effect in both cases is infinitesimal for each listen; it might take thousands, even millions of replays to render the data unusable, but it will happen. In an effort to counter this, two independent strands of research exploring non-destructive methods for playback are currently underway. Scientists in Switzerland are experimenting with taking ultra high resolution digital photographs of vinyl records, and using mathematical algorithms to derive from them the sound data stored on the record itself (Johnson et al., 2003). The second strand of research emanates from a United States Department of Energy Research facility. Using metrology and digital image processing, engineers have been able to map the contours of 78-rpm record grooves with astonishing precision (Fadeyev and Haber, 2003). Once the discs have been mapped in their entirety, the aim is to interpolate corrections to rectify groove wear, scratches, and other damage to the discs. This holds tremendous promise, but at the moment it is neither cheap nor convenient; effectively mapping one side of a record in three dimensions can take more than 100 hours (Fadeyev et al., 2005).

Of course, different platforms are subject to different degradation processes, resulting in different rates of decay and, consequently, different lifespans for different media. Unfortunately, our knowledge of some of these decay behaviours is limited at best. CDs have only been around for 35 years or so, MiniDiscs for about 20, and numerous other platforms are still relatively young. So, despite having the ability to subject media to duress and accelerated conditions testing in a laboratory environment, we have little idea of how these younger platforms will deteriorate or last in real world conditions. Compounding this uncertainty is the sheer variety and quality of media produced. Few CDs, for example, are born equal: different batches will be made in different factories, using slightly different materials, and it is entirely possible that each will respond differently to the conditions of use and storage to which they are subjected. Ultimately, the lifespans of such media are at best very varied, at worst wholly unpredictable.

4.3.1 Archival implications

Nowhere is this unpredictability a more pressing issue than in the context of archival storage. Vast amounts of sound data are stored on analogue (and digital) media, and only one thing is for certain: these media *will* decay in time. Archivists have acknowledged that "no medium has proved stable enough to be called permanent" (Brylawski, 2002: 7). Given this admission, it is surprising—almost alarming—how long it took archivists to see the benefit of storing archives digitally. Though such transfer has been "discussed for many decades, it has been disdained as a viable solution for nearly as long" (Brylawski, 2003: 2). This reluctance on the part of archivists is not entirely irrational. When digital storage first became an option for sound archives, the potential for longevity was not as apparent as it is now; many people considered digital to be as impermanent as analogue. In addition, early digital sound storage often required a large amount of compression and perceptual coding to be applied to the data, in order for it to be stored practically (Brylawski, 2003: 2). Whilst this might have been perfectly acceptable for pop music destined for an iPod and cheap earphones, archivists were understandably less keen on potentially losing valuable data by voluntarily subjecting their collections to such reformatting.

Elizabeth Cohen—an archivist of sorts herself—admits, with a refreshing honesty, "the search for the perfect technical solution is a diversion from the painstaking work and art of transfer" (Cohen, 2001: 1). Given the slow but unstoppable decay of all analogue sound archives, this diversion has serious consequences: "To delay the transfer of analog media into the digital domain until it [the digital domain] has reached perfection and reliability is to compromize preservation. The more time that passes, the more we allow the further degradation of analog materials" (Cohen, 2001: 1). As Richard Hess helpfully suggests: "If the content is important and should not be lost, copy it now. Do not rely on old tape. Unlike wine, tape does not improve with age" (Hess, 2008: 28).

Kevin Bradley notes that getting the best possible signal from the source material is "the indispensable starting point of each digitization process" (Bradley, 2003: 7). Thanks to the current or impending obsolescence of many platforms, this is becoming increasingly difficult. There are hundreds if not thousands of different sound storage media, each invariably requiring specific equipment for playback. As this equipment ceases to be manufactured, it becomes more and more difficult to extract the data from an older medium, even if the medium itself is in good repair. Nor will it always be possible to cobble together something from available equipment today that will be able to extract data from older media. Analogue tape is a case in point: "Machines that are able to extract an adequate signal from a tape are sophisticated, complex machines dependent on proprietary parts and custom integrated circuits. Maintenance will not be an easy task once the existing parts have been exhausted. Nor will it be possible to build satisfactory machines in a workshop, as has been done with cylinder replay equipment. The technology requires industrial support" (Bradley, 2003: 6). Unfortunately, residual industrial support—in the form of equipment, parts and expertise—will only continue to exist for the most commercially successful of platforms:

> Concern extends to the availability of an adequate parts supply and technical expertise to transfer all of the remaining two-inch quadruplex videotape, let alone formats with lesser market penetration. We are even starting to find it difficult to obtain cassette splicing blocks and who knows how much longer high quality calibration tapes will be available?
>
> (Hess, 2008: 26)

Even if archivists *do* have access to the necessary equipment, it might be completely useless—or even destructive—unless the media in question can be identified. To generations brought up on uniquely shaped and labelled media (such as VHS, CD, and MiniDisc) this may seem like a rather unlikely issue, but for generic platforms such as open-reel tape, it is hugely problematic. Hess points out that "a few manufacturers marked their name on the back of the tape, and fewer marked the type designation. Short of such marking, there is no guarantee as to the manufacturer or type designation of the product" (Hess, 2008: 5). Successful identification is not the final piece in the puzzle either. Information about the physical and chemical specifications of the tape has usually been kept as "trade secrets" (Hess, 2008: 5) by the companies manufacturing them. This makes decisions about appropriate storage and preservation of these fragile media very difficult.

Clearly, there is no better time than the present to start converting collections from analogue to digital. Nonetheless, this is easier said than done for many institutions and curators of collections. Given the amount of sound data already stored, and the rate at which new material is produced—even ignoring that which is deemed unworthy of preservation—copying one recording at a time will not suffice. There must be mass reformatting. The fly in the ointment, however, is that "to accomplish mass reformatting more than one source must be duplicated at a time, which will preclude continuous, real-time monitoring of the recorded signal by an engineer. By its nature, a mass reformatting system will compromize existing preservation standards" (Brylawski, 2003: 5).

This begs several questions, the first of which must be: what are the existing preservation standards? In 2003, on behalf of UNESCO, the Technical Committee of the International Association of Sound and Audiovisual Archives undertook a survey of over a thousand sound archives, with a similar survey having been conducted in 1995 (Boston, 2003). The intention of the 2003 survey was to establish a greater awareness of the rate of decay of media in the archives. The full impact of the paper is best gleaned by reading it in its entirety, but it does make one thing abundantly clear. Audio data comes in a vast array of platforms and formats, each created with its own idiosyncracies and propensities for storage, according to a range of standards. Crucially, there is very little consistency between approaches. In a forward-looking paper that implores a more logical and calculated approach to media design and archiving, Cohen agrees that "all sound collections are imperiled by a lack of agreement on standards for description and access" (Cohen, 2001: 498).

Digital metadata provides the means to bridge this chasm of inconsistency into which valuable sound sources may disappear. As an electronic corollary of the information traditionally stored on library index cards, digital metadata provides information about the content and context of the particular file or files to which it is attached: when the file was created, what program was used to make it, what language it is in, and so on. This not only makes the file itself more valuable for its accessibility, it also allows for more efficient grouping and cross-referencing of files within and between archives. It also allows for some element of digital watermarking, helping curators and users alike to avoid the risk, as Cohen puts it, "of being unable to define a faithful copy" (Cohen, 2001: 1). Discipline-specific metadata standards do exist but, as Brylawski rightly argues, if digital preservation is to be effective then uniformity must extend well beyond the realms of metadata (Brylawski, 2002: 9).

He points to substantial debate among sound engineers and curators about the principles and guidelines that govern the conversion of sources from analogue to digital. A great deal of the fuel for this debate comes from the variety of sources types that would be affected (i.e., speech versus music, professional versus amateur). Most camps seem to agree that the chosen format for archiving ought to be free of compression and perceptual coding, and that Red Book CD specifications (i.e., a 44.1 kHz sampling rate and 16-bit digital word length) are of insufficient quality for archival purposes. These frequent and ongoing debates suggest that, to Brylawski at least, "it is unlikely that there will ever be universal agreement on standards" (Brylawski, 2002: 9). As mentioned previously, though, data storage has improved dramatically since Brylawski was writing. Even if an agreement regarding standards cannot be forged, this tendency toward cheaper and smaller facilities will hopefully allow archivists to consider using much higher sampling rates and bit lengths without compromising the amount of material that they are able to store.

Much of this discussion has quietly assumed the analogue materials in question to be historic anomalies in a digital age. In fact, the production of analogue material has not stopped. Many people, artists, and institutions still favour the quality of sound associated with analogue equipment, and plenty of modern music is still recorded in analogue format. It is less and less likely, however, that the sound data in question will exist *only* in analogue format; digital versions now usually accompany such releases. Nonetheless, the continuing presence and production of analogue recordings add further considerations to an already complicated archival strategy debate.

Whatever forms digital archiving may take, it is painfully apparent that any system will require its curators to put quite a lot of faith in "the assurances of a professional IT infrastructure" (Brylawski, 2003: 3). Obvious tasks include the selection, procurement, installation and maintenance of equipment appropriate for digital storage, as well as design and authoring of software—quite probably bespoke—to control the access to (as well as the storage and back-up of) digital collections. Institutions must also consider the training of staff in order that they might be able to use the software and hardware safely, efficiently, and effectively. None of this will be cheap, and those institutions with the least financial support might find themselves left behind.[1]

Policy makers should also be aware of the distinct lack of interplay between public and commercial archives. The attitudes of museums and record labels towards the recordings in their possessions may be understandably very different but the potential benefit of collaboration should not be overlooked (Brylawski, 2002: 9–10). Journalist Bill Holland brought to light the tendency of record companies to discard master recordings after copies had been made, leaving them with only partial archives of the intellectual property that they have come to guard so fiercely but which now might exist only in institutional or personal collections (Holland, 1997: 3). Conversely, institutional collections would benefit from the addition to their collection of rare recordings that may only exist in record company vaults. Perhaps more importantly, both parties could stand to gain something from joint digitization ventures. Institutions might perhaps get a welcome injection of funds from the record companies who, in turn, might be able to secure their valuable recordings without having to establish or maintain any preservation infrastructure of their own.

---

[1] Richard Hess acknowledges the political and organizational significance and complexities involved in securing "a robust and truly permanent digital repository" (Hess, 2008: 27–28) and a fuller consideration of the issues is given in greater detail elsewhere (see Gladney, 2007).

From a cultural-historical perspective, it is encouraging to see that preservation remains a hot topic and a high priority for so many people and institutions. But let us fantasize for a moment: pseudo-permanent storage facilities are widely and cheaply available; consensus on audio and metadata standards has been achieved; once-obsolete equipment is rebuilt and every piece of analogue sound data could be converted to digital with the absolute minimum of distortion of the original signal; and all of this can be achieved within the cost and time budgets of every institution and archivist. What then?

4.3.2 Canonic issues

In 2001, the "world's stock" of audio recordings was estimated to be in excess of 50 million hours (Schuller, 2001: 619). Cohen reckons that "one hundred years of sound recording has left us with a legacy of the equivalent of more than 5 PB of professionally recorded audio" (Cohen, 2001: 3).[2] Estimations cited by Cohen suggest that, even 12 years ago, audio data production and traffic was alarmingly high:

> There is no mercy; according to J. A. Moorer of Sonic Solutions, it is estimated that we are distributing terabytes of new garage band music each day (personal communication, September 28, 2000). Three million new Web pages appear daily, and a growing percentage include streaming audio (Lyons, 2000: 146). Currently, 4,271 radio stations 'broadcast' their signal on the Internet, up from 2,615 stations a year ago and up from a mere 56 in 1996 (BRS Media Inc., 2000). In autumn 2000, Arbitron's website reported that 25 per cent of the American population (57 million) had listened to Internet audio; 20 per cent (45 million)

[2] These two figures, though expressed in different units, more or less complement each other, using the assumption made earlier in the chapter in relation to audio data density: that 1 GB equates to 546 minutes of recorded music.

> listened to radio stations online and 13 per cent (30 million) listened to Internet-only audio. Information appliance companies are initiating music delivery to phones, to personal digital assistants, and into an array of portable entertainment devices. Lest you think that 64-kilobit audio is the sole character generator that is stimulating the data storage industry, the surround sound community is creating its own information-rich recordings. With the standard sample rate shifting to 192/96 kHz, 24-bit, and 4.76 GB of audiovisual data per DVD, multi-channel audio is swelling the data banks as well. As FedEx Chief Information Officer Robert Carter said, "There is this tidal wave of storage demand coming at us".
>
> (Cohen, 2001: 3)

Taking into account both the intervening decade and the increasing rate at which such audio recordings are produced, it is reasonable to assume that Schuller and Cohen's estimates could well have increased to 60 million hours or 6 PB by now.

This leaves scholars and, perhaps more pertinently, archivists with a difficult question. What and how much of this perpetual onslaught of sound data do we retain and preserve? Sterne homes in on the central problem, arguing that "there's too much to collect and not enough of a sense of, or agreement about, what should be collected" (Sterne, 2009: 62). He goes on to highlight the inadequacy of the strategies employed in modern archives—many of which he deems "woefully vague"—whilst acknowledging the helplessness of archives in the face of audio deluge: "When you add seemingly endless permutations of recording formats, software updates and reference-quality standards, even the most basic decisions about preservation become incredibly complex" (Sterne, 2009: 62).

4.3.3 The preservation paradox

Many scholars have asserted that recording destroys the ephemerality of sound, making it durable, repeatable, existing in the memories of machines and surfaces as well as the memories of people. Contrary to the flow of received opinion, Sterne argues that by accelerating the pace of fashion and turnover (in popular music at least) recording has actually made sound more ephemeral (Sterne, 2009: 60). From this proposition we arrive at what Sterne calls the 'preservation paradox' of digital audio. The ease with which digital data can be transferred and stockpiled suggests a state of plenitude that Sterne thinks is illusory (Sterne, 2009: 64). Given the huge range of recordings of any type that are made—dance tracks from the 1990s, for example—and the multitude of instances in which they exist (shared on Napster, stored in archives etc.), the only way for them to become rare and thus worth preserving is if most of the recordings like it are lost. By preserving everything, we never leave the present: "Scarcity is fundamental condition of possibility for historicity, but that scarcity has to be created from a condition of abundance" (Sterne 2009, 60).

Micromaterialization has liberated digital data from the shackles of a single platform; the fate of sound data is no longer necessarily tied to the physical health of a particular medium. The ability to transfer sound repeatedly and without error enables a level of distribution that was impossible with analogue data. Cohen reminds us that such distribution is not just important for preservation, it *is* preservation: "Our collections are far more likely to survive the scars of mayhem if they are robust and alive in many hands" (Cohen, 2001: 1). Look far enough into the future, though, and any music from the last 100 years that has survived will, according to Sterne:

> be open to interpretation and subjected to questions and frameworks we cannot imagine and of which we might not

approve—or know to approve. But the future does not need our consent or approval. This is not an abdication of the responsibility to preserve or remember. It is only an acknowledgement that history, like all forms of memory, is first predicated on forgetting.

(Sterne, 2009: 65)

4.4 Economic viability

The ability of a platform to survive and thrive in prevailing economic circumstances, as determined by a variety of inherent cost factors.

A great deal of what could reasonably be brought under the heading of 'economic viability' has been, and will be, considered and integrated elsewhere, particularly throughout the following chapter. Doing so will illuminate the complex relationship between the rituals of production, distribution, and consumption on the one hand, and value—economic and otherwise—on the other. As with the rest of this chapter, this section is not designed to be an exhaustive exploration of every aspect of the economic viability of every platform. Consideration has already been given, in the section on compatibility, to the relative costs associated with switching between different platforms and rendering them compatible. Fortunately, these relative comparisons are quite straightforward when considered in the abstract. Absolute comparisons of cost, however, are much more difficult, especially when calculated with a particular platform and a particular consumer (or group of consumers) in mind. Rather, the purpose of this chapter is to provide a qualitative analysis of the ways in which digital music files have superseded their predecessors and, in doing so, provided the *most* economically viable platform.

As a recent and arguably the most successful predecessor of digital music files, it would make sense that CDs and their associated technology provide the strongest and most keenly felt opposition to the popularity that digital music files currently enjoy. For the purposes of outlining how digital music files have become a paragon of economic viability, therefore, the following discussion will use CDs by way of a comparison. Other platforms will of course have their own specific economic advantages and disadvantages, but the basic economic principles are the same. So why the rather cumbersome term, 'economic viability'? It is tempting to label this characteristic 'cost', but to do so would oversimplify the matter. With any platform, there are multiple costs involved, none of which in isolation would necessarily prevent the platform from achieving market success or widespread adoption. Certain aspects of the platform's production, for example, might be costly to manufacturers, but if this outlay can be recouped through distributors and, ultimately, consumers, then such a platform may well retain its economic viability on the balance sheets of manufacturers. Conversely, a competing platform may be cheaper to manufacture but, if the distribution is disproportionately expensive, or the switching costs for consumers are too high for them to consider changing allegiance, the manufacturers are likely to make scant return on their investments. These examples illustrate the multitude of angles from which the economic viability of a platform can be viewed. Given the attention already paid to consumers earlier in the dissertation, it seems appropriate to start where any platform begins its life: at the drawing board.

4.4.1 Research and development strategies

By his own admission, Edison more or less stumbled upon the idea of recorded sound whilst working on telegraphy in his laboratory in Menlo Park, New Jersey:

> I start here with the intention of reaching here in an experiment, say, to increase the speed of the Atlantic cable; but when I've arrived part way in my straight line, I meet with a phenomenon, and it leads me off in another direction and develops into a phonograph.
>
> (Edison quoted in McLuhan, 1964: 294)

This seems like a startlingly casual explanation for the creation of one of the most widely exploited inventions of the last century and a half. Particularly so to those of us who live in an age where the research and development programmes of some individual companies—particularly pharmaceutical firms—are approaching $100bn per year, even exceeding $10bn for a single product (Herper, 2012). This disparity tells us an enormous amount about the precision and focus with which many firms now approach the invention of new products.

Though the scale is undoubtedly smaller, the same principle applies to the designers and manufacturers of consumer audio equipment. The meandering approach favoured by privately funded inventors like Edison (and no doubt some of his contemporaries) has been replaced by a structured, programmatic and results-driven outlook. But why? When devising research and development programmes, modern audio and consumer electronics firms must establish a target market for the product in question and familiarize themselves with it in order to gauge the likelihood of the product's success. After all, business is business. Companies will only make capital outlays of this size if they think they can recoup it when the product goes to market. The necessary familiarity and awareness, however, are not always easy to achieve:

> Firms endeavouring to develop new markets confront a frighteningly long list of uncertainties: will buyers adopt the new product and, if so, over what time frame?; will the technology work and be produced at the price point required to make a sale (usually determined by substitutes/alternatives)?; and will the firm be insulated enough from competitors to get a return on its up-front investments (usually determined by several isolating mechanisms: speed to market, patent protection, secrecy, complimentary assets, barriers)?
>
> (Dew et al., 2004: 81)

If a market for a new product cannot be identified, or the success of a product cannot be ensured with any certainty—that is, if costs are unlikely to be recouped—it makes sense to reduce the cost of research and development as far as possible to minimize potential losses. No wonder, then, that exaptations like those mentioned in the previous chapter can represent such an attractive option.

The incompatibility of many music platforms with non-proprietary equipment is well documented. Here and by contrast, then, lies one of the keys to the success and ubiquity of digital music files. Once the algorithms and inner workings of formats such as MP3 had been standardized internationally, they were made available to firms across the world. Though this would have come with a price tag, it gave such firms the option to pursue the development, improvement, miniaturization, etc., of equipment that used the format, rather than investing untold sums on developing a whole new competing format. Not only that, it also relaxed the entry criteria for the market. Once upon a time, companies like Philips and Sony (along with their competitors) had been able to monopolize this kind of development industry because the equipment, facilities and expertise involved were expensive, complex, and often restricted. When it came to digital music files, however, the doors were wide open. Software companies and even individuals could write code and programs that made use of digital formats, without having to concern themselves too much with the physical aspect of the product.

As mentioned above, the sheer variety of platforms, manufacturers and retailers involved in the conveyance of recorded music from artist to consumer prevent a thorough quantitative economic analysis here. But, the example of CDs provides an insight into how the economic viability of a traditional platform—i.e., those prior to digital music files—is often affected.

4.4.2 The economics of CDs

Information on the precise costs of getting a CD to market is very scarce. Peitz and Waelbroeck note, however, that a CD is a prime example of a good that demonstrates large fixed costs and low variable costs (Peitz and Waelbroeck, 2004: 2). In simple economic terms, total cost (TC) equals fixed costs (FC), plus the variable costs (VC) multiplied by the quantity produced (q):

$$TC = FC + (VC \times q)$$

Thus, when the quantity produced is low, the fixed costs are likely to represent a larger proportion of the total costs. When the quantity produced is high, the fixed costs will start to represent a smaller proportion of the total costs. Marginal cost is a measure of how much the total cost will change if the quantity produced is increased by one unit. If variable costs are zero, then the marginal cost is zero; increasing the number of units produced does not increase total costs.

In creating a CD for sale, the record industry is faced with very low variable costs and high fixed costs, whether producing one CD or a million. The fixed costs mainly derive from traditional A&R activities (searching for and developing talent), production of the music to be released (studio costs, financial support for artists), the marketing (promotion and advertising) of the release, and the acquisition and maintenance of factory equipment. The variable costs are things like the raw materials for the CD itself, the energy and manpower needed to record the CD and print the artwork, and so on.

Citing statistics from a report by the International Federation of the Phonographic Industry (IFPI) on the average costs involved the release of a CD, Peitz and Waelbroeck (2004: 2) provide the following:

Process	Cost (€)
Recording	2.25
Production	0.25–5.00
Marketing and promotion	0.25–5.00
Pressing	1.00
Retailer margin	2.00–2.50
Record company margin	2.50–4.00
Royalties to artist	1.25
Tax	3.50

Figure 4.5 *Average costs of a CD (€) in 2002*

The same IFPI report determined that the average cost of purchasing a CD in 2002 (within the European Union) was approximately €17. As can be seen from Figure 4.5, one of the largest costs involved is marketing and promotion. But why? Music is widely regarded as an experience good; it needs to be sampled by consumers in some way before they can gauge its perceived value. By promoting CD releases with radio play, accompanying music videos, television appearances, press releases, and so on, record companies are able to give consumers this opportunity to sample the good and, in doing so, encourage them to purchase a CD that they might otherwise have perceived as being of indeterminable value.

Following the basic economic equation outlined earlier, when carefully orchestrated marketing campaigns do result in very high unit sales, the fixed costs of producing and releasing the CD come to represent a much smaller proportion of total costs. In other words, economies of scale are engaged, and each additional CD sold represents a higher profit margin than the previous one. This means that, when a CD release is successful, the profit margins can be spectacular. Conversely, when the release is unsuccessful, the financial losses can be severe. Hence, the tendency of record companies to focus their attention on 'reliable' artists who have an established following or brand and whose releases are likely to sell in large quantities. It is now common knowledge that many releases do not even recoup costs, let alone make a profit. In 2001, various music industry executives—on condition of confidentiality—granted investigative journalist Chuck Philips access to "internal budgets and cost-analysis data for dozens of recording projects, from marquee stars to failed unknowns" (Philips, 2001: 1). Philips found evidence that only *one* out of every 10 releases made a profit. That the record companies were able to continue trading at all is indicative of the extent to which one successful release could counteract the losses incurred by so many unsuccessful releases. As such, the CD was an economically viable platform from the perspective of the record companies.

The technical and sonic advantages of CDs over the preceding vinyl and tape platforms were clear: no wow and flutter, unlike tape; the ability to track-skip with precision, unlike vinyl; and a sound quality arguably superior to both. These advantages encouraged many consumers to absorb the switching costs—financial or otherwise—involved in transferring their music collections onto (or replacing them with) CDs. Nonetheless, many consumers felt that the CDs themselves were often over-priced, a feeling exacerbated by the knowledge that record labels usually kept approximately a third of the retail price in profit (see Figure 4.5). Once domestic CD-copying equipment became affordable, many consumers resorted to buying the relatively cheap blank discs (i.e., CD-Rs or CD-RWs) and copying CDs from friends or libraries.

4.4.3 The digital economy

The discussion above suggests that, within the music industry extant at the time, the CD was economically viable for all parties involved.

Consumers may have been paying more than strictly necessary in order to keep record company coffers well stocked but, on the whole, all parties involved—artists, distributors, retailers, manufacturers, labels, consumers, promoters—were able to derive an income somewhere along what might be called the traditional value chain (implied by data in Figure 4.5).

It is tempting to assert that digital music files are the most economically viable platform of recorded music the industry has ever known. Future improvements notwithstanding, the cost of storing, reproducing, and replaying recorded music is continually diminishing, even if marginal costs (such as the price of electricity to power a computer and its speakers) prevent it from ever reaching zero. But to make such an assertion would be to overlook the fact that economic viability is somewhat perspective-dependent. That consumers—some audiophiles aside—have welcomed digital music files with open arms is unsurprising. But those who have traditionally mediated the conveyance of music from artist to audience have been, understandably, sceptical. The fundamentally different nature of digital music files to their predecessors has all but exploded the traditional value chain, leaving in its wake a reconstructed value chain that the traditional music industry did not adapt to quickly.

There are new opportunities for artists to connect directly with audiences, obviating the need for physical media and the royalty agreements that determine so much of an artist's income and an audient's expenditure. This often results in lower costs, presenting consumers with lower prices, and artists with a share of profits that was previously absorbed by the record companies (Bockstedt et al., 2006: 3). Bockstedt et al. (2006: 9) provide the following overview of the effect that the shift in value chains has had for the various actors within the industry:

Actor	Traditional value flows	Digital value flows	Change
Artist	• Composition • Recording • Performances and appearances	• Composition • Recording • Performances and appearances • Production and distribution deals	• Increased control of production and distribution • Potential increase in profits • Decreased copyright protection
Label and production company	• Copyright enforcement • Production and manufacturing • Distribution, marketing, and promotion	• Copyright enforcement • Marketing, and promotion	• Loss of monopoly over production, distribution, and manufacturing • Potential decrease in profits
IP rights enforcement body	• Limited IP rights enforcement	• IP rights enforcement • Piracy prevention • Prosecution of piracy cases	• Increased control of legal distribution • Increased awareness of and ability to track illegal distribution
Traditional retailer	• Distribution to customer • Advertising	• None	• Loss of customers and/or sales • Decreased profits
Digital retailer	• None	• Distribution to customer • Advertising • Extras (such as recommendation and search services)	• Growth of digital market • Potential increase in profits • Increased competition
Consumer	• Purchase or pirate physical platforms	• Purchase or pirate physical or digital platforms	• New supply channel • More product choices • More power over prices

Figure 4.6 *Changes in value chains*

Although the shift from traditional to digital value flows has been gradual and chaotic, the changes outlined in Figure 4.6 can be summarized as follows:

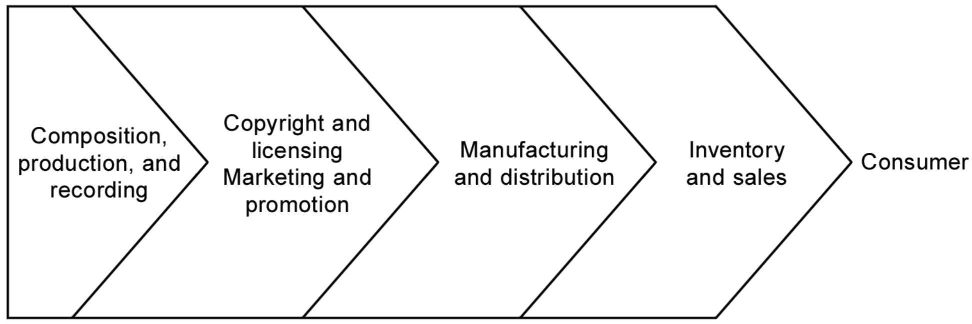

Figure 4.7 (a) *Traditional value chain*

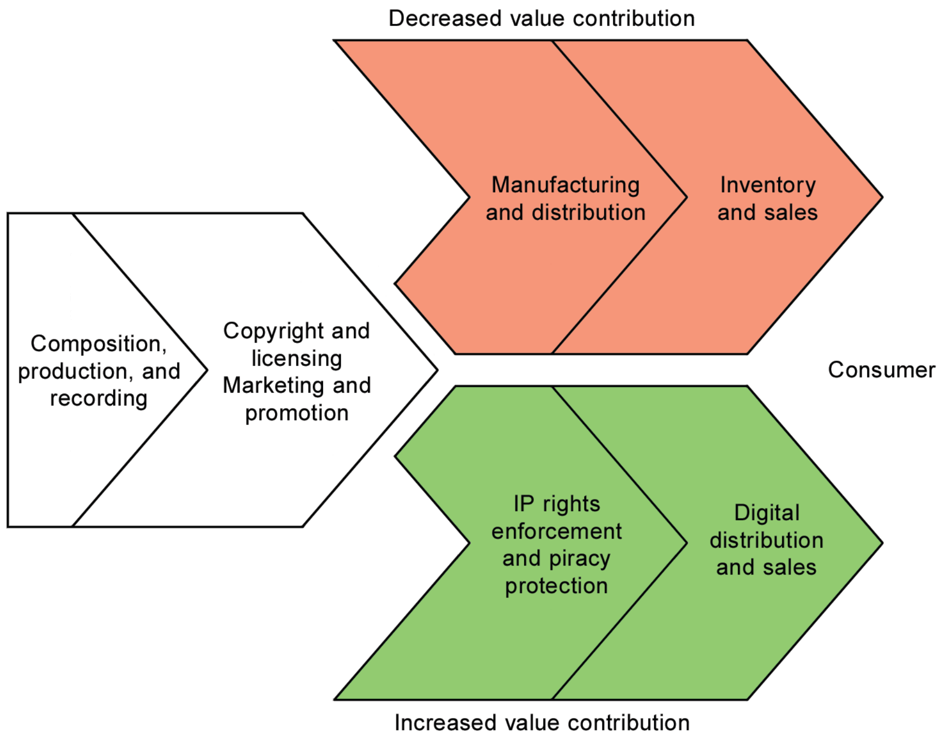

Figure 4.7 (b) *Digital value chain*

Comparing these two value chains, it becomes apparent that in the digital era, those services that traditionally only record companies have been able to provide, are the only ones that—in theory—detract from the value of a product. This puts the record companies in an uncomfortable position.

Record companies have always relied on external actors (i.e., artists, bands, writers, and performers) to provide them with their 'goods' (i.e., sound to be recorded for exploitation). The music these recordings represented was usually owned by the artists, but controlled by the labels and their partners in distribution and retail. This allowed labels to exploit the recordings in a variety of ways to maximize their revenue, even if it involved distorting the market (usually via targeted marketing and promotional campaigns) in order to do so.

Andrew Leyshon and his colleagues note that major record companies have often been heard to "justify their role within the musical economy through their role in making popular music both possible and successful" (Leyshon et al., 2005: 189). Faced with ranks of consumers who were able to access a broader spectrum of music, usually for less money, record companies tried even harder to emphasize their importance the digital market:

> My company invests millions of pounds each year in new writing talent and new composers. To recover that money we need to be paid. If we don't get paid because it goes on the Internet and everyone gets it free, then we can't continue to make that investment in new talent.
>
> (William Booth of Sony Music quoted in McCann, 1998: 2)

This raises two issues. First, the Sony representative quoted above is less than emphatic about the fact that the extent of this investment is necessary, paradoxically, in order to help the label recoup the losses of their 'failures': the nine out of 10 releases that *do not* make a profit. Second, and perhaps more pressingly, the digital music industry has demonstrated that talent in writing, performing, and composing, does not always require the economic nurturing that traditional major labels profess to offer. There are, of course, many instances in which the investment is necessary in order for an act to be commercially successful. This was particularly true when, for example, the cost of hiring a studio or distributing a record, was prohibitively expensive for all but the wealthiest or most-established musicians. With digital music files and the Internet, however, this is no longer the case.

The ways in which digital music files have altered the economic structure of the music industry are many and varied. Some are discussed in this dissertation, and some are beyond its scope. It is abundantly clear, however, is that after a decade or so of interaction with digital music files, audiences and the majority of artists (though by no means all) have found their economic viability to be, by and large, unparalleled. Traditional record companies have found them to be less economically viable than many of their predecessors, primarily because—in a profound rupture with the past—a lot of artists are willingly giving away their music for free. This is not to say that there is no possibility for reconciliation. But, in order for digital music files to be economically viable for record companies and other traditional players in the music industry, substantial rethinking of business models is needed to accommodate the radical restructuring of traditional value chains that digital music files and their associated technologies have effected.

4.5 Editability

How manipulable a platform is in terms of techniques such as cutting, splicing, looping, fading, scratching, multi-tracking, in both professional and domestic audio environments.

Is music ever truly unedited? Is it ever heard utterly raw? Or, by the time it reaches a listener's ears, has it always been modified in one way or another? In the context of live performance, the answers to these questions are likely to stray into realms philosophic. After all, music in a sonic sense—as opposed to a textual, manuscript sense—is modified by even the plainest of acoustic spaces. When considering recorded sound, however, the questions are a little easier to unpack.

As explained in Chapter 2, microphones and other recording equipment inevitably inflect the sounds that they capture. The extent to which this happens has been greatly reduced over the last 130 years. Acoustic recording with limited frequency response gave way to electrical recording, which has gone from strength to strength. One thing that has not changed, though, is the desire to modify the sounds after they have been recorded. From the first splicing of magnetic tape to the latest in surround-sound software emulators, musicians, producers, engineers, and consumers have been tweaking, chopping, slicing, splicing, burning, looping, fading, dubbing, scratching and otherwise manipulating recorded music media to achieve sounds that were otherwise impossible (singers accompanying themselves simultaneously on backing vocals), too difficult to recreate consistently by any other means (think 'Bohemian Rhapsody' by Queen), or simply creatively explorative (the ethereal backward guitar solos of many psychedelic bands in the 1960 and 1970s).

So where did it all begin? On the earliest recorded music platforms, *meaningful* editing was nigh on impossible. Of course it would have been (and still is) possible to drag something sharp across the surface of a wax cylinder, or reshape the grooves of a vinyl record by filling them with resin; both of these would have 'edited' the sound produced on playback. The results of such processes, however, are unlikely to bear witness to any genuinely musical or aesthetic intentions.

It was not until the 1940s that editing of recorded media started to become at all commonplace. In the closing stages of the Second World War, as the Nazi presence in mainland Europe weakened, members of the United States Army Signal Corps were sent to search various Nazi sites for any information or equipment relating to German communications technology. One of the signallers, John Mullin, visited a studio at Bad Neuheim near Frankfurt, where he discovered two AEG Magnetophon tape recorders (Fenster, 1994: 59). He had them shipped back to the United States and, on his return, seeing the commercial potential of the machines, he set about bringing the technology to market. Mullin's pitches caught the attention of Bing Crosby's technical director, who then arranged for Mullin to meet the singer and demonstrate the tape recorder to him (Fenster, 1994: 59).

Crosby, reluctant to perform live every week (and preferring the atmosphere of the recording studio) asked his bosses at broadcaster NBC if he could record his scheduled radio performances to tape in advance of the broadcasts themselves. Executives were sceptical at first; a ban on pre-recorded shows had been introduced to avoid the poor broadcast quality produced by vinyl discs. Succumbing to Crosby's financial clout, industry connections, and a demonstration of the capabilities of Mullin's remarkable new device, NBC acquiesced. On 1st October 1947, the first magnetic tape broadcast in America made its way across the airwaves. Soon, other artists were clamouring for the same quality of sound and professional flexibility that Crosby was clearly enjoying (Fenster, 1994: 59).

Broadcasting from vinyl recordings was evidently possible, even if commercial studios had ruled it out on grounds of quality. But what made tape *so* attractive to artists like Crosby—and all the other people involved in the process of conveying the sound of his voice from the studio to listeners' homes—was the ability to record, erase, and record again on the same medium repeatedly, and to do so with relative ease. This simply had not been possible with cylinders or vinyl. In contrast to the micromaterialization of digital music files, it was the very physicality of magnetic tape that made this possible.

Although far from obvious at the time, tape technology provided the first real opportunity for engineers and others to start turning the editing of sound on media into a craft. It dramatically affected the way recording studios operated:

> In contrast to the wax disc recorders they replaced, reel-to-reel tape machines could be stopped and restarted quickly and easily. This meant that pieces of music no longer had to be recorded in their entirety, from beginning to end. If anyone made a mistake, the machines could be stopped and started again, with musicians starting to play in the middle of a piece if a suitable 'drop-in' point could be found, or starting again from the beginning and recording over the previous take.
>
> (Brend, 2005: 48)

The reception, however, was not always positive. Musicians were under no illusions about the advantages in continuity and convenience that tape offered but, as Brend indicates, they *were* concerned about the effect that tape recorders would have on the public's perception of musicians as a profession:

> Surely, the doubters said, it was now no longer necessary to have a command of your instrument or your voice, and a firm grasp of the music you were performing? Now any half-trained amateur could go into a studio and record bits and pieces that engineers could make into something coherent. And surely this wasn't the proper way to make music?
>
> (Brend, 2005: 49)

Truthfully, the musicians were probably less concerned about the aesthetic effects on music as a whole or the adherence to a tradition than they were about paying their bills. They were worried, Brend suggests, that lowering the bar for entry into the music profession "would somehow do 'real' musicians out of a job" (Brend, 2005: 49).

4.5.1 Pierre Schaeffer and musique concrète

Innovations emerging in Western commercial and broadcast studios soon started to spill over into other spheres, marking the beginning of a wave of musical development and creativity that was centred around magnetic tape technology and its editability. At the vanguard of the tape movement was Pierre Schaeffer: an academic, broadcaster, composer, and radio engineer. In 1942, Schaeffer started working at the research studio of Radiodiffusion Nationale (RDN), the French state broadcasting organization. Though primarily concerned with wartime communications, the studio gave Schaeffer the opportunity to explore sound manipulation techniques and research into "noises" (Palombini, 1993: 14). *Cinq études de bruits*—written in 1948 and one of Schaeffer's most famous compositions from this time—comprised the sounds of everyday objects and environments (such as trains, toys, and kitchenware) as well as voices and instruments, recorded and manipulated using wax-disc recorders and associated equipment. This made live performance of the piece very tricky; it required precise synchronization of multiple turntables (Brend, 2005: 49).

This type of music was dubbed (by Schaeffer) *musique concrète*, which, loosely translated, means 'real' or 'concrete' music. Schaeffer placed significant emphasis on the 'acousmatic' nature of the sounds involved, i.e., the inability to *see* the original source of the sound. Such avant-garde 'compositions' were treated with scepticism by audiences and derision by the rather conservative French musical establishment (Born, 1995: 75). Schaeffer, however, was far from discouraged.

In 1949, the Groupe de Recherche Musicales (GRM) was founded by Schaeffer and his colleague, the composer Pierre Henry (Born, 1995: 75).[1] With the new group came a new studio, complete with magnetic tape recorders of the kind that John Mullin had popularised in the United States (Brend, 2005: 49). The practice of physically editing tape was in many ways a "natural development" of the practices that had emerged in recording studios throughout the previous decade (Brend, 2005: 48). Nonetheless, it was within the GRM's unique environment of hi-tech, forward-thinking creativity and research that Schaeffer and his colleagues would go on to develop techniques for editing tape that would have a profound and prolonged effect on virtually every aspect of music.[2]

The two most fundamental techniques for editing tape—though one was seldom performed without the other—were cutting and

---

[1] Brend suggests that the institute was actually known as the Group de Recherche de Musique Concrète (Brend, 2005: 49). I have chosen to use Georgina Born's label, given the rather more immersive nature of her study of the institute's history.

[2] Born notes that: "In the 1950s and 1960s the GRM became a focus for many young composers and fostered an important French school of electro-acoustic composition and research; for a period, this lay claim to be the main French avant-garde. Other approaches to electronic music were emerging simultaneously in Germany and the United States, yet Schaeffer was the pioneer of an influential technique and aesthetic" (Born, 1995: 75).

splicing. Both relied on the speed at which the tape moved past the magnetic heads during recording and playback: often as fast as 32 inches per second. This high speed meant that small physical anomalies in the tape (or the data recorded on it) did not manifest themselves audibly.[3] As such, it was possible to cut out a section of the recorded tape, and 'splice' the two remaining ends together with adhesive tape, without a listener being able to 'hear' the join. The inconspicuousness of this editing depended, of course, on the splicing being carried out carefully, and the sonic material being somehow contiguous:

> So, assuming that the music on separate pieces of tape matched up, the illusion of a live performance could be created by splicing together several sections of music from different performances to make a complete piece or song.
>
> (Brend, 2005: 48–49)

As Brend points out, this had obvious application to broadcasting situations. Entire radio shows—such as those starring Bing Crosby—could be recorded, cut, and spliced ahead of the eventual broadcast. This encouraged a level of continuity in radio shows that audiences had rarely experienced before.[4]

Back at the GRM, Schaeffer and his colleagues had developed the process at a more granular level. Rather than editing together entire performances or sections of speech, for example, they followed on from Schaeffer's *Cinq études* by assembling much smaller sections of tape—often single notes or sounds from various traditional and

3 At 32 inches per second, each inch of tape represents a semi-hemi-demi-semi-quaver (or quasi-hemi-demi-semi-quaver) at a metronome mark of ♩ = 60. Or, temporally speaking, 0.03125 seconds.

4 This process of editing and arrangement, though seemingly primitive by today's standards, is actually reflected very faithfully in the interfaces used on most digital studio software. Recorded sounds appear like strips of tape, which can be squashed, stretched, cut, spliced, cross-faded and so forth.

concrète sources—into compositions. The large-scale broadcast-style editing usually involved splicing together the silences at the beginning or end of sections of speech or music. By contrast, the GRM approach involved splicing the ends of individual sounds and notes (often cut before the sound had naturally decayed) to the beginning of others (often cut after the sound's initial attack).

While repeating this process countless times, Schaeffer and his colleagues realized that the angle at which two pieces of tape were spliced changed the sound of the join on playback:

> For example, a diagonal cut created a soft attack or decay that may not have been a feature of the original sound recorded. So by using different types of diagonal splices, sounds could be altered and musical expression created. A vertical cut, on the other hand, gave an abrupt attack or finish to a note or sound, again, creating a dynamic in the music and also a new sound.
>
> (Brend, 2005: 50)

In this way, Schaeffer and other composers at the GRM created entire compositions, often out of hundreds or even thousands of pieces of tape.[5] Powerful and radical though this process was, what was on the pieces of tape was often more interesting. As noted above, Schaeffer and his colleagues used recordings of traditional instruments and voices, as well as *concrète* sounds. In between these seemingly irreconcilable poles lay a compositional technique that would go on to influence generations of musicians, many of whom would never know who Pierre Schaeffer was.

[5] The practice of splicing became so commonplace that equipment manufacturers began shipping units with splicing blocks included: "These were small channels in which tape could be placed, with different angled guide slots to aid the cutting of the tape" (Brend, 2005: 50).

The variable playback and recording speeds on tape machines such as those installed at the GRM allowed engineers and composers to generate different pitched sounds from the same piece of tape, in much the same way that a vinyl record played at twice its normal rotational speed would sound an octave higher than intended. A *concrète* sound, such as saucepan lid being struck, might generate a muddy note, rich in harmonic overtones, but one nonetheless discernible as a middle C, for example. Once recorded, this note could be played back at a higher or lower speed, and the resulting note (correspondingly higher or lower in pitch) recorded to another tape machine.[6] With sufficient precision and repetition, an 'instrument' could be generated out of the original sound. A series of notes, perhaps a couple of octaves, could all be derived from the original recording of the saucepan lid. By duplicating, cutting, and splicing these different notes, it effectively became possible to 'play' music (familiar or otherwise) on a saucepan.

Far-fetched and ludicrous as the practice may have seemed to the mid-twentieth-century musical establishment, Schaeffer and his colleagues had demonstrated the first instance of sampling; a technique whose subsequent impact is hard to overstate.

As Schaeffer and his contemporaries in the burgeoning tape music movement were moving on to pastures new, Brend tells us, "more populist manifestations of their ideas began to emerge" (Brend, 2005: 51–52).[7] There are plenty of examples: multi-tracking, tape loops, echo, delay, chorus, and many others. Explanations of and discussions about these techniques can be found elsewhere, and in much greater detail than this chapter can possibly hope to offer (see Brend, 2005). All of these techniques, and more besides, found their way into the popular

[6] The presence of multiple tape recorders, allowed composers at the GRM to circumvent the complex synchronization of turntables that had been so problematic in the past.

[7] Their influence was not limited to popular music. *The Forbidden Planet* (1956) was the first film to be accompanied by an entirely electronic soundtrack. It was composed, produced, and recorded by Louis and Bebe Barron.

music of the late 1950s and, particularly, the 1960s, with The Beatles, The Beach Boys and many psychedelic bands putting them to famous effect.[8]

Despite the tremendous advances in tape techniques discussed above, and the sonic adventures that sprang forth from them, the inherent limitations of magnetic tape technology (discussed in Chapter 2) were still present in every manipulation. Each additional track bounce, each layer of delay, each wash of chorus—all of these would contribute to an overall background noise that could not be overlooked indefinitely.

Meanwhile, though the materials used to produce vinyl records—and the precision with which the discs themselves and associated equipment were engineered—improved substantially in many ways over the latter half of the twentieth century, their editability remained non-existent.

4.5.2 Computer editing and the granularity of editability

It is useful here to delineate between two types, or 'granularities', of editing and editability. On the one hand, there is the ability to manipulate and affect individual sounds and waveforms, as a studio engineer or sound technician might be employed to do. This will be referred to as 'fine' editing. On the other hand, there is the ability to move around entire recorded musical pieces or tracks, which often takes the form of creating and organizing playlists, or perhaps ripping tracks from a CD to a computer. This will be referred to as 'coarse' editing.

[8] Joe Meek was perhaps the epitome, for many people, of the tape composing movement. He bridged the gap between avant-garde and populist musics, releasing songs such as the Novello-award-winning 'Telstar'.

Despite the level of fidelity that CDs boasted, they failed to offer any options for meaningful editing—coarse or fine—using the medium itself. The combination of nanometre precision, laser reading, the frailty of the data stored, and the need to decode the data, all placed the CD—as an object, at least—well beyond the reach of practically minded engineers.

MiniDisc offered a hybrid of CD and tape, welcomed by many for its combination of coarse editability (and the relative ease with which this could be accomplished) and high quality sound. Although, theoretically, it does not offer such high quality audio as CD (thanks to Sony's ATRAC perceptual compression encoding), MiniDisc was a vast improvement on tape in that repeat copying and editing did not introduce inherent noise (like tape hiss) every time it was edited. Suddenly it was possible to create 'mixtapes'—a long-standing tradition associated with tape technology—with near-CD quality audio, not just one or the other.

At the same time that CDs (and, to a lesser extent, MiniDiscs) became widely adopted, personal computers were becoming an increasingly common feature in the homes of many music consumers. Before long, it was possible even for lay consumers to convert their physical music collections into streams of digital data stored on the hard drive of their computers.

Computers were already engineered and designed to create, amend, and delete data with the utmost precision. Moreover, consumers were also used to controlling these processes through ergonomically straightforward and familiar interfaces: enormously complex data manipulation processes were subsumed within a single click; streams of digital information on a hard drive were translated into individual entities and rendered as images, text, movies, and sounds. At this point, not only did audio data once stored on physical media become inherently more malleable in an objective, physical sense, but convenient editing of it was now within the grasp of many non-specialist computer users and consumers.

The earliest computer-based sound editing programs were developed in the late 1970s and early 1980s but the equipment involved made them prohibitively expensive for consumers (Fine, 2008). As the 1980s progressed and computing components became more affordable and more compact, personal computers began to have enough processing power to cope with the demands of digital editing. The first programs designed for these newly capable machines—such as Sound Designer and SoundEdit—were used primarily to edit sound for audio samplers, offering basic editing techniques such as cutting, splicing, and cross-fades. These programs soon found purchase amongst consumers looking to edit audio for other purposes and such programs (or ones like them) continue to have application in environments like the modern radio station, where quick editing of recorded phone conversations and past broadcasting is essential.

The first generation of home-user digital editing software was soon superseded by complete digital studio programs like Logic and Pro Tools. New version of these programs are still being developed and released, but even in their first incarnation they offered an unparalleled level of fine editing control. Features such as automating volume and pan changes, and even layering live recordings with ultra-realistic samples of the Vienna Philharmonic orchestra (instrument by instrument), are now commonplace. Yet, these are only a tiny fraction of the capabilities of such programs. People who possess the skills and knowledge to exploit everything these programs have to offer are much valued. Their ability to improve, create, edit, and manipulate sounds has made them an integral part of most recording practices (Schmidt Horning, 2004) and they are often regarded as musicians in their own right: "In today's recording studios the sound engineers can be as important in the production of 'the sound' as are the musicians themselves" (Pinch and Bijsterveld, 2004: 635). Brend has a similar perspective: "If the tape machine was indeed a musical instrument, then mastering these techniques was learning to play it" (Brend, 2005: 50).

In doing so, studio engineers effectively created a new instrument, and a new actor in the creation of music; a sort of meta-musician who, like the sampler, invariably works with other people's material. Far from any accusations of plagiarism, engineers are often credited with contributing to the very originality of a particular recording. This is perhaps more true of popular music, where bands or artists will often craft their songs—to a greater or lesser extent—in the studio. In the classical music world, the composition of the work in question is generally fixed, and the majority of interpretive work takes place between and amongst the conductor and the players.

But these incredibly powerful software packages are not limited to the professional recording studio. Programs like Logic and Pro Tools are widely used by amateur musicians, DJs, and audio enthusiasts alike. Such software costs hundreds (sometimes thousands) of pounds, but it is almost certainly cheaper than paying for a studio and an engineer to run it.[9] Even people who cannot afford such heavyweight software (or do not have the time and inclination to familiarize themselves with it) can download and use—often for free—much more simple editing programs like GarageBand, which comes free with modern Apple Mac computers. This represents a generalization and acquisition by many of skills that once were highly specialized and possessed by very few.

The tools to fine-edit sound can now be so technically advanced and intricate as to count as instruments in their own right. More broadly, though, and perhaps more pertinently, people who are simply interested in listening to the music they like—rather than recording,

---

[9] At the time of writing, a student version of Logic Studio retails for $499.00 on the Apple web store (Apple, 2012a). At the same time, the United States Bureau of Labor Statistics records the mean hourly wage of 'Sound Engineering Technicians' in the 'Sound Recording Industries' as $26.76 (United States Bureau of Labor Statistics, 2012).

remixing, or otherwise manipulating their favourite tracks—are also reaping the benefits of the editability of digital music files. Something that any music consumer under the age of 30 (and many who are older) will take for granted is the ability to coarse-edit their music collections. That is, the ability to make and manage playlists at the click of a mouse or touchscreen; dragging and dropping tracks into the desired order, reshuffling them at will, even electing to have the playback randomised.[10] This is a far cry from the days of high-speed dubbing from one cassette to another, or running out of space on a MiniDisc. Playlists can be infinite, and infinitely modified.

4.5.3 The ramifications of editability

Far from being a mundane practicality, the ability to edit recorded music has revolutionised the way music is thought about, distributed, performed, and consumed. Schaeffer and his colleagues demonstrated conclusively that people could make music even if they were considered by the establishment to be non-musicians. As Brend points out: "For the first time, non-musicians (and Schaeffer was one of those) could make music . . . Many electronic and dance records are made by people who can neither play an instrument nor sing; they simply manipulate and order sound using computer technology. Schaeffer was their father, whether they know it or not" (Brend, 2005: 50).

Today, whole genres of music (such as electronica) are dependent on the capabilities offered by sound editing software and technology. The technology and the abilities and practices it encourages have changed traditional perceptions of musicianship. 100 years ago, someone who could not play a musical instrument or sing would have been easily classed as a non-musician. Today, it might seem a little

[10] Some software and services (such as Spotify) provide the option for listeners to create playlists based on their mood, using aggregated data about the songs in the user's library.

trickier to label producers of dance and other electronic and music as non-musicians, particularly given the enormous impact of and audience for their music.

It turns out though, that the doubts first raised by the Bing Crosby-era musicians—about being "done out of a job"—have not been entirely dispelled. Regardless of whether consumers (and musicians) like it or not, the facilities now exist to manipulate sound with ease and precision. Some will argue, not unreasonably, that this can result in musicians and singers with limited talent being made to sound better than they are. A prime example of this is the use of 'auto-tune', a form of pitch adjustment applied (particularly to recorded vocal lines) in order to 'correct' notes that are out of tune. Subtly applied, this can give lush backing vocal arrangements a consistency and evenness that might be otherwise impossible for the singer(s) to achieve. Used less sparingly however, it can add an almost robotic quality to vocal performances.[11] It can also be used during live performances, a particularly salient example of which being the 2010 season of the *X-Factor*.[12] On several occasions, contestants' voices were allegedly auto-tuned *as* they performed live. The reaction of the public and press was substantial and largely negative, and the show's producers denied using auto-tune (British Broadcasting Corporation, 2010). Ironically, the practice is widespread, featuring on the majority of recorded music releases (Savage, 2010). It would appear that being confronted with it so bluntly is less acceptable to many audiences than enjoying its subtle application through the accepted tinkering of album mixing.

One of the less obvious side effects of advanced post-recording editing techniques (of which auto-tune is but one) is the shift in the expectations that audiences have of performers. Audiences used to

---

[11] A famous example of this is the main vocal line in the 1998 song 'Believe' by Cher, from the album of the same name.

[12] The *X Factor* is a singing talent show where contestants are required to perform live each week in order to secure their place in the following week's show and, eventually, victory over their other contestants in the final show.

hearing note perfect recordings, immaculately tuned, are likely to become less tolerant of mistakes made by players or singers in live performance. This effect was already extant before digital editing techniques became so advanced or widespread. For many, recording itself created similar expectations:

> A new kind of performer is needed, the virtuoso of the repeated take. The effect is different in different musical camps. In pop music, this tendency leads to products that depend entirely on recording technique, and which cannot be performed live at all.
>
> (Chanan, 1995: 18)

It is reasonable to assume that the emergence of techniques like auto-tune and quantization of live recordings—retroactively rendering performances more 'in-time'—will only serve to exacerbate the effect on performance that Chanan noted in the first instance.[13]

Whether or not this sense of perfection and audience expectations of it are desirable is not a debate that can be undertaken effectively or authoritatively within the context of these pages. The important thing is that, due to advanced sound editing techniques made possible only by digital audio recordings, the issue is there. Ultimately, digital music files are, in terms of editability, almost beyond compare with older platforms. The limiting factor in the editing process is no longer the quality or pliability of the media. Instead it is the imagination of the engineer, the interface used for editing, the raw material recorded, and, increasingly, the desired effect.

[13] As a response to what they considered the increasing sterilization of recorded music by the digital-fuelled obsession with perfection, the rock band Foo Fighters recorded their seventh studio album *Wasting Light* (2011) entirely on analogue equipment, without using computers for any part of the process. For a detailed exploration of the recording process and the motivations behind it, see Micallef (2011).

4.6 Fidelity

The extent to which a platform is able to reproduce sound faithful to its recorded source.

The definition provided above gives a plausible explanation of what many people understand fidelity to be, but the reality is more complex. In order to elucidate, it is important to examine exactly what the concept of fidelity comprises. Ostensibly, it can be divided into two parts: absolute fidelity and relative fidelity.

4.6.1 Absolute fidelity

Absolute fidelity is the ability of a recorded music platform to reproduce the experience of a live performance. This is based on what Matthew Malsky describes as "an ideological assumption that there should, or even could, be a direct correspondence between a live and a reproduced sound—the desire to believe that recording isn't a symptom" (Malsky, 2003: 239). Much of the commentary on this subject seems to quietly assume that absolute fidelity is something to which all platforms aspire: that recording is a necessarily inferior facsimile of performance, and that the performance is the central musical text.

In the classical music world, the performance itself tends to be the main object or text, with recordings of such performances functioning as little more than accounts of a particular performance that can be played at the listener's convenience. Creatively speaking, very little of the recorded performance is conjured up in the post-production phase. Things like reverb, frequency equalization, and compression—tweaks essentially—are sometimes applied, but the performative and compositional aspects reside primarily in the act of abstract composition and actual interpretation and realization through performance. Rarely, if ever, do such recordings demonstrate any overdubs, multi-tracking, or obvious effects. There are often retakes and drop-ins, but classical performances captured on recorded media are—almost without exception—wholly reproducible on stage (save for the odd wrong note).

In the world of popular music, the situation is very different, and has been for a long time. For many popular music artists, the studio functions as an environment in which creativity and compositional techniques can be taken well beyond the boundaries and possibilities offered by the musicians themselves. Many recordings contain material that is either very difficult or even impossible to recreate in a live situation. Backing vocals are a case in point. In genres like pop and rock, most recorded tracks will have sections where the lead singer's voice appears simultaneously in (usually) harmonious layers, an effect achieved by multi-tracking the voice in two or more stages. The result is often pleasing to the ear, but very difficult to accurately reproduce on stage, unless backing tracks are used. This is seldom, if ever, found on classical music records, not because the performers or studio engineers are any more or less capable than those in the pop and rock world, but because the culture surrounding composed music and the audience rarely calls for it.

Thus, in popular music there is an implicit understanding (whether on the part of the composers, performers, the audience, or all three) that recorded music need not necessarily be a faithful account of what happens on stage. In many instances, artists and bands will write songs *in the studio*. Of course, most will keep in mind that fans will invariably want to hear a version of the song performed live, so the band or artists are unlikely to create songs that are completely unperformable on stage in any incarnation. But many fans *expect* to hear stripped down versions of otherwise lavishly arranged songs because they appreciate that in many instances the album comes first; the performance should be an interpretation of the album. Consequently, the recording cannot reasonably be accused of failing to be faithful to the original performance because *there is no original performance*. The recording is not an account of an interpretation of the intentions of the composer or songwriter. Rather, it becomes its own musical text, with performances compared against *it*, rather than the other way round. As a result, the notion of absolute fidelity must be exercised with caution when considering any popular, non-classical, or other music that can be described as 'composed on record'.

Although writing over a decade ago—a time in which a great deal has changed—Rothenbuhler and Peters understood the elusive nature of absolute fidelity:

> Whether consciously grasped or not, it is the possibility of perfection that motivates the values of the audiophile. Since in real life it is so improbable, and our own stereo systems are so obviously far from it, fidelity operates as a transcendent value.
>
> (Rothenbuhler and Peters, 1997: 253)

The sonic aspect of this 'transcendent value' is limited first and foremost by the quality of the equipment used to capture a performance, and is complicated further by the quality of equipment used to reproduce the performance once it has been transferred to a given medium.

Imagine arriving late to a concert and standing alone in the foyer outside the auditorium. Through the doors you can hear the muffled strains of the orchestra. You wait until the applause swells at the end of the first piece to open the door and creep in. Once inside however, you realize something is amiss. There is no audience, no orchestra just an empty hall and an array of speakers.

Does this qualify as absolute fidelity? Any experience of listening to a live performance—whether an orchestra in a concert hall, a covers band in a club, or a traditional drumming group on the plains of Africa—is contingent upon so many more factors than just the sound that reaches one's ears: travel to and from the venue or location, the visual quality of the surroundings, discussing the performance with friends, meeting acquaintances, seeing the musicians play, contributing to the applause, and more besides.[1] Although these actions, exchanges, and thought processes do not—in a physiological sense—contribute directly to the sound of a performance that absolute fidelity would seek to emulate, their presence in varying combinations (according to the performance and individual) is fundamental to the 'consumption' of an actual performance. There is little doubt that our expectations regarding what we are *about* to hear influence our assessment and perception of what we actually *do* hear. As such, the absence of such non-sonic elements in any emulation of a performance would create an insurmountable cognitive dissonance, akin to the bewilderment and confusion that would arise when opening the door to a concert hall to find a sound system in an otherwise empty room. This dissonance would greatly undermine any attempt to emulate a performance with absolute fidelity, as well as one's ability to be convinced by such an emulation. The phenomenon of live performance and its experience involves far more cultural, social, emotional, and psychological association than many consumers realize, and certainly more than any technology is likely to be recreated in an affordable and practical way.[2]

---

[1] Research suggests that the visual aspect of performance—specifically, the manner in which a performer moves—contributes significantly to an audient's perception of a performance (Davidson, 1993).
[2] The efficacy of such systems (assuming they could exist and could be made affordable) is dependent upon whether or not they would be practical and compatible enough for listeners to adopt and use them.

4.6.2 Relative fidelity

If absolute fidelity is impossible to achieve, producers and consumers of recorded music platforms contend only with *relative* fidelity, i.e., how one platform compares to another in terms of its ability to be true to the original recording. Or, to put it another way, the extent to which any platform distorts the recording. In this sense, fidelity means being true to the original *recording*, and overlooking (at least temporarily) that the original recording may be far from true to the original performance, whether the performance was a live concert, a studio session, or something else. Once again, Malsky provides a useful explanation:

> Every established audio reproduction technology is considered to be completely adequate to the task of representing sound, at least until it is displaced by 'something better'. Long-playing records were considered a high definition medium, and the inherent surface noise of LPs disturbed few listeners, until they were measured against compact discs.
>
> (Malsky, 2003: 239)

Malsky acknowledges the *objective* element of relative fidelity, citing "a sound recording's acuity and precision in terms of measurable sonic characteristics" as a platform-specific benchmark to which other platforms can be compared. What he fails to address, however, is the *subjective* element of relative fidelity. Sterne worries that the difference between the two is often elided: "Sound is a product of perception, not a thing 'out there'—the only thing 'out there' is vibration, which the body organizes and stratifies into what we call sound" (Sterne, 2006: 834).

The objective elements of any aural perception amount to vibrations that reach the ear by being propagated from their source, through any compressible medium (whether solid, liquid, or gas). Such vibrations and disturbances are objectively measurable using sound pressure level meters and other specialised acoustic equipment. The sort of recording phenomena that affect objective fidelity have been indirectly discussed elsewhere in this chapter: wow and flutter on magnetic tape, sampling rates and aliasing in digital formats, the limited frequency response of early analogue platforms, and so on. Common to all the elements of objective fidelity is their ability to be measured in a quantitative or scientific manner, independently of human perception.

The methods and processes by which these elements can be analyzed are many and varied. As such, it lies beyond the scope of this thesis to discuss them extensively. It is important to note, however, that the primary usefulness of such analysis lies in comparing one sound signal to another. If, for example, a sound signal is digitally processed and the sampling rate lies below the Nyquist frequency, it is reasonable to assume that a listener would perceive some aliasing, even if the listener would not recognize it as such. If modern recording and production techniques allow vinyl platforms to exhibit a greater frequency response, it is likely that playback will produce a fuller, more expansive sound in audition. The key limitation to this objective analysis (and the inferences that can be drawn from it) is that all humans perceive sound differently to one another, even if only marginally.[3]

Subjective fidelity is, by its very nature, a qualitative phenomenon. A measurable and consistently repeatable sonic stimulus is likely to be perceived in subtly or substantially different ways by different

---

[3] It is worth noting that objective measurements are useful in specifying or engineering the performance of audio equipment and systems, though these are often carried out with a degree of perceptual evaluation in mind. One example is the PEAQ (Perceptual Evaluation of Audio Quality) test, an algorithm for objectively measuring human perception of audio quality, developed in the 1990s by the Radiocommunication Sector of the International Telecommunication Union. Using software to emulate psychoacoustic properties of the human ear, it produces a 'mean opinion score' from one to five (ITU, 1998).

listeners. In the gap between such listeners lies the subjectivity of sound that generates so much of the debate surrounding fidelity. Much like the perception of colour in vision, it is hard to describe sound in concrete terms of fixed meaning. The adjectives used to describe sounds seem intuitive enough—bright, rich, full, sparse, shimmering, wooden, mellow—but they are not capable of communicating precise and often minor differences between two sounds (particularly in situations where some language translation is required). Furthermore, it is easier for a single listener to communicate the difference between two different sounds than it is to convey accurately the differences in perception by two separate listeners. Why is it that different people can perceive the same sound in different ways? The answer lies in three aspects of human nature that are unique to each person: anatomy, neurology, and experience.

The human auditory system is enormously complex, but can be usefully summarized as follows:

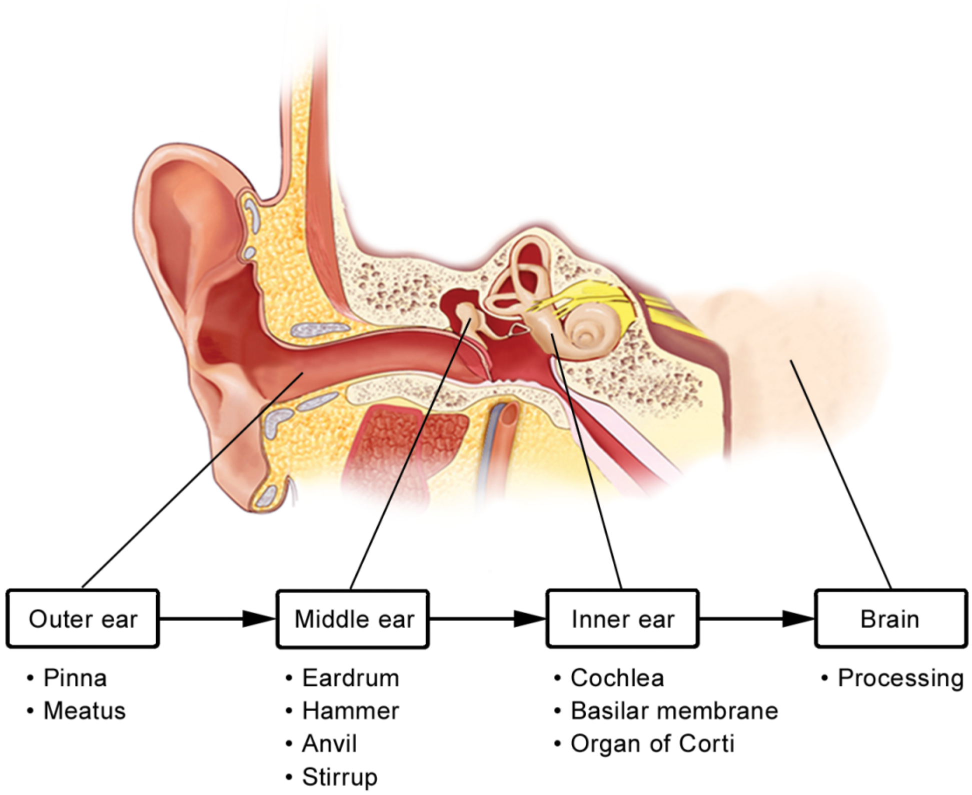

Figure 4.8 *Outline of human auditory system*

Sound waves arriving at the ear are funnelled into the auditory canal by the pinna. The eardrum then transduces these vibrations to the bones of the middle ear. This movement causes distortions in various parts of the cochlea, which then converts the signal into electrical impulses in the brain.

Figure 4.8 only illustrates one side—or 'channel'—of the auditory system. In order for a human to make sense of three-dimensional sound, both left and right channels are required.[4] By comparing the incoming signals from each ear, the brain is (usually) able to localize a sound source. It does so using many subtle inter-aural differences. These include:

- Time
- Phase
- Loudness
- Spectral reflections (from and around head and shoulders/torso)
- Amplitude of high-frequencies

Differences in anatomy between one person and another—shape and size of the head, for example—can result in subtly different inter-aural cues being sent to the brain, and thus a difference in perception of the same sound (Møller, 2006: chapter 9). A common example is the reduced ability of older people to register high frequency sound. Very loud sounds can damage parts of the inner ear, and in younger people this damage is temporary, but as humans get older the damage is not repaired to the same extent. A young person might be able to hear a mobile phone ringtone perfectly clearly whereas an elderly person might struggle to hear anything at all. Moreover, certain people are likely to be more susceptible to such hearing loss than

[4] It is of course, perfectly possible to hear with only one ear, but the result is greatly reduced spatial imaging ability. In the same way, covering or closing one eye leaves a person less able to judge distances than they might be when using two eyes.

others, depending on factors such as race and gender (Helzner et al., 2005; Jerger et al., 1986; McFadden, 1993).

Once the mechanical parts of the auditory system have registered a sound wave, the signal passes to the brain where it is processed in a variety of ways. A full exploration of the neurology of human hearing—and the differences between subjects—would require greater detail and scope than can be provided here. It is clear, however, that all humans are not neurologically equal. A number of neurological conditions of varying seriousness and progression have been shown to adversely affect hearing, including autoimmune disease (van Wijk et al., 2006), multiple sclerosis (Häusler and Levine, 1980), and Parkinson's disease (Ondo et al., 2003).

Compounding the subjective variations in sound perception induced by anatomical and neurological differences is the issue of *experiential* differences. Such differences are at one remove from the immediacy of neurological sensory perception and could be usefully described as: the way in which a listener's prior knowledge, disposition, and hearing experience affect the brain's cognitive processing and organization of simple or complex auditory stimuli. If two listeners with the same anatomy and neurology hear the same sound, for example, will it *mean* the same thing to both?

By way of example, consider Ivan Pavlov's famous research into reflexivity, which showed that dogs can be conditioned to salivate at the sound of bell once they have learnt to associate it with the arrival of food (Pavlov, 1910). The memories and cognitive associations possessed by the conditioned dogs led to a different physiological response to that demonstrated by unconditioned dogs. Humans demonstrate a similar ability to cognitively bias or associate sounds in one way or another.

4.6.3 Vinyl records and digital music files

When considering the effect of such associations on the adherence of listeners to a particular platform (or their enthusiasm for it), it is helpful to look at the vinyl record, a much lauded platform despite its seniority relative to platforms such as CD and digital music files. Often celebrated for the direct correlation between the actual fluctuations in sound pressure levels generated by the musicians being recorded, the physical shape of the grooves on the disc, and the sound produced on playback, it has become emblematic of a certain kind of audiophilia.

Chanan cites the ubiquity and persistence of marketing and advertising as a cause for the transformation of the phonography business into one of "promotion, manipulation and 'hype' whose function is not only the creation of demand but also of the model consumer" (Chanan, 1995: 17–18). One does not have to look hard in order to find examples of 'model consumers' playing their role, portraying vinyl as a platform superior to CD or digital music files. These range from straightforward praise for its sound quality to enthusiasts waxing lyrical about its tactility:

> There is something intrinsically pleasurable about the whole process of selecting, buying and playing a record. Indeed the dedicated hi-fi enthusiast probably derives as much pleasure from browsing through his collection, extracting the record from its sleeve, carefully cleaning the surfaces, and adjusting the controls of his hi-fi, as from listening to the music.
>
> (Oord, 1977: 16)

Even those supposedly writing in a detached and objective way can unwittingly demonstrate a degree of bias toward older platforms and against newer ones:

> The history of phonography is one of repeatedly discovering that old records can sound better than anyone had realized at the time. Put an old record on a new and better player and we discover more and better-sounding music in those grooves than had been heard before. By significant contrast, the short history of digital is one of discovering that earlier digital recordings, like earlier digital playback equipment, still sound dreadful.
>
> (Rothenbuhler and Peters, 1997: 254)

But the debate is not one-sided. Increasingly common are scholars who, less enthralled by (or perhaps more detached from) the non-sonic aspects of analogue, demonstrate an appreciation for digital offerings:

> Many previous recordings sound better in their new digital reincarnation than they ever did in their original form. Engineers of CD transfer removed technical flaws such as the surface noise of old discs and the hiss of a pre-Dolby master tape without falsifying, say, the timbre of a singer's voice. For original recordings made within the last 40 years or so, the task is relatively simple. During that period, recording tape was in general use, and the object of CD transfer was mainly to get all the sound from the original master tape onto the disc. This was never possible before the advent of digital techniques. To fit within the confines of the narrow LP grooves, the range of dynamics on the studio tape had to be curtailed, draining the performances of some of their expressive intent. Moreover, the bass was often deliberately thinned, so the LP stylus could track the groove more easily. In many cases this made the sound shallow and diminished its sonority. No such constraints hamper a CD transfer, which can accommodate all the sound from the original tape. As a result, the new versions elicit unexpected sonic virtues from old recordings.
>
> (Harchaoui and Hamdad, 2000: 500)

Harchaoui and Hamdad highlight two issues that are of great importance when considering the notion of vinyl as a somehow superior or more authentic medium than other platforms. First, the physical peculiarities and limitations of vinyl playback often require original recordings to be adjusted. Bass frequencies are 'thinned' in order to keep the inscriptions of sound within the boundaries of the record's grooves. But this is not the only way in which 'expressive intent' is affected. In addition, the varying speed at which grooves are tracked during playback—slower when tracking grooves closer to the centre—means that louder sections are more likely to cause the needle to jump or pop out of the groove it is tracking when they are recorded at the outside edge of the disc, i.e., where the needle is moving fastest. Thus, the order of tracks or pieces on an album was often dictated by their loudness. Artists might have wanted a particular track to be played first, but if it was too loud and liable to dislodge the needle, the track would be shifted further down the order (Blair-Oliphant, 2012).

Second, and more importantly, Harchaoui and Hamdad remind us that, almost without exception, performances (studio or otherwise) were not recorded direct to vinyl. Though the process is possible and is occasionally used, it requires not only one-take recording, but also that the sound be mixed appropriately first.[5] Once recorded to vinyl, there is no option to multi-track, adjust levels, alter panning, apply reverb, or any other typical post-production processes. If we accept that the great majority of recordings to which vinyl consumers listen were first recorded to tape (and quite possibly compressed or somehow adapted in order to give consistent playback), it stands that the 'direct connection' with the original performance, musicians, or other sound source—so often cited as the basis for vinyl's superiority as a medium—does not exist. If this connection is invariably absent, are

[5] Metropolis Studios in London offers the ability to record 'live-to-vinyl' (Metropolis Studios, 2012a), and their MySpace page includes pictures of singer Amy MacDonald and indie band Bombay Bicycle Club using the facilities to record upcoming releases (Metropolis Studios, 2012b).

vinyl enthusiasts succumbing to cultural cues about how to value vinyl and the music recorded onto it, rather than evaluating the musical on its perceived sonic qualities alone? Tassos Patokos argues that:

> It should be mentioned here that what makes the product more desirable is not just the fact that it is a physical commodity, as opposed to being a 'weightless' good, but mainly because it is not unusual for music enthusiasts to get sentimentally attached with [sic] a vinyl record or a CD, thinking of it as an item to be treasured—a feeling that could hardly be prompted by digital files on someone's computer. The implication of this is that the very same work of art may be valued a lot differently when listened to from its original artifact than when listened to in its pure digital format.
>
> (Patokos, 2008: 238)

The history of digital audio, Sterne argues, has been understood as being primarily about the relationship between originals and their copies, focusing particularly on the relative fidelity that exists between copies and the sounds that gave rise to their originals (Sterne, 2006: 836–837). In the early days of digital music files it is easy to see why such an understanding prevailed. Now, however, digital platforms are becoming (or have become) the primary vehicle for many creators, distributors, and consumers of music. 'Digitals'—once spoken of with a degree of disparagement—are increasingly becoming 'originals', and their synonymity with flawed or unfaithful copies is waning.

By the same token, Sterne argues, "discussions of the sound of MP3s have been limited largely to audio engineers and audiophiles, who range from dismissals on the basis that MP3s sound 'bad' to analyses of the sonic limitations of MP3s as a 'problem'" (Sterne, 2006: 827). In the early days of digital music files this was not unreasonable. The quality of the first MP3s really was substantially inferior when compared to CD quality audio and even vinyl. But that was the whole point; Fraunhofer and the other parties made no apology for ripping out sound data in order to make the files smaller and more easily storable. Nor, agrees Sterne, did they need to:

> MP3s of songs do not sound the same as the CD recordings; a professional audio engineer could certainly tell the difference. But the amazing thing is that as we move from ideal listening environments into the situations in which people usually hear MP3s, it becomes increasingly difficult to distinguish. MP3s are designed to be heard via headphones while outdoors, in a noisy dorm room, in an office with a loud computer fan, in the background as other activities are taking place and through low-fi or mid-fi computer speakers. They are meant for casual listening.
>
> (Sterne, 2006: 835)[6]

Not only that, but the MP3 has long served as a catch-all term for every type of digital music file. Once again, this was understandable in the early days of digital audio—when referring to the full range of less catchily titled file formats might have made journalists and academics wince—but while it continues to be used as such, a great disservice is being done to other file formats that today boast audio specifications of a much higher quality.

As discussed earlier, the compression algorithms applied to digital music files exploit several principles of psychoacoustics in order to reduce the overall file size. This allows the data that are least crucial to the sound to be removed whilst preserving to a greater or lesser extent the resulting playback. The gold standard of such compression is complete 'transparency': achieved if the compressed playback is

---

[6] Sterne goes even further, suggesting that behind the psychoacoustic coding of MP3 is an understanding of the ideal listener as "Theodor Adorno's nightmare: the 'distracted' consumer of mass culture" (Sterne, 2006: 836).

indistinguishable from the original, uncompressed playback. Transparency, therefore, depends on perception and, as such, is at least partly subjective.

A variety of tests can be used to gauge the transparency of sound compression protocols. One of the most commonly used is ABX testing, which can be used to compare a variety of sensory stimuli.[7] In the case of sound, the procedure is as follows:

- Listener is presented with the first sample, overtly labelled A
- Listener is presented with the second sample, overtly labelled B
- Listener is presented with a sample randomly selected from A or B, overtly labelled X

If the listener (or several listeners) cannot detect—usually with a certain frequency over a number of trials in order to allow for issues of probability—whether X is in fact A or B, it is assumed that there is no perceptible difference between A and B. If, for example, A were an uncompressed digital sound signal and B were its compressed counterpart, the satisfaction of an ABX test would suggest that the compression method used in transforming A into B was fully transparent.

Lossless encoded formats ought, in theory, to be entirely transparent. If, however, the listener is familiar with the content of samples presented—a favourite song, perhaps—subjective bias towards or against particular compression formats can skew informal comparisons and thence the estimation of transparency. A crucial advantage of ABX testing over perhaps less structured comparison, is that neither A nor B (nor, by extension, X) need to be familiar to the

[7] A related example is the comparison between various forms of visual data compression (such as JPEG) used to reduce the storage requirements of image files.

listener. This allows listener bias based on the experiential differences mentioned earlier to be greatly reduced or even entirely removed.[8]

The compression of audio data in order to facilitate minimal storage and maximum mobility is less and less necessary now that digital storage space is cheaper and more capacious, computer processors are cheaper and more powerful, and the Internet is faster and more reliable. Lossless-encoded audio files are becoming commonplace and their quality is arguably better than any platform to date. But can the improvements continue? If they can, it is possible that further improvements might be surplus to requirements:

> Put simply, the auditory nerve fires with less frequency than the frequencies of sound. The nerve in the inner ear cannot keep up with sound as it actually happens. Yet somehow, between the cochlea, the auditory nerve and the auditory centre in the brain, people get a sense of the detailed rise and fall of sounds. Scholars of psychoacoustics have proposed a number of analyses as to why the ear works in the way that it does, but no one theory is dominant. The key point is that . . . the human ear is not capable of such fine distinctions. In fact, people can lose most of the vibrations in a recorded sound and still hear it as roughly the same sound as the version with no data compression.
>
> (Sterne, 2006: 834)

It is conceivable, then, that recorded music platforms may have already reached a stage where the limiting factor is the human auditory system. If this were true, it would render many of the arguments espoused by audiophiles redundant. Even the 'analogue faithfulness' with which vinyl is so often credited might be a culturally crafted illusion.

---

[8] For further reading on perceptual audio testing, see Bech and Zacharov (2006).

Rothenbuhler and Peters contend that "whatever the merits or flaws of ABX testing, it obviously cannot be used to compare things that differ in such interesting ways as records and CDs" (Rothenbuhler and Peters, 1997: 258). A comparison of a performance played back on a vinyl record with the same performance played back via a CD is likely to elicit some substantial audible differences. But why do Rothenbuhler and Peters think ABX testing is inadequate for such a comparison? Because, "it hides the embodiment of each medium, the source of their differential pull on the on the imagination. What matters in phonography is, to speak theologically, its incarnation" (Rothenbuhler and Peters, 1997: 258). Clearly, ABX testing is not designed to offer qualitative evaluation of different equipment based on the cultural, social, or emotional associations that a listener might have with one platform or another. Furthermore, Rothenbuhler and Peters are right to suggest that such associations—pivotal to many consumers' understanding and appreciation of particular platforms—are engendered by the "incarnation" of a medium or platform. If, then, there is an influence of culturally-acquired assumptions, beliefs, and practices on listeners' adherence to or enthusiasm for certain platforms, this influence must be separated (as far as is possible) when considering fidelity and sound perception at their most technical and objective level.

As for public understanding of audiophilic attitudes and the emotional or cultural attachment to older recorded music media, a great deal can be explained by the relatively short time span over which the successes and eventual failures of analogue and digital platforms have been played out. The first generation of music consumers whose listening, purchasing and sharing habits have been shaped around digital platforms alone have yet to find a journalistic, scholarly, or other public voice. The academic and cultural debate is populated and dominated to a great extent by people who have, at one time or another, been users and consumers of analogue or pre-digital-music-file media. That is not to say that any of those people are therefore unthinking and inevitable advocates for vinyl or analogue media. However, it is understandable that such people might seek—casually or fervently, consciously or unconsciously—to preserve or champion something with which they have a historical, emotional, and cultural association. Few people are likely to bemoan the fact that written publications are no longer made on traditional printing presses because we now have vastly more efficient and versatile technologies at our disposal. All this is not to say that future generations will be indifferent to the emotional, cultural, and historical appeal or significance of analogue audio, but rather that they are less likely to fetishize in the way that some first-generation users appear to.

Rothenbuhler and Peters once again prove useful in this area, offering an analogy with literature, which, as a discipline:

> generally assumes an indifference to the embodiment of the text: we have grown used to thinking of *Hamlet* as *Hamlet* whether it is found in twelve- or ten-point type, handwritten or calligraphed. And yet we insist—with a fussiness due only to sacred objects—on the integrity of a painting's or a sculpture's form in every detail.
>
> (Rothenbuhler and Peters, 1997: 259)

This is a crucial point. Ultimately, we—as consumers, critics, commentators—are willing to overlook or compensate for that which does not provide us with, or amount to, value. The meaning of Shakespeare's words are, as far as we can know, discernible whether cemented in large or small text, in Times New Roman or Century Gothic. There may have been inflections in his handwriting that would have communicated extra shades of meaning to his contemporaries, but current readers, on the whole, have no choice but to make do with the editions available to them.

4.6.4 The future

If absolute fidelity is impossible to achieve, two questions arise. First, how far *can* technology go toward achieving it? Second, how far *should* it go? For many consumers, the currently level of fidelity is sufficient; it does not need to get any better. A significant proportion of modern consumers listen to music through laptop speakers or relatively cheap earphones or headphones. Those audiophiles who choose to spend tens of thousands of pounds on precision audio equipment through which to listen to vinyl records, can do. If there are rewards to be gained (in terms of objective fidelity) then such listeners will be able to enjoy them. If not, there is a good chance they will be able to convince themselves of the benefits by looking at their bank statements. The downside of such equipment is, of course, that it tends not to be very portable. As such, many listeners will be content with the current and easily-accessible level of fidelity offered by digital music files and their typical equipment counterparts: iPods, smartphones, laptops, and inexpensive earphones. The situation is likely to continue as data storage, Internet speeds, and lossless encoding formats improve. For the first time, as far as fidelity is concerned, there is an effectively perfect recording technology. Few consumers or manufacturers are chasing absolute fidelity, save perhaps those on the pathological fringe whose protestations—that vinyl (or analogue in general) is really better—are increasingly likely to be seen as displays of connoisseurship, rehearsed publicly in order to demonstrate adherence to a particular taste, lifestyle, or set of cultural values.

In Blosiu and Blosiu's terms, the perfection of relative fidelity within the technological confines of each platform has moved us a little closer to the ideal of absolute fidelity, and now we seem to have come so close to the ideal that for many it does not matter. Some, however, are less easily contented. When asked whether or not such fidelity has yet been in any way achieved, Amar Bose (founder of the Bose audio engineering company) summed up the situation quite neatly: "It's a journey to which I am not sure there is an end. We are nearer than when we started, but there is a lot of work to be done" (quoted in Jones, 2007).

4.7 Sociological implications

If ideality is an unattainable goal, it is hard to state with any certainty whether or not digital music files have achieved ideality in any or all of the six characteristics explored above. Though the editability of magnetic tape, for example, may have been *perfected*, in doing so the collective understanding of *ideal* editability may have been pushed slightly further out of reach.

What *is* certain, however, is that the artificial divisions placed between different platforms are not always helpful. The six characteristics act as clear threads that unite different platforms across temporal and cultural gulfs. Rather than reinforcing the traditional notion of platforms as entirely separate entities, connected only by occasional struggles for compatibility, a more robust approach might consider every platform as features on a single gradient (or one of six) tending ever closer toward ideality but never quite reaching it.

By way of illustration, consider other technologies that have evolved over a comparable timespan. The Wright brothers' first successful powered aircraft bears very little relation, if any, to modern aircraft such as commercial planes or military fighter jets. The only thing that the two ends of the techno-historical spectrum have in common is the intention underpinning each development: to keep man and machines in the air. But most would consider the evolution from the Wright brothers' first craft through to the modern state-of-the-art fighter jet as a continuous evolution of 'the aeroplane'.

Television technology provides another example. The technology of a modern flatscreen (plasma, LCD, LED and so on) is so vastly different to traditional cathode ray tubes (or even stroboscopes and zoetropes) that it now seems to be a different beast entirely. Yet, the aim is the same. Likewise, digital audio files bear virtually no resemblance to Edison's phonograph, but they still serve the same fundamental purpose.

Although it may not be possible to draw firm conclusions or even make useful guesses about the future of each characteristic, it is abundantly clear that their collective and individual tendencies toward perfection and ideality have had some serious sociological and behavioural consequences. Whilst the preceding technical explanations might seem unnecessarily lengthy and detailed, they are vital preparation for what follows here. It is by no means a comprehensive catalogue of the sociological and behavioural consequences, but the salient examples should provide ample food for thought. Thus nourished, readers should be better able to assess the extent to which Attali's dystopian future chimes with the present reality.

4.7.1 Capacity

Limitations in the capacity of any given platform are likely to restrict the amount of music that consumers—whether individually or collectively—can afford to purchase or, if money is no object, store conveniently. Such restrictions invariably create a demand for some kind of wider communal access at a lower financial cost, which in turn necessitates the existence of libraries or public repositories of music. So, limited capacity compels societies to come up with storage and access solutions that are inherently socialized and socializing.

By way of example, consider the record, tape, or CD section at a typical local lending library (whether extant or erstwhile). For this to be populated with music—preferably music that visitors to the library do not already own—someone has to decide which recordings should be included, and on which platforms they are offered. Newcomers might reasonably assume, upon visiting the library in question, that the presence of some recordings and the absence of others are the results of reasoned deliberation and assessment, that the recordings available for lending have been selected for their cultural value, and that those unavailable have been deemed non-essential. In practice, it is likely that omissions would be made on aesthetic grounds or due to a lack of resources such as shelf space or the funds with which to acquire more recordings. This author knows that, in the 1970s, the local library of a certain London suburb had no 'popular' recordings at all; like many others, it housed only Western classical music. As such, there would have been a degree of canon formation around the existence of that library. Even if visitors quickly became conscious of the limited range offered by such libraries—and even if the limitations were only slight—this was happening across the country, all over the world. Where institutions are networked or have some alignment in their acquisition policies, the canonisation of certain genres or artists over others is likely to be more pronounced.

So capacity has behavioural implications on a public, social level. The same is true, however, in the commercial sphere. Questions of social welfare are less likely to influence the marketing strategies of retailers than the decisions of publicly funded institutions, but bricks-and-mortar shops nonetheless operate with a finite amount of shelf space. Retailers have to choose what to put on those shelves and it makes business sense to fill them with the items that will generate the most profit. The market is thus left vulnerable to a degree of distortion; if retailers promote bestsellers above all else, consumer decisions—on a collective level—are likely to be swayed in favour of music that is already popular.

In 1986, global music retailer HMV opened a flagship store on Oxford Street in London.[1] At the time it was the largest record shop in

[1] The first branded HMV store opened in 1921 at a different location on Oxford Street.

the world, and its opening was accompanied by a ceremony that included performances by Michael Hutchence and Bob Geldof, and attended by tens of thousands of people (Beeching, 2012). Such a huge store could reasonably pretend to have a comprehensive stock of all the music that consumers might like to browse through and buy. As a result, many people would go to the trouble of travelling to it in order to access music that simply was not available elsewhere.[2]

Today, that idea is risible. It is hard to conceive of a shop that would hold more than a tokenistic collection of all the music available to consumers. Even a single copy of one album from every band would most likely be impractical. Bricks-and-mortar shops cannot contend with the range offered by online retailers.[3] Each online retailer has an enormous catalogue, and if one does not offer a particular song or artist, then another probably will.

4.7.2 Compatibility

The near-global compatibility of digital music files highlights the lack of compatibility between most of the preceding platforms of recorded music. As a result of this incompatibility, the arrival of a new platform has invariably been followed, sooner or later, by its gradual or sudden obsolescence. The exploitation of this obsolescence by record companies and retailers—in order to create fresh demand for old recordings—is well documented. In a similar way to the world of fashion, these cycles have, until recently, been not only expected but

---

[2] The entire store was once closed to the public in the middle of the day so that the singer Michael Jackson, visiting from the United States, could shop in private (Beeching, 2012).

[3] HMV's share price has been steadily declining from a peak of £1.92 when the company floated on the stock market in 2002, to £0.30 in August 2012. The company's estimated worth fell from £1 billion to £15 million over the same period (Beeching, 2012). On 15th January 2013 the company entered administration.

also *relied* upon. Multi-billion dollar global business operations have been fed by revenue streams that derive from the ability to sell the same recordings in new formats. This author once attended an interview for a job as an assistant at a major classical record label. During the interview, the label manager explained that it was too expensive to commission new recordings, so the label simply re-released old recordings in different combinations, perhaps with new liner notes or packaging. The reliance on consumer naïveté was depressingly candid. One might argue that such a *modus operandi* may serve to keep flagging businesses alive, but that it does little to promote new music over old, or even to give it an equal footing. There is, however, a less sinister side effect. The technological 'clear-out' that follows the emergence of a new platform makes room for new artists, new genres, and encourages a new generation of consumers to support them by buying their new and existing releases on an appealing new platform. If vinyl were still the most recent platform on offer, private and public music collections would probably look very different.

4.7.3 Durability

Durability is also connected to this technologically induced spring-cleaning. In theory, the bulk of recordings on earlier platforms still exist; the arrival of a new platform does not automatically destroy or render unusable the media associated with previous platforms. In practice, however, the recordings are sufficiently few in number and random in their distribution to be inaccessible to the majority of contemporary consumers. This process has a disproportionate effect on the recordings of the genres or performers that are a little more recherché or less widely distributed and consumed in the first instance.

One only has to go back a few decades to find a time when it was quite hard to consume certain types of music in any way other than through live performance. Record shops and libraries in the early 1980s would have had little to offer their customers by way of trad jazz, for example. Most people wanting to hear trad jazz would attend live gigs, often at the smaller and more informal end of the venue spectrum. Why? Because CD re-releases of early trad jazz recordings were rare, and the original recordings were often either difficult to find or degraded to the point of being unplayable. If a recording could be found in good repair, its audition depended on having something to play it on.

At the time of writing, a quick search on Spotify for "trad jazz" brings up 560 different recordings, and searches for specific artists bring up thousands more. Trad jazz enthusiasts can now access a huge selection of recordings, on demand, for free, and listen to them as often as they like. Live performance once represented the most attractive and most viable option for hearing certain sorts of music, but consumers can now circumvent the cost, unpredictability, and impermanence inherent in such performances.

4.7.4 Economic viability

It has already been said that much of a platform's economic viability is a result of combinations of its other characteristics. Similarly, the behavioural changes that emerge from the potential perfection of a platform's economic viability are really a compound of the behavioural changes stimulated by the evolution of the other five characteristics.

The business models that governed the traditional music industry may have been less than noble, but they did make it possible for a performer to earn a decent living, and many musicians did exactly that. It is clear, however, that digital technology has reduced the marginal costs of producing, distributing, and selling recorded music to as close to zero as they are likely to get. Consequently, the opportunities for traditional mediators like manufacturers and record labels to add value (or generate profit, depending on your perspective) have diminished spectacularly. The result—regardless of one's stance on the ethics or potency of piracy and copyright—is that the role of the professional musician is no longer as secure as it once was. The industry will probably continue to create mega-stars who make extraordinary amounts of money, and enthusiastic amateurs will continue to involve themselves in the music they enjoy with the same cheerful ignorance of matters financial as they always have. A substantial cohort of professional and largely anonymous musicians used to reside between these two extremes, providing services for which they were paid a reasonable fee or salary. Predictions are unlikely to be helpful here, but it is fair to say that the tightening of corporate purse strings, coupled with continued improvements in synthesized music, is squeezing these musicians out of the picture.

4.7.5 Editability

The behavioural consequences of editability's steady march towards its own perfection are mixed. Increased editability has bestowed enormous creative potential on composers and producers of music. Tape, in particular, gave rise to whole new genres of music and to principles of recording whose physical techniques still underpin the virtual software studios in use today. In tandem with this, though, editability has had a tendency to drive a wedge between the talents of live performers and the expectations of audiences and consumers.

Listening to recorded music—whether at home, in the car, on an iPod—has become a perfectly viable musical experience for the great majority of consumers. Such consumers anticipate that recordings will take full advantage of the editing resources of modern technology to produce a note-perfect, immaculately tuned, impeccably timed, and ultimately highly polished rendition of whatever song or piece of music is being performed. If this sounds a bit over the top, consider the likely reaction of a consumer who purchases a recording and, listening to it, hears several split notes on the trumpet, poor intonation among the violins, the sound of guitar string breaking, an ill-timed drum fill. When these things occur in the live performances of established recording artists—and they do—audiences are brought face to face with the mistakes only briefly. There is no repeated audition, and no one expects the performer to go back and change it. Implicit in the production of a recording, however, is the duty of performers and producers to spot 'mistakes', and edit them out of existence; no one but those present in the recording studio at the time should ever be aware that they happened.[4]

The primary side effect of fulfilling this duty—and for some the most pernicious—is the artificial and temporary improvement of musicians whose talents are unable to withstand the scrutiny of performance: artificial because it commits to record a performance that never actually happened and perhaps never *could* happen; temporary because the armour of repeated takes and advanced editing is quickly pierced by exposure to the immediacy of live performance. It can lead consumers to expect great things from the live performances of musicians who are not all that great. This is not to say that performers should refrain from using recording to present their talents in the best possible light, but rather that audiences should be aware that this happens, and that digital recording technology allows it to happen to a surprising and unprecedented extent.

There has been, and continues to be, a lot of nostalgic rhetoric—often delivered by the disciples of older, less editing-friendly platforms—suggesting that live performance will always offer listeners

[4] The term 'mistakes' is given emphasis to highlight the ambiguity with which it is laced. Deviations from expected performance that might be considered mistakes have gone on to become recognizable, charming, or even desirable aspects of some recordings.

a experience superior to recordings. There is little doubt that live performance tends to offer a greater degree of interaction—even if sometimes it is illusory—but notions of superiority in this case are rather complex. To corral all live performances into one enclosure, and all recordings into another is to grossly oversimplify the situation. What about recordings of live performances? What about live performances that incorporate recorded material? Furthermore, the enjoyment of such experiences is unique to each listener, and depends on an assortment of criteria: the motivations for attending a performance or listening to a recording, the type of music in question, the context of performance, the quality of the recording, and so on.

Tickets to see the most famous performers and productions can be prohibitively expensive and, faced with an infinity of recorded music available at zero cost through convenient channels, might appear less appealing than they once did. Editability seems, therefore, to have shifted music away from the concert hall and into the domestic environment, but not entirely. Live performance still thrives, a new recording industry is establishing itself on digital ground and, ultimately, each provides healthy competition for the other.

4.7.6 Fidelity

50 years ago, someone wanting to hear music performed with a certain degree of fidelity had to go and hear it *in person*. People would attend concerts to access music that was otherwise practically inaccessible: they did not own it on record, it was not being broadcast on the radio, or perhaps it had not even been recorded yet. This necessity was even more pronounced in the earlier days of recording, when there was no recorded emulation that came even close to approximating a live performance. Audiences could only experience a really fine-sounding rendition of a favourite symphony or a vibrant and

dynamic performance by a jazz band by being within earshot of the performers when the sounds were made. Today, though, this is no longer the case. If the theoretical limits on absolute fidelity discussed earlier in the chapter are accepted, then the perfection of relative fidelity has transformed live music from a necessity into an option. Recordings can now function as passable simulacra of their live counterparts, and a comparable aural experience can be enjoyed in the comfort of one's own home, at very little cost in terms of effort or money.

That is not to say, however, that live performance is defunct or surplus to requirements. If live performers are able to create a worthwhile social experience for a group of real people, then they will likely still draw an audience. Similarly, if a group of people want to get together and sing once a week—because doing so will reward them with something that listening to recordings cannot—they still can, and many still do. Rather, as the fidelity of recorded music platforms and the availability and range of music committed to record has increased, so the *need* to attend live performances has diminished to the point where it is really just a matter of preference. For some listeners, no amount of expensive audio equipment and multi-channel surround sound will ever supplant the feeling of listening and responding to a live performance: being part of a visceral, collective experience that engages all of the body's senses. For others, eschewing the unpredictability of live performance (and other audience members) for the autonomy and repeatability of recording is a more attractive option. The majority of consumers probably enjoy a bit of both and, thanks to improvements in technology, are now at liberty more than ever before to combine them in proportions to suit their tastes.

In this respect, attending live music has become a bit like eating in a restaurant. Few people (if any) *need* to go to a restaurant in order to eat: cooking at home is probably easier than it ever has been, and all but the most impoverished have ready access to a supply of decent ingredients, essential equipment, and appropriate instruction with which to make a meal that will satisfy various needs: social, nutritional, familial, emotional, or otherwise. Nonetheless, some people choose to eat out occasionally or frequently for similarly varying reasons: a lack of time or energy, in order to celebrate an occasion, as a tool of courtship or negotiation, the opportunity for an intense aesthetic experience, or even just as something to talk about with friends, family or colleagues, a social currency of one form or another.

Let me return to the other side of the analogy through an avenue of personal anecdote. Some of my friends and I listen to a band that we like—the ska-punk group Reel Big Fish—in the comfort of our own homes or cars or offices, at a level of fidelity that far exceeds the agility of our ears. Nonetheless, when it transpires that Reel Big Fish will be playing at a local venue in the near future, I call up my friends and ask them if they would like to go along. This is not born out of a *need* to hear them live, nor because they are a band I have been desperate to see for years. Instead we use the concert primarily as an excuse to get together over a few drinks, to affirm our social bonds and public identity as fans of the band. I may be irrevocably indicting my friends and myself by saying this, but none of us concerns himself too much with how the music will actually *sound*, or if the band will play our favourite songs. We still passionately enjoy the music, but the choice of listening to it live or on a recording is now ours to make.

4.7.7 What next?

This chapter's analysis allows Attali's dim prophecies to be exposed to the light of time's passage. With the intervening decades laid out for examination, it is possible to achieve a much more sophisticated understanding of the technology that has evolved and the forces that propelled its evolution. Through no fault of his own, Attali lacked a full comprehension of what recording is and does and can do, but his nescience is particularly forgivable given its location within a wider blind spot of sociological thought. The type of behavioural consequences ushered in by the perfection of these six technological characteristics have not been fully analyzed in a sociological sense, primarily because orthodox thinking on the sociology of music was more or less solidified *before* digital technologies emerged. Concepts that now seem rather mundane were far removed or completely absent from the currents of thought that shaped the landscape of twentieth-century sociology. The Internet, email, personal computers, digital music files, virtual communities—all these have rapidly transformed the world in which music operates and sociology (like any other academic discipline) is taking a while to catch up. A full appraisal of digital technology's likely sociological impact is best left to sociologists but I am confident that, should they read it, this dissertation will prove helpful.

This is the meat and marrow of the thesis and my biggest single contribution to the debate: a socio-cultural analysis of recording technology and its consequences for music so far. Thus armed, it is possible not only to give a more accurate and compelling picture of the current situation, but also to speculate meaningfully about what might happen next. These are tasks to which the next two chapters have been assigned.

The rules for making a living making music have been remade over and over, from the first drum-beat.

(Kevin Kelly, 2002: New York Times, 17 March)

188

5 Ritual de lo habitual

For a long time music existed as a purely oral tradition. The ability to transcribe and notate it provided a means to overcome the inherent evanescence of sound, allowing a record of the music to be fixed in physical form. The invention of the printing press formalized and commercialized this process, allowing a thriving industry to grow up around the production, distribution, and consumption of sheet music. This was the most saleable and portable commodity that the music business had to offer. It was a big business, too; unless you had the rare ability to play from memory *and* by ear, the only way to hear music in the comfort of one's own home was to find the score and either learn to play or sing it oneself, or find someone else who could. The socio-cultural sensibilities engendered by the market for sheet music went unchallenged until the ability to physically capture sound itself in real time provided consumers with not only an alternative means to enjoy music but also, and perhaps more profoundly, a new vessel in which to store their "cultural meanings and personal emotional investments." (Perlman, 2003: 346). Sheet music also created among consumers certain expectations about accessing and interacting with music that would shape—and, ultimately, be shaped by—the advent of different platforms of recorded music.

The history of recorded music provides a useful means for charting the development of the rituals surrounding the production, distribution, and consumption of music. On the whole, though, as Leslie Gay points out, "most studies concerned with the nexus of music, culture, and technology exist . . . within a frame defined almost exclusively by the historical span of electronic media technologies" (Gay, 2003: 204). The erection of such a conceptual barrier, Gay argues, stems from a genuine appreciation of the "profound cultural implications with the application of electricity to communications", but has a tendency to obscure "the ways in which technological adaptations of the past—notably writing and printing—have shaped social relations and remain critical to our lives" (Gay, 2003: 225).[1]

Many histories of recorded music exist. Some cover particular eras, some focus on specific technologies, and some even provide a comprehensive overview of the development of recorded music from its beginning to the present day, though where these boundaries lie is up for debate.[2] Nonetheless, such stories invariably portray each of the technological advancements outlined in Chapter 2 as catalysts for dramatic change in the rituals of production, consumption, and distribution. It would be naïve to suggest that these technological developments yielded little or no change to the *facts* of production, distribution, and consumption of recorded music: consider how much more durable a vinyl LP is than a shellac 78 record, or how much more data a MiniDisc can hold than a wax cylinder despite being much smaller. However, as this chapter explains, the *rituals* surrounding the production, distribution, and consumption of recorded music have, until recently, changed little since their inception.

---

[1] Perlman notes that there has been "a desultory tradition of reflection on the influence of music technology on the listener"—citing Adorno (1945) on radio, Eisenberg (1988) on the record, and Hosokawa (1984) on the Walkman—but that "little of this work has focused specifically on the listener as a consumer of technology" (2003: 247). Following, amongst others, Manuel (1993), Sterne urges scholars to consider recorded music "from a 'holistic' vantage point that examines its production, circulation, and consumption (Sterne, 1997: 25)

[2] Janet Sturman suggests that "while a narrow interpretation of the term 'technology' might refer primarily to electronic devices, computer-related operations, and the latest in telecommunications, in a broader sense technology refers to the tools people use to make work easier, enhance efficiency, or transform the nature or quality of the task." (Sturman, 2003: 159). In this chapter, and the thesis as a whole, I have declined to draw specific boundaries in favour of promoting the idea that any means of 'storing' music—the emission and absorption of live performance, the ink and paper of notation, the hill and dale of vinyl records—however technologically advanced or culturally primitive, has the capacity to affect our interaction with music.

The technological differences between digital music files and their predecessors is explored in the preceding chapters, and it is clear that these differences, coupled with the proliferation of the Internet and its continuing improvement as a means of transferring data, have reshaped our interactions with and through music more than any other platform. Highlighting the substantial technological differences between digital music files and older forms of recorded music allows us to understand just how similar these older forms are to one another and, in turn, to gauge the extent to which they have affected the rituals surrounding the production, distribution, and consumption of music.[3]

Subjecting the driving forces behind these rituals to a degree of social analysis adds weight to the argument that many of the technological developments were not so much revolutions as progressions. Each platform shift took the production, distribution, consumption of recorded music further along their respective trajectories, but without altering that trajectory very much, if at all.[4] Clearly, there have been developments prior to digital music files that truly altered the musical landscape; notation and sheet music changed the way music was produced, distributed, and consumed by giving us the ability to consider music as a physical object, divorced from the act of performance. However, such departures are fewer and further between than most histories of recorded music would suggest.[5]

---

[3] For the purposes of interest, chronology, rhetorical structure, and brevity it has in places been helpful to artificially punctuate the transitions between various recording technologies. The reality is that such divisions are, in fact, less pronounced than they often appear, and invariably less sequential; the lives of various recording technologies overlap considerably and their developments are, to a greater or lesser degree, often connected.

[4] It is often convenient, when looking through the neatly ordered lens of hindsight, to attribute to such developments unwarranted weight and significance. Gay admits to being sceptical of "views that take technological developments and adaptations—even such seemingly fundamental technologies as language, literacy, and print—as deterministic, as 'thunderclaps of history' [quoting Finnegan, 1988] that predictably transform human societies" (Gay, 2003: 224).

[5] Once again, Gay flags up the tendency to allow current engagement with recorded music to colour our current perception of historical

5.1 Oral rituals

From its earliest inception through to the first instance of its notation, music existed as a purely oral tradition. Not oral in the sense that instruments were not involved—they clearly were—but in the sense that any music would need to be played, sung, or spoken aloud for it to exist at all. The sound of such traditions "existed only as it went out of existence" (Sterne, 2003: 1).[6] This evanescence necessitated a reliance on "human memory for storage" (Rubin, 1997: 3) and, as a result, such traditions were inherently social. A tune or story, for example, could only be conveyed to or sustained across a given time or space by being repeated, heard, and remembered. This required at least one performer and one listener: "It is possible to sing to oneself on occasion, but for an oral tradition to exist longer than the lifetime of the singer, others must be present as it is sung" (Rubin, 1997: 66).[7]

---

interaction: "these technologies and access to them delineate and maintain a public culture . . . a point that bears emphasis, lest we let our familiarity with the 'nuts and bolts' obscure the social significance of such old technologies." (Gay, 2003: 224).

[6] This is a phenomenon unique to music. Although other, non-musical ancient art forms (e.g., cave paintings) are not wholly *un*-evanescent and, as such, are still liable to be lost with the passage of time, music is fundamentally different in that "the musical score, or whatever the graphic representation of music may be called, does not constitute the work in the same simple sense that a canvas or a printed page constitutes a visual or literary work . . . Re-creation is not a mechanical process, just as a good cookery book is not a guarantee of good cooking" (Roth, 1969: 18).

[7] Roth contends that music of an oral tradition "had no staying power, it did not last . . . Every generation created the music that suited it and regularly took it to its grave, as the pharaohs did their retinue, and the next generation saw it disappear without regret" (Roth, 1969: 74). This assertion seems to be based on the assumption that such generations had the option to preserve their musical culture. It might be more realistic to acknowledge that although various traditions could be sustained from one generation to the next, they would almost certainly undergo a degree of mutation, bequeathing traces of their musical culture to subsequent generations rather than definitive snapshots (e.g., autograph scores) to be pored over by historians.

5.2 Notation rituals

Although a precise date on which music evolved into a written tradition does not exist—and would be of limited import even if it were in some way discernible—Leo Treitler's suggestion that "before the tenth century the tradition of Western art music was an oral tradition" is a useful approximation (Treitler, 1981: 474).[8] Hence, the departure from a purely oral musical tradition was not a sudden one. Citing Michael Clanchy, Treitler asserts that "a musical tradition corresponding to the paradigm of literacy is not demonstrable in Europe before the thirteenth century, four centuries after the earliest music writing" (Treitler, 1981: 486). Nor was the transition absolute. First, written music would have initially served to support the pre-existing traditions, capturing the fruits of the oral tradition—which were necessarily memorized—in "a precipitation of that corpus" (Treitler, 1981: 475). Second, as is true today, it is unlikely that written music was ever perceived to be a substitute for the performed work, even in the case of those highly skilled in reading notated music, who may have been able to hear the music in their minds (Clanchy, 1993: 285). Third, it is likely that few people would have been able to read music. Thus, any proliferation of written music as a tradition would have been dependent on a preceding spread of written musical literacy. This could be fairly described as "something that is intuitively plausible and that has been generally understood by historians of writing; that writing everywhere has been introduced into oral traditions, that it has not initially displaced those traditions but assumed a role within them" (Treitler, 1981: 485). Thus, from the perspective of composers, performers, and audiences, the assimilation of notated music into the rituals of production, distribution, and consumption would have initially had little obvious, tangible effect. Nonetheless, argues Chanan,

[8] There is some evidence to suggest that written forms of music existed in Ancient Greece and even Ancient Egypt, though "neither a scrap of Egyptian music nor a single theoretical treatise has come down to us" (Gamble, 1923: 3).

notation forced music into "a peculiar kind of straitjacket" that would eventually cause many traditional elements of performance to be "demoted or repressed" (Chanan, 1995: 11).

Written music became common in the churches of the Middle Ages but the time and effort required for reproduction forced the church to economize. Scribes would be charged with producing very large music books, which were placed on stands and read by multiple singers, or even whole choirs, at once: ". . . for naturally the making of a separate copy for each singer in the days before the invention of printing was impracticable" (Gamble, 1923: 21). By the thirteenth century, writing had become "the normal basis for government and property transactions" (Treitler, 1981: 486) and a more widespread means of recording and communicating amongst the population as a whole. Nonetheless, the cost and labour involved in manual reproduction meant that it was rarely undertaken on a large scale: "A pirate who had copied an author's manuscript by hand had to invest the same physical labor as the author or scribe who penned the original; the cost advantage of the pirated copy was virtually nil." (Goldstein, 2003: 31).

5.3 Printed rituals

The small-scale nature of such operations allowed the church and state to control the dissemination of works deemed to be heretic or seditious (de Sola Pool, 1983: 14). Legitimate business was conducted through the Stationers' Company, a liveried guild comprising booksellers, bookbinders, illuminators, and scribes. By the time Johannes Gutenberg invented the printing press, the guild had become "a closely knit, powerful cartel" and as printing became ubiquitous, so the Stationers' Company evolved in order to continue "maintaining order and profits in the publishing trade" (Goldstein, 2003: 32). Following Gutenberg's invention, the primary threat to the Guild's hegemony was the proliferation of unauthorized, mass-produced books. To a greater or lesser extent, music was just as ready a target, but the complexity of notated music required further refinement of the technology in order for piracy to be a worthwhile endeavour. Somewhere between 1501 and 1503, having developed a cheap and accurate method of printing polyphonic music, Ottaviano Petrucci published *Harmonices Musices*, the first known collection of printed music in history (Roth, 1966: 84 and Hamm et al., 1975: 269). The immediate effects of the printing press on contemporary (i.e., early-modern) literary and social culture are well documented.[9] For the purposes of this discussion, however, it is sensible to give special consideration to how such a revolution affected the practices and thinking around music. The first collections of printed music available for purchase "were not used to perform from at first, but were means whereby music could be circulated more easily and widely than before. A noble at a royal court, the musical director of a cathedral, a prince in his palace, could all purchase prints containing a large number of pieces and have these copied into manuscripts, from which they would be sung" (Hamm et al., 1975: 269). Eventually, with improvements in print quality and reductions in cost, performers began to read directly from the printed scores. Coupled with the evolution and standardization of musical notation this led to a widespread increase in musical literacy and, in turn, an ever-growing market for printed music.

All of these developments allowed consumers of music (both amateur and professional) to become comfortable with the existence of a musical object that was divorced from the physical act of performance. Previously, the popular conception of cultural production had consisted, as Mark Giese suggests, "of either handcrafted, one-of-a-kind artifacts, such as paintings or sculptures, or live performances". The ability to mass-produce and mass-distribute these productions "elided the difference between cultural production and cultural artifacts that were the instantiations of that production" (Giese, 2004:

[9] For a detailed study see Eisenstein (1983).

348). Music now existed both as an instance of cultural production that was unique and temporary (i.e., a performance) and as a cultural artifact that could be written, manufactured, sold, bought, copied and destroyed (i.e., a score).

Composers were thus able, in addition being paid for the performance of their music, to derive extra income by exploiting the physical instantiations of their work. In theory, this had always been possible; it was not necessary to have access to a printing press in order to make copies of a score. But, as has already been mentioned, the time and labour involved in producing such copies (legitimate or otherwise) made it an economically unattractive pursuit. As Goldstein argues, "the printing press, and later improvements in printing technology, dramatically altered the economics of authorship. Cheaper copies meant larger audiences, and larger audiences brought the prospect of greater revenues overall" (Goldstein, 2003: 31). The sheer scale of reproduction afforded by the printing press, coupled with the growing enforcement of copyright law, made it possible for composers to have their scores reproduced on a commercial scale. This meant that, for the first time, "the value of the author's genius could outweigh the cost of the scrivener's labor" (Goldstein, 2003: 31). By the time printed music had become a part of daily life for many people, the rituals surrounding the production, distribution, and consumption of it were well established. In each case, these rituals served to allow producers, distributors, and consumers (individual or collective) to extract value from music, often in ways that had not been possible with manuscript or oral music traditions.

Some rituals were very public, some very private, and some were a mixture of both. The private side of rituals emerged precisely because people were able to take the music home and consume it without anyone else around. It goes without saying that music had existed in the home before printed sheet music, but by making well-known or highly-esteemed music available in printed form (especially piano scores and reductions of famous pieces), someone with the money to buy it and an instrument to play it on could recreate, to a greater or lesser extent, a situation that had previously been accessible only through public performance. This ability to take music home encouraged other domestic rituals to emerge, such as the rise of private tuition for people wishing to be able to play at home. Public rituals, on the other hand, emerged largely because music could be distributed on a scale and with an ease that were completely unprecedented. The standardization of musical texts, both educational and commercial, led to a more widespread and coherent music culture on a local, national, and international level.

A comprehensive overview of all the rituals that arose out of printed music would require much more space than is available within this chapter, but there are several areas that highlight particularly well the effect of printing technology on the rituals surrounding the production, consumption, and distribution of music.

As suggested above, the effect of the printing press on music was felt perhaps most keenly in the publishing industry. Although Petrucci's *Harmonices Musices* dates from the beginning of the sixteenth century, printed music was often prohibitively expensive for the average consumer—despite its practical convenience and relative affordability—until a long time after its introduction.[10]

Three primary methods of music publication emerged as the market for printed music expanded: subscription, private, and third party (Burchell, 2004: 94).[11] As Burchell points out, subscription

---

[10] However, notated music was not given the same copyright protection as books until 1831 (Goldstein, 2003: 51).

[11] All of these still exist today as means of 'publishing' recorded music, i.e., funding the production and distribution of recorded music. Third party publication corresponds most closely to the traditional notion of a record company's involvement with an artist, band or roster of talent. Private publication has always been possible, but was contingent upon the private party having a sufficient amount of disposable funds to

publication allowed costs to be covered in advance: "The intention to publish would be advertized, usually in London papers and often much further afield, by the composer or sponsoring organization, and publication would not proceed until sufficient subscriptions had been received." (Burchell, 2004: 94). The work would then most likely be printed, distributed, and sold by a printing house, with the majority of the proceeds—the printer taking a cut for distribution and sale—going to the author.

In cases where a publisher doubted the presence or availability of a market for a particular work or collection of works, composers would often turn to private publication, paying for the engraving, printing, and distribution out of their own pocket. Without the network of contacts and customers maintained by publishing houses, the venture was often a risky one: "Independent private publication and the consequent personal advertising could work in the composer's favour, however, notwithstanding the costs of engraving and advertising the work" (Burchell, 2004: 100).

These two options, however, represented a relatively small proportion of the music published in Britain. The option of third party publication was "from the composer's perspective . . . almost certainly the simplest, since it involved no financial outlay in preparation, nor the considerable attendant complications of storing engraved plates once printing was complete" (Burchell, 2004: 100). Moreover, works that were reissued by a publisher (whether initially printed privately or not)

---

undertake the project and being able to weather a market flop. In the age of the Internet, MySpace, and iTunes, it is possible to do the same thing for a negligible outlay. Subscription models have been dormant for many years, but websites such as Sellaband.com allow consumers to purchase a stake in a band or artist in return for merchandise, face-to-face meetings, a share of the revenues, or even a specially written song. This venture capital model is often used by aspiring artists to fund projects such as the recording of an album or a tour, but has also been used by bands such as Public Enemy (who, arguably, do not need the money) in order to democratize their music and allow fans to become more closely engaged with its creation and consumption.

would have secured their authors additional income for little or no effort. As Burchell's research indicates, "it is scarcely surprising to find that a relatively high proportion of works printed privately were indeed later reissued, or published in new editions—once their market worth was proved. In practice most composers used a combination of private and direct publication" (Burchell, 2004: 100). Private publication was not seen as the preserve of less successful composers, so much as "an indication of caution on the part of the publisher . . . often followed by a reprint or new edition in the publisher's name alone " (Burchell, 2004: 109).[12] By testing the water in this way the publishing houses served as market mediators, easing any tension between what consumers wanted to listen to and what composers thought they should be hearing.[13] Burchell identifies "the problematic nature of this endeavour [as] one of the reasons for the bankruptcy of so many eighteenth-century music publishers" (Burchell, 2004: 109). As an antidote to these economic pressures, publishing houses would often strike up business relationships with each other, sharing or selling printing plates and drawing up selling agreements across wide geographical areas to increase distribution (Gay, 2003: 207–208).

But composers did not always publish their music in order to make money through sales. It could also lead to a number of other useful outcomes. First, it served to publicize the author's skill as a

---

[12] The following quote from George Bernard Shaw (*Star*, 6 December 1889) gives an idea of just how transparent this process might have appeared: "On the first occasion it so happened, fortunately for me, that a firm of music publishers, having resolved to venture on the desperate step of publishing six new pianoforte sonatas, had just sent out a circular containing an appeal *ad misericordiam* that at least a few people would, either in public spirit or charity, take the unprecedented step of buying these compositions" (quoted in Golby, 1986: 236).

[13] Although the easing of market friction has continued to be a necessary task, it is interesting to note that the editorial power wielded by the early publishers—and, subsequently, their descendants in the modern music industry—led to a power shift. There are many people who would say that record companies have, at certain points and with varying degrees of success, been able to dictate to consumers what they ought to be listening to, and subsequently create the artists and music for them to consume.

composer. By enhancing their reputation, composers stood a better chance of securing a lucrative position in a wealthy or noble household, or at court. John Dowland published his final lute songbook—*A Pilgrim's Solace*—in 1612, just before being appointed to the court position he had sought for almost two decades. It may not be coincidence that, following his appointment, he ceased to publish any lute collections (Rupp, 2003). Second, and in a similar vein, composers would often dedicate their published works to powerful figures in the nobility and gentry, or members of the Royal Family. Invariably this was either an act of gratitude (because the dedicatee had previously employed the composer) or an act of pleading (the composer was hoping to be employed by the dedicatee in the future). Dedicating a book to a potential patron was a mutually advantageous strategy. If the dedication was accepted, there was a chance that the composer would be rewarded, either through a payment or other gifts and benefits, or perhaps through employment in the household of the dedicatee (or elsewhere, helped by a positive recommendation from the dedicatee). This arrangement also bestowed great prestige upon the dedicatee. It showed them in a favourable light—as a benevolent patron, as a connoisseur with discerning taste—and it showed others that they were powerful and wealthy enough to be able to afford the luxury of household musicians, ultimately serving to underline their status among the elite of society (Wegman, 2005). In fact, the concern for appearance among the upper echelons of society often motivated composers of high social status to distance themselves from publishing simply for profit's sake. Working for money was something more closely associated with lower class citizens; there was an assumption that the elite already had the money necessary to enjoy a life of leisure. If such high-ranking composers did publish, they often did so under the pretence that they were doing so only in order to stem the circulation of defective, unauthorized versions of their works that were already available, not because they needed the income (Saunders, 1951).[14]

[14] I would like to thank Michael Gale for sharing so generously his invaluable knowledge of early printing and publishing practices.

Publishers soon realized that there was scope to create additional revenue by allying themselves with the makers, sellers, and repairers of instruments. Through his study of songsheet publishing in nineteenth century Galveston, Gay theorizes that, in fact, publishing enterprises often "established themselves as, or emerged from, a music shop offering music instruction and the sale of instruments along with songsheets, instrumental dance music for the piano, and instruction manuals" (Gay, 2003: 207). Gay uncovers informal documentary evidence of the likely relationships between music publisher Thomas Goggan & Bro., piano tuner William F. Reitmeyer, and music teacher Louise Bonnot (Gay, 2003: 204). Such an alliance would have drawn these three enterprises together under one roof, allowing each to tap into the other's pool of customers. A piano teacher, for example, who had ready access to a healthy supply of sheet music (at discounted prices) and who could put pupils in touch with a trusted piano tuner would no doubt have been an attractive proposition for a potential pupil.[15] As a business model, it seemed to work well, and its success was responsible, in part, for a huge surge in piano sales: "The period from the Civil War through the Great Depression was a golden age for the piano business in the United States. In 1866 . . . piano sales reached $15 million, accounting for some 25,000 new instruments (Gay, 2003: 210).[16]

Back in nineteenth-century England, the piano experienced a similar groundswell of popularity and was, before long, to be found "in every better-class home" (Roth, 1969: 85). It became particularly

[15] The relationship between teachers and publishing houses would have been sufficiently close for teachers to acquire sheet music "at a 50 per cent discount from most firms" (Gay, 2003: 211). Citing Sanjek and Sanjek (1988: 347, 350, 370), Gay goes on to suggest that teachers would have derived around 50 per cent of their total income from selling music, "even as publishers profited 500 to 600 per cent on each music sheet" (Gay, 2003: 211).

[16] Although the study of Galveston provides only a glimpse of the music industry in the United States in the nineteenth century, Gay notes that "research on publisher histories in the United States portrays important similarities and connections among publishers and links America's publishers with London models" (Gay, 2003: 207).

favoured among women, providing "a gauge of a woman's training in the required accomplishments of genteel society" (Burgan, 1989: 42). Above and beyond its role as a marker of a woman's refinement, the piano became no less than "an emblem of social status . . . It's presence or absence in the home could be a sign of social climbing, security of status, or loss of place" (Burgan, 1989: 42). Why was such social impact not found in other instruments? Gay (2003: 210) suggests that "the piano and the songsheet helped define a space of 'culture' and 'comfort' for women and their families" and as the "mounting tide" of sheet music published for amateur consumption became widely available, "singing to piano accompaniment became a favoured form of home entertainment" (Braden, 1992: 155).

In order for this home entertainment to take place, at least one member of the household would need to learn how to play the piano, and, with a dearth of self-tuition literature, the most common way of learning was by hiring a private tutor. During the eighteenth century, private teachers had been confined to what Richard Crawford calls "the secular cosmopolitan tradition" but the proliferation of middle-class home music-making required that "the aspirations of this new set of performers [be] served by a new corps of private teachers" (Crawford, 1993: 56). Deborah Rohr emphasizes the flexibility and ubiquity of the private lesson, calling it "undoubtedly the most important source of early training for children of professional musicians, and especially for women" (Rohr, 2001: 71). Lessons did not come cheap; although they were within financial reach of many middle and upper class families, poorer students would often work with a relative to improve their skills (Rohr, 2001: 71).[17] The expansion of the domestic music market not only made teaching an attractive and financially rewarding profession, it also "widened the range of occupational skills and expectations of the musicians who taught them" (Crawford, 1993: 56).[18]

---

[17] For a detailed example of what a typical music teacher might earn from their various endeavours, see Crawford (1993: 56).

[18] In the United States, the 1887 report of the Music Teachers National Association indicates that half a million pupils were being taught by its

Alongside the flourishing private tuition market, there was an increasing recognition of music as a subject worthy of inclusion in public education. The ability to print vast quantities of sheet music allowed music curricula to be rolled out more or less uniformly to many different schools. This formalized musical education in a way that had previously been impossible. In the latter half of the nineteenth century musical literacy was still lagging behind its textual cousin, and singing in schools was generally taught by ear. By 1891, however, and following the lobbying of government by the increasingly respected music establishment, "60 per cent of children in English and Welsh elementary schools were being taught from one form of notation or another" (Russell, 1987: 46).[19]

By the time Britain reached its industrial peak, sheet music was sufficiently cheap for amateur music groups and societies to be set up in and around the working class communities of the factory towns and villages.[20] The number and scope of these various ensembles and societies varied hugely from place to place, but first hand accounts suggest that in some areas, music was virtually everywhere. In the eight years following the opening of his factory in 1832, owner Samuel Greg created a musical community that he described to factory inspector Leonard Horner:

> Our music and singing engage many of both sexes—young and old, learned and unlearned. We have a small glee class that meets once a week round a cottage fire. There is another, more

---

members alone (Gay, 2003: 211). This is all the more remarkable considering that the population of the United States at the time was a little over 50 million (US census, 1887: 169).

[19] Roth points out that, by the middle of the twentieth century, the issue of whether or not to include music as a subject in schools was "no longer a matter for debate but an accepted fact of life" (Roth, 1969: 90).

[20] These communities numbered more than ever by that point, following a "striking increase in the urbanization of England during the course of the eighteenth century"; between 1700 and 1800 the percentage of the population that lived in provincial urban centres rose by approximately 20 per cent (Peter Borsay, 1990: 5).

> numerous, for sacred music, that meets every Wednesday and Saturday during the winter and really performs very well, at least I seldom hear music that pleases me more. A number of men have formed a band with clarionets, horns, and other wind instruments, and meet twice a week to practice, besides blowing and trumpeting nightly at their own homes. A few families are provided with pianos and here I believe all the children of the household play on them. The guitar is also an instrument not unknown among us, and to these may be added sundry violins, violoncellos, serpents, flutes and some sort of thing they call a *dulcimer* . . . and when you remember how few families we muster—not more than seventy or eighty—you will think with me that we are quite a musical society.
>
> (Russell, 1987: 21–22)

As the above account suggests, these groups and societies were often instigated by factory owners seeking to boost morale.[21] Music's close ties to religion and its ability to elicit emotional responses also made it "a particularly popular component in the various schemes whereby reformers sought social and moral regeneration through 'rational recreation'" (Russell, 1987: 18). At a local concert in 1857, a Leeds-based solicitor and moral reformer called John Hope Shaw, expounded on the merits of socially performed music: "It was impossible that all classes of society could mingle with each other week after week, as at these concerts, without feeling their mutual regard for each other strengthened and confirmed" (Russell, 1987: 19–20). The effects of the musical activities on the weaving communities of northern England were also given a glowing review:

[21] In addition to their immediate social benefit, such projects were hugely important in the long-term "not merely because they were amongst the first but because they created the principle of industrial sponsorship of working-class music, which was to become so important later in the century" (Russell, 1987: 22).

> The spirit of industrious independence maintains its ground among them in spite of the demoralising progress of pauperism and poor laws; they are religious in spite of the spread of infidelity; and they love their families and friends, in spite of the attractions of the beershop. All this, of course, is not universally the case, but its general truth, to a remarkable extent, will be doubted by no one who has lived among and known the people of this neighbourhood. The power to which these effects are, in a very considerable degree, to be ascribed, we hesitate not to affirm, is SACRED MUSIC [original emphasis].
>
> (Hogarth, 1834: 131–133)

This flurry of musical activity spilled out of industrial life, creating a musical sensation up and down the country:

> With curiosity excited everywhere, and hopes flattered on all hands, the desire to study music spread like a wave over the country, affecting secluded hamlets, as well as conspicuous cities. Few were exempt from its influence. Young and old went sol-faing, and even the prejudices of class were in many cases broken down by a common desire to sing with understanding.
>
> (Anon, 1887: 397)

With such a huge profusion of groups and ensembles came a corresponding expansion of the concert and festival scene in Britain and beyond: "By the mid-nineteenth century concerts were a firmly established feature of social life in most European centres. Even a moderately-sized English provincial town such as Leeds or Manchester could expect to enjoy thirty to forty public concerts a year" (Russell, 1987: 27). Even with the widespread public and private enthusiasm for music, the concert culture of the nineteenth century would not have come into existence without the economies of scale afforded by cheap printing processes. It was now possible for performances of similar music to be staged all over the country and for the ensembles and choruses to be far larger than ever before:

> As a matter of fact, the time for regarding an ensemble of 4,000 performers as a prodigy has gone by; and the sooner we begin to consider the feasibility of adding another thousand or so to the number, and varying the repertoire a little, the longer our national interest in the [Handel] Festival is likely to last.
>
> (George Bernard Shaw quoted in Golby, 1986: 227)

Such thinking would have been inconceivable in an era when performers had to share oversized, handwritten copies of an original.[22]

Although regular attendance at more highbrow concerts (particularly those held in London venues such as The Royal Opera House) was “a financial impossibility” for many working class people, there was still a thriving city music scene that did not go unnoticed (Russell, 1987: 27). In 1889, George Bernard Shaw (a music critic for the *Star* at the time) was encouraged by his editor, Thomas O’Connor, to investigate:

> The fact is, my dear Corno, I don't believe that music in London is confined to St James's Hall, Covent Garden, and the Albert Hall. People must sing and play elsewhere. Whenever I go down to speak at the big Town Halls at Shoreditch, Hackney, Stratford, Holborn, Kensington, Battersea, and deuce knows where, I always

[22] By the late nineteenth century, printed music had, in some quarters, allowed economic interests to outweigh aesthetic concerns: "We do not mean to imply that the highest interests of music would be served by increasing a choir already so large as to entail conditions of performance incompatible with strict justice to the master. But a justification of such a course might be found in the increase of sensational attraction; for the aims of the Festival-givers necessarily are, firstly, commercial; secondly, phenomenal; and, lastly, artistic." (George Bernard Shaw quoted in Golby, 1986: 227).

> see bills at the door announcing oratorios, organ recitals, concerts by local Philharmonic and Orpheus societies, and all sorts of musical games. Why not criticize these instead of saying the same thing over and over again about Henschel and Richter and Norman Neruda and the rest?
>
> (Thomas O'Connor, then-editor of the *Star,* quoted in Shaw, 1889: 7)[23]

Here, O'Connor inadvertently touches on a concept that, though nascent at the time, could only have come into being with the widespread dissemination of mass-produced sheet music: a public musical canon. Before printed music and publishing took off, it would have been almost impossible to establish a canon of musical works, however nebulous or temporary, which could be considered to be representative of the country's taste as a whole, or even the taste of a particular class or demographic. Burchell acknowledges that, although eighteenth-century music publishers covered the whole gamut of styles from cabaret to symphony and beyond, "local repertoire was influenced by local taste and circumstances" (Burchell, 2004: 93).[24] Even when publishing began to take hold, the canon was slow to emerge, particularly in less urban areas: the majority of the "common core repertoire" was printed and consumed in London (Burchell, 2004: 93). London was, perhaps unsurprisingly, the dominant influence over the cultural life of the country and the birthplace of various musical institutions and social practices "some of whose basic characteristics still exist today as the foundation of musical culture" (Weber, 2004: 75).

These institutional models and social practices gradually spread across the country, engendering a public musical culture that had

---

[23] Shaw wrote his music criticism under the *nom de plume* Corno di Bassetto, the Italian term for the basset horn.

[24] For an illustration of an early gatekeeper-cum-tastemaker, see Burchell's discussion of eighteenth-century commentator Robert Bremner (Burchell, 2004: 111–112).

simply not existed before the application of printing technology to music. Gay concludes:

> In retrospect, the existence of such a technologically based public culture should surprise no one . . . Songsheet technologies, like more recent electronic ones that merge domestic spaces with a cosmopolitan world, may offer a prospect of crossing social boundaries . . . but they more often mediate among similar, like-minded folks near and far, connecting them and defining, in part, their social relationships.
>
> (Gay, 2003: 224)

5.4 Phonographic rituals

If the rituals of printed music had gone some way to recasting the social and cultural relationships surrounding music, recording technology would take the transformation even further. In oral traditions, music had existed only as performance. Written and printed music allowed it to be documented, and thus "detached from its source, from its ties to any particular setting and location." (Cox and Warner, 2008: 65).[25] Until music became recordable, however, performances of this written music remained a product of their location and participants and thus "could not be documented and reproduced in an identical form" (Fikentscher, 2003: 291).[26] Consumers were more or less comfortable with the idea

[25] This detachment would be formalized in Pierre Schaeffer's notion of 'acousmatic listening', i.e., listening to sounds in the absence of their original sources. It is also known as 'schizophonia' (see Cox and Warner, 2008: 34).

[26] It should be noted here that broadcasting forms a semi-acousmatic exception to this rule. Even though it divorced the locus of performance from its consumption, the lack of recording facilities still meant that broadcast performances could not be documented and studied in the same way. It did, however, go some way to making audiences more comfortable with acousmatic listening.

of music being fixed in some way, and for such musical objects to be interpreted by performers on a regular basis. Recorded music, in contrast, facilitated the existence of musical objects that were fixed on a more profound level. Once recorded, interpretation was only possible at the point of listening, and because the performance was fixed, consumers were restricted to interpretations of cultural or economic worth. A record could not be interpreted and brought to life by a phonograph in the same way that a score could be realized by a performer. Rothenbuhler and Peters contend that, with the dawn of recording, "creation is sundered from recreation; making and enjoying music become increasingly remote tasks" (Rothenbuhler and Peters, 1997: 244).

By the end of the nineteenth century, the rituals established by the proliferation of printed music had become firmly entrenched. More and more people were able to afford sheet music, and pianos had become a common feature in the home. Just as written music traditions had continued to thrive in the early days of printed music, recorded music did not immediately displace sheet music as the consumer favourite.[27] Even though the ability to conjure up a musical performance on demand made the record a "potent rival" to sheet music, that potency was "only slowly recognized" (Fikentscher, 2003: 291).[28] Coupled with misgivings about recorded performances constituting genuine musical objects, the sheer cost of buying both records and the equipment on which to play them deterred many people from abandoning their pianos and excursions to live performances.[29]

---

[27] Nor, as contemporary readers will appreciate, did recording *ever* completely displace printed music. Printed music is still a significant economic activity, over a century later, even though there has been some migration to Internet-based distribution and consumption.
[28] Reebee Garofalo reveals that records did not outsell sheet music (in terms of revenue) until 1952 (Garofalo, 1996: 84).
[29] Hamm suggests that the difference in purchase price of the different available playback equipment and media established a dichotomy: "the disc was directed at one general class and the cylinder at another" (Hamm et al., 1975: 257).

However, with reductions in manufacturing costs and an increasingly competitive market, listening to music in the home slowly became a more and more commonplace activity. Although the use of recorded music in the home was similar to that of printed sheet music—the purpose of its consumption was to entertain—this new means of dissemination was fundamentally different in terms of what it required of the consumer: "while it was necessary to have enough musical ability to play or sing in order to use sheet music (or at least to be in the company of someone with these abilities), a phonograph record could be played by anyone who owned or had access to the proper equipment. In other words, it was possible to consume popular music passively, by merely listening, rather than actively, by performing the music" (Hamm et al., 1975: 126).[30]

This democratization was not, however, without its drawbacks. Recorded music had opened up domestic consumption to those who lacked the education or skills to perform it themselves, but the sonic experience provided by early platforms like the cylinder, graphophone, and phonograph was far inferior to that of a concert hall or equivalent live performance. Despite fears to the contrary, recorded music could not operate as a comparable substitute for live performance. This was due partly to the still unignorable difference in absolute fidelity, but mainly to the shortcomings of recording technology at the time:

> By 1900 the repertory of recorded art music in both the United States and Europe . . . consisted mostly of arias and other selections from opera. There were practically no attempts to record orchestral music; the reason for this was technical limitations. The voice, with piano accompaniment, was all that the recording horn of that day could handle. An orchestra, with its

[30] Roth reminds us that "neither pocket-scores nor school music could prevent a sharp decline in the sheet-music trade. If the new methods of listening to music had not come to his rescue with records, record-players, radio and television sets and tape-recorders, the dealer might have disappeared altogether" (Roth, 1969: 92).

complex acoustics, was simply beyond the capabilities of recording techniques at the time.

(Hamm et al., 1975: 255–256)

With the first decade of the twentieth century came 78-rpm discs—capable of holding four minutes of music on each side—and electric recording and playback equipment that provided a much broader frequency response and higher fidelity all round at an ever decreasing cost, allowing performances by even larger and more varied ensembles to be committed to record.[31] All this rendered the record "a more satisfying musical product", which by 1905 had been exploited by leading performers and composers of the day, such as Mattia Battistini and Claude Debussy (Hamm et al., 1975: 256). This, in conjunction with targeted advertising from companies like Victor and the release of more and more large-scale classical works, persuaded consumers that recorded music and 'serious' music were not mutually exclusive.[32] [33]

Although popular music continued to outsell classical music throughout the 1910s, the burgeoning market was kind to both. Total United States sales in dollars reached "a peak not surpassed for almost thirty years" (Hamm et al., 1975: 257). Classical music was perhaps a more powerful market force then than it is now, with artists like the Italian tenor Enrico Caruso earning more than two million dollars from the sale of his recordings before his death in 1921 (Hamm et al., 1975:

[31] Hamm et al. point out that by 1915 "Victor [the leading phonograph record company in the United States at the time] could offer the buyer six different versions of the 'Toreador Song' from Bizet's *Carmen*" (Hamm et al., 1975: 257).
[32] The release of works such as Wagner's *Tristan und Isolde* and Bach's *B Minor Mass*, though possible, would have been rather impractical prior to the advent of double-sided discs. Hamm notes that "*Tristan und Isolde* was released almost uncut (thirty-eight sides!), and Bach's B Minor Mass was issued, complete, on thirty-four sides" (Hamm et al., 1975: 259).
[33] In fact, by the 1930s, societies had been set up with the sole purpose of recording a particular composer's complete output, usually by the "less economically depressed Europeans" (Hamm et al., 1975: 259).

256). The popularity of recorded music had been helped in no small part by the increased portability of music playback equipment: "The fact that a 78-rpm recording of Enrico Caruso's voice did not quite sound like a concert performance by Caruso was deemed less important than the fact that the Victrola used to play this recording could be taken along to a picnic in the park." (Fikentscher, 2003: 291). Consumers were starting to enjoy music in ways that had previously been inconceivable, and record companies soon realized that "popular music was the money-maker, the commodity that made it possible for record companies to expand their listing of classical music, almost as a prestige-seeking public service" (Hamm et al., 1975: 258).

The bulk of today's popular music is generally written, recorded, sold on CD or as a download, and *then* exploited in other commercial arenas such as film, advertising, and even Broadway musicals (even if it does enjoy much greater success as a single or album *after* its exploitation in other arenas). In contrast, the majority of songs that became famous during the first few decades of the twentieth century were first introduced in movies, musicals, or revues—sheet music would often be released more or less simultaneously—and if the song was a success it was often recorded and re-released by other artists (Hamm et al., 1975: 127).[34] Although countless songs faded into obscurity relatively quickly, the re-recording process and successive associations with various bands and artists afforded some songs what might now be considered an extraordinarily long chart life.[35]

The progression of recorded music did, however, meet a certain

---

[34] The notion of particular songs actually *belonging* to particular artists was uncommon at the time: "Even a song closely associated with one singer would be performed and recorded by others." (Hamm et al., 1975: 127). This may be because a smaller proportion of performers wrote their own music, or perhaps because the sense of proprietorship inculcated by copyright legislation was less keenly felt. Recently—with the rise of the Internet, digital music and video files, and reality talent shows—consumers and artists have become more comfortable with the re-use of songs through covers and mash-ups.

[35] See Hamm et al. (1975: 127–128) for closer study of George and Ira Gershwin's 'Embraceable You', which, thanks to some notable cover versions, enjoyed an initial chart life of about 30 years.

amount of resistance. As per the discussion in Chapter 4, many of those involved in the music world (particularly performers) were concerned that the record would displace live performance and leave many musicians out in the cold:

> By making a performance repeatable, [recording] gives it an authority that is entirely foreign to its nature—or was, until it began to affect the art of repetition . . . It freezes the work; it reifies the human voice and hand. A new kind of performer is needed, the virtuoso of the repeated take.
>
> (Chanan, 1995: 18)

Similarly, there was widespread concern that the public, collective engagement with music that had been so prevalent in the nineteenth century would be cast aside in favour of more isolated activities, leaving behind a musically bereft society: "With the phonograph vocal exercises will be out of vogue! Then what of the national throat? Will it not weaken? What of the national chest? Will it not shrink?" (John Philip Sousa quoted in McLuhan, 1964: 293).

There were some advantages, however, that did not become immediately apparent. The ability to fix performances and subsequently transport them to other locations provided consumers with access to authentic performances of musical styles and genres from other regions—or even other countries—without having to travel there in person. Despite its portability, this had not been possible with sheet music because a 'non-native' performer could not guarantee delivery of an authentic interpretation of the music. This was particularly true of music from genres that were less widely published, did not lend themselves to available forms of notation, or were simply never written down.[36]

[36] Fikentscher highlights the importance of sound recording in creating a new branch of archival work and, in turn, musicology: "Since

The rise of radio broadcasting expanded the potential audience even further. Before recording technology was used in radio, broadcasts were necessarily live and thus somewhat restricted in their output. Even as records found their way into radio studios, the general understanding was that a record was a facsimile of a musical performance and should be enjoyed as such. Broadcasts continued to be formatted as "make-believe concerts" until the 1920s, when disc jockeys (to use modern parlance) began to think of records "not merely as documents of musical performance but as the basic elements for performance on their radio shows" (Fikentscher, 2003: 292).[37] As radios became cheaper and more households acquired them, so the influence of disc jockeys and broadcasters grew.[38]

Broadcasting's success lay in the fact that, after the initial outlay for a radio, listeners were rewarded with a huge variety of music (and other programming) for free. In an effort to sway consumer loyalty towards the purchase of recorded music, the major record companies expanded their rosters to include some of the most influential artists, bands, and orchestras and began promoting their output more vigorously. In addition, the price of individual records was slashed: "They [Columbia] dropped their price from four dollars to one dollar for each 78-rpm disc" (Hamm et al., 1975: 259). Suddenly, consumers had access to an ever-increasing library of cheap, high-quality music.

Just as the piano had been a status symbol in the nineteenth century, so various records and the equipment on which to play them became indicators of both a household's wealth as well as the tastes

---

recordings could serve as a form of documentation of musical performances, record libraries and archives emerged in the first decades of the twentieth century. This helped to put scientific weight behind a fledgling new academic field, comparative musicology. Types of music that hitherto had been cultivated entirely as oral traditions by their respective practitioners became available to interested outsiders on a scale previously unimaginable." (Fikentscher, 2003: 292).

[37] This was, as Fikentscher suggests, the birth of "the concept of the deejay as creative authorial agent" (Fikentscher, 2003: 292).

[38] See, among many others, Wallis and Malm (1984).

and predilections of its inhabitants. As the music on offer began to exceed the amount of music most people could afford to buy, consumers were faced with questions about which records to buy, rather than whether or not to buy them at all. Decisions such as these allowed consumers to construct a cultural identity through the music they chose to purchase, display, and share. No longer was musical taste defined by the concerts one had seen, or which instruments one's family played. Visitors to a house would be able to see what records had been purchased and, therefore, which composers, artists, or types of music were valued more than others in that household.

As improvements in material and audio technology led the 78-rpm record towards 45-rpm singles and 33-rpm albums, these emerging rituals were exaggerated and reinforced. LPs were cheaper, lighter, more durable, and held more music—hence long player—than their predecessors, and the ever-increasing amount of music available on the new medium persuaded more and more consumers to invest in turntables and auxiliary equipment such as speakers and amplifiers. One particular development that is often overlooked is the arrival of the jukebox.

Although jukebox technology had been around since the nineteenth century, the relatively rudimentary technology and, in particular, the lack of electric amplification meant they were not initially well suited to the environment where they eventually became most successful, i.e., social spaces such as bars, clubs, restaurants and diners (Fikentscher, 2003: 296, footnote 20). The development of electric amplification "enabled jukeboxes to cut through the din of social dancing environments, where earlier popular technologies such as the Victrola phonograph and the 'player piano' had fallen short" (Fikentscher, 2003: 296). In the United States, these developments coincided neatly with the repeal of Prohibition laws, and venues reopened with the new jukebox technology installed. As Fikentscher indicates, such venues served as precursors of the discotheque and "the idea of dancing to technologically mediated music became a familiar one" as a result (Fikentscher, 2003: 296).

The discotheque was also responsible for elevating the previously functional role of disc jockey (which had its origins in radio) to that of a creative performer. In many ways, DJs became the successors to swing band leaders: choosing songs to suit the mood of the crowd, interacting with the audience, and providing a visual presence and focal point. Instead of harnessing the power of a live band to do their bidding, the DJ played recordings of definitive or well-known performances, juxtaposing music from disparate times and places for effect and, eventually, blending strands of different records to provide a seamless, creatively-driven, and ultimately unique experience for their audience. The interaction between DJ and audience encouraged the notion of active rather than passive listening; the way in which a crowd responded to a DJ's performance would, in turn, affect that performance. "In this way", says Fikentscher, "since the disco era, recorded music has been reintegrated into the process of musical performance, rather than just serving as commodified, authoritative text." (Fikentscher, 2003: 294). Despite not actually generating any of their own sounds (as per a 'traditional' instrumentalist or singer), some DJs "became identifiable through their programming and treatment of recorded music material" (Fikentscher, 2003: 294).[39]

By the early 1950s, consumer markets were "burgeoning to almost mythic proportions" with the results of wartime technology transfers, and in the home audio sector "the magnetic tape recorder was the new star" (Malsky, 2003: 233). It was estimated that, by 1952, approximately 1.2 million tape recorders had been sold in the United

[39] It is not only the opportunities brought by *new* technology that give rise to new music and musical techniques. Frustrations with older technologies can provoke resourceful responses: "The need to mix originally arose from the limitations of early deejay technology. When using just one turntable to play records for dancing, there would be 'dead' time between each record that was contrary to the continuous dynamics of a dance floor atmosphere" (Fikentscher, 2003: 303).

States alone (Olson, 1954: 643). Tape provided much better fidelity than its wire recording predecessor, but the wow and flutter inherent to tape technology ensured that it never completely outclassed vinyl records, despite its ability to provide much greater manipulation of material once it had been recorded—both in terms of multi-tracking and post-production techniques.[40]

Although tape technology's effect on the production of music was marked, its arrival heralded significant changes in the realms of consumption as well. First, the ability to make one's own recordings; previous generations of recorded music consumers simply could not have afforded the equipment necessary to record and press their own records. Suddenly it was possible to make bootlegs, mixtapes, home studio projects and countless others with relatively cheap, simple, and compact equipment.[41] As Malsky explains:

> For the hobbyist, the tape recorder was the audio equivalent of the photo album; it could be used to preserve and comment upon

[40] Once audio tape and the various splicing and multi-tracking techniques had appeared—i.e., once people were able to manipulate the sound of an event after recording it—"a recording no longer necessarily documented a performance at all. Instead, it was a new type of authoritative text, a sonic score. For example, the material on the Beatles' landmark album *Sgt Pepper's Lonely Hearts Club Band*, created on two 4-track recorders, was unperformable onstage by its authors after its release in 1967." (Fikentscher, 2003: 293).

[41] Rock band The Grateful Dead are famous for encouraging their fans (known affectionately as 'Deadheads') to create bootleg tapes of their concerts. The practice became so prevalent that sound engineers at the concerts had to allocate particular areas to the 'tapers' in order to avoid the equipment interfering with their own. Far from impinging on the success (financial or otherwise) of The Grateful Dead, the band went on to become "the most popular touring band of their era, selling hundreds of millions of dollars' worth of tickets, and creating a highly profitable corporation in the process. Without hit records, the Grateful Dead achieved elite success, becoming one of the most iconic rock bands of its era and inventing a brand that democratically included their consumers" (Meerman-Scott and Halligan, 2010a: 16). In 2010, Meerman-Scott and Halligan published a book that championed the Grateful Dead's 'freemium' model, arguing that it was surprisingly innovative, and has many applications in today's world of social media and online communities (see Meerman-Scott and Halligan, 2010b).

> both special events and daily living, so that they could be relived, scrutinized, or enjoyed later. People used the tape machine to record their children's performances, to make soundtracks for home movies, and to record music from the radio.
>
> (Malsky, 2003: 233–234)

Second, the compactness of tape technology allowed for playback devices with a portability that was previously unthinkable. This miniaturization catalyzed the first profound change in how music was consumed since the birth of the phonograph. At the forefront of this change were two products in particular: the Walkman and the boom box.

The Walkman allowed consumers to take their music with them wherever they went (assuming they had sufficient battery power), and listen to their music without disturbing or involving anyone else. No longer confined to attending concerts or listening to records or the radio at home, music consumption could now be a private affair. People began to use music in a more personal way. With one's own customized jukebox, any activity—going for a run, commuting, or even sitting in the park—could be soundtracked. This ability to 'ubiquitize' music also nourished the fledgling idea that music could function in a way it never had before. Instead of a rare spectacle worthy of utmost attention, music could now be a form of sonic wallpaper with which to conceal the blemishes of one's aural surroundings. The advent of the Walkman was the first time that *domestic* consumers (rather than people using sound recording equipment as part of their job) were willing to sacrifice fidelity in favour of being in charge of what they listened to, when they listened to it, and who they listened with, if anyone.

The boom box stood neatly between the home audio system and the Walkman. It was portable enough to be carried from home to the park or town square, but was inherently a more public way of listening to music. In allowing the conspicuous consumption of music, the boom box was ideal; it could be taken anywhere, play all music (tapes were relatively easy to copy, even on basic systems), and those nearby (whether by design or by accident) could listen to it or would hear it.

CD technology provided a brand new level of fidelity, becoming the benchmark in audio quality against which all other media were measured for more than two decades (much to the chagrin of some audiophilic vinyl enthusiasts). As far as the rituals of production, distribution, and consumption were concerned, the arrival of CD technology did not prompt a great deal of change. Tapes and CDs existed side by side for many years, with new releases being made available on both platforms.

Despite their vastly improved fidelity and durability, CDs were, in one way, a step back from tapes: they were not editable. For the first decade or so after CDs were introduced, the equipment used to manufacture and press them was prohibitively expensive, and most consumers could only listen to official releases bought through conventional channels. In contrast to tape, one could not make a compilation of favourite tracks for a friend, nor could one make impromptu recordings (recording directly to the medium in real time was impossible). It was this restriction that fuelled the popularity of tape long after the introduction of CDs. For all their superior sound quality, CDs, as physical objects and 'containers' of music, were treated in much the same way as tapes and even vinyl.

The supremacy of CD technology looked set to be challenged when Sony unveiled their new MiniDisc technology. Its selling point was CD quality audio with magnetic tape editability. The players (with built-in recording capability) became popular as robust, versatile field recorders that would capture a great deal of material in high fidelity on small, easily stored media. However, this rendered pre-recorded MiniDiscs rather defunct from the outset. Because it was relatively easy to buy the latest number one album on CD and copy it straight to MiniDisc, few people opted to buy the MiniDisc instead. Not only were prerecorded MiniDiscs on the whole more expensive than CDs, it was also harder to copy audio data from a MiniDisc to a CD than the other way round. In addition, the majority of consumers already owned CD players and few seemed eager to buy another piece of equipment when the CD player would do the job. Why pay more for a prerecorded MiniDisc and not have a CD to put in the car stereo system or your friend's hi-fi, when you could buy the CD, and copy whichever tracks you like for your high-fidelity MiniDisc compilation? Although MiniDisc was not an entirely short-lived platform, its impact on broader consumer behaviour was minimal.

5.5 Digital rituals

Digital music files have affected virtually every corner of the music industry, including production, distribution, and consumption. Of these three areas, the rituals governing the production of music seem to be the least affected by the arrival of the Internet and digital music files. Why? Because so many of the processes involved in this sphere depend on what Leyshon calls "embodied skills, performances, and sub-cultural knowledges" (Leyshon, 2001: 68). Such aspects of music production—composing, performing, and editing, for example—rely heavily on human individuality and idiosyncracy for their merit, however it is measured. (Of course music can be composed by a computer with negligible human input, but it is likely to lack certain elements that resonate with listeners.) By contrast, the process for distributing music requires labour in order to be executed effectively but not aesthetic judgement or artistic intuition. As a result, these processes have been much more profoundly affected than those in the sphere of production as the digital era has progressed.

5.5.1 Acquisition channels

From a consumer perspective, the various modes of distribution appear as a variety of channels from which the consumer can elect to acquire his or her music. These channels can be divided into four categories, based on two dichotomous dimensions: tangibility and chargeability (Makkonen et al., 2011). A tangible acquisition channel is one through which music is delivered on physical media such as CDs, while intangible channels provide digital content via audio streams or as downloadable files. The technological and theoretical advantages of such intangibility were discussed at some length in the previous chapter. In a more practical and concrete sense, though, there are some differences at the point-of-sale or point-of-consumption that warrant further discussion here, due to their effect on how consumers decide to acquire their music. As recently as 2005, Bockstedt et al. suggested that:

> Though digital music has advantages over physical formats, the product is incomplete. Digital music does not include some of the important attributes of the physical CD. These include artwork, lyrics, liner notes, and additional content found in enhanced CDs (video games, desktop wallpaper, video clips). But these can be made available in a digital form for distribution.
>
> (Bockstedt et al., 2006: 8)

Without delving too deeply into philosophical discussions of what constitutes a tangible musical product, it is clear that Bockstedt et al.—among many others both outside and inside academia—consider it to include a great deal more than merely the audio data necessary for playback. Since the emergence of the record industry, this list of additional content has evolved from perhaps simple cover art and a few hundred words of acknowledgement and legal disclaimer into a substantial and carefully coordinated package, providing consumers with an experience designed to enhance their listening (or drive sales, depending on who you ask). Somewhere between these two extremes lie the majority of music releases: accompanied by cover art designed to reflect the image of the band or artist, lyrics for some or all of the songs, and sometimes liner notes that explore part or all of the band or artist's history, or even the creative drivers behind the music itself.

Unfortunately, Bockstedt et al. make the rather problematic assumption that everyone in the pre-digital era *actually* read or digested the additional content. Many consumers did, and many would rush to buy a second copy of an album simply because it had expanded liner notes or limited edition artwork. Perhaps unsurprisingly, it is most likely to be these consumers who mourned digital's initial inability to carry such content alongside the primary audio data. The term 'initial' is used because music files are now able to carry textual and other information, and software (such as iTunes) is increasingly designed to make displaying and absorbing such information as easy as possible.[42] In instances where this is insufficient, the band or artist's website can serve as a rich source of additional content. Most such websites will provide lyrics, credits, photos, videos, tour dates, and even the opportunity for fans to participate in live discussions with the band or artists and other fans. Crucially, the site is likely to provide not only more content than a CD or LP, but also premium content that might unavailable elsewhere (merchandise, limited edition CDs), and regularly updated content (tour dates, video diaries etc.). This may represent an uncomfortable departure for some, but for many it is a vast improvement.

The second of the two dichotomous dimensions governing the categorization of acquisition channels is chargeability. Intuitively, this distinguishes between channels for which consumers pay to receive

[42] By way of example, iTunes has (for some years now) allowed users to upload or download album covers, which—in an emulation of record store browsing—users can 'flick through' using their mouse or trackpad.

music content, and channels through which consumers can acquire music free of monetary charge. This separation is not, however, to be casually connoted with legal and illegal methods of acquiring music. Traditionally, many free acquisition channels have been synonymous with the illegal sharing of copyrighted content, but today many continue to provide free access to music without infringing copyright (Makkonen et al., 2011: 896). Not only are there free streaming services, but also legitimate opportunities to acquire music through file-sharing without automatically engaging or contravening copyright law.

This is a very important distinction to make. A great deal of scholarship on the matter—as well as most of the relevant rhetoric emanating from the traditional quarters of the music industry—is too quick to gloss over the difference. Peitz and Waelbroeck, for example, state quite bluntly that "contrary to sharing music files on the Internet, audio-streaming is legal" (Peitz and Waelbroeck, 2004: 17). Underpinning that statement is an assumption that "sharing music files on the Internet" is illegal. A great deal of the file-sharing that goes on *is* illegal, and it would be foolish to pretend otherwise. However, many artists, labels, and associated entities actively choose to exploit the copyright in their works by not exploiting it at all: by giving it away free. A closer examination of some of these instances takes place later in the chapter, but it is important to drive home the fact that file-sharing is not inherently illegal or illegitimate.

Constructing a matrix of these two dimensions results in four categories of acquisition channel[43]:

[43] The 2004 IFPI Online Music Report (page 9) cited by Peitz and Waelbroeck, (2004: 58) provides a more granular separation of acquisition methods, but these are less useful than those provided by Makkonen et al., particularly given the changes in distribution practices that have occurred since.

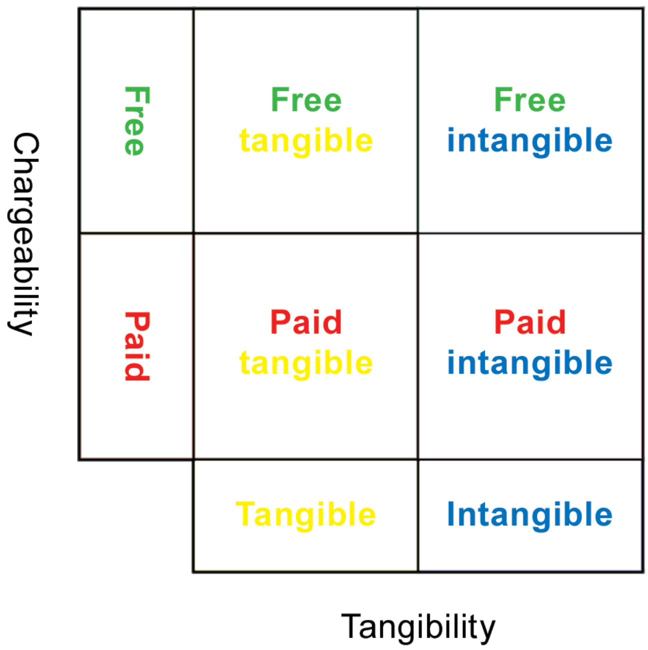

Figure 5.1 *Matrix of acquisition channels*

As Makkonen et al. point out, the category of *free tangible* channels is "by far, the least common of the four" (Makkonen et al., 2011: 896). Typically taking the form of promotional copies (often given away with publications or other products) or pirate copies of physical media, such channels feature very infrequently in consumer acquisitions, and as a result their impact on consumption habits and the revenues generated by consumption of recorded music is negligible. That is not to say, however, that they have no impact at all. In 2008 English pop-rock band McFly released a 12-track studio album of brand new material called *Radio:ACTIVE*. Rather than releasing it through traditional distribution channels—e.g., via online retailers or bricks-and-mortar stores—the band elected to give away a copy with every purchase of the 20th July 2008 issue of the *Mail on Sunday* newspaper.[44] The paper's incentive for collaboration is obvious; circulation that day was approximately 300,000 copies more than the paper's non-promotional average (Brook and Fitzsimmons, 2008). According to McFly's lead songwriter, Tom Fletcher, the motivation for the band was

[44] The album was officially released on 22nd September 2008, with four extra tracks, and one of the original tracks missing.

a similar desire to increase circulation: "We get to put it into almost three million homes, which is an incredible opportunity for us. Hopefully the three million people will all enjoy the music and they'll decide to see us when we go on tour" (Mzimba, 2008: 2). How this manoeuvre influenced later concert ticket sales is uncertain, but McFly are not alone in pursuing a strategy that is slightly unconventional by traditional music industry standards. The *Mail On Sunday* has also given away music from Prince, Barry Manilow, Simply Red, UB40, and Paul McCartney. A 2004 survey by Rainie and Madden found that 83 per cent of songwriters and musicians provide samples of their music online, presumably for the similar reasons (Rainie and Madden, 2004).

Though their influence and prevalence are diminishing in the wake of Internet commerce, *paid tangible* acquisition channels are still more common than their free tangible counterparts. The quintessential example is the bricks-and-mortar record shop, whether an independent outlet or part of a larger chain. It is important to reinforce the distinction between the tangibility of the selection or purchase method on the one hand, and the delivery method on the other. Many retailers have digitized the purchasing process, allowing consumers to browse their stock online, but continue to deliver physical carriers such as CDs or vinyl records. From the consumption perspective, these still qualify as tangible acquisition channels. These days, most bricks-and-mortar stores will offer the option to select and purchase music online as well. Exceptions to this are the majority of independent record shops, for whom the practical and financial implications of online retailing are at best ineffective, at worst prohibitive. Although such shops are unlikely to compete with major retailers in terms of price or variety of stock, they tend to occupy a niche position that capitalizes on special interest musics and a sense of community that many older music consumers prefer. Leyshon (2001: 67) suggests that independent stores continue to function as nexuses of consumption, especially amongst enthusiasts of a particular genre. Moreover, "such stores can play an important part in networks of creativity, as they act as meeting points for encounter and informative exchange between actors with an active interest in music, either as audiences or as performers, or both" (Leyshon, 2001: 67).

Online retailers (such as Amazon) capitalize on their ability to offer a wider variety of music, usually at lower prices, and often in a way that is more convenient for the majority of consumers. This is made possible primarily by two things. First, the ease with which consumers can browse the stock of online retailers, using the Internet to access shopfront-style websites, compile virtual baskets of goods, and pay using secure electronic transaction systems. This is now common practice within technologically enabled societies, but without it many consumers would be discouraged from browsing (or would be unable to browse) such expansive repositories of music and other products.

Second, the absence of the physical constraints that hinder independent stores. Every shop has finite shelf space, and this necessarily limits both the amount and variety of music that can be stocked. In contrast, warehouses such as those used by Amazon can store huge volumes and variety of music (often in different places), do not need to be consumer-friendly, and the cost of buying or renting such facilities is cheap compared to high street or shopping centre real estate. For the average music consumer—that is, a non-enthusiast who is unlikely to benefit from the niche selections offered in independent stores—this represents "value over and above what traditional music sales (of CDs) has traditionally been able to provide" (Duncan and Fox, 2005: 3).

This retailing concept has come to be known as 'The Long Tail'. Chris Anderson co-opted the term from the field of statistics and brought the idea to mass attention through his article in technology magazine *Wired*—of which he is, at the time of writing, editor-in-chief—and two subsequent books (Anderson, 2004; 2006; 2009).[45] The term describes a situation in which an equal or larger share of the 'probability population' (for which, in this case, read 'individual music releases') resides within the tail of a probability distribution curve than under a normal distribution.

Figure 5.2 *Long tail graph, showing green and yellow areas of equal size*

Taking the sales of recorded music as a context, consider the graph of popularity against inventory above. The green area to the left—the 'head'—represents the most popular or highest-selling releases (for example, albums) over a given time period.[46] The yellow area to the right—the 'tail'—represents less popular or lower-selling releases and corresponds to less lucrative markets. Traditionally, bricks-and-mortar retailers have, in deference to the infrastructural limitations mentioned above, elected to prioritize albums from the 'head' in an effort to maximize their profits from a limited catalogue.

---

[45] The term has been studied in one form or another since the middle of the twentieth century and is closely related to other statistical distributions such as Zipfian and power-law distributions. The Pareto principle is a common analogy, wherein 80 per cent of the occurrences (in this case, album sales) are accounted for by 20 per cent of the population (bands or artists).
[46] Although the fine detail and mathematics would be slightly different, the same graph can, in theory be applied to artists or bands, rather than albums or singles.

Meanwhile independent record shops have focused on the market for the less lucrative items in the 'tail', precisely because larger retailers could not. The need to coordinate stock, branding, and advertising across multiple outlets prevented larger retailers from achieving the agility and sensitivity with which independent retailers could respond to changing musical fashions.[47] Modern online retailers are able to exploit both, offering popular releases at lower cost than many of their competitors whilst continuing to stock (and making it easy to browse and select) a huge number of less popular titles. Josh Petersen, a former employee of Amazon, explains it pithily if a little cryptically: "We sold more books today that didn't sell at all yesterday than we sold today of all the books that did sell yesterday" (Petersen, 2005). The effect is likely to become more exaggerated if retailers are liberated entirely from the shackles of physical music carriers such as CDs and vinyl records. If traditional stock is replaced with digital music files—storable in their millions on devices the size of a shoebox[48] and infinitely reproducible—the 'head' can be infinitely tall and the 'tail' infinitely long.

Paid intangible channels are, according to Makkonen et al., "exemplified by the digital music stores and services that sell and deliver music recordings as different types of digital deliverables over the Internet" (Makkonen et al., 2011: 896). Invariably, these digital deliverables are digital versions of albums or individual tracks, offered either as an open-coded file (such as MP3) or in some kind of proprietary format (such as Microsoft's WMA). Many of the newer retailers (such as the iTunes Store), offer only intangible delivery but

[47] This mirrors the duality of the record labels that comprised the music industry for the majority of the twentieth century: "While majors put more emphasis on product differentiation and likely brand proliferation of the well-known repertoire, independents' strategy relies more on product innovation and a lower sunk cost" (Harchaoui and Hamdad, 2000: 501).
[48] The LaCie 5big Network 2 external hard drive provides 10 terabytes of storage (enough to store one million 10 MB music files) and measures 17.3 cm wide, 19.6 cm high, and 22 cm deep (Wex Photographic, 2012).

retailers established prior to the advent of digital music files tend to act as hybrids, offering digital downloads alongside tangible platforms and allowing customers to browse for both simultaneously.

Because online music retailing does not require the traditional bricks-and-mortar infrastructure of a record shop, many companies that took no part in the physical retailing of music have been able to start trading without having to overcome the enormous advantage that traditional chain retailers have always had over smaller start-up companies. Peitz and Waelbroeck list some notable categories and businesses that have emerged as important players in the new market: "Traditional/hybrid stores (Fnac, Amazon, Walmart, BuyMusic), technology companies (Apple's iTunes/iPod, Microsoft Media Player, RealNetworks), online content providers (Yahoo! Launch), online music sites (MP3.com, OD2), electronics companies (Sony Connect Store), and Internet service providers" (Peitz and Waelbroeck, 2004: 38–39). Since Peitz and Waelbroeck were writing, many mobile phone operators (as opposed to manufacturers) have started to offer music download services as well. The music files are often downloaded direct to customers' handsets, and come in a variety of proprietary formats that can restrict usage of the files to particular devices. The format or type of encoding that retailers use can have serious implications for their success in the market. In choosing one format over another, retailers can ally themselves to, or distance themselves from, various software and hardware platforms that consumers may be reluctant to part with or acquire.

The way in which intangible channels offer music for download has provided consumers with more control of not only *what* they acquire, but also *how* they acquire it. Consumers can very easily buy individual tracks from an album for a fraction of the cost of the whole thing. They are no longer forced to pay for tracks they may not want simply because the tracks are bound together on a single physical object. Some established actors in the music industry see this as some kind of sacrilege: the disruption of the natural order of things at the hands of convenience. Duncan and Fox note that, on the contrary, the concept of the album was an artifice from the beginning:

> Up to the mid-1960s the primary unit of musical currency was the single; albums were created from several singles and typically contained a lot of "filler". However, during the 1960s artists began to conceptualize the creation of the album as a uniformed expression of some vision or theme. Many artists welcomed this move toward viewing the album as a whole rather than as just the sum of its parts. This gave artists greater creative flexibility; rather than telling one 'story' in a three-minute pop song, they could have a series of songs that would fit together in some way so as to tell a more complex story (e.g., Pink Floyd's *The Wall,* or the Who's *Tommy).*
>
> (Duncan and Fox, 2005: 3)

The micromaterialization of recorded music by digital technology permits a degree of divisibility previously shrouded by the physicality of the media on which albums were traditionally consumed. This change affords consumers a previously unavailable level of autonomy. Instead of dutifully purchasing an entire album of songs, some of which might be of little or no interest, consumers can now create their own "listening experiences . . . bypassing the context in which (many) artists envisaged their work would be listened to when purchased" (Duncan and Fox, 2005: 3). Consumers can, of course, still purchase entire albums if they wish, but they are no longer compelled to do so.

If record companies and recording artists find this consumer autonomy uncomfortable, it should be noted that such divisibility was, in theory, possible with some previous platforms. What makes the change so striking is the *ease* with which digital music files can be purchased, arranged, and consumed in a granular fashion. Similarly, it is more than likely that many consumers of physical media would have listened to only a handful of tracks on an album, skipping over the songs they did not want to hear. It is only now that the choice is there and the effect quantifiable in terms of individual downloads that such autonomy has caused consternation.[49] Furthermore, the lionization of the album by the music industry may have been based less on aesthetic merit and more on the album's importance as part of a revenue cycle upon which the recorded music industry has relied heavily for decades. The careers of many bands and artists comprise repetitions of a familiar sequence: write an album, record it, release it, release singles from it, and go on tour to promote it. This has been the lifeblood of the music industry for decades, and threats to its security have usually (and understandably) been met with resistance.[50]

Makkonen et al. consider the category of *free intangible* channels to be the most divergent of the four, and divisible into two sub-categories: "First, there are the traditional radio stations that broadcast their programmes either nationally or internationally. Second, there are the various free online sources that deliver music content digitally over the Internet" (Makkonen et al., 2011: 896). The first category includes commercial and non-commercial radio stations (whether broadcast online or via 'the airwaves') whose broadcasts are devised by employees of the station to provide a range of content appropriate to the station's intended audience. Many of these stations cater to particular demographics, usually within a specific age range or with well-defined interests. The output of the BBC's Radio 1, for example, is

[49] Despite the ability of retailers to generate sales data based on individual downloads, it is still impossible to know for certain whether consumers actually listen to them. This is particularly true if consumers acquire their music through other channels—file-sharing, ripped CDs, etc.—or if they use multiple music player software for different formats.
[50] As always, though, there are some exceptions. Alternative rock band Ash announced in 2007 that they would cease to record and release traditional albums (NME, 2007). Citing frustrations with the restrictive nature of the marketing and release schedules associated with traditional albums, the group elected to release songs as they were written, with the intention of possibly grouping them together retrospectively (Diver, 2007).

aimed at 15–29 year olds, while its sister station 1Extra focuses on contemporary black music, and issues that are likely to interest ethnic minorities in Britain (British Broadcasting Corporation, 2012a).[51] The second category is far broader, encompassing artist or record label initiatives, audio-streaming services, on-demand services, and file-sharing platforms.

Artist and label initiatives represent a fairly small proportion of this category, generally mirroring the promotional nature of the free tangible acquisition channels discussed above. A record label might, for example, offer a free download of a song from each band on their roster, or a specific band might allow fans to download a track from an upcoming album, in order to generate word-of-mouth promotion before the album's release. Traditional music industry economics would dictate that such a strategy deprives the labels and artists of income from sales of the single. However, singles have gradually come to function as loss leaders in the promotion of albums, and album sales have become a more accurate indicator of an act's market success than sales of their singles (Anand and Peterson, 2000: 274). There are, as always, some exceptions to the rule. The experimental rock band Radiohead pursued a decidedly bold strategy, releasing their seventh album, *In Rainbows*, as a download through their website, and asking customers to pay as much or as little as they wished before downloading. According to ComScore, an Internet research company, the figures after the first month were as follows:

> About 17 per cent plunked down between a penny and $4, far below the $12 and $15 retail price of a CD. The next largest group (12 per cent) was willing to pay between $8 and $12—the cost of

---

[51] In the commercial sphere, these niche stations are particularly useful for advertisers, as it allows them to effectively target a particular demographic that is likely to purchase their products or services. In much the same way that traditional, pre-digital local radio stations would (and still do) include adverts for products or services that are *geographically* proximate, niche or genre-specific stations usually include adverts for products or services that are *culturally* proximate.

> most albums at Apple's iTunes Store is $9.99. They were followed by the 6 per cent who paid between $4.01 and $8 and 4 per cent coughed up between $12 and $20.
>
> (ComScore statistics quoted in Sandoval, 2007)

The remaining 62 per cent was accounted for by those who paid nothing at all to download the album. Radiohead said little about the precise financial outcome of the manoeuvre, but their management company acknowledged that the average price paid was around £4 per copy of the album (Brandle, 2007). ComScore estimated the average price to be significantly less, at $2.26 per download (Sandoval, 2007). Both of these figures are substantially lower than the average price of a CD in 2007, estimated above to be $12–15 and by the Entertainment Retailers Association to be £8.65 (Music Week, 2010). Nonetheless, Radiohead consider their independent distribution strategy to have been a financial success: "We sell less [sic] records, but we make more money" (Ed O'Brien quoted in Colbert, 2011). According to Radiohead's bassist, Colin Greenwood, there are perhaps more important gains to be made, whether the figures add up or not:

> In August 2007, we had finished our first record after the end of our deal with EMI. Previously, we would have given it to our record company at least three months up front, and then gone through the protracted round of meetings to decide on videos and singles—experiences we'd had for the previous six records. This time there was no EMI, and no one to decide anything but ourselves. We owned it outright, and could do whatever we wanted with it. This coincided with the growth of the Internet as a medium to discover and share music, something we had used to reach fans while we made In Rainbows. This desire to use the technology was driven by distrust and frustration with trying to broadcast our music via traditional media, such as radio and television. Music on television is scarce, and hard to do well. Radio

> has such regulated playlists that disc jockeys are lucky to have one free play per show. Why go exclusively through such straitened formats when you could broadcast directly to people who are interested in you, in that moment?
>
> (Greenwood, 2010)

Greenwood's final sentiment echoes Leyshon's theory of disintermediation; digital technology allows bands and artists to bypass traditional music industry structures, communicating directly with their fans and, arguably, conveying a truer and more autonomous sense of their musical aesthetic:

> The Internet makes it easier for everything to be live, and that's what we do. While we were in our studio, making the last few records, we would schedule last-minute "web casts", and, at short notice, make small, spontaneous and impromptu programmes where we would play our favourite records, talk to fans, play new and old songs live, and even cover versions of songs from bands that had inspired us. It was stitched together on old Sony cams and video editors from eBay. It did feel like a Ruritanian broadcast, but it was thrilling to be sharing a live moment with our fans that wasn't mediated by anyone except the Internet service provider, and a live show that could be created ten minutes from home. I'd like to think the equivalent of this in broadcasting history would be the mom and pop radio stations that set up in America between the wars, when the excitement of a new medium was explored through the immediate community. In the same way, we saw the Internet as a chance to treat the global constituency of Radiohead fans as our community.
>
> (Greenwood, 2010)

Radiohead may have been in a privileged position in terms of their success prior to the release of *In Rainbows*, and thus better able to exploit the kind of opportunities mentioned above. Nevertheless, these are very real possibilities for *any* act that elects to operate outside the traditional music industry structure, especially if their music is up to scratch:

> . . . the most important reason for the success of *In Rainbows* was the quality of the music. I think this was overlooked, but without the great songs that we were proud of, the online release would have counted for nothing. I am optimistic that if you make good work you can secure the patronage of your fans.
>
> (Greenwood, 2010)

Returning to the second overall category of free intangible channels, a section of the audio-streaming services already mentioned almost warrant the creation of a third category—'recommendation radio'. These are semi-autonomous radio stations, generating 'broadcasts' for individual consumers based on consumer-led information about personal taste. Examples of recommendation radio include Last.fm and Pandora. Last.fm collects information about a user's listening habits in order to help users "discover more music based on the songs [they] play" (Last.fm, 2013). This is achieved using 'scrobbling' software—specifically, Audioscrobbler—which can relay to Last.fm's database details of any songs that the consumer has listened to on scrobble-enabled devices or services, such as Internet radio stations, portable music players, games consoles, or home music systems such as Sonos. This listening profile is then parsed using various algorithms and compared with other user data, allowing the service to recommend new artists to the original user. The system also provides recommendations for gigs and live events, and includes social networking facilities to encourage the sharing of music and information.

Pandora allows users to 'tune in' to specific stations, though not necessarily in the traditional sense. 'Stations' can be predetermined broadcasts (music only) based around a particular genre, or they can be generated based on the user's selection of a particular artist, song, or a group of either. Pandora will then play tracks in succession—rewinding and repeating tracks is not possible—and users can choose to rate each song, giving it a 'thumbs up' or a 'thumbs down'. A 'thumbs down' will cause the player to skip to the next track, and the user's negative response to the song in question will be recorded. If the same artist receives a second 'thumbs down' without an intervening 'thumbs up', the artist will no longer be recommended to the user. The ratings are used to 'tune' the station, the aim being to provide the user with more successful recommendations.[52] Users also have the option to buy the current track via Amazon or iTunes. Repeated playing of a single artist or track is not possible with Pandora; it is explicitly a recommendation system, rather than a play-on-demand service. Due to licensing restrictions, the service is only available to users with an Internet Protocol (IP) address emanating from the United States.[53]

Both these services constitute further evidence of disintermediation within the music industry. Rather than relying on careful branding, targeted advertising campaigns, the opinions of the gatekeepers staffing A&R departments, radio stations, and the music press—that is to say, parties who potentially stand to gain from influencing the listening and purchasing choices of audiences—

---

[52] User data are used to refine the process underpinning Pandora's selection algorithms, created by the Music Genome Project. For further explanation of the project, see <www.pandora.com/about/mgp>.
[53] Similar services are now available as part of offline music listening programs. Recent releases of Apple's iTunes software have included a plug-in called Genius, which generates themed playlists based on the selection of a single song from the user's music library. The key difference between this and online services (such as Last.fm and Pandora) is that Genius creates playlists using only music that users already have indexed in their iTunes library or music that they have yet to buy from the iTunes store. Thus, recommendations for 'new' music are limited to short excerpts, unless the user chooses to purchase the tracks in question.

consumers can access dispassionate, aggregated, personalized and increasingly accurate recommendations from sources that are ostensibly more impartial.

The third sub-section comprises on-demand streaming services such as Grooveshark and Spotify. Unlike early Internet streaming platforms such as RealPlayer, these allow users to choose from a vast library of music of the order of tens of millions of individual tracks, covering most genres, performers, and composers. This obviously represents a huge increase in autonomy over recommendation radio stations like Last.fm and Pandora. This autonomy, however, comes at a price. Invariably these services subject users to certain restrictions such as capped listening allowances (e.g., 24 hour per month) and adverts after a certain period of listening (e.g., every 5 songs). Users are given the option to remove both listening allowances and adverts by paying a monthly fee. Spotify, for example, charges users £5 per month to enjoy advert-free and unlimited listening per month, and £10 if users wish to have their playlists available offline and to access them on mobile devices such as phones and MP3 players. Many services also provide direct download links, allowing customers to buy individual tracks or albums if they wish to.[54] Like their recommendation radio counterparts, there are also social networking options embedded in the software. Spotify allows users to share and subscribe to user-created playlists, 'scrobble' data to Last.fm, and publish their listening activities to Facebook and Twitter.

The fourth and final sub-section in the category is file-sharing, discussed in detail below.

---

[54] Bhattacharjee, et al. suggest that any digital music distributor is likely to maximize their profits by offering a business model that mixes purchase and subscription options (Bhattacharjee et al., 2003).

5.5.2 File-sharing

File-sharing platforms and software—such as Napster, KaZaA, newsgroups, and BitTorrent—allow users to share digital files of varying size and content with other users on the Internet. For everyone involved in the production, distribution, and consumption of music, the emergence of this ability represents "one of the most important episodes in the history of the music industry" (Leyshon et al., 2005: 181). The traditional music industry has relied on the controlled exploitation of copyrighted material for financial return since its inception (Leyshon, 2001: 52). [55] Thus, the ability of consumers to transfer copyrighted works for little or no money—and with relative impunity—signals the reappearance of "the spectre of 'piracy' which haunts all copyright industries, but in a new more virulent form" (Leyshon, 2001: 52). This spectre is, however, something with which copyright industries ought by now to be more familiar. Every advance in copying technology has been accompanied by a well rehearsed round of legislative proposals, industry lobbying, and general opposition from content providers (Zhang, 2002: 8).[56] [57]

Leyshon's careful handling of the word 'piracy' is entirely deliberate, and not unwarranted. The Oxford English Dictionary defines file-sharing as "the practice of making computer files available to other users of a network, in particular the illicit sharing of music and video via the Internet" (Oxford Dictionaries, 2012). This latter part of this

---

[55] Leyshon cites the following sources in support of his assertion: Bettig (1996); Frith (1987); Negus (1992); Ryan (1998); and Sadler (1997).
[56] Zhang cites the introduction of the photocopier in 1959, the VCR in 1974, and the digital audio tape in the 1980s as prime examples (Zhang, 2002: 8).
[57] In the past, content providers ought perhaps to have been less afraid of the spectre. In markets where pirate copies can only be made from originals, the returns that manufacturers and producers receive can actually increase with piracy (Liebowitz, 1985). Obviously, this does not apply to digital music files because the copies *become* originals, capable of spawning more illegal copies, and the process can be repeated ad infinitum.

definition is telling; the potential for file-sharing to facilitate illegal behaviour has become one of its defining characteristics, even though the sharing of files across computer networks is not inherently illegal. This is an important distinction, but one that is often elided, usually in an effort to portray file-sharing as the industry's *bête noire*; a ubiquitous and perennial scapegoat for the decline in both sales of traditional media and the music industry's health at large. Patokos notes that:

> For their part, record companies have been engaged in a war against piracy, responding with several reactions that range from pessimism to panic, blindly (and perhaps inaccurately) assuming that any decrease in CD sales must reflect the negative effects of the Internet and the file-sharing phenomenon on the industry.
>
> (Patokos, 2008: 246)

Leyshon and his colleagues agree:

> In seeking to account for the poor performance of their businesses in recent years, record company executives are almost as one in identifying the main cause of their current malaise; the Internet. Or, more particularly, it is the rise of digital file-sharing systems, such as peer-to-peer networks that have significantly increased the rate of circulation of illegal copies of copyrighted music, which is identified as the clear and present danger to the survival of the mainstream musical economy.
>
> (Leyshon et al, 2005: 178–179)

It would be foolish to assert that file-sharing had not impacted at all on sales of music, but the picture is perhaps more complex than the traditional industry would care to admit. There is evidence to suggest, for example, that "substitution between different types of media can potentially explain the downturn in CD sales . . . the year 2000 also coincides with the end of a strong substitution/replacement effect between cassettes and CDs. When such a replacement no longer takes place, revenues are lost" (Peitz and Waelbroeck, 2004: 24). Figures also show that the variety of music available on traditional media may be shrinking. As early as 2003, research showed that the number of new releases decreased by up to 20 per cent in the preceding two years (Peitz and Waelbroeck, 2004: 22). The fewer CDs that are released, the fewer reasons consumers have to make new purchases.

Leyshon et al. highlight the uncertain nature of the relationship between "what might be described as 'traditional' musical 'piracy', such as the counterfeiting of music in media such as cassettes and CDs, and what has become known as 'Internet piracy'" (Leyshon et al, 2005: 180). How different *is* illegal file-sharing to traditional modes of piracy associated with analogue platforms?

The Federation Against Copyright Theft (FACT) is an organization that represents the film and cinema business in the United Kingdom, liaising with law enforcement agencies in an effort to eradicate (or at least reduce) copyright infringement within the industry. FACT has created a number of adverts designed to discourage consumers from creating or purchasing pirated copies of legitimate releases, one of which became a familiar sight during the 1990s after being included at the start of almost every VHS film release. The advert showed a man attempting to return a previously purchased video cassette to a trader at a busy market stall because the poor sound and picture quality render the film unwatchable. The clip finishes with a slogan: "PIRATE VIDEOS: DAYLIGHT ROBBERY" (FACT, 1996).

Another FACT-produced trailer, present on most DVD releases since the early 2000s, updates the message to reflect changing piracy habits. It begins with a teenage girl apparently downloading "feature films" on a bedroom computer. A series of captions then appear: "YOU

WOULDN'T STEAL A CAR; YOU WOULDN'T STEAL A HANDBAG; YOU WOULDN'T STEAL A TELEVISION; YOU WOULDN'T STEAL A MOVIE", punctuated by scenes of the respective thefts taking place. The clip is accompanied by an aggressive soundtrack, and finishes with more captions: "DOWNLOADING PIRATED FILMS IS STEALING; STEALING IS AGAINST THE LAW; PIRACY IT'S A CRIME" (FACT, 1997). The juxtaposition of 'traditional' crimes of theft and digital piracy is no doubt designed to shock the viewer into a realization (or admission) that, however harmless digital piracy may seem, it is as illegal as stealing someone else's *physical* property.[58]

Even though their eventual efficacy as deterrents to piracy may be hard to gauge, the motivation behind the adverts is understandable. The first advert is now rather outdated, and the second overlooks a crucial theoretical difference between traditional and digital piracy. The premise of the first advert rests on the assumption that pirated videos are inherently inferior precisely because they are copies and that vendors of pirated films are thus taking money from their customers and giving them nothing in return, hence the comparison with 'daylight robbery'. With digital copies of digital film files—and by extension, digital music files—the copies are not inherently inferior. The likelihood of a consumer downloading a 'duff' copy—whether corrupted, incorrectly dubbed, or of poor video or audio quality—is greatly reduced. Moreover, digitally pirated copies of music and films are seldom paid for. There is no obvious vendor, and no means for returning a copied file. As such, individual pirates do not benefit financially from making digital media files available for free.

The parallels drawn by the second advert seem to gloss over the difference between excludable and non-excludable goods. Stealing a car

[58] Viewers can skip the piracy trailer on video cassettes by fast-forwarding the tape. On DVDs, however, the ability to fast-forward or skip chapters is disabled during the trailer. As a result, the adverts have been criticized for being forced upon those people who have bought genuine versions of the film; unsurprisingly, the adverts seldom appear on pirate copies.

or a television prevents its rightful owner from exploiting its utility because there is no copying involved—the original has been appropriated. Acquiring an illegal copy of a digital music file is fundamentally different; possession of it does not deprive anyone else of the file from which it was copied.

Whilst neither of these differences makes digital piracy of copyrighted material any less illegal, they do undermine the application to digital piracy of arguments typically used against traditional piracy. Far more important, it seems, is the difference in scale between digital piracy and traditional piracy:

> . . . although identified as an illicit activity, which led to a technical loss of income, [traditional piracy was] mainly undertaken by an active group of music users who also bought records and CDs as well as home taping. Moreover, any distribution of illegally taped material tended to be very local, amongst groups of friends and colleagues and, because of its relatively low reproductive quality and perishability, may have induced additional purchases of the music in a more durable format. However, the rise of software formats is seen as a far more sinister development, because it allows digital recordings to be copied more faithfully and, thanks to the distribution capabilities of the Internet, to be disseminated through a music community of worldwide dimensions.
>
> (Leyshon, 2001: 52)

Leyshon's argument aligns with the theory put forward at the beginning of the chapter; namely, that this dramatic change in scale is a result of a shift from physical to non-physical networks, from geographical communities to virtual communities. The increase in network externalities brought about by file-sharing platforms is problematic for the traditional music industry but valuable to the consumers who choose to use such networks.[59]

The vast majority of file-sharing is conducted through peer-to-peer networks using a variety of software clients that allow users to search for content, connect to other users, manage file transfers, and, ultimately, download digital content. These can be divided into three 'generations', although they are not temporally exclusive and continue to co-exist. Shawn Fanning's original Napster software (released in 1999) was the first, utilizing a central server to index the available music files—the system prevented the transfer of any other file types—and facilitate their transfer from one peer to another. Napster soon encountered legal difficulties and, after protracted disputes, was forced to shut down its entire network in July 2001, by which time it had registered more than 80 million users (Lam and Tan, 2001). Peter Honigsberg reports that "at Napster's peak use, during a one hour period, over three million people exchanged more than three hundred [and] fifty million songs" (Honigsberg, 2002: 473).[60]

Following Napster's decline, a second generation emerged, led by the Gnutella network. Gnutella software clients such as Limewire and Gnucleus allowed users to connect directly to each other via the Gnutella network, creating a fully decentralized service that, unlike Napster, did not rely on a proprietary server.[61] This generation of file-sharing is still very common, although legal disputes have resulted in the demise of many popular clients.

---

[59] Despite the overwhelmingly negative effect that file-sharing is alleged to have had on the traditional music industry, record companies have derived some benefit from it by using data from file-sharing services to inform their promotional campaigns for emerging artists (Chmielewski, 2004).

[60] For a detailed account of Napster's rise and fall, see Menn (2003).

[61] A number of other file-sharing software clients (such as KaZaA, iMesh, Morpheus, and Grokster) run on the FastTrack network. This network uses a semi-centralized system, in which multiple servers are used, but no single entity is responsible for the network as a whole.

The third generation of file-sharing relies on the BitTorrent protocol and a number of associated software clients, such as μTorrent. BitTorrent allows users to download a file as discrete chunks of data from multiple sources, using a torrent file (created by the person who initially shares the file) to manage and map the download and reassembly of the file from its constituent parts. Whilst the user is downloading the file, the software client makes any fully downloaded chunks available for other users to download. This greatly increases the availability of the file—or rather, the file chunks—thus permitting faster and more reliable downloads. The sequence of diagrams below shows how a complete file (represented by the six coloured chunks) can be transferred piecemeal from a host source *to* multiple peers, *via* multiple peers, using the BitTorrent protocol:

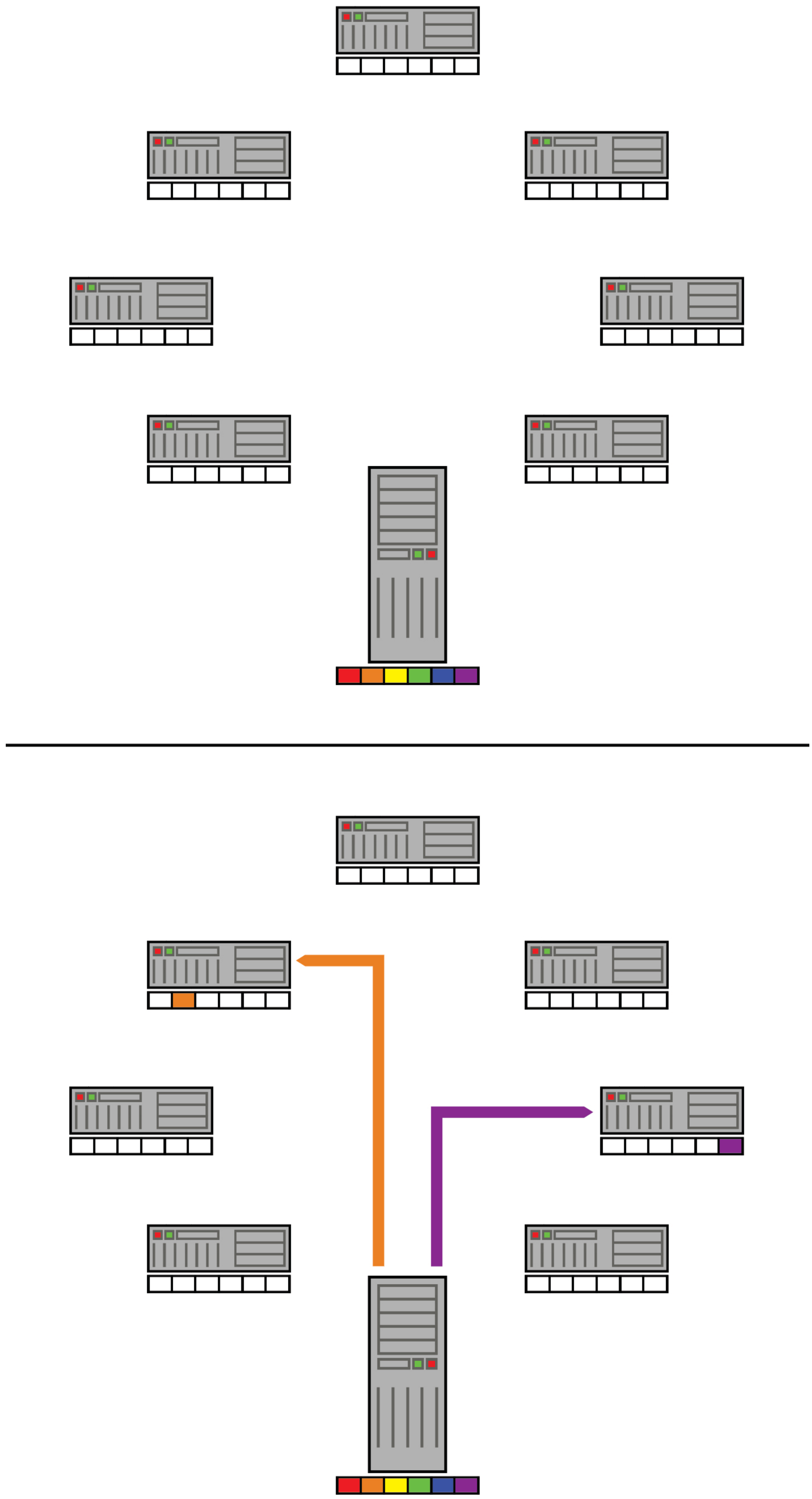

Figure 5.3 *Torrent transfer protocol sequence* **(a)** and **(b)**

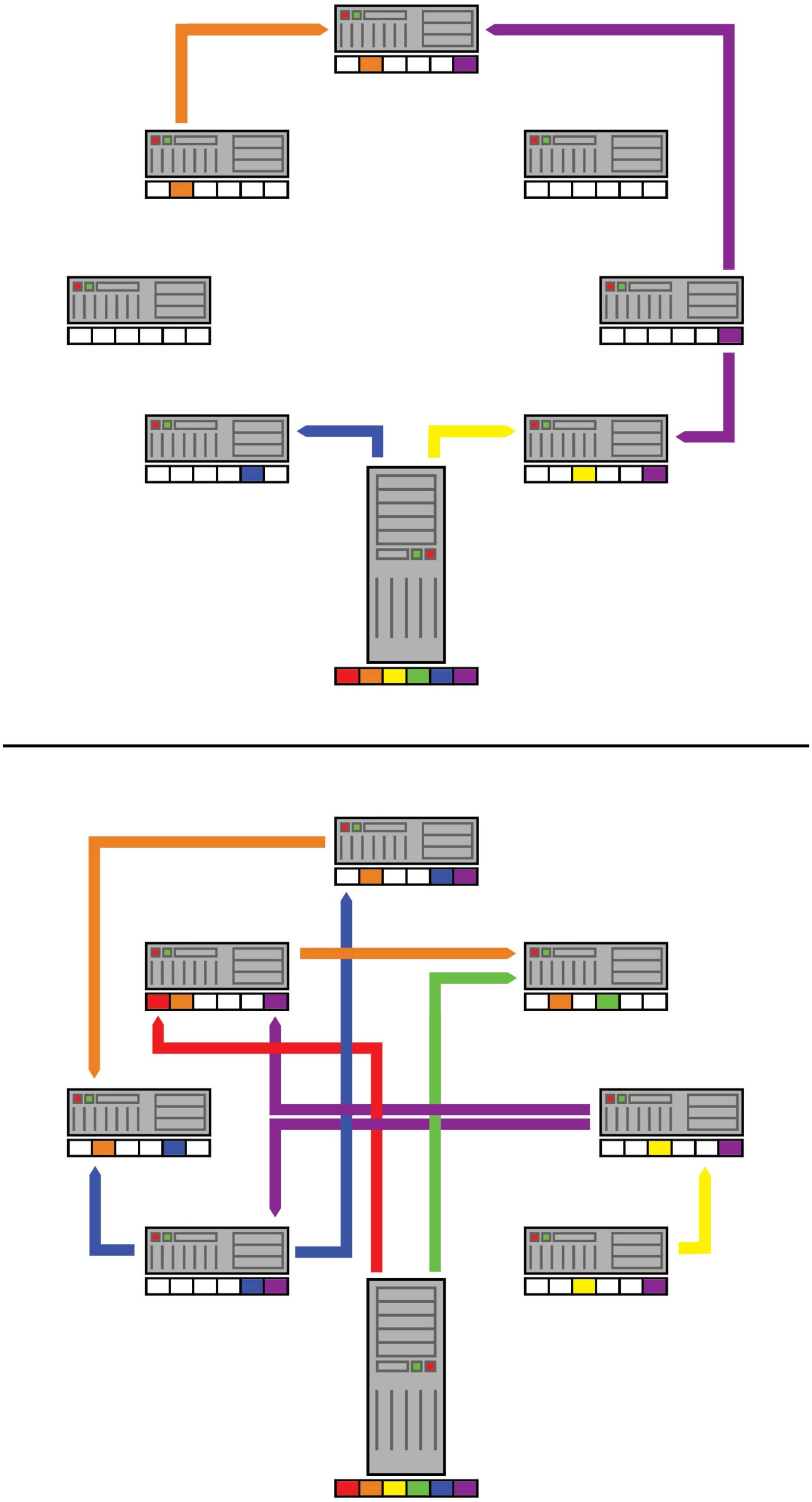

Figure 5.3 *Torrent transfer protocol sequence* **(c)** and **(d)**

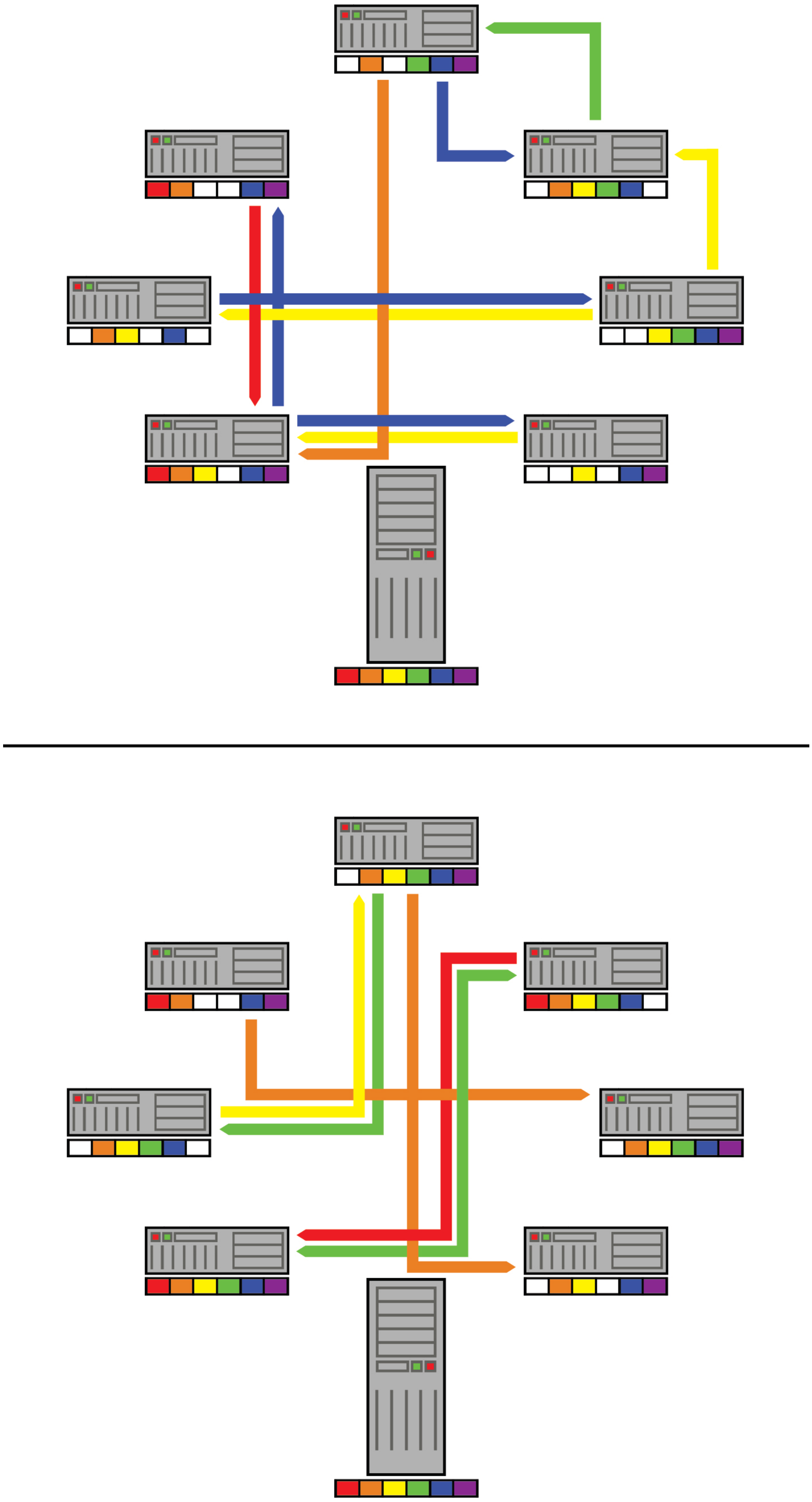

Figure 5.3 *Torrent transfer protocol sequence* **(e)** and **(f)**

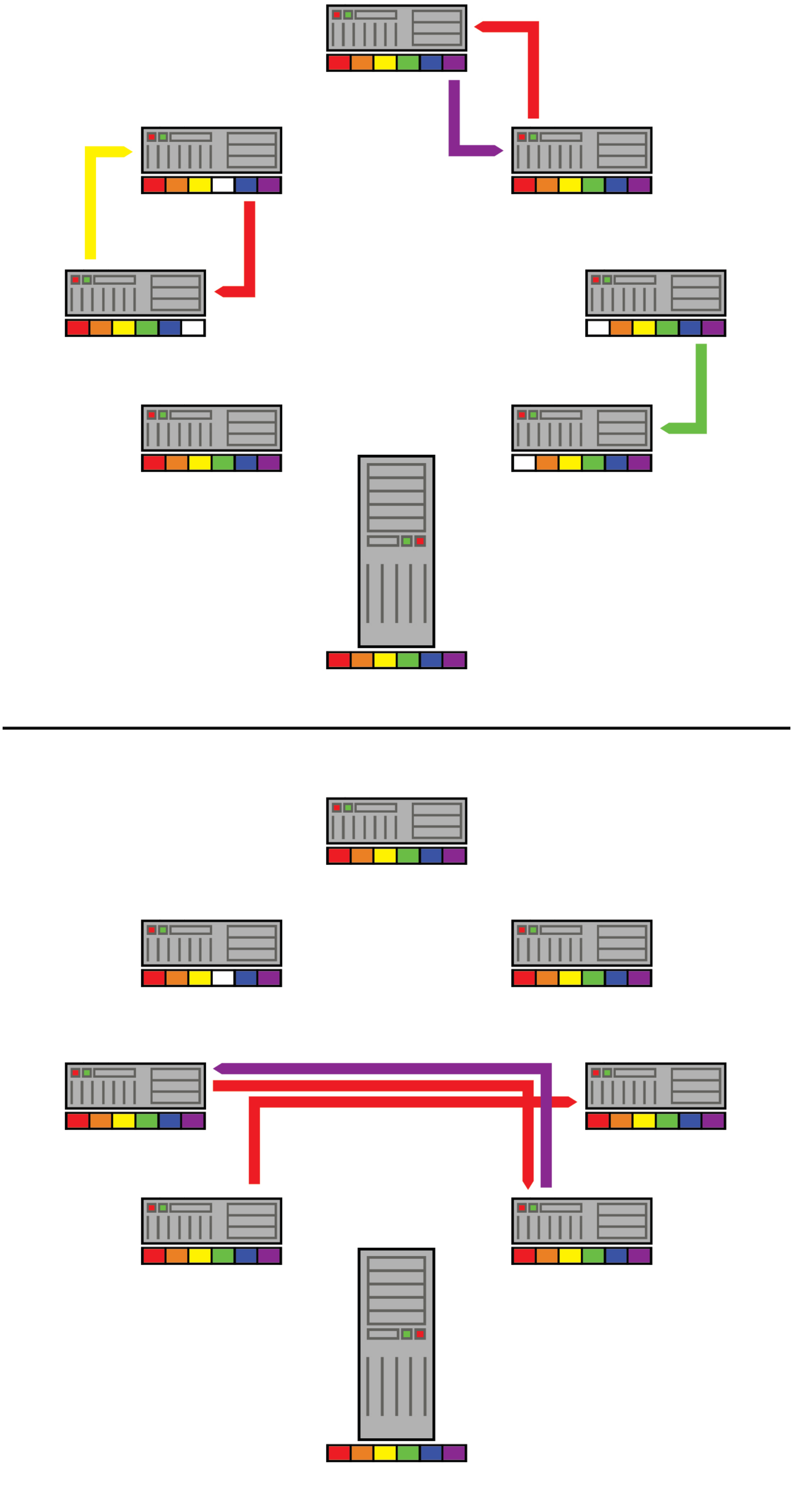

Figure 5.3 *Torrent transfer protocol sequence* **(g)** and **(h)**

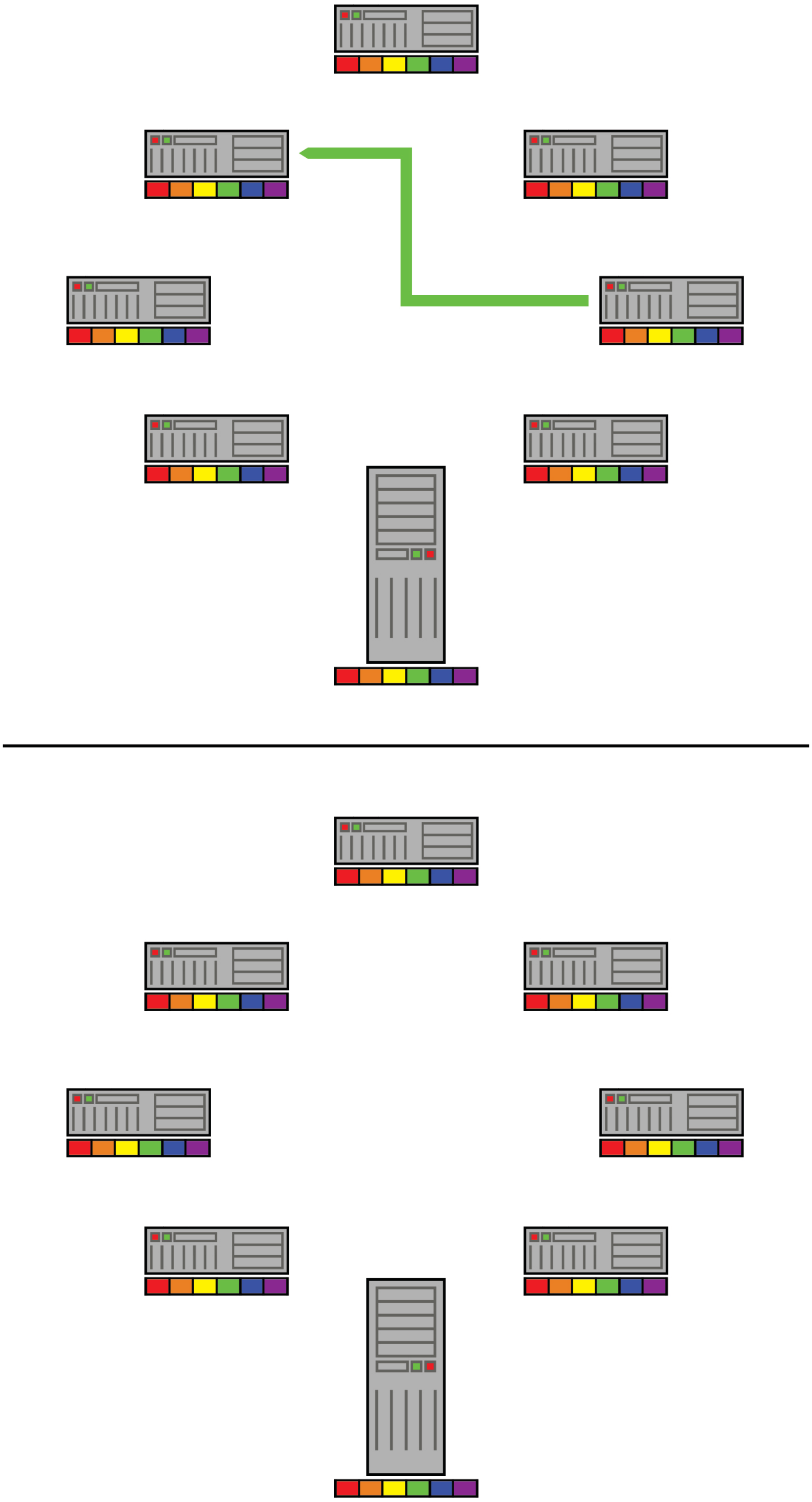

Figure 5.3 *Torrent transfer protocol sequence* **(i)** and **(j)**

The positive network effect associated with file-sharing is, from a consumer perspective, very pronounced. Across every generation of file-sharing, an increase in users is likely to result in an increase in the selection of music available for download. For third generation file-sharers, however, the increase in users also makes for faster downloading; the more users downloading a file, the more it becomes available (as per the diagrams above). This makes third generation file-sharing particularly problematic for the traditional record industry.

In addition, the collaborative nature of the BitTorrent protocol makes it harder for individuals or entities accused or guilty of piracy to be held to account, legally or otherwise. Rarely, if ever, does the responsibility for sharing a file lie with a single user. More often than not, multiple users are sharing multiple parts of a file to many other users. Popular torrent-searching and torrent-hosting websites—such as The Pirate Bay and Mininova—are obvious targets, but the torrent files themselves are the property of whichever user created them, not the owner of the copyright in the file that is being shared. To reiterate an earlier point, file-sharing is not *inherently* unlawful, but both legal and illegal file-sharing can and do take place within the same channels. In the absence of any Digital Rights Management (DRM) measures being built in to the files—or such measures having been removed or circumvented—the software and networks do not discriminate between files being legitimately shared by the copyright owner (or someone with their permission to do so) on the one hand, and files being illegally shared by people who do not have the right to distribute the copyrighted material on the other.

DRM technology encompasses a variety of access-control mechanisms that are designed to limit in one way or another the use of digital devices or content. When present in the context of digital music, DRM is often used to restrict the devices on which a digital music file can be played, either by limiting the number of devices that are authorized to play the file in question, or by preventing playback of the file on hardware or software from competing manufacturers.[62] Ostensibly, DRM is implemented to protect the interests of copyright holders by restricting unauthorized access to their works. In theory, these restrictions allow artists to control the exploitation of their copyright in order to generate financial revenue. In practice, a great deal of the decisions regarding the exploitation are made by 'content providers'—usually record labels—on behalf of their roster of artists, often in liaison with digital distributors or hardware and software manufacturers. Despite these seemingly honourable intentions (and the legislative framework supporting them) the implementation of DRM has proven to be problematic for several reasons.

Given the multitude of hardware and software manufacturers and content providers involved in the digital music market, it is unsurprising that issues of compatibility have been at the heart of much of the opposition to DRM.[63] Much like the rest of recorded music's history, it seems the desire for market dominance on the part of corporations often eclipses any incentive to make life easy for consumers or profitable for artists. The fact that DRM can be implemented in playback devices, music software, and the computer operating systems on which the software runs makes the situation particularly vulnerable to influence from corporate interests (Peitz and Waelbroeck, 2004: 52). By way of example, consider Sony's music download store, Connect. Through Connect, Sony offered digital music files that would only play on computers running Microsoft Windows operating systems, or on Sony hardware. It seems unlikely that these restrictions were helping to secure greater 'creative incentive' for artists and bands. It seems much more likely that Sony's refusal to

---

62 Until 2009, music bought from Apple's iTunes Store could only be played on Apple devices such as iPods and iPhones. In addition, the first time such a track was played on a new device, the device would have to be authorized by the user who purchased the file, and only 5 devices could be authorized simultaneously per user account.

63 As a result of such incompatibilities, the acronym DRM has, in certain quarters, acquired an alternative expansion: "Down-Right Messy" (Peitz and Waelbroeck, 2004: 52).

create interoperability with Apple devices or software stemmed from a combination of the desire to promote their own hardware and an attempt to compete with Apple's market-dominating iTunes Store.[64] This is only one instance of a wider, almost collective hostility to creating a common standard.

The tendency for DRM to outgrow its original purpose has also been met with opposition from a variety of sources. First, some DRM schemes can prevent users from listening to music that they have legally bought. In 2004, EMI fought legal action brought by European consumer rights groups, acting on behalf of consumers whose legitimately purchased CDs would not play on older hardware such as car stereos (Peitz and Waelbroeck, 2004: 47). What are consumers supposed to do when, assuming they choose to purchase all their music in a particular format with a restrictive form of DRM, the software or hardware they use ceases to be produced? A consumer buying music from the Sony Connect store would not have been able to transfer their music library from a Windows-based personal computer to, for example, an Apple Mac. Sony's DRM would prevent playback of the files on any Mac operating system and the consumer would be forced to purchase the same music again if they wished to listen to it on their new computer.[65] Second, DRM is capable of protecting digital data over an infinite amount of time. It can continue to restrict usage of the files

---

[64] The attempt was unsuccessful. On 30th August 2007, Sony announced the imminent closure of their Connect store (Sony, 2007).
[65] The act of copying music from one medium to another (often 'ripping' from CD to computer) is known as 'format-shifting'. Consumers and policy makers alike have long contested its illegality. Following the Hargreaves review of intellectual property (launched by David Cameron in 2010), in which Professor Ian Hargreaves recommended that legislation be altered, the government is in the process of carrying out a "more detailed . . . evidence-based analysis" of the situation, and expects that a "copyright exception based on personal use or use within the private sphere might prove most practicable and justifiable" (Business, Innovation, and Skills Committee, 2012). Furthermore, in a striking illustration of both the constantly evolving nature of the digital world and the comparative sluggishness of legal systems, debate has recently sprung up about the legality of bequeathing digital collections of music and other media upon death (see Osborne, 2012).

long after the statutory period protecting the recordings themselves has expired, which is arguably contrary to the basis on which copyright is founded (Peitz and Waelbroeck, 2004: 48). Unless, of course, the DRM is somehow circumvented. There are almost as many ways of circumventing DRM as there are DRM technologies. Some methods are complex—reverse engineering software, reprogramming it and distributing it as freely available source code—and some are far simpler. The Mediamax CD-3 copy protection for CDs was foiled by an American student who found that, on computers running Microsoft Windows, holding down the 'shift' key whilst loading the protected CD into the drive would bypass the protection software (Halderman, 2003). A more common instance of DRM circumvention is the process of 'burning' or copying protected audio files (such as those downloaded from the iTunes Store before 2009) from a computer's hard drive to an audio CD, and then 'ripping' or importing that CD back onto the same hard drive. Assuming the files can be copied to a CD in the first place, this removes any copy protection and allows a user to listen to, copy, convert, and distribute the files unimpeded. 'Virtual' CD drives exist that allow the same process to take place using only software, rather than a physical CD copying drive.

Sterne notes that, for consumers, the shortcomings of DRM (circumvention notwithstanding) can be more than just frustrating; they can become an actual incentive to pursue illegal file-sharing in order to acquire DRM-free music files: "In other words, it is probably easier to install a Gnutella client and acquire illegal files than it is to manage two separate MP3 collections and two separate playback programs" (Sterne, 2006: 830). This might go some way to explaining why illegal file-sharing is now by far the largest form of digital music distribution around the world. A 2009 report by the IFPI estimated that 95 per cent of tracks that year were downloaded "without payments to rights holders" (IFPI, 2009: 8). The interests of the IFPI and the people and institutions it serves, coupled with the rather vague wording of the report—many tracks are available for legitimate download without payments to rights holders—mean that this figure is likely to be slightly inflated. Legal retailing of digital music files has, after a slow start, come to represent a significant force in global music sales. By 2010, digital music constituted 29 per cent of global recorded music sales, and the relatively large upswing in demand for digital music files around that time could well be correlated to the removal of DRM from the files offered by many major digital music retailers (IFPI, 2009). The IFPI admits that, nonetheless, illegal file-sharing remains a barrier to "growth and investment by record companies", citing reports that 28 per cent of Internet users globally access "unauthorized services" on a monthly basis (IFPI, 2009: 9). Although the IFPI does not qualify their definition of "unauthorized", it is clear that file-sharing remains an important acquisition channel for some consumers.

The appeal of file-sharing to such consumers is, of course, that it costs virtually nothing. Torrent and peer-to-peer networks do not provide consumers with the means to pay money in return for the files that are downloaded. Even if they did, distributing the revenue to rights holders would be prohibitively complicated, given the uncertain provenance and sheer volume of the files being shared. The only financial cost of file-sharing for consumers is the price of the electricity, connectivity, and equipment necessary to sustain an Internet connection. For most consumers, however, these are sunk costs and become negligible when considered on a download-by-download basis (particularly when the majority of consumers will use their Internet connection and computer hardware for other tasks). So why is file-sharing not the primary acquisition channel for all consumers? In short, because there are other, non-financial costs involved.

Knowledge. Acquiring music via file-sharing is usually a more complex process than downloading files from a provider like the iTunes store. It requires a certain degree of technological and computer savvy that many music consumers do not possess.

Choice. Given that file-sharing is the rather unstructured product of individual contributions from millions of users, rather than the coordinated effort of a single content provider, searching for files can be problematic. Popular bands (and their songs) are relatively abundant and easy to find, but the output of less mainstream artists are generally more difficult (or even impossible) to access via file-sharing.

Time. Using file-sharing platforms to acquire specific files takes time, often more than would be spent acquiring the same file from a legitimate provider. Again, because of the user-led nature of file-sharing, naming conventions for files can vary wildly—it would be very easy for a user to download an album using BitTorrent, only to find out after it had fully downloaded that it was in a format incompatible with the user's device or existing software. Systematic quality control is also non-existent on file-sharing platforms—the audio (and video) quality of files can vary wildly, often requiring users to search for and download another higher-quality version of the file. The speed of downloads via file-sharing is also very unpredictable, subject as it is to the number of users sharing the necessary information (see Figure 5.3, above), and the vicissitudes of Internet traffic and connection speeds.

Vulnerability. The uncontrolled nature of file-sharing also means users are susceptible to malicious software (malware) such as viruses, trojans, worms, and spyware. These can disrupt computer or device function, allow access to private systems and sensitive information, or even just be very inconvenient.

Advertising. Most peer-to-peer networks, BitTorrent sites, software clients, and their associated websites fund their operation and development using embedded advert software to target users. These can take the form of banners or pop-ups, in some instances rendering the service unusable until the advert has been acknowledged or dismissed.

Legal ramifications. Users downloading or sharing copyrighted material without making payment to the appropriate parties are likely to be breaking the law. The international nature of file-sharing networks, the relative inexperience that legislatures have in governing and policing them, and the scarcity of relevant common law mean that the infringement of copyright via file-sharing often occupies somewhat murky legal territory. The multitude of users and their relative anonymity can make prosecuting offenders difficult, but far from impossible. By August 2011 over 200,000 BitTorrent users were threatened with legal action on the grounds of copyright infringement. Various copyright holders (and their corporate representatives) obtained injunctions forcing Internet Service Providers (ISPs) to divulge the personal information associated with IP addresses that had been logged as sharing copyrighted material. The people associated with the IP addresses were then sent a letter requiring them to pay a fine (Franco, 2011). In 2011, a United States judge ruled that the people associated with an infringing IP address are not necessarily guilty of copyright infringement themselves. Citing a raid by federal agents on a home that had been linked by a similar method to downloads of child pornography, Judge Harold Baker stated:

> The identity and location of the subscriber were provided by the ISP. The desktop computer, iPhones, and iPads of the homeowner and his wife were seized in the raid. Federal agents returned the equipment after determining that no one at the home had downloaded the illegal material. Agents eventually traced the downloads to a neighbor who had used multiple IP subscribers' Wi-Fi connections (including a secure connection from the State University of New York). The list of IP addresses attached to [the plaintiff's] complaint suggests, in at least some instances, a similar disconnect between IP subscriber and copyright infringer. The ISPs include a number of universities, such as Carnegie Mellon, Columbia, and the University of Minnesota, as well as corporations and utility companies. Where an IP address might

> actually identify an individual subscriber and address the correlation is still far from perfect . . . The infringer might be the subscriber, someone in the subscriber's household, a visitor with her laptop, a neighbor, or someone parked on the street at any given moment.
>
> (Baker, 2011)

The alacrity with which record companies, publishers, and other content providers have resorted to legal action in the last decade will no doubt be tempered as the appropriate legislation matures and as proper protocols for compensating rights holders are established. In the meantime, though, users who acquire music via file-sharing platforms face a very real prospect of a hefty fine 'out of the blue' and possibly further legal action, the cost of which would be likely to dwarf the fine itself.

Just like the 'switching costs' discussed in Chapter 4, the costs (both financial and non-financial) of file-sharing have different implications for different types of consumer. Although its publication precedes even first generation file-sharing by almost fifteen years, William Johnson's mathematical analysis of copying sheds some useful light on copying as an economic practice (Johnson, 1985). He suggests that a user's decision to buy a product rather than copy (or vice versa) will be determined by three factors: the user's valuation of the product, the user's wage rate, and the cost of copying. He separates the market into three categories of user: those who are not interested (low valuation), those who choose to copy rather than purchase an original (higher valuation and a low copying cost), and those who choose to buy an original rather than copy (highest valuation and a high copying cost). The relevance of this to file-sharing is clear, though Zhang contends that the theory cannot be applied generally to current file-sharing practices for two reasons. First, consumers with a very low wage rate may not be able to afford a computer or the Internet connection necessary to access file-sharing channels. Second, consumers with a very high wage rate may enjoy "a high cognitive surplus" by downloading music illegally simply in order to show that they can (Zhang, 2002: 9).[66]

On the whole, older consumers are likely to be less au fait with computers, relatively time-poor, and many will have disposable income to spend on music. They are likely to be put off illegal file-sharing by its complexity, inconsistency, and inconvenience relative to legitimate intangible acquisition channels. Younger consumers, by contrast, are more likely to be computer savvy, relatively time-rich, but with less disposable income to spend on music. As a result, they are likely to use the knowledge they already have to offset the time and searching costs and the risks of malware against the benefit of free music.

A perfunctory review of the scholarship and commentary on file-sharing might leave the reader with the impression of a Robin Hood-style dichotomy. From the perspective of the wealthy and law-abiding record companies, users of file-sharing platforms are cast as lawless, parasitic individuals intent on depriving rights holders of what is justly theirs. From the perspective of the needy and well-intentioned users, record companies appear to be greedy monopolists who owe a great deal of their financial security to the very people who they seek to tyrannize. The reality, of course, is substantially more nuanced. There are a whole host of other actors in the drama, and some of these play crucial roles in determining the behaviour and opinions of everyone involved.

Apple occupy a very powerful position, commanding more of the digital download market than any other retailer and manufacturing the most popular portable devices capable of playing digital music files. Given the discussion above, it is not surprising that some of these devices, such as Apple's iPod, eventually end up being stocked with

[66] At least two separate studies have shown that, perhaps counter-intuitively, consumers who download music illegally also spend the most on legitimate purchases (Cheng, 2009; Shields, 2009).

illegally downloaded files. Does this mean Apple are somehow facilitating illegal file-sharing? On the face of it, probably not. Not only are they not responsible for how users choose to employ the equipment they produce, but also as a provider of legitimate download services one would expect them to encourage legitimate acquisition channels, in order to stimulate their own profits. At the time of writing, the largest-capacity iPod available through Apple's online store is capable of holding 160 gigabytes of data. It costs £199 and, according to Apple, will hold 40,000 songs (Apple, 2012b). To fill the iPod entirely, using only music downloaded legitimately through Apple's iTunes store, would cost approximately £39,500. This obviously does not constitute proof that Apple endorse illegal file-sharing; no doubt they would rather each consumer spent nearly £40,000 with them instead. Nonetheless, it is worth considering the complicity of hardware manufacturers in fanning the flames of illegal file-sharing, particularly those that are unlikely to be deprived of revenue by the piracy itself.

Despite all this, legal distribution of digital music files through file-sharing services is becoming increasingly common. Many rights holders publish their work using Creative Commons licences, a set of legal tools developed by Creative Commons (a non-profit organization founded by Lawrence Lessig, Eric Eldred, and Hal Abelson). These allow the producers of creative works to "mark creative work with the freedom the creator wants it to carry, so others can legally share, remix, use commercially, and so on" (Creative Commons, 2012).[67] Although the licences have continued to evolve since their inception, the basic framework revolves around four 'conditions':

- Attribution. Grants permission to copy, distribute, display, and perform the work and make derivative works based on it only if they give the author or licensor the credits in the manner specified by these.

[67] These sorts of licences are often described as 'copy*left*': a play on words that emphasizes the use of copyright law to promote distribution and re-use without financial reimbursement.

- Noncommercial. Grants permission to copy, distribute, display, and perform the work and make derivative works based on it only for noncommercial purposes.
- No derivative works. Grants permission to copy, distribute, display, and perform only verbatim copies of the work, not derivative works based on it.
- Share-alike. Grants permission to distribute derivative works only under a licence identical to the licence that governs the original work.

(Creative Commons, 2012)

These conditions can be used individually or combined in order to grant the appropriate amount of latitude to anyone wishing to use or distribute the work in question. The Creative Commons licensing framework has been designed to co-exist with traditional copyright systems in a multitude of jurisdictions, but it belies a very different attitude. Adherents to traditional copyright systems—at least in the United States and United Kingdom—invoke copyright as a protector of property and an inducement to creativity.[68]

The music industry in the United Kingdom—as represented by umbrella body UK Music—has, over the last few years, been lobbying government to amend copyright legislation. The primary aim of the lobbying has been to persuade government to extend the protection of a performer's work from the original provision of 50 years after the first recording, to 70 years after the performer's death. Despite commissioning and publicly endorsing the independent Gowers report—which was published in 2006 and concluded that the current 50 year term was adequate—the government has performed a volte-face and now supports the proposed extension (Halliday, 2011). This is all the more alarming against the backdrop of European Union (EU)

[68] For more detail on the social dimension and validity of copyright, see Lessig (2004).

activities. Ignoring the policy proposals of an EU-funded report by Professor Bernt Hugenholtz—Head of the Institute for Information Law at the University of Amsterdam—the European Commission was considering legislation that will extend the term to 95 years, though this legislation has now been modified to 70 years, and was passed in 2011 (European Commission, 2011).

Many supporters of the move have taken a *moral* standpoint, arguing that creators should have the right to compensation for their whole lives, and should not have their royalties cut off as they approach old age. In reality, though, the *economic* motivations for securing lengthier copyright provisions are probably more powerful. UK Music seeks to ensure that those it represents receive appropriate compensation for their creative efforts. It is ironic, but perhaps unsurprising, that the most vocal of supporters for extending copyright are usually very wealthy musicians and record labels. Analyzing the financial effects of the EU's proposed extension explains quite a lot.

According to grassroots digital liberties organization Open Rights Group, the division of money likely to be secured through the extended term bears a striking correlation to the audibility of support for the extension itself: 90 per cent will go to record labels and publishers, 9 per cent to the highest earning 20 per cent of performers, and 1 per cent to the remaining 80 per cent of performers (Hill and Hogge, 2008). Those 80 per cent of lower-earning performers will stand to make, on average, a *maximum* of €26.79 per year (Hill and Hogge, 2008). Even the EU's figures only promise an extra €150 to €2000 for the average artist (Hill and Hogge, 2008). In an open letter to the British government's IP minister David Lammy, several prominent European academics pointed out that "in reality, copyright extension will serve the shareholders of four major multi-national companies that control the valuable recordings of the 1960s (Universal, Warner, Sony and EMI)" (Bently et al., 2009). Hugenholtz speaks just as plainly, asserting that the whole process "seems to reveal an intention to mislead the council and the Parliament, as well as the citizens of the European Union. In doing so the Commission reinforces the suspicion, already widely held by the public at large, that its policies are less the product of a rational decision-making process than of lobbying by stakeholders" (Hugenholtz, 2008: 2). It seems that concern for the livelihood of aging, poor musicians is unlikely to be the primary driver for the reform.

Lessig, an eminent law professor and political activist, distinguishes helpfully between 'Read Only' (RO) engagement with cultural products and 'Read Write' (RW) interaction, which allows consumers to modify products while engaging with them (Lessig, 2008).[69] He underlines the educational importance of RW experimentation—young people learn to make music, for instance, by copying models or improvising around given structures with greater and greater freedom as their confidence grows. Lessig also appreciates RW's practical necessity for amateurs. Without adaptation, works 'intended' for performance in one way may not be performable at all. Lessig believes that, because non-professional RW engagement with art is socially beneficial, legal interventions discouraging or totally preventing it should be resisted, hence his involvement in the founding of Creative Commons.

All this is not to suggest that the weight of history and informed judicial opinion should be ignored, or that the law should bend to legitimize every new social practice. But if Lessig is right, and "the form and reach of copyright law today are radically out of date" (Lessig, 2008: 253), then it seems misguided to apply the law, in its current incarnation, anything more than cautiously. The balance between public and private interests is skewed, and Creative Commons goes some way to redressing it, by "making it easier to legally share and build upon the work of others" (Creative Commons, 2012). But what do advocates of this more public-minded stance on copyright stand to

[69] Though with no claim to originality; Lessig borrows 'the language of today's computer geeks' (Lessig, 2008: 28).

gain? To answer the question, consider the case of artists who take the copyleft approach to its extreme, not even bothering to use permissive licences like those provided by the Creative Commons.

Visitors to the torrent-sharing website The Pirate Bay have, for many years, been greeted on arrival with a simple search engine page bearing the logo of The Pirate Bay and a offering a few options with which to refine their search for torrent files. Following the launch of a recent promotional campaign, however, the largely empty page has hosted a succession of banners advertising various performing artists, with the text of the logo changed to 'The Promo Bay'. After announcing the campaign, The Pirate Bay received over 5000 applications from a variety of musicians, authors, and other media producers to receive a week-long slot on the home page in return for offering a creative product for free, such as an album, a movie, or a book (Gabbard, 2012). During the week beginning Monday 2nd April 2012, visitors who clicked on the banner were taken to the website of Swedish singer Sophia Somajo, known artistically as SoSo. The website offered visitors a free download of SoSo's latest album, and contained a stylized letter from the artist herself:

> HELLO LOVER.
> MY NAME IS SOPHIA, BUT YOU CAN CALL ME SOSO.
> I AM NOTHING BUT A SO-CALLED 'ARTIST' WITH NARCISSISTIC TENDENCIES.
> I HAVE WRITTEN, PRODUCED, AND RECORDED THIS ALBUM IN MY BEDROOM.
> IT'S THE STORY OF MY LIFE.
> LITERALLY.
> I AM NOT POETIC.
> THIS PROJECT IS AN ANTI-SOCIAL EXPERIMENT PUSHING THE BOUNDARIES OF THE MUSIC INDUSTRY.
> I HAVE EVEN GONE SO FAR THAT I HAVE LEFT MY MAJOR RECORD LABEL AND STARTED UP MY OWN.

I CALL IT:
DO IT YOURSELF BITCH PRODUCTIONS.
SIMPLY TO SEE HOW FAR YOU CAN TAKE IT WITHOUT EXTERNAL HELP OR MUSCLE FROM PRODUCERS, A&RS, OR RECORD RESELLERS.
AS A RULE, I MAKE ALL OF MY VIDEOS AND PRESS SHOTS TOGETHER WITH MY BOYFRIEND WITHIN MY APARTMENT.
I GUESS WE'VE SHOT SOMETHING IN EVERY ROOM.
IT'S ALL A VERY DOMESTIC PROCESS.
I HAVE NO INTEREST IN TRYING TO SELL MY MUSIC.
SO I AM GIVING AWAY MY ALBUM FOR FREE.
FROM ME TO YOU.
NO MIDDLE MAN.
PEOPLE ASK ME WHY, AS AN ARTIST, WOULD YOU COLLABORATE WITH THE PIRATE BAY WHEN THE MUSIC INDUSTRY HAS SUFFERED SO MUCH AS A RESULT OF ILLEGAL FILE-SHARING?
I GUESS I JUST BELIEVE THAT YOU CAN'T FIGHT EVOLUTION.
IT'S ALREADY HAPPENING.
I FEEL THAT WE AREN'T BEING ROBBED OF ANYTHING IF WE GAIN LISTENERS.
THE CD IS AN OLD FORMAT.
I MEAN I STILL MOURN THE LOSS OF THE CASSETTE, BUT I DON'T EXPECT PEOPLE TO STILL TRY TO SELL IT?
THE OLD WAY OF DISTRIBUTING MUSIC IS DATED.
LET'S JUST FACE IT AND INSTEAD OF DWELLING ON THE LOSS, FOCUS ON THE NEW POWER WE AS ARTISTS HAVE, TO TARGET AND REACH OUR AUDIENCES DIRECTLY.
HONESTLY I DON'T CARE ABOUT THE 'MUSIC INDUSTRY'.
I CARE ABOUT MUSIC.
MUSIC IS COMMUNICATION.
LET'S TRY AND GET BACK TO THE MAIN REASON MUSICIANS REALLY MAKE MUSIC.
TO BE HEARD, NO?

IT'S MY PERSONAL REASON ANYWAY.
SO I AM QUITE BLUNTLY PIRATING THE PIRATE BAY.
CHOOSING FOR MYSELF.
I GUESS YOU COULD SAY, THAT I'M THE PIRATE.
ALL MY LOVE,
SOSO

(Somajo, 2012)

During the week commencing 7th May 2012, another band called Monster Cat offered their latest album as a free torrent download and posted a similar missive:

HELLO, WE ARE MONSTER CAT.
WE'VE PUT UP A TORRENT OF OUR DEBUT ALBUM *MANNEQUINS* FOR YOU.
IT IS A WORK BORN OUT OF MUCH HEART, TIME, AND MONEY.
WHAT THE PIRATE BAY SYMBOLIZES TO US IS THE ACCESSIBILITY OF ALL ART FORMS.
TAKE THIS MUSIC—CRITICIZE IT, PRAISE IT, LOVE IT, OR HATE IT.
LET US KNOW WHAT YOU THINK.
FOR IN ANY SHAPE OF SOCIETY, AN ARTIST IS WORTH NOTHING WITHOUT AN AUDIENCE.

(Monster Cat, 2012)

These are just two examples—albeit relatively prominent ones—of musicians who have chosen not to combat piracy, as the traditional music industry and organizations like UK Music would have them do. Instead, they have wholeheartedly embraced piracy, hitching their fortunes to the popularity of illegal file-sharing. The Pirate Bay website attracts an enormous amount of traffic and is regularly ranked among the 100 most visited websites in the world (Alexa, 2012). On Monday

30th April 2012, the High Court ordered Internet Service Providers in the United Kingdom to block their respective customers from accessing The Pirate Bay's website (British Broadcasting Corporation, 2012b). Despite an initial dip in the number of users visiting the site following the High Court's order, The Pirate Bay soon announced that traffic had not only returned to normal levels but actually *exceeded* the previous all-time high by 12 million users. Representatives of The Pirate Bay attributed the surge to the increased advertising generated by the press coverage surrounding the High Court case. One spokesman wryly suggested that "we ought to write a thank you note to the BPI [British Phonographic Industry]", whose legal actions precipitated the High Court's decision to block the site (Westaway, 2012). Another source from The Pirate Bay suggested that the spike in users would also provide a prime opportunity to "teach even more people how to circumvent Internet censorship" (Torrent Freak, 2012).[70] Artists like SoSo and Monster Cat obviously believe that their careers stand to benefit more from capitalizing on the huge (and apparently dedicated) audience of file-sharers by engaging with them on their own terms, rather than engaging solely with the traditional music industry on perhaps more restrictive terms. The advertising opportunity is priceless; millions and millions of unique users visit The Pirate Bay each day, and the promotional campaign makes it very easy for users to download the albums on offer. Although the distribution of their music through The Pirate Bay and other file-sharing services will not create any direct sales income for these artists, it is likely that *indirect* revenue may be generated as a result of becoming higher profile artists. Services like Spotify are of course open to such artists, but deriving any meaningful income from these usually requires a level of popularity that only a small proportion of acts in the music industry can boast. Figure 5.4 provides a striking comparison:

---

[70] A variety of proxy services exist (many of them free to download and use) that allow Internet users to bypass such bans, either by convincing the website they seek to access that the request for data originates from somewhere else, or by fooling an ISP's server into thinking they are accessing a different website entirely.

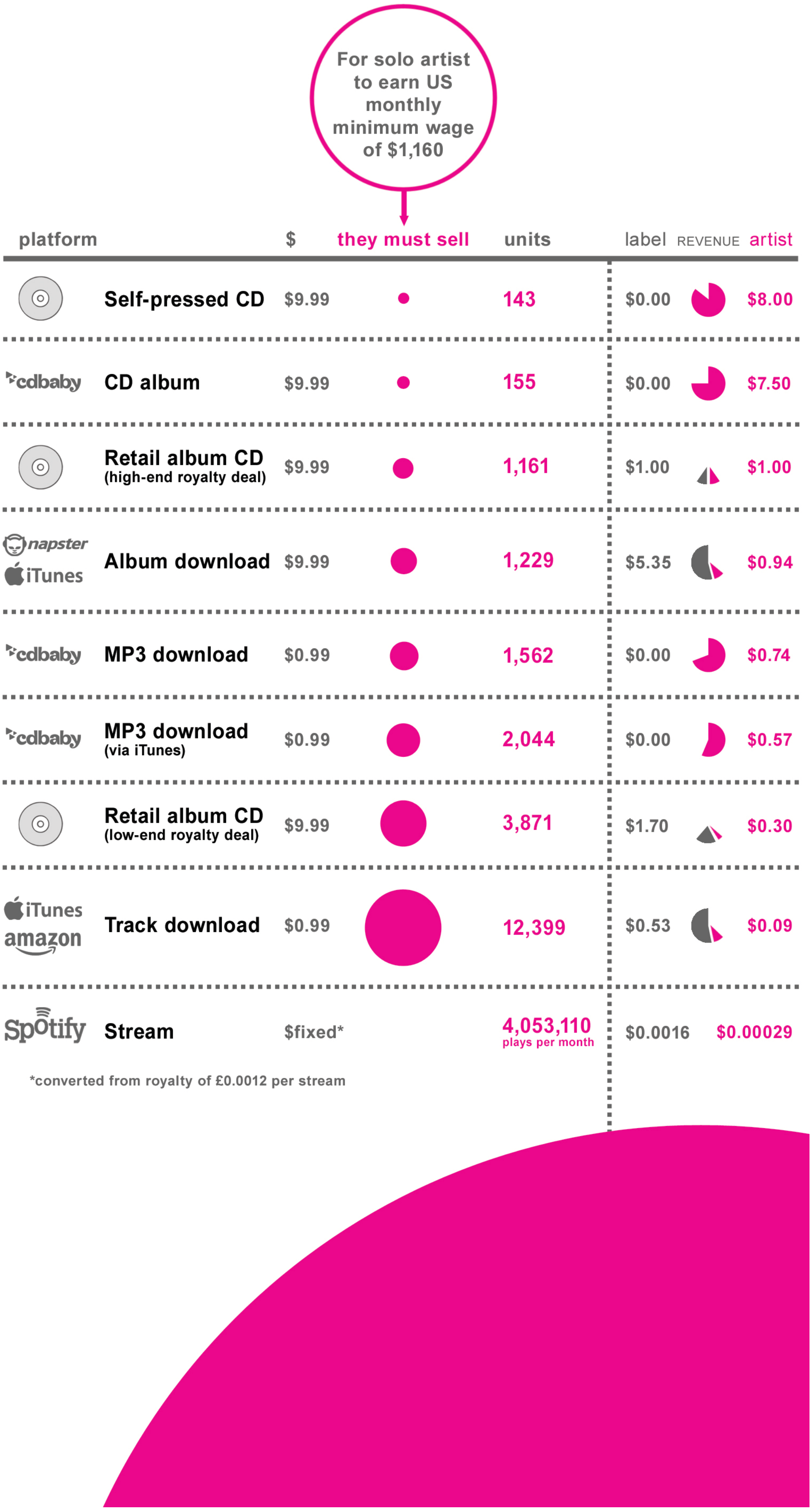

Figure 5.4 *Artist earnings from different acquisition channels*

At $0.00029 per play, obscure artists are unlikely to make much money through Spotify. These kinds of services clearly favour established acts that can rely on the loyalty of existing fans in great numbers. Even album downloads via major retailers are not as lucrative for the artists as they might initially seem. Of the $9.99 that consumers might pay for an album download via Amazon, the artist is only likely to receive $0.94. For those artists who can sell millions of albums based on their existing reputation, this small amount soon adds up. If, however, you have little or no fan-base, you are unlikely to get the 4 million or so 'listens' on Spotify required to make even minimum wage.

In other industries where piracy is rife, tactics similar to those of SoSo and Monster Cat have been employed to seemingly good effect. Due to its digital nature, computer software has long been susceptible to piracy because copies can be made and distributed relatively easily. Registration processes—including the creation of hard-to-forge serial numbers—have been included in lots of commercial software to ensure that, even if customers are able to copy the software, their use of it once installed is restricted (usually in terms of function or duration) until they have paid for a licence. Dominic Power and Johan Jansson point to the example of companies that produce music creation and editing software:

> Whilst these firms deal in relatively small revenue volumes, niche markets and are traditionally viewed as of only sideline interest to the music industry, the companies' response to the ease of which their products have always been pirated holds clues of wider significance to the music industry as a whole. Interviews revealed that the firms thought it impossible and wasteful, especially in the long-term, to attempt to copyright-protect computerized products; instead the firms have attempted to build 'communities' around their products that can only be accessed by registered users. Firms' attempts to establish 'community relations' surrounding their products is a classic survival strategy not just to

> add value but to avert risk; a strategy of using associations, alliances, and network relations in order to help manage or offset risk.
>
> (Power and Jansson, 2004: 430)

Ernst Nathorst-Böös, co-founder of popular studio emulation software Reason gives candid support for such an approach:

> There exist enormous numbers of pirate copies of our programs out there . . . There are two ways to deal with this. One is the stick the other is the carrot. The stick in our case is embedded copy-protection software. We have a copy protection but it is rather mild, not that tough. For instance one can easily copy our disks. Instead we have gambled everything on the carrot and this is why we use our website a lot. The carrot is to do with giving folk as many reasons as possible to register the product. And what they get when they register, they get tech support, they get add-on programs, they get more sounds, they get the possibility to download from our song archives and above all lots of free stuff such as access to other sites which includes sounds compatible with our program. It is in this type of way we try and solve the problem; we try and build loyalty.
>
> (Nathorst-Böös, quoted in Power and Jansson, 2004: 430)

Power and Jansson also note that the enthusiasm of such communities can result in useful, targeted feedback and even "valuable R&D work when users develop solutions to bugs, etc." (Power and Jansson, 2004: 430). Like the approach adopted by SoSo and Monster Cat, this turns piracy on its head. Instead of expending resources trying to combat piracy, such companies save money on having to acquire such data and expertise through more formal channels by embracing piracy.

Transport of the mails, transport of the human voice, transport of flickering pictures—in this century, as in others, our highest accomplishments still have the single aim of bringing men together.

(Antoine de Saint-Exupéry, 1939: 69)

6 A digital paradox

So has Attali's nightmare come true? Is ours a world in which music that no one wants to buy or listen to is cynically and soullessly pumped out to consumers? Has capitalism's "frank and abstract interest" in music brought about "the death of the original"? Has consumption ceased to be collective? Has listening become a solitary activity? Have recordings become simply a stockpileable sign of sociality? Has music's storied existence as a saleable commodity supplanted aesthetic value as its *raison d'être*? This final chapter provides realistic answers to these questions, as far as is possible. The aim is not to dismantle Attali's work and thus prove its irrelevance but rather to update it and offer clarification where necessary.

The invention of recording technology towards the end of the nineteenth century enabled a variety of new activities, entities, and expectations within music, which soon coalesced into an industry. Over the course of the twentieth century, the continued improvement and commercialization of this technology entrenched these rituals more deeply, and the industry began to rely on the semi-regular arrival of new recording platforms for economic stimulus. The industry spawned several generations of producers, distributors, and consumers, who saw the control and exploitation of recordings as essential to the continued enjoyment of music. Thus perceptions of music's social and cultural functions became bound up with the financial health of the industry even though, in the grand scheme of things, the industry itself was a very recent and in some ways artificial creation. Recording technology continued to develop and improve and the industry reached its pinnacle in the last few decades of the twentieth century. Today, the same technology—now more or less perfected—has left a great deal of the industry redundant or greatly demoted.

Substantial changes in economic relations between composers, audiences, and performers are immediately apparent. The financial bases shoring up so much of the music industry have been reconstructed, and traditional value chains grounded in the physical delivery of goods and services have been commuted into new value chains that operate through digital and often intangible means. This has led to the disintermediation of many transactions within the industry and a substantial reduction in economic engagement with and through these transactions. Traditional actors whose roles were dependent upon their ability to add value through their commercial mediation have been displaced, business models that capitalize on the new industry landscape have emerged, and a number of once proud and immutable companies and institutions have receded or disappeared entirely.

Given these changes to the music industry's livelihood it would seem, at first glance, that Attali was right to voice his concerns about the effect that recording would have on music's social future. It is important to realise, however, that none of this *economic* change prevents music from creating or encouraging rewarding *social* interactions between individuals and groups of individuals. Socially enacted musical activities continue to take place: local music groups like church and amateur choirs, listening clubs, communities attached to particular venues, and so on. But no longer do these physically anchored interactions wield the same national influence or cultural significance as they once did. Why? Because, of all the social engagement with and through music that occurs today, a far greater proportion of it happens via virtual or geographically unrestrained modes of communication and interaction, primarily through the Internet.

Digital technologies have given music enthusiasts—whether producers, distributors, or consumers—ample opportunity to isolate themselves from one another: to render music, as Attali feared, an entirely private phenomenon. But instead, these technologies have been used as tools with which to construct new ways of socializing through music. YouTube discussion boards, Spotify playlist sharing, and many other new forms of interaction discussed earlier in the thesis all demonstrate unequivocally that people continue to talk about, write about, share, praise, criticise, and ultimately produce and listen to music if not truly collectively, then at least in far less isolation than Attali predicted. These interactions are increasingly virtual in nature, taking place not face-to-face, but over large geographical and cultural distances.

The tendency toward virtualization is widespread, and stems from the application of advanced technologies to a huge variety of activities. For music in particular, this tendency has been propelled by the gradual perfection of six characteristics common to every platform of recorded music: capacity, compatibility, durability, economic viability, editability, and fidelity. The inexorable improvements to these characteristics not only *enable* music to move into a virtual realm, leaving behind the physically anchored world it once occupied, but also in a sense *force* the transition. (It would be a rather perverse consumer who today resolutely continued to consume music only in physically anchored situations.) There are overlaps between these characteristics and their effect on social behaviour around music, but they all point in more or less the same direction.

Reductions in the number and scope of opportunities to participate or intermediate along traditional value chains have affected not only large-scale or corporate interests within the industry, but also individuals. Although not strictly limited to recording, the facility that digital platforms lend to the synthesization of sound—creating musical sounds on computers and similar equipment—is a potent force for virtualization and one example of how the opportunities for professional (if anonymous) musicians can be squeezed out of the financial picture. Consider the amateur or professional composer who writes a musical using Logic Studio as a virtual studio and, with the help of software samples, uses sounds *actually* made by the Vienna Philharmonic Orchestra to flesh out the composition. To the composer this represents a tremendous resource. No longer are compositional instincts limited by the unrealistic synthesized instruments that were common to many MIDI platforms (and quite a lot of music from the 1980s). Very simply, the composer can achieve a realistic orchestral sound without a real orchestra, the sound of a bassoon without a bassoonist, the sound of a trumpet section without a trumpet section. The advantages to composers are obvious, but no less so than the disadvantages faced by the musicians who, once upon a time, would have stepped into the recording studio to have their sounds captured *ex fonte*.[1]

There are no doubt many instances in which such virtual instruments are not replacing real-life musicians; composers operating on a low budget are unlikely to have hired the Vienna Philharmonic Orchestra (or any of its peers) in the first place. But such substitutions regularly take place within smaller scale projects, and although the extent of this change is hard to quantify, it represents just one example of how technological developments across the board have added to the momentum that is transporting music to increasingly virtual climes. Even in the instances where work is augmented beyond the budget of the composer *without* depriving professional musicians of an income—e.g., a university student using professional orchestra samples to enhance an assignment—the practice still has an important effect. Echoing the discussion at the end of Chapter 4 regarding audience expectations, such use of virtual instruments will often result in a recording that creates expectations of a live performance that never happened.

[1] Some might query why synthesizability was not included as one of the characteristics outlined in Chapter 3. The rationale is the same that guided the decision to omit separability; it is not an aspect of recorded music platforms that engineers, developers and pioneers have ever deliberately sought to improve upon as part of recording technology.

The case of the instrumentalist-for-hire being replaced by software-for-purchase is also emblematic of a more widespread drift towards deprofessionalization, which digital music technologies seem to have induced. For example, a teenager in possession of a computer and some spare time can now approximate (or perhaps even surpass) work that was once the preserve of a traditional recording engineer in a state-of-the-art studio. This deprofessionalization makes it difficult to discern what will happen to the motives of young or aspiring musicians and music industry professionals. For over 100 years, one could reasonably aspire to a job in music that *did* exist: playing flute in an orchestra, being a sound engineer in a studio, playing saxophone for a record label. These were all jobs that existed, required specialized skills and training, and paid enough to make a living. People without the expertise and equipment simply *could not do the job*. But what constitutes reasonable professional aspirations for people wanting to work in the music industry today?

Superstars and multi-million dollar record contracts are likely to exist for a long time to come, but this level of achievement is in many ways as unlikely (or at least unpredictable) as it ever has been. Deprofessionalization—as part of a wider economic restructuring—means that even 'normal' jobs in the industry are not as secure as they once were. This is not to say, however, that they no longer exist. It is entirely possible for an artist or a band to construct a social world around their music and themselves on a much more granular level using resources like social networking, free intangible distribution channels, novel reward schemes, and other new media tools. The crucial difference is that, in contrast to the superstars of *X Factor* and the like, this granular approach may not allow the artist or band in question to make a traditional living through music, i.e., to have music as their only job. Perhaps, though, they no longer need to. What the digital revolution *has* done is allow people to exist as credible musicians without having to give up everything else in order to compete with a handful of superstars. Channels exist for the distribution of amateur or commercially unsupported music to anyone who can find it (or who stumbles across it) and wants to listen: performances can be posted on YouTube, home-made recordings can be submitted to iTunes and Spotify, local venues are still there to be performed in, and so on. If such efforts attract sufficient popularity—a YouTube video going viral, say—the performer in question is likely to be ushered into a higher echelon of the industry fairly swiftly, even if it is only for a proverbial and capricious fifteen minutes.

Rags-to-riches stories do happen, often spectacularly, but they illustrate only a tiny corner of a much bigger picture. What about the musicians whose output does not go viral? Those who remain in relative obscurity and get paid little or nothing for their efforts? Surely it does not make sense for people to invest time, effort, and money in producing music for little or no real financial return? Such an approach would run counter to the very basis and enforcement of the copyright legislation that has underpinned so many of the music industry's activities for so long. The function of copyright, according to its proponents, is to incentivize creativity. Given the examples of Pirate Bay darlings SoSo and Monster Cat, it would seem that artists do not necessarily need a financial incentive to be creative.[2] In truth, it is likely that a lot of activities, which for several generations were professional (and prestigious because they were professional), will only be able to continue happening on a semi-professional or amateur basis. Allowing for the occasional sinecured performer or composer—Haydn once, Coldplay now—this is the way the music industry has operated for centuries.

Plenty of evidence exists to suggest that success in the music industry is as unpredictable in the digital age as it ever was. The fundamental difference, however, is that prospective stars are now

---

[2] In addition to the indisputably disruptive effects of file-sharing, this is the primary reason that traditional copyright legislation has suffered accusations of being unfit for purpose and generally outdated to all but those who stand to benefit from maintaining the status quo.

competing against the aggregate opinion of millions of people with relatively little individual influence, rather than laying themselves at the mercy of a single person or a handful of individuals with much greater relative influence, such as an A&R department. The opinions of such individuals have, historically, been critical in determining the allocation of huge sums of money which the traditional record industry would invest in particular 'products', i.e., artists and their music. The investments were invariably made as part of a wider strategy geared towards dictating or steering consumer tastes, and to create and stimulate demand. Nine out of every 10 investments would fail, but the 10 per cent that succeeded would generate enough profit to cover the losses incurred by the other 90 per cent. As a result of the new value chains that have been created by the emergence of digital music files—and the decreasing control that traditional actors seem to be able to wield over the market—record companies can no longer afford the same level of investment. To many, this profusion of music that is free to access but under-invested by its producers might sound like bad news. The truth, however, is that the level of investment previously offered by record companies is no longer necessary; virtually every process or facility that once required copious funding is now much cheaper, and well within the means of most artists. Consequently, many artists are making the investment themselves, whether through choice or necessity, and the industry is less able to control the demand that it has tamed and fed for so long.

The issue of demand brings to the fore a fairly serious flaw in the thinking that has governed the study and operation of the music industry to date. The majority of current scholarship on value chains and the economic structure of the music industry *assume* a demand for recorded music. However understandable or intuitive such an assumption may seem, it betrays a certain degree of sociological and technology illiteracy that has prevented a proper understanding of music's social function and its susceptibility to technological influence. Few people—whether part of the music industry or not—are prepared to concede that the demand fuelling the music industry for the last 100 years (and perhaps longer) was constructed rather than natural. This should not be shocking. In the case of most cultural goods, demand is manufactured, and in the music industry major record labels have traditionally manufactured this demand.

Chapter 4 included a brief discussion of the technological clear-outs that occurred when the arrival of a new recording platform highlighted the shortcomings in its predecessors. A newly created, newly perceived lack of editability in vinyl technology, for example, created a market for ultra-editable magnetic tape. This was a market from which companies could extract profit and pay their employees; new songs could be written and instrumentalists drafted in to record them; retailers could re-stock their shelves and consumers could avail themselves of the latest in home audio experiences. This is where the perfection of the six characteristics becomes so problematic for those who are attuned to or invested in traditional value chains and business models. Digital technologies have inoculated recorded music against the afflictions that sooner or later blighted every other platform, and the markets that preyed on these recurring weaknesses have collapsed. The very technology that labels and other industry actors have cultivated in order to manufacture and exploit this demand has outgrown its original purpose.

Back in 1987, Kurt Vonnegut lamented that:

> . . . moderate giftedness has been made worthless by the printing press and radio and television and satellites and all that. A moderately gifted person who would have been a community treasure a thousand years ago has to give up, has to go into some other line of work, since modern communications put him or her into daily competition with nothing but world's champions.
>
> (Kurt Vonnegut, 1987: 75)

Vonnegut was astute to realise the role of technology in un-levelling the cultural playing field. By 1987, some digital technologies had emerged—CDs had been released five years earlier, the World Wide Web was gestating in European science laboratories—but few of them had truly taken hold. Although the situation would arguably get worse before it got better, it technology in the form of digital communications and media platforms that has eventually *re*-levelled the playing field. Community treasures can once again be treasured, although not necessarily by the same community. Rather than a physical community such as a town or village cherishing a much-loved performer from among its own ranks, one is far more likely to encounter a virtual community on the Internet waxing lyrical about a performer of recherché music that none of them has met. Communities of enthusiasm are increasingly virtual and topic-centric rather than physical and location-centric.

Musicians can still, of course, create demand in traditional ways: composing and performing works that are of sufficient quality or emotional resonance to make people want to hear them. It is not necessarily any easier, however, to make oneself heard above the din of the competition. There is now an infinity of music and within it an unprecedented diversity of genres and a broad spectrum of quality. Certain artists and labels have kept their music away from free, legitimate acquisition channels like Spotify, but the majority of music is freely available. It need not cost the consumer any *money* to access this infinity of music, but to enjoy it costs *time*, of which many consumers have not nearly enough. Improvements in capacity and compatibility have allowed this infinity of music to exist, but there is a lot of meaningless noise. You can turn on your computer and just click the first thing you see, but the catalogue on offer is so vast that carving a meaningful route through it is not easy.

Thus the problem of selecting music becomes particularly acute. As recently as 30 years ago, there was nothing like the profusion of music available to consumers that there is now. Almost all the music that made it past gatekeepers to the point of public consumption and consumer selection was of a certain quality, and—relatively speaking—there was not very much of it. Modern consumers face difficult questions: how does one behave as a rational consumer when there is an immense amount of music available for consumption, but either one does not have enough *time* to find the good stuff amongst the detritus, or one simply does not have the *ability* to find it, for want of knowledge or resources? Moreover, what if the good stuff can be found, but one does not have enough time to listen to it?

Furthermore, it is not just an abundance of new music vying for consumer attention. Compared to their predecessors, digital music technologies are much better at absorbing and rejuvenating recordings made on older and less compatible platforms. Something found in a junk shop can, with relative ease, be converted to one of many digital formats—or several, if necessary—and posted on YouTube, Facebook, MySpace, Spotify, iTunes, Pirate Bay, and so on. The result is that a huge amount of music that in the past would have been relegated to a literal or metaphorical bargain bin (for lack of re-issue on the latest platform) now remains an active competitor in the market. And a very effective competitor it is too: An amateur trad jazz band performing and recording today are pitted against past masters like Louis Armstrong in a way that simply would not have happened were his early recordings still languishing, unplayable, in someone's attic. At the time when recording offered very low fidelity and thus a poor emulation of live performance, a local trad jazz band—however amateur their musicianship or poor their choice of material—would have provided an enthusiast with a relatively rare opportunity to hear their favourite music. Today, with hours or even days of Louis Armstrong recordings available for free at the touch of a button, the incentive to go and see such a band is greatly reduced. This may be a caricatured example, but it exaggerates very real features of selection and consumption that consumers must now negotiate.

Record companies have historically acted as the primary gatekeepers *and* the primary tastemakers of the industry: two sides of the same coin, depending on whether you were an artist or a consumer. Now, though, they are neither. The economic disruptions wrought by the advent of digital technologies made being a gatekeeper a financially unrewarding and potentially futile task, and left the door for tastemakers wide open. Following a period of wound licking, during which a number of lawsuits and lobbying campaigns were pursued with varying degrees of aggression, record companies have attempted to reconfigure their role and maintain a tenable position in the digital music industry by leveraging their existing brands and back-catalogues. The degree to which this renovation will eventually be successful is not certain but, judging by the mergers of major labels and increasingly involvement of private equity firms thus far, the future does not look promising.

Other producers and distributors of music also played their part in tastemaking. Esteemed institutions, orchestras, and concert halls have until recently been very influential in determining public tastes. Many of these institutions were created with the professed aim of making accessible to ordinary consumers a particular repertoire of music deemed worthy of such promotion. To achieve this aim, it was necessary for such institutions—according to the people and organizations that ran them—to overcome the limitations placed on 'good' music by the inadequacies of recording technology, to champion live music rather than some feeble recorded imitation. For many years, audiences submitted to their recommendations because the driving forces behind these institutions had access to so much more music and informed opinion than an 'ordinary' consumer, whether in terms of decision-making individuals or the collective cultural understandings and traditions that have a habit of growing up around these sorts of entities.

Now that digital music files have removed such limitations, these institutions and their associated cultural and economic practices have perhaps outlived their musical usefulness. Thus, trying to perpetuate or preserve them is unlikely to be economically viable, as many record companies and retailers have already discovered to their financial misfortune. This is not to say that they have outlived their *social* usefulness, but maintaining the social utility without a musical purpose to underpin it is proving to be a challenge for the people at the helm. Subsidy can help to skew the figures in favour of a flagging institution, but no amount of subsidy can totally reverse the effects of technology.[3] Hence the appeal of Attali's rhetoric to traditionalists; choosing to blame the decline of such institutions on the deleterious effects of digital technology makes the need for increased and ongoing subsidy more palatable to donors and beneficiaries alike.[4] It is well beyond the remit of this thesis to offer public policy solutions, but the problematical nature of the situation for policy makers is worth flagging up.

A great deal of Attali's fears and assumptions rest on the idea that without tastemakers the consumers of music become an undifferentiated crowd; a mass of equal and, in his opinion, rather wayward consumers led by their own differing tastes and habits, with no person or agency leading the way. If all these venerable institutions had simply come crashing down, and there was nothing or no one to step into the breach, then perhaps these fears might have come true. The reality is, however, that the monopoly once exercised by such institutions has crumbled away, revealing an active market for new

---

[3] Even before the turn of the millennium, serious questions were being asked about how institutions like the Royal Opera House could continue to operate. Despite an extraordinary amount of public subsidy from the Arts Council—which made up almost half of its annual income—*and* a £78m National Lottery grant, the Royal Opera House's deficit was projected to increase by over £6m each year (Towse, 2001: 39).

[4] Towse provides ample evidence that, since the end of the Second World War, the Arts Council has "evaded effective accountability" and that many of its activities have been surrounded by secrecy (Towse, 2001: 42).

tastemakers both large and small. Modern initiatives such as the BBC's *Introducing* platform and commercial enterprises like *X Factor* operate on a national and international level, creating widespread demand and large communities around a relatively small amount of music. But there is a new, more agile breed of tastemakers that collectively promote a much broader spectrum of music to a wider audience, even if each individual tastemaker's influence is perhaps less visible and extends to a much smaller sphere than, say, *X Factor*. This is, to borrow Chris Anderson's words, the 'long tail' of tastemaking. It includes independent music critics, bloggers, recommendation systems (whether powered by human or algorithmic analysis), prominent members of Twitter and other social networking sites (particularly individual celebrities), and many more. The perfection of the six characteristics allows even previously anonymous individuals to become not only tastemakers but curators as well, something that would have been impossible in the analogue era.

The French Republican Guard ('La Garde Républicaine') is a part of France's *gendarmerie* and comprises, amongst other sections, a renowned military band. Someone wanting to hear recordings of the band from the interwar period would, until recently, have struggled to find any. Today, though, a quick search for 'Garde Républicaine 78' on YouTube produces about 90 distinct results. The majority of these are sound recordings, transferred from old 78 records, accompanied by a series of still photographs or images. They have been uploaded by a small handful of users who seem have had access to a good selection of original 78 recordings and provided the means and inclination to transfer them to digital formats. Were it not for digital technologies, the value in these recordings (whatever the estimation of it) would have almost certainly have been restricted to occasional listens by only a handful of probably unconnected enthusiasts. As a result of their altruism, the recordings have become an invaluable and readily accessible resource. Prior to the digital age, collecting and listening to such records was quite probably a lonely and rather inscrutable pastime, but sharing them through digital channels allows the distributors to be alerted to the presence of other enthusiasts. They might not converse with each other at great length, or even at all, but the ability to comment on a YouTube video, to give it a 'thumbs-up', and to see how many times it has been viewed allows a community of sorts to spring up around this small and virtual purlieu. (If nothing else, the curator might receive more recognition for the significance of his enthusiasm than his spouse is willing to give).

The handful of users who posted the videos now have an informal but undeniably international curating role, and more and more people have taken on a similar mantle for different areas of or enthusiasms within music. This is made possible by two things. First, the lack of any need for approval or condonement from a traditional gatekeeping body such as an archive that might need persuading to admit the recordings and even then would struggle to exhibit them to as many people as YouTube can. Second, the absence of any necessity for formal or expensive infrastructure or resources. Historically, the extraction, conversion, preservation, and distribution of such materials would require specialist equipment, trained professionals, and probably a great deal of man-hours. Today, all that a would-be curator of old recordings needs is an Internet connection, a YouTube account, and a digital turntable or microphone. Reiterating a point of compatibility made in Chapter 4, most people in the developed world will probably have two of these, and the third need not be expensive. Services like YouTube will store the recordings, index them, make them searchable and accessible by anyone, at any time of day or night, at no cost.

The infinity of music does not lend itself to browsing in the way that, say, the blues section of the Oxford Street HMV once might have. Thus, targeted searching—within one repository or across many—has become an essential tool for today's consumer. It constitutes a change in acquisition habits, but more importantly it engages behaviours that were fundamentally discouraged during the pre-digital age previous eras. Rather than being met with blunt refusal by traditional gatekeepers to even entertain the idea of investing in something so unprofitable, those pursuing musical passions of a more arcane nature can now find themselves rewarded with the discovery of previously unknown or unheard recordings.

Now and in the future, the abundance of once obscure and elusive recordings may not seem particularly remarkable to those consumers who have never known the analogue world of bricks-and-mortar acquisition. If Sterne's notion of scarcity being a fundamental condition of historicity is true, how will cultural history process an ever-growing, perpetual, perennial infinity of music? Will any music ever reach the point of scarcity again?

In theory, the ubiquity and multiplicity of music available to consumers could have pushed niche musics even further off the beaten track. If bricks-and-mortar record stores were still the primary acquisition channel for recorded music, the extension of the global back catalogue might simply amount to an even longer 'tail': a more expansive list of performers whose records gave slim profit margins and thus could not be given shelf space. In practice, the micromaterialization of storage media and the widespread impact of long-tail retail policies, combined with the ability to access music through intelligent and targeted searching, increases the likelihood of niche music being found by those who want to find it. Targeted searching is, however, arguably less receptive to serendipity than physical browsing; chance discoveries are perhaps less likely to happen online than they would be in a secondhand record shop.

So the newly appointed curator has—thanks to virtualization and digital technologies, not in spite of them—found a social role for himself and his collection that simply was not open to him in the analogue world. This is in stark opposition to Attali's predictions. The stockpiling of recording which he fingered as the culprit of music's inevitable downfall, the annihilator of all but the most commercially robust performers and compositions, may well be the thing that protects it from such a fate. Not only has recording failed to *remove* the social function in favour of stockpiling, it has also *facilitated* a social function that, without the stockpiling of recordings by some careful enthusiasts, would have been impossible. If the interwar incarnation of the French Republican Guard will never perform again, then surely it must be a good thing that so many people can now access and celebrate their performances? The presence of new tastemakers whose interests are, on the whole, less commercial and more philanthropic than their predecessors prevents the infinity of music becoming the eternity of meaningless noise that so worried Attali.

There are consumers who have always relied on commercially mediated tastemakers (such as major record labels) to solve the conundrum of selecting music, to dictate their tastes, and to provide them with the music itself. The way in which such consumers acquire taste or selection preferences can therefore be described as very much 'market-push', and they are likely to continue to acquire them in the same vein. Market-push consumers might once have bought the latest chart releases in major bricks-and-mortar retailers, and discussed the previous night's *Top of the Pops* show over the office watercooler; collective consumption of the same market-push tastes gave common ground for social rituals. Although voting for *X Factor* contestants via text and conversing on social media sites about the results may, to an extent, have replaced these rituals, the attraction of market-push tastes still exists. Even if the task might be made more manageable by following the new generation of tastemakers, the prospect of wading through tens of millions of hours of music in order to find diamonds amongst the rough will hold little joy for market-push consumers when the likelihood of their friends or colleagues having done the same—and thus providing membership to the social rituals—is very slim. Market-push consumers might no longer be dictated to solely by record companies, but they remain susceptible to an artificially created demand for music.

On the other hand there are those more independently minded consumers who in times past might have relied more heavily on independent labels and chance discoveries via friends or at concerts to help them select music. Amid the new landscape of the digital music industry these people are more likely to exist as 'knowledge-pull' consumers, seeking out less commercially-mediated or strategically-minded tastemakers and turning instead to blogs, opinion aggregators, independent critics, recommendation radio, and algorithm-based selection systems. The joy of sharing in and socializing through music is still present for such consumers, but perhaps more appeal lies in being one step ahead of the cultural zeitgeist or becoming an early fan of a band that later achieves fame and success. Obviously, there are more than two types of consumer, and many will lie somewhere between these two extremes. But the fact that such options still exist in the digital music industry suggests that the change in music precipitated by new technologies might not be as profound or threatening as it could have been.

6.1 The social future of music

So, the digital era presents us with a paradoxical situation. On the one hand, digital music files have clearly revolutionized the music industry in ways that previous platforms have not: a practical infinity of music, freely available on a variety of devices and in a wide range of formats, offering the highest quality, representing economically sound choices for consumers, and lasting indefinitely. Coupled with the Internet and its associated technologies, this revolution has enabled many forms of social activity around music that are emphatically not reliant upon physical, geocentric networks. This was simply not the case with previous platforms, nor could it have been. On the other hand, the digital revolution is *not* revolutionary insofar as the effect it has had on the social motivations of people who like making music and listening to music—these net changes are small. In that sense, all the digital revolution has done is shake the economic foundations of the music industry, much like every other platform that came before it.

Attali was hugely pessimistic about the future of cultural engagement with music. However paradoxical the current situation may appear, it is not as problematic as he imagined it to be. The cultural significance of music has not been damaged. Even if the ways in which such significance is created have undergone mutation, people still make music, disseminate it, share it, listen to it, and trade in it. If anything, music is perhaps *more* culturally significant than ever before. Digital technologies allow a wider demographic to engage with a broader spectrum of music, on a more frequent basis.

And music still has a social function, even if the precise nature of that social function has changed. The *social* capital of music used to be inextricably linked to the *cultural* capital of music, through the physical contexts and relationships that surrounded amateur groups, famed venues, professional orchestras, and so on. Policy makers seeking to achieve certain social ends could use music as a device to manage or otherwise influence physically anchored interactions. But as soon as social interactions become grounded in virtual spheres, as soon as physical boundaries and manifestations are removed or made optional, the ability to control these interactions is greatly diminished or, in some cases, removed entirely. No longer can music be used as vigorously to stimulate the wider interactions that may have been initiated as a result of music, but that spilled over into other areas of life and society. Thus, the move towards the virtual sphere curtails the ability of music to effect social change. There are some small pockets of resistance that still exist, but the separation of music's cultural and social capital is a challenge. Some of those affected are likely to surmount it, and some are not.

The future is by no means certain, but the prognosis is good: an infinity of music, a greater democracy in its production, distribution, and consumption, and a compelling body of evidence to suggest that, stripped of its social obligations, music itself is in rude health.

Appendices

Appendix 1

Data pertaining to Figure 4.2 (graph showing cost per gigabyte of data storage from 1980–2009).

Date	Manufacturer	Size (MB)	Hard drive cost (US $)	Cost per GB (US $)
1980	Morrow Designs	26	5,000.00	193,000.00
1980	North Star	18	4,199.00	233,000.00
1981	Apple	5	3,500.00	700,000.00
1981	Morrow Designs	10	2,999.00	300,000.00
1981	Morrow Designs	10	2,949.00	295,000.00
1981	Seagate	5	1,700.00	340,000.00
1981	VR Data	6	2,895.00	460,000.00
1981	VR Data	19	5,495.00	289,000.00
1983	Corvus	20	3,495.00	175,000.00
1983	Davong	10	1,650.00	165,000.00
1983	Davong	21	2,495.00	119,000.00
1983	Xcomp	10	1,895.00	190,000.00
1983	Xcomp	16	2,095.00	131,000.00
1984	Comrex	10	1,995.00	200,000.00
1984	Corvus	6	1,695.00	283,000.00
1984	Corvus	11	2,350.00	214,000.00
1984	CTI	11	1,995.00	181,000.00
1984	Percom/Tandon	5	1,399.00	280,000.00
1984	Percom/Tandon	10	1,699.00	170,000.00
1984	Percom/Tandon	15	2,095.00	140,000.00
1984	Percom/Tandon	20	2,399.00	120,000.00
1984	Tecmar	5	1,495.00	299,000.00
1989	Western Digital	20	899.00	53,000.00
1989	Western Digital	40	1,199.00	36,000.00
1990	Quantum	128	4,500.00	9,000.00
1991	Quantum	256	1,749.99	7,000.00
1992	Areal	256	999.99	4,000.00
1993	DEC	512	999.99	2,000.00
1994	Tamir Tech	1,000	949.99	950.00
1995	Seagate	1,000	849.00	850.00

continued . . .				
Date	**Manufacturer**	**Size**	**Hard drive cost**	**Cost per GB**
1995	Seagate	1,700	1,499.00	880.00
1995	Seagate	2,100	1,699.00	810.00
1995	Seagate	2,900	2,899.00	990.00
1996	IBM	1,760	379.99	263.00
1996	Maxtor	2,000	439.99	259.00
1996	Quantum	3,200	469.00	173.00
1996	Western Digital	1,600	399.99	295.00
1997	Maxtor	3,500	359.99	118.00
1997	Maxtor	4,300	439.99	118.00
1997	Maxtor	5,200	438.99	97.10
1997	Maxtor	7,000	669.99	110.00
1997	Maxtor	7,000	579.99	95.30
1997	Maxtor	8,400	679.99	93.10
1997	Quantum	3,200	285.00	102.00
1997	Quantum	4,300	379.00	101.00
1997	Quantum	6,400	475.00	85.40
1997	Quantum	6,400	549.99	98.80
1997	Western Digital	2,100	329.99	181.00
1997	Western Digital	2,100	279.99	153.00
1997	Western Digital	3,100	399.99	148.00
1997	Western Digital	3,100	329.99	122.00
1997	Western Digital	3,200	289.00	104.00
1997	Western Digital	4,000	490.99	141.00
1997	Western Digital	4,300	365.00	97.60
1997	Western Digital	5,100	459.99	104.00
1997	Western Digital	5,100	449.99	101.00
1997	Western Digital	6,400	445.00	80.00
1998	Fujitsu	3,200	227.00	81.60
1998	Fujitsu	4,300	282.00	75.40
1998	Fujitsu	4,300	257.00	68.70
1998	Fujitsu	5,200	331.00	73.20
1998	Fujitsu	5,200	299.00	66.10
1998	Fujitsu	5,200	252.00	55.70
1998	Fujitsu	6,400	368.00	66.10
1998	Fujitsu	6,400	328.00	58.90
1998	Fujitsu	6,400	289.00	51.90
1998	Fujitsu	6,400	291.00	52.30
1998	Maxtor	4,300	319.99	85.60
1998	Maxtor	5,100	379.99	85.70
1998	Maxtor	5,700	299.99	60.50
1998	Maxtor	6,800	279.99	47.40
1998	Maxtor	8,400	379.99	52.00
1998	Quantum	4,300	349.99	93.60
1998	Quantum	4,300	228.00	61.00

continued . . .				
Date	Manufacturer	Size	Hard drive cost	Cost per GB
1998	Quantum	6,400	479.99	86.30
1998	Quantum	6,400	339.99	61.10
1998	Quantum	6,400	298.00	53.50
1998	Seagate	6,400	349.99	62.90
1998	Seagate	6,400	329.99	59.30
1998	Seagate	6,400	279.99	50.30
1998	Western Digital	5,100	262.00	59.10
1998	Western Digital	6,400	529.99	95.20
1998	Western Digital	6,400	294.00	52.80
1998	Western Digital	8,400	382.00	52.30
1999	Fujitsu	6,400	179.99	32.30
1999	Fujitsu	6,400	139.99	26.30
1999	Fujitsu	8,400	229.00	31.40
1999	Fujitsu	8,400	198.00	27.10
1999	Fujitsu	8,400	253.00	34.60
1999	Fujitsu	8,400	235.00	32.20
1999	Fujitsu	10,200	189.00	21.30
1999	Fujitsu	10,200	279.00	31.50
1999	Fujitsu	10,200	245.00	27.60
1999	Fujitsu	10,200	299.00	33.70
1999	Fujitsu	10,200	285.00	32.10
1999	Fujitsu	13,000	208.00	18.40
1999	Fujitsu	17,300	248.00	16.50
1999	Fujitsu	17,300	369.00	24.50
1999	Fujitsu	20,400	299.00	16.90
1999	Fujitsu	27,300	388.00	16.30
1999	Maxtor	8,400	199.99	27.40
1999	Maxtor	10,000	249.99	28.80
1999	Quantum	8,000	299.99	43.10
1999	Quantum	10,200	199.00	22.40
1999	Quantum	13,600	219.00	18.50
1999	Quantum	13,600	249.00	21.10
1999	Quantum	18,200	348.00	22.00
1999	Quantum	19,200	512.46	30.70
1999	Western Digital	20,000	359.00	20.60
1999	Western Digital	20,500	398.00	22.30
1999	Western Digital	27,300	489.00	20.60
2000	Fujitsu	13,600	199.00	16.80
2000	Fujitsu	13,600	197.80	16.70
2000	Fujitsu	17,300	238.00	15.80
2000	Fujitsu	17,300	232.30	15.40
2000	Fujitsu	20,400	299.00	16.90
2000	Fujitsu	27,300	375.00	15.80
2000	IBM	20,300	245.00	13.90

continued . . .				
Date	**Manufacturer**	**Size**	**Hard drive cost**	**Cost per GB**
2000	IBM	20,500	279.00	15.70
2000	Maxtor	15,000	149.99	11.50
2000	Maxtor	15,000	192.00	14.70
2000	Maxtor	15,000	189.99	14.60
2000	Maxtor	15,200	199.00	15.10
2000	Maxtor	15,300	144.00	10.80
2000	Maxtor	17,000	204.00	13.80
2000	Maxtor	20,000	259.00	14.90
2000	Maxtor	20,000	217.00	12.50
2000	Maxtor	20,400	164.00	9.25
2000	Maxtor	27,000	320.00	13.60
2000	Maxtor	27,000	299.00	12.70
2000	Maxtor	30,000	249.99	9.58
2000	Maxtor	30,000	308.00	11.80
2000	Maxtor	30,000	319.99	12.30
2000	Maxtor	30,500	298.00	11.20
2000	Maxtor	30,700	214.00	8.02
2000	Maxtor	30,700	194.00	7.25
2000	Maxtor	30,700	244.00	9.17
2000	Maxtor	30,700	278.00	10.40
2000	Maxtor	36,500	411.00	13.00
2000	Maxtor	40,000	349.99	10.10
2000	Maxtor	40,000	399.99	11.50
2000	Maxtor	40,900	254.00	7.14
2000	Maxtor	40,900	318.00	8.93
2000	Maxtor	40,900	388.00	10.90
2000	Maxtor	61,400	398.00	7.46
2000	Maxtor	80,000	479.99	6.90
2000	Maxtor	81,900	518.00	7.30
2000	Samsung	15,000	162.00	12.40
2000	Samsung	20,000	175.00	10.10
2000	Samsung	30,000	189.00	7.25
2000	Seagate	17,200	218.00	14.60
2000	Seagate	28,000	349.00	14.30
2000	Western Digital	13,600	179.99	15.20
2000	Western Digital	20,000	218.00	12.50
2001	Fujitsu	30,000	169.00	6.49
2001	Fujitsu	40,000	199.00	5.71
2001	Maxtor	40,000	158.88	4.57
2001	Maxtor	60,000	329.99	6.33
2001	Quantum	40,000	260.00	7.46
2001	Western Digital	40,000	219.99	6.33
2002	Maxtor	40,000	128.88	3.70
2002	Maxtor	80,000	259.99	3.73

continued . . .				
Date	**Manufacturer**	**Size**	**Hard drive cost**	**Cost per GB**
2002	Western Digital	40,000	149.99	4.31
2002	Western Digital	40,000	89.99	2.59
2002	Western Digital	40,000	89.99	2.59
2002	Western Digital	40,000	99.99	2.87
2002	Western Digital	60,000	149.99	2.87
2002	Western Digital	60,000	139.99	2.68
2002	Western Digital	100,000	229.99	2.65
2002	Western Digital	100,000	179.99	2.07
2002	Western Digital	120,000	269.99	2.59
2003	Maxtor	40,000	89.88	2.58
2003	Maxtor	80,000	98.88	1.42
2003	Maxtor	80,000	134.00	1.93
2003	Maxtor	120,000	158.00	1.52
2003	Maxtor	120,000	144.88	1.39
2003	Maxtor	120,000	168.00	1.61
2003	Western Digital	80,000	124.00	1.78
2003	Western Digital	120,000	158.00	1.52
2004	Barracuda	400,000	280.00	0.70
2004	Cicero	160,000	269.95	1.94
2004	Maxtor	80,000	98.00	1.41
2004	Maxtor	120,000	129.00	1.24
2004	Western Digital	80,000	109.00	1.57
2004	Western Digital	120,000	144.00	1.38
2004	Western Digital	160,000	269.99	1.94
2004	Western Digital	160,000	169.99	1.22
2004	Western Digital	250,000	369.99	1.70
2004	Western Digital	250,000	249.99	1.15
2005	Hitachi	250,000	130.00	0.52
2005	Seagate	200,000	140.00	0.70
2006	Maxtor	300,000	150.00	0.50
2006	Samsung	80,000	35.00	0.44
2006	Seagate	500,000	300.00	0.60
2006	Western Digital	250,000	140.00	0.56
2007	Seagate	160,000	70.00	0.44
2007	Seagate	250,000	100.00	0.40
2008	Beyond Micro	1,000,000	270.00	0.27
2008	Seagate	750,000	200.00	0.27
2009	Hitachi	1,000,000	74.99	0.07

Data courtesy of Matt Komorowski. Retrieved 5th May 2012 from <http://ns1758.ca/winch/winchest.html>.

Appendix 2

Data pertaining to Figure 5.4 (infographic showing artist earnings from different acquisition channels).

Outlet	Format	Retail price	Record label cut	Record label revenue	Artist share of label rev-enue	Artist rev-enue	Month-ly sales target to earn min. wage
Self-pressed	Album CD	$9.99	0.0%	$0.00	81.0%	$8.09	143
cdbaby	Album download	$9.99	0.0%	$0.00	75.0%	$7.49	155
Commer-cial album sales CD (high royalty)	Album CD	$9.99	20.0%	$2.00	50.0%	$1.00	1,161
Napster	Album download	$9.99	63.0%	$6.29	15.0%	$0.94	1,229
iTunes	Album download	$9.99	63.0%	$6.29	15.0%	$0.94	1,229
cdbaby	Single download	$0.99	0.0%	$0.00	75.0%	$0.74	1,562
cd baby (via iTunes)	Single download	$0.99	63.0%	$0.62	91.0%	$0.57	2,044
Commer-cial album sales (low royalty)	Album CD	$9.99	20.0%	$2.00	15.0%	$0.30	3,871
iTunes	Single download	$0.99	63.0%	$0.62	15.0%	$0.09	12,399
Amazon	Single download	$0.99	63.0%	$0.62	15.0%	$0.09	12,399
Spotify	Streaming	–	fixed	$0.0017	15.0%	$0.000255	4,053,110

Data courtesy of David McCandless. Retrieved 12th November 2012 from <http://bit.ly/DigitalRoyalty>.

Glossary

Absolute fidelity
The ability of a recorded music platform to reproduce the experience of a live performance. See also 'relative fidelity' (below).

Aliasing
The situation in which a sampling rate is insufficiently frequent to describe the input signal upon reproduction.

Allgemeine Elektricitäts-Gesellschaft (AEG)
A German manufacturer of electrical equipment, founded by Emil Rathenau in 1883.

Angular velocity
The rate of change of angular displacement, which specifies the rotational speed of an object and the axis about which it is rotating.

ARPANET
A network created by the Advanced Research Projects Agency (ARPA) of the United States Department of Defense. The network was used to share information about ARPA's projects between research laboratories, universities, and other associated institutions.

Artists and repertoire (A&R)
A common department within record companies, responsible for recruiting talent and managing artistic development. In the early years of the popular music industry, the A&R department of a record label would be responsible for finding performers (artists) appropriate songs (repertoire).

Badische Anilin- und Soda-Fabrik (BASF)
Founded in 1865 by Friedrich Engelhorn, BASF began manufacturing dyes and water softeners and is now the world's largest diversified chemical company.

Bit
Short for 'binary digit', a bit is the most basic unit of capacity in digital information and can have a value of 0 or 1.

Bitrate
The number of bits that are processed or transferred in a given period of time, often measured in bits per second (bps) and kilobits per second (kbps).

BitTorrent
A protocol for peer-to-peer file-sharing.

British Phonographic Industry (BPI)
The trade association of the British record industry.

Byte
A string of eight 'bits' in digital information and communications.

Capacity
How much audio data can be stored on a given media ‘unit’ of a particular recorded music platform.

Cloud computing
The term for a collection of computing services that rely on remote services connected by a variety of wired and wireless networks.

Columbia Broadcasting System (CBS)
An American television and radio broadcasting network, launched in 1927.

Compatibility
The extent to which a recorded music platform can co-operate with existing or future platforms.

Consumer Price Index (CPI)
A tool that allows inflation to be measured and adjusted for by monitoring changes in the cost of a range of typical consumer goods.

Decibel (db)
A logarithmic unit, most commonly used to measure sound, that defines the ratio of a physical quantity (such as sound pressure level) to a specific or implied reference level.

Durability
The ability of a recorded music platform to resist the loss or corruption of data caused either by normal use (e.g. wearing out of vinyl records), benign neglect (e.g. de-magnetization of tape) or by extraordinary damage (e.g. unanticipated physical trauma).

Economic viability
The ability of a platform to survive and thrive in prevailing economic circumstances, as determined by a variety of inherent cost factors.

Editability
How manipulable a recorded music platform is in terms of techniques such as cutting, splicing, looping fading, scratching, multitracking, both in professional and domestic audio environments.

Electric and Musical Industries (EMI)
A British multinational music company founded in 1931 through the merger of the Columbia Gramophone Company and the Gramophone Company. One of the largest record label groups in the world until its acquisition by Universal Music Group in 2012.

Encoder-decoder (Codec)
A type of software that is capable of encoding and/or decoding a compressed signal, such an MP3 audio file.

Exaptation
The process by which a feature of one technology is co-opted for use in another domain, or the result of this process.

Exobyte (EB)
10^{18} bytes, 10^{15} kilobytes, 10^{12} megabytes, 10^{9} gigabytes, 10^{6} terabytes, or 10^{3} petabytes (see 'byte', above).

Federation Against Copyright Theft (FACT)
A trade organization based in the United Kingdom that aims to protect the intellectual property interests of its members.

Fidelity
The extent to which a platform is able to reproduce sound faithful to its recorded source.

FireWire
An interface standard (known officially as IEEE 1394) developed by Apple in the late 1980s and early 1990s for high speed transmission of data, typically between personal computers and external devices such as hard drives.

Flutter
A relatively fast, unintended fluctuation in frequency caused by uneven tape speed during playback or recording. Often used in contrast to 'wow' (see entry below).

Fraunhofer Institute
A German organization (comprising 60 institutes across Germany) that conducts and supports research into a variety of applied sciences.

Gigabyte (GB)
10^{9} bytes, 10^{6} kilobytes, 10^{3} megabytes (see 'byte', above).

Groupe de Recherche Musicales (GRM)
An experimental music group founded by Pierre Schaeffer and incorporated into the French broadcasting organization L'Office de Radiodiffusion Télévision Française.

Hertz (Hz)
A unit of frequency defined as the number of cycles per second of a periodic phenomenon.

International Electrotechnical Commission (IEC)
An independent organization that produces and disseminates international standards for electrical, electronic, and related technologies.

International Federation of the Phonographic Industry (IFPI)
The worldwide trade association for the international record industry.

International Telecommunication Union (ITU)
A branch of the United Nations with responsibility for the development, coordination, and implementation of information and communication technologies.

Internet protocol (IP)
The primary communications protocol that governs the transmission of data across the Internet.

Internet service provider (ISP)
A company that provides businesses, institutions, and households with access to the Internet.

Kilobyte (kB)
10^3 bytes (see 'byte', above).

Kilohertz (kHz)
10^3 Hertz (see 'Hertz', above).

Linear pulse code modulation (LPCM)
A form of 'pulse code modulation' (see entry below) modified by linear quantization.

Lossless
Used to describe a form of data compression that, in contrast to 'lossy' compression (see entry below), allows the original input signal to be faithfully reconstructed.

Lossy
Used to describe a form of data compression that, though often more effective in reducing data size than 'lossless' compression (see entry above), does not allow the original data input to be reconstructed in its entirety.

Megabyte (MB)
10^6 bytes, 10^3 kilobytes (see 'byte', above).

Megahertz (MHz)
10^6 Hertz, 10^3 kilohertz (see 'Hertz', above).

Military Network (MILNET)
A section of the ARPANET (see entry above) designed for unclassified information traffic from the United States Department of Defense.

Moore's law
Named after Gordon Moore (co-founder of Intel), the law states that, based on past and current evidence, the maximum number of

transistors than can be housed on an integrated circuit more or less doubles every two years.

Moving Picture Experts Group (MPEG)
A group of research and industry experts, created by the International Standards Organization and the IEC (see entry, above) to set international standards for audio and video data compression.

Music Corporation of America (MCA)
An American talent agency, founded in 1924 by Jules Stein and William Goodheart, Jr, that later acquired (by a merger of equals) Decca Records.

National Broadcasting Company (NBC)
An American television network and broadcaster founded in 1926 by RCA (see entry below).

Nippon Hōsō Kyōkai (NHK)
The Japanese national broadcasting corporation, launched in 1925 and funded by a licence fee payable by viewers.

Nyquist frequency
The frequency below which sampling rates can gather insufficient information to accurately represent the original signal, often resulting in aliasing (see entry above).

Performing Rights Society (PRS)
As a counterpart to the Mechanical-Copyright Protection Society (MCPS), the Performing Rights Society (PRS) collected and managed royalties for performance rights in music. In 1997, the two entities merged to form PRS for Music.

Petabyte (PB)
10^{15} bytes, 10^{12} kilobytes, 10^{9} megabytes, 10^{6} gigabytes, 10^{3} terabytes (see 'byte', above).

Platform shifting
The process by which audio data is transferred from one medium—or platform—to another. It is commonly known as 'format-shifting', but the distinction between platform and format (made earlier in the thesis) allows the term format-shifting to refer specifically to the conversion of audio data from one digital, intangible file format to another.

Post Office protocol (POP)
A form of Internet protocol used by email software and networks to retrieve emails and related information over an Internet connection. See also 'SMTP' below.

Pulse code modulation (PCM)
A standard method for representing analogue signals as digital information. The magnitude of the analogue input signal is sampled at regular intervals (see 'sampling rate', below) and the amplitude of the signal is quantized to the nearest digitally-expressible value.

Radio Corporation of America (RCA)
An American electronics company founded in 1919 as a result of the exigencies of the First World War.

Recording Industry Association of America (RIAA)
A trade association that represents distributors and record labels in the United States, famed and criticized for its public and tenacious opposition to Internet piracy.

Red Book audio
An informal name for the international standard governing CD-quality audio. It is named after a red book that contained details of the specification—part of a series of standards documents known as the Rainbow Books.

Relative fidelity
How one recorded music platform compares to another in terms of its ability to be true to the original recording. Also, the extent to which any platform introduces artifacts that colour or alter the recording. See also 'absolute fidelity' (above).

Ripping
The process of copying data to a computer hard drive or other storage device, usually from CDs or DVDs.

Sampling rate
The number of samples per unit of time made from an analogue signal to create a correlated digital signal. Usually measured in Hertz (see entry above).

Simple mail transfer protocol (SMTP)
A form of Internet protocol used by email software and networks to send emails and related information over an IP (see entry above) connection. See also 'POP' (above).

Solid-state
Used to describe—amongst other things—data storage devices that do not utilize any moving parts.

Terabyte (TB)
10^{12} bytes, 10^{9} kilobytes, 10^{6} megabytes, 10^{3} gigabytes (see 'byte', above).

Transparency
A subjective measure of how faithfully a compressed signal corresponds to its uncompressed counterpart.

UK Music
An umbrella organization representing the interests of a wide variety of music industry actors such as collecting societies, record labels, artists, managers, songwriters, and so forth.

Universal Serial Bus (USB)
An interface standard for transmission of data between (and sometimes the supply of power to or from) devices such as personal computers, printers, and external hard drives.

Unskilled Wage Index (UWI)
A tool that allows inflation to be measured and adjusted for by monitoring changes in the wages paid to unskilled labourers.

Westrex
The export arm of American manufacturer Western Electrical.

Wi-Fi
An international standard (IEEE 802.11) that governs the wireless transmission of data across local area networks.

Wow
A relatively slow, unintended fluctuation in frequency caused by uneven tape speed during playback or recording. Often used in contrast to 'flutter' (see above).

References

Abbate, J. (2000). *Inventing the Internet.* MIT Press: Cambridge, MA.

Adorno, T. (1945). 'A social critique of radio music'. *The Kenyon Review*, 7 (2): 208–217.

Ajzen, I. (1985). 'From intentions to actions: a theory of planned behaviour' in Kuhl, J. and Beckman, J. (eds) *Action-control: from cognition to behaviour*. Springer: Heidelberg.

Ajzen, I. (1991). 'The theory of planned behaviour'. *Organizational Behaviour and Human Decision Processes*, 50 (2): 179–211.

Ajzen, I., and Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour.* Prentice Hall: Englewood, NJ.

Alexa (2012). 'The Pirate Bay', *Alexa Rankings*. Retrieved 2nd May 2012 from <http://www.alexa.com/siteinfo/thepiratebay.se>.

Anand, N., and Peterson, R. (2000). 'When market information constitutes fields: sensemaking of markets in the commercial music industry'. *Organization Science*, 11 (3): 270–284.

Anderson, C. (2004). 'The long tail', *Wired*. Retrieved 8th May 2009 from <http://www.wired.com/wired/archive/12.10/tail.html>.

Anderson, C. (2006). *The long tail: why the future of business is selling less of more.* Hyperion: New York, NY.

Anderson, C. (2009). *Free: the future of a radical price.* Hyperion: New York.

Anderson, P., and Tushman, M. (1990). 'Technological discontinuities and dominant designs: a cyclical model of technological change'. *Administrative Science Quarterly*, 35 (1): 604–633.

Anon. (1887). 'Victorian music'. *Musical Times*, 28 (533): 396–398.

Antonopoulos, N., and Gillam, L. (eds) (2010). *Cloud computing: principles, systems, and applications.* Springer: London.

Apple (2012a). 'Logic Studio', *Apple*. Retrieved 7th November 2012 from <http://store.apple.com/us/product/MB795Z/A/logic-studio?fnode=62>.

Apple (2012b). 'iPod classic', *Apple*. Retrieved 13th November 2012 from <http://store.apple.com/uk/browse/home/shop_ipod/family/ipod_classic>.

Aspray, W. (2008). 'File sharing and the music industry' in Aspray, W. and Ceruzzi, P. (eds) *The Internet and American Business*. MIT Press: Cambridge, MA.

Aspray, W., and Ceruzzi, P. (eds) (2008). *The Internet and American business.* MIT Press: Cambridge, MA.

Attali, J. (1977). *Noise: the political economy of music* [English translation by Brian Massumi, 1985]. University of Minnesota Press: Minneapolis, MN.

Baddeley, G. (1989). 'News update'. *MAC Audio News*, 178 (1): 19–21.

Baert, L., Theunissen, L., Vergult, G., Maes, J., and Arts, J. (eds) (1995). *Digital audio and compact disc technology [3rd edition].* Focal Press: Oxford.

Baker, H. (2011). 'VPR Internationale v. Does 1–1017'. *United States District Court: Central District of Illinois*. Retrieved 5th November 2012 from <http://infojustice.org/wpcontent/uploads/2011/05/VPR-v-Does.pdf>

Basalla, G. (1989). *The evolution of technology.* Cambridge University Press: Cambridge.

Battelle (1973). *Interaction of science and technology in the innovative process: some case studies.* Battelle Research Institute: Columbus, OH.

Baumol, W. (1977). *Economic theory and operational analysis.* Prentice Hall: Englewood, NJ.

Bech, S., and Zacharov, N. (2006). *Perceptual audio evaluation: theory, method and application.* John Wiley and Sons: Chichester.

Beeching, P. (2012). 'Why companies fail: the rise and fall of HMV', *Philip Beeching*. Retrieved 14th February 2013 from <http://www.philipbeeching.com/2012/08/why-companies-fail-rise-and-fall-of-hmv.html>

Bekenstein, J. (2003). 'Information in the holographic universe'. *Scientific American*, 289 (2): 58–65.

Bell, A., Bell, C., and Tainter, C. (1886). 'Reproducing sounds from phonograph records'. *United States Patent Office* no. 341,212.

Bently, L., Pollock, R., Kay, J., Klemperer, P., Kretschmer, M., Macqueen, H. et al. (2009, 23rd March). 'No case for copyright extension'. *The Times*: Letters to the editor.

Berliner, E. (1887). 'Gramophone'. *United States Patent Office* no. 372,786.

Berners-Lee, T. (1992). 'World Wide Web', *W3.org*. Retrieved 6th August 2012 from <http://www.w3.org/History/19921103-hypertext/hypertext/WWW/TheProject.html>.

Berners-Lee, T. (1996). 'WWW: past, present, and future'. *Computer*, 29 (10): 69–77.

Bettig, R. (1996). *Copyrighting culture: the political economy of intellectual property.* Westview: Boulder, CO.

Bhattacharjee, S., Gopal, R., and Sanders, L. (2003). 'Economics of online music'. *5th International Conference on Electronic Commerce*: 300–309.

Billboard (1966, 16th July). 'Mercury issue 49 cassettes'. *Billboard*: 69.

Billboard (2005). 'DualDisc artists holding top spots', *Billboard*. Retrieved 10th March 2011 from <http://billboard.blogs.com/billboardpostplay/2005/05/dualdisc_artist.html>.

Blair-Oliphant, R. (2012). *Personal communication with author*.

Blosiu, J., and Blosiu, C. (2000). 'Perfection, ideality, and technology road map as measured by a sliding scale'. *Proceedings of the 2000 IEEE International Conference on Management of Innovation and Technology*: 321–326.

Blumlein, A. (1931). 'Electrical transmission device'. *United States Patent Office* no. 1,975,709.

Bockstedt, J., Kauffman, R., and Riggins, F. (2006). 'The move to artist-led online music distribution: a theory-based assessment and prospects for structural changes in the digital music market'. *International Journal of Electronic Commerce*, 10 (3): 7–38.

Born, G. (1995). *Rationalising culture: IRCAM, Boulez, and the* *institutionalization of the musical avant-garde.* University of California Press: Berkeley.

Borsay, P. (1990). *The eighteenth-century town: a reader in English urban history, 1688–1820*. Longman: London.

Boston, G. (2003). 'Survey of endangered audiovisual carriers', *UNESCO*. Retrieved 28th September 2012 from <http://www.unesco.org/pv_obj_cache/pv_obj_id_6CEF1109BD4466B150499E3B6DCF1751B0990200/filename/programme_doc_survey_report.pdf>.

Braden, D. (1992). 'The family that plays together stays together: family pastimes and indoor amusements, 1890–1930' in Foy, J. and Schlereth, T. (eds) *American home life, 1880–1930: a social history of spaces and services*. University of Tennessee Press: Knoxville, TN.

Bradley, K. (2003). 'Critical choices, critical decisions: sound archiving and changing technology'. *Pacific and Regional Archive for Digital Sources in Endangered Cultures*: 6–13.

Brandle, L. (2007). 'Radiohead returning to the road in 2008', *Billboard*. Retrieved 13th July 2012 from <http://web.archive.org/web/20080208234628/http://www.billboard.com/bbcom/news/article_display.jsp?vnu_content_id=1003660154>.

Breebaart, J., van der Par, S., Kohlrausch, A., and Schuijers, E. (2005). 'Parametric coding of stereo audio'. *Journal on Applied Signal Processing*, 9 (2): 1305–1322.

Brend, M. (2005). *Strange sounds: offbeat instruments and sonic experiments in pop.* Backbeat Books: Milwaukee, WI.

Breznican, A. (2005, 25th April). 'DualDisc breaks sound barrier', *USA Today*. Retrieved 10th March 2011 from <http://www.usatoday.com/life/music/news/2005-04-25-springsteen-dualdisc_x.htm>.

British Broadcasting Corporation (2010). 'X Factor admits tweaking vocals', *BBC*. Retrieved 23rd October 2012 from <http://www.bbc.co.uk/news/entertainment-arts-11056050>.

British Broadcasting Corporation (2012a). 'Freedom of information: the services we offer', *BBC*. Retrieved 5th August 2012 from <www.bbc.co.uk/foi/publication_scheme/classes/services/radio.shtml>.

British Broadcasting Corporation (2012b) 'The Pirate Bay must be blocked by UK ISPs, court rules', *BBC*. Retrieved 2nd May 2012 from <http://www.bbc.co.uk/news/technology-17894176>.

Brook, S., and Fitzsimmons, C. (2008). 'McFly album giveaway lifts Mail on Sunday sales to 2.4m', *Guardian*. Retrieved 5th July 2011 from <http://www.guardian.co.uk/media/2008/jul/23/pressandpublishing1>.

Brylawski, S. (2003). 'Review of audio collection preservation trends and challenges', *Association of Research Libraries*. Retrieved 28th January 2012 from <http://www.arl.org/preserv/sound_savings_proceedings/Review_Audio_Collections~print.shtml>.

Burchell, J. (2004). 'The first talents of Europe: British music printers and publishers and imported instrumental music in the eighteenth century' in Wollenberg, S. and McVeigh, S. (eds) *Concert life in eighteenth-century Britain*. Ashgate: Aldershot.

Burgan, M. (1989). 'Heroines at the piano: women and music in nineteenth-century fiction' in Temperley, N. (ed.) *The lost chord: essays on Victorian music*. Indiana University Press: Bloomington, IN.

Business, Innovation, and Skills Committee (2012). 'Appendix: government response'. *The Hargreaves Review of Intellectual Property: Where next? Government Response to the Committee's 1st Report of Session 2012–13: Business, Innovation and Skills Committee Contents*. Retrieved 12th December 2012 from <http://www.publications.parliament.uk/pa/cm201213/cmselect/cmbis/579/579.pdf>.

Camras, M. (1988). *Magnetic recording handbook.* Van Nostrand Reinhold: New York, NY.

CERN (2003). 'CERN celebrates web anniversary', *CERN*. Retrieved 13th

August 2010 from <http://public.web.cern.ch/press/pressreleases/Releases2003/PR04.03EWeb10Years.html>.

Chanan, M. (1995). *Repeated takes: a short history of recording and its effect on music.* Verso: New York, NY.

Chandler, F. (1967, April 8th). 'European manufacturers bid for market share'. *Billboard*: 6–7.

Cheng, J. (2009). 'Study: pirates biggest music buyers. Labels: yeah, right', *Ars Technica*. Retrieved 8th March 2011 from <http://arstechnica.com/tech-policy/2009/04/study-pirates-buy-tons-more-music-than-average-folks/>.

Chivers-Yochim, E., and Biddinger, M. (2008). 'It kind of gives you that vintage feel: vinyl records and the trope of death'. *Media, Culture and Society*, 30 (2): 183–195.

Chmielewski, D. (2004, 31st March). 'Music labels use file-sharing data to boost sales'. *Mercury News*: 28.

Clanchy, M. (1993). *From memory to written record: England 1066–1307.* Blackwell: Oxford.

Clark, M. (2003). *Data networks, IP, and the Internet: protocols, design, and operation.* John Wiley and Sons: Chichester.

Clarke, A. (1962). *Profiles of the future: an inquiry into the limits of the possible.* Harper and Row: New York.

Cohen, E. (2001). 'Archiving, preservation, and metadata considerations for information appliances'. *Proceedings of the 18th International AES Conference on Audio for Information Appliances*: 473–501.

Colbert, S. (2011, 26th September). 'The Colbert report' *Comedy Central*. New York, NY.

Coleman, M. (2005). *Playback: from the Victrola to MP3, 100 years of music, machines and money.* Da Capo Press: New York, NY.

Comer, D. (2007). *The Internet book: everything you need to know about computer networking and how the Internet works.* Pearson Prentice Hall: Upper Saddle River, NJ.

Comroe, J. (1977). *Retrospectroscope: insights into medical discovery.* Von Gohr Press: Menlo Park, CA.

Cook, P. (ed.) (1999). *Music, cognition, and computerized sound: an introduction to psychoacoustics.* MIT Press: Cambridge, MA.

Coufal, H., Sincerbox, G., and Psaltis, D. (eds) (2000). *Holographic data storage.* Springer-Verlag: Secaucus, NJ.

Cox, C., and Warner, D. (eds) (2004). *Audio culture: readings in modern music.* Continuum: New York, NY.

Crawford, R. (1993). *The American musical landscape.* University of California Press: Los Angeles, CA.

Creative Commons (2012). 'About Creative Commons', *Creative Commons UK*. Retrieved 13th November 2012 from <http://www.creativecommons.org.uk/about-creative-commons/>.

David, P. (1985). 'Clio and the economics of QWERTY'. *American Economic Review*, 75 (2): 332–337.

Davidson, J. (1993). 'Visual perception of performance manner in the movements of solo musicians'. *Psychology of Music*, 21 (2): 103–113.

de Saint-Exupéry, A. (1939). *Terres des hommes*. Éditions Gallimard: Paris.

de Sola Pool, I. (1983). *Technologies of freedom.* Harvard University Press: Cambridge, MA.

Dew, N., Sarasvathy, S., and Venkataraman, S. (2004). 'The economic implications of exaptation'. *Journal of Evolutionary Economics*, 14 (1): 69–84.

Dhebar, A. (1995). 'Complementarity, compatibility, and product change: breaking with the past?'. *Journal of Product Innovation Management*, 12 (1): 136–152.

Diver, M. (2007). 'Ash reveal all about their "no more albums" attitude.', *Drowned in Sound*. Retrieved 5th October 2011 from <http://drownedinsound.com/in_depth/2100774-ash-reveal-all-about-their-no-more-albums-attitude>.

Dowd, T. (2002a). 'Culture and commodification: technology and structural power in the early United States recording industry'. *International Journal of Sociology and Social Policy*, 22 (1–3): 106–

140.

Duncan, N., and Fox, M. (2005). 'Computer-aided music distribution: the future of selection, retrieval and transmission'. *First Monday*, 10 (4): 1–15.

Edison, T. (1878a). 'Phonograph or speaking machine'. *United States Patent Office* no. 200,521.

Edison, T. (1878b). 'The phonograph and its future'. *North American Review*, 126 (3): 527–536.

Egerton, H. (1917). 'Electric amplifier system'. *United States Patent Office* no. 1,232,514.

Ehmer, R. (1959). 'Masking by tones vs noise bands'. *The Journal of the Acoustical Society of America*, 31 (9): 1253–1256.

Eisenberg, E. (1987). *The recording angel: music, records and culture from Aristotle to Zappa.* McGraw-Hill: New York.

Ensmerger, N. (2008). 'Resistance is futile? Reluctant and selective users of the Internet' in Aspray, W. and Ceruzzi, P. (eds) *The Internet and American business*. MIT Press: Cambridge, MA.

European Commission (2011). 'New rules on term of protection of music recordings (PRES/11/303)', *European Commission*. Retrieved 13th November 2012 from <http://europa.eu/rapid/press-release_PRES-11-303_en.htm>.

Evangelista, B. (2004). 'Walkman vs iPod: Sony takes aim at Apple with new music players', *San Francisco Chronicle*. Retrieved 20th January 2010 from <http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2004/07/05/bug267f5521.dtl>.

FACT (1996). 'Daylight robbery', *YouTube*. Retrieved 23rd May 2012 from <http://www.youtube.com/watch?v=QEYjIZ-K7UE>.

FACT (1997). 'Piracy: it's a crime', *YouTube*. Retrieved 23rd May 2012 from <http://www.youtube.com/watch?v=HmZm8vNHBSU>.

Fadeyev, V., and Haber, C. (2003). 'Reconstruction of mechanically recorded sound by image processing'. *Journal of the Audio Engineering Society*, 51 (12): 1172–1185.

Fadeyev, V., Haber, C., Maul, C., McBride, J., and Golden, M. (2005). 'Reconstruction of recorded sound from an Edison cylinder using three-dimensional non-contact optical surface metrology'. *Journal of the Audio Engineering Society*, 53 (6): 485–508.

Farmer, H. (1931). *The organ of the ancients.* William Reeves: London.

Favre, J. (1865). 'Notice sur Sainte-Croix'. *Journal de la Société vaudoise d'utilité publique*, 82 (1): 3–23.

Fenster, J. (1994). 'How Bing Crosby brought you audiotape'. *Invention and Technology*: 58–59.

Fikentscher, K. (2003). '"There's not a problem that I can't fix, 'cause I can do it in the mix": on the performative technology of 12-inch vinyl' in Lysloff, R. and Gay, L. (eds) *Music and technoculture*. Wesleyan University Press: Middletown, CT.

Fildes, J. (2008). 'Oldest computer music unveiled', *BBC*. Retrieved 21st January 2010 from <http://news.bbc.co.uk/1/hi/7458479.stm>.

Finnegan, R. (1988). *Literacy and orality: studies in the technology of communication.* Basil Blackwell: New York, NY.

Fishbein, M., and Ajzen, I. (1975). *Belief, attitude, intention, and behaviour: an introduction to theory and research.* Addison-Wesley: Reading, MA.

Fishbein, M., and Ajzen, I. (2010). *Predicting and changing behaviour: the reasoned action approach.* Psychology Press: New York, NY.

Fogg, C. (1996). 'MPEG-2 FAQ', *University of California (Berkeley) Research Pages*. Retrieved 14th April 2012 from <http://web.archive.org/web/20080616113041/http://bmrc.berkeley.edu/research/mpeg/faq/mpeg2-v38/faq_v38.html>.

Fox, B. (1981). 'A hundred years of stereo: fifty of hi-fi'. *New Scientist*, 92 (1285): 908–911.

Franco, J. (2011). 'Over 200,000 BitTorrent users sued for file-sharing in the U.S.', *Tech Spot*. Retrieved August 27th 2011 from <http://www.techspot.com/news/45020-over-200000-bittorrent-users-sued-for-file-sharing-in-the-us.html>.

Frayne, J. (1985). 'History of disk recording'. *Journal of the Audio Engineering Society*, 33 (4): 263–269.

Friedel, R. (2007). *Culture of improvement: technology and the Western millennium.* MIT Press: Cambridge, MA.

Frischmann, B. (2001). 'Privatization and commercialization of the Internet infrastructure: rethinking market intervention into government and government intervention into the market'. *The Columbia Science and Technology Law Review*, 2 (1): 1–70.

Frith, S. (1987). 'Copyright and the music business'. *Popular Music*, 7 (1): 57–75.

Funk, J. (2007). 'Technological change within hierarchies: the case of the music industry'. *Economics of Innovation and New Technology*, 16 (1): 1–16.

Gabbard, C. (2012). 'Pirate Bay promotions draw over 5,000 artists', *Web Pro News*. Retrieved June 20th 2012 from <http://www.webpronews.com/pirate-bay-promotions-draw-over-5000-artists-2012-04>.

Gamble, W. (1923). *Engraving and printing: historical and technical treatise.* Benjamin Blom: New York, NY.

Garofalo, R. (1996). *Rockin' out: popular music in the USA.* Pearson Prentice Hall: Upper Saddle River, NJ.

Gay, L. (2003). 'Before the deluge: the technoculture of songsheet publishing viewed from late-nineteenth-century Galveston' in Lysloff, R. and Gay, L. (eds) *Music and technoculture*. Wesleyan University Press: Middletown, CT.

Gelatt, R. (1977). *The fabulous phonograph: 1877–1977.* Cassell: London.

Giese, M. (2004). 'Community property: digital music and the economic modalities of transmission and ritual modes of communication'. *Journal of Communication Inquiry*, 28 (4): 342–362.

Gitelman, L. (2006). *Always already new: media, history and the data of culture.* MIT Press: Cambridge, MA.

Gladney, H. (2007). *Preserving digital information.* Springer: New York.

Gladwell, M. (2000). *The tipping point.* Little, Brown and Co.: Boston, MA.

Golby, J. (ed.) (1986). *Culture and society in Britain, 1850–1890.* Oxford University Press: Oxford.

Goldstein, P. (2003). *Copyright's highway.* Stanford University Press: Stanford, CA.

Gracyk, T. (2002). 'Outline of Jacques Attali, "Noise"', *Minnesota State University*. Retrieved 25th February 2009 from <http://www.mnstate.edu/gracyk/courses/aesthetics%20of%20music/attali'snoise.htm>.

Greenwood, C. (2010). 'Set yourself free', *Index On Censorship*. Retrieved 13th July 2012 from <http://www.indexoncensorship.org/2010/09/radiohead-copyright-freespeech-music/)>.

Gregg, D. (1967). 'Photoelectric transducer head'. *United States Patent Office* no. 3,349,273.

Gregg, D. (1969). 'Video recording medium and transport'. United States Patent Office no. 3,430,966.

Gregg, D. (1970). 'Video signal transducer having servo controlled flexible fiber optic track centering'. *United States Patent Office* no. 3,530,258.

Grier, K. (1992). 'The decline of Memory Palace: the parlor after 1890' in Foy, J. and Schlereth, T. (eds) *American home life, 1880–1930: a social history of spaces and services*. University of Tennessee Press: Knoxville, TN.

Hainge, G. (2007). 'Vinyl is dead, long live vinyl: the work of recording and mourning in the age of digital reproduction', *Culture Machine*. Retrieved 22nd January 2010 from <http://www.culturemachine.net/index.php/cm/article/viewArticle/81/68>.

Halderman, A. (2003). 'Analysis of the Mediamax CD3 copy-prevention system', *JHalderm*. Retrieved 13th August 2011 from <https://jhalderm.com/pub/cd3/>.

Halliday, J. (2011). 'Musicians win copyright extension to 70 years', *Guardian*. Retrieved 13th November 2012 from <http://www.guardian.co.uk/media/2011/sep/12/musicians-copyright-extension>.

Hamm, C., Nettl, B., and Byrnside, R. (1975). *Contemporary music and music cultures.* Prentice Hall: Englewood, NJ.

Harchaoui, T., and Hamdad, M. (2000). 'The prices of classical recorded music: a hedonic approach'. *International Journal of Industrial Organization*, 18 (3): 497–514.

Häusler, R., and Levine, R. (1980). 'Brain stem auditory evoked potentials are related to interaural time discrimination in patients with multiple sclerosis'. *Brain Research*, 191 (2): 589–594.

Helzner, E., Cauley, J., Pratt, S., Wisniewski, S., Zmuda, J., Talbott, E. et al. (2005). 'Race and sex differences in age-related hearing loss: the health, aging and body composition study'. *Journal of the American Geriatrics Society*, 53 (12): 2119–2127.

Herper, M. (2012). 'The truly staggering cost of inventing new drugs', *Forbes*. Retrieved 11th April 2012 from <http://www.forbes.com/sites/matthewherper/2012/02/10/the-truly-staggering-cost-of-inventing-new-drugs/>.

Hess, R. (2008). 'Tape degradation factors and predicting tape life'. *Association for Recorded Sound Collections*, 39 (2): 240–274.

Hill, G., and Hogge, B. (2008). 'Response of the Open Rights Group to EU proposal to extend the term of copyright protection on sound recordings', *Open Rights Group*. Retrieved 13th November 2012 from <http://www.openrightsgroup.org/uploads/080829_ukipo_ectermextension.pdf>.

Hogarth, G. (1842). 'A village oratorio'. *Mainzer's Musical Times*: 131–133.

Holland, B. (1997, 12th July). 'Labels strive to rectify past archival problems'. *Billboard*: 3.

Honigsberg, P. (2002). 'The evolution and revolution of Napster'. *University of San Francisco Law Review*, 36 (1): 473–509.

Hosokawa, S. (1984). 'The Walkman effect'. *Popular Music*, 4 (1): 165–180.

Huffman, D. (1952). 'A method for the construction of minimum-redundancy codes'. *Proceedings of the Institute of Radio Engineers*, 40 (9): 1098–1101.

Hugenholtz, B. (2008). 'Open letter concerning European Commission's intellectual property package', *Institute for Information Law*.

Retrieved 13th November 2012 from <http://www.ivir.nl/news/Open_Letter_EC.pdf>.

Hutchison, T., Macy, A., and Allen, P. (2010). *Record label marketing.* Focal Press: Burlington, MA.

Intel (2011). 'Moore's Law', *Intel*. Retrieved 14th January 2011 from <http://www.intel.com/technology/mooreslaw/>.

International Federation of the Phonographic Industry (2009). 'Digital music report 2009', *IFPI*. Retrieved 27th August 2012 from <http://www.ifpi.org/content/library/DMR2009.pdf>.

International Telecommunication Union (1998) 'Recommendation BS 1387', *International Telecommunications Union*. Retrieved 8th November 2012 from <http://www.itu.int/rec/R-REC-BS.1387-0-199812-S/en>.

Immink, K. (1998). 'The compact disc story'. *Journal of the Audio Engineering Society*, 46 (1): 458–465.

Jerger, J., Jerger, S., Pepe, A., and Miller, R. (1986). 'Race difference in susceptibility to noise-induced hearing loss'. *American Journal of Otology*, 7 (6): 425–429.

Johnson, W. (1985). 'The economics of copying'. *Journal of Political Economy*, 93 (1): 158–174.

Jones, J. (1901). 'Production of sound-records'. *United States Patent Office* no. 688,739.

Jones, K. 'Bose founder discusses audio perfection and digital music', *Wired*. Retrieved 5th November 2012 from <http://www.wired.com/techbiz/people/news/2007/10/bose_qa>.

Kang, C. (2009). 'Internet speeds are often slower than what consumers pay for, FCC finds', *Washington Post*. Retrieved 9th August 2012 from <http://voices.washingtonpost.com/posttech/2009/09/consumer_often_get_slower_inte.html>.

Katz, M. (2004). *Capturing sound: how technology has changed music.* University of California Press: Berkeley, CA.

Katz, M., and Shapiro, C. (1986). 'Product compatibility choice in a market with technological progress'. *Oxford Economic Papers*, 38 (1): 146–165.

Keller, A., and Rafuse, B. (1938). 'Sound recording and reproducing system'. *United States Patent Office* no. 2,114,471

Kelly, K. (2002). 'Where music will be coming from', *New York Times*. Retrieved 12th February 2009 from <http://www.nytimes.com/2002/03/17/magazine/where-music-will-be-coming-from.html?pagewanted=all&src=pm>.

Koetsier, T. (2001). 'On the prehistory of programmable machines: musical automata, looms, calculators'. *Mechanism and Machine Theory*, 36 (5): 589–603.

Krasner, M. (1979). *Digital encoding of speech and audio signals based on the perceptual requirements of the auditory system* [doctoral dissertation]. Massachusetts Institute of Technology, Boston, MA. Retrieved 5th October 2011 from <http://hdl.handle.net/1721.1/16011>.

Kroeber, A. (1923). *Anthropology.* Harcourt, Brace and Co.: New York, NY.

Laing, D. (1993). 'World record sales figures 1992'. *Popular Music*, 12 (3): 302–303.

Lam, C., and Tan, B. (2001). 'The Internet is changing the music industry'. *Communications of the Association for Computing Machinery*, 44 (8): 62–69.

Langlois, R., and Robertson, P. (1992). 'Networks and innovation in a modular system: lessons from the microcomputer and stereo component industries'. *Research Policy*, 21 (4): 297–313.

Last.fm (2013). 'About', *Last.fm*. Retrieved 9th January 2013 from <http://www.last.fm/about>.

Lessig, L. (2008). *Remix: making art and commerce thrive in the hybrid economy.* Bloomsbury: London.

Leyshon, A., Webb, P., French, S., Thrift, N., and Crew, L. (2005). 'On the reproduction of the musical economy after the Internet'. *Media, Culture and Society*, 27 (2): 177–209.

Liebowitz, S. (1985). 'Copying and indirect appropriability:

photocopying of journals'. *Journal of Political Economy*, 93 (5): 945–957.

Maes, J. (1996). *The MiniDisc.* Focal Press: Oxford.

Makkonen, M., Halttunen, V., and Frank, L. (2011). 'Exploring the acquisition and consumption behaviour of modern recorded music consumers: findings from a Finnish interview study'. *International Journal of Computer Information Systems and Industrial Management Applications*, 3 (1): 894–904.

Malsky, M. (2003). 'Stretched from Manhattan's back alley to MOMA: a social history of magnetic tape and recording' in Lysloff, R. and Gay, L. (eds) *Music and technoculture*. Wesleyan University Press: Middletown, CT.

Mann, C. (2000). 'The heavenly jukebox'. *Atlantic Monthly*, 286 (3): 53.

Manuel, P. (1993). *Cassette culture: popular music and technology in North India.* University of Chicago Press: Chicago.

Martland, P. (2013). *Recording history: the British record industry, 1888–1931*. Scarecrow Press: Lanham, MD.

Matutes, C., and Regibeau, P. (1988). 'Mix and match: product compatibility without network externalities'. *RAND Journal of Economics*, 19 (2): 221–234.

Maxfield, J., and Harrison, H. (1926). 'Methods of high quality recording and reproducing of music and speech based on telephone research'. *Bell System Technical Journal*, 5 (1): 493–523.

Mayer, A. (1894). 'Researches in acoustics'. *London, Edinburgh and Dublin Philosophical Magazine*, 37 (1): 259–288.

McCann, P. (1998). 'A new CD costs pounds 14.49, or, you could download it for free on the Internet: no wonder the music business is sounding off', *Independent*. Retrieved 30th October 2012 from <http://www.independent.co.uk/news/a-new-cd-costs-pounds-1449-or-you-could-download-it-for-free-on-the-internet-no-wonder-the-music-business-is-sounding-off-1156440.html>.

McElhone, K. (2004). *Mechanical music.* Shire: Oxford.

McFadden, D. (1993). 'A speculation about the parallel ear asymmetries and sex differences in hearing sensitivity and otoacoustic emissions'. *Hearing Research*, 68 (2): 143–151.

McLuhan, M. (1964). *Understanding media.* Kegan Paul: London.

Mearian, L. (2012). 'IBM smashes Moore's Law, cuts bit size to 12 atoms', *CIO*. Retrieved 7th November 2012 from <http://www.cio.com/article/697977/IBM_Smashes_Moore_s_Law_Cuts_Bit_Size_to_12_Atoms>.

Meerman-Scott, D., and Halligan, B. (2010, 1st August). 'Marketing lessons from the Grateful Dead'. *The Sunday Times*: 16–17.

Meerman-Scott, D., and Halligan, B. (2010b). *Marketing lessons from the Grateful Dead: what you can learn from the most iconic band in history.* John Wiley and Sons: Hoboken, NJ.

Menn, J. (2003). *All the rave: the rise and fall of Shawn Fanning's Napster.* Crown Business: New York, NY.

Metropolis Studios (2012a). 'Welcome to Metropolis Studios', *Metropolis Studios*. Retrieved 8th November 2012 from <http://metropolis-group.co.uk/studios/>.

Metropolis Studios (2012b). 'Studio session photos', *MySpace* (*Metropolis Studios*). Retrieved 8th November 2012 from <http://www.myspace.com/metropolisstudios/photos/albums/studio-sessions/1005617>.

Micallef, K. (2011). 'Grohl's garage', *eMusician*. Retrieved 28th September 2012 from <http://www.emusician.com/features-interviews/0777/the-foo-fighters--grohls-garage/140095>.

Millard, A. (1995). *America on record: a history of recorded sound.* Cambridge University Press: Cambridge.

Mock, T. (2004). 'Music everywhere: it's all about the algorithm, but which one will win?', *IEEE Spectrum*. Retrieved 28th January 2012 from <http://spectrum.ieee.org/consumer-electronics/standards/music-everywhere/0>.

Mokyr, J. (2000). 'Evolutionary phenomena in technological change' in Ziman, J. (ed.) *Technological innovation as an evolutionary process*. Cambridge University Press: Cambridge.

Møller, A. (2006). *Hearing: anatomy, physiology, and disorders of the* *auditory system.* Elsevier: Burlington, MA.

Monaco, J. (1999). *The dictionary of new media: the new digital world of video, audio, and print.* Harbor Electronic Publishing: New York, NY.

Monster Cat (2012). 'Hello', *The Pirate Bay*. Retrieved 8th May 2012 from <http://www.thepiratebay.se>>.

Morton, D. (2004). *Sound recording: the life story of a technology.* Greenwood Press: Westport, CT.

Music Week (2010). 'Average CD price bottoms out', *Music Week*. Retrieved 13th July 2012 from <http://www.musicweek.com/story.asp?storyCode=1040591&sectioncode=1>.

Mzimba, L. (2008). 'McFly announce new album giveaway', *BBC*. Retrieved 5th July 2011 from <http://news.bbc.co.uk/1/hi/entertainment/7472226.stm>.

Negus, K. (1992). *Producing pop: culture and conflict in the popular music industry.* Edward Arnold: London.

Nijsen, P. (1984a). 'And the music went round and round on rolls, disks, or reels: part 1'. *Journal of the Audio Engineering Society*, 32 (3): 162–178.

Nijsen, P. (1984b). 'And the music went round and round on rolls, disks, or reels: part 2'. *Journal of the Audio Engineering Society*, 32 (4): 262–273.

NME (2007). 'Ash deny they're splitting', *NME*. Retrieved 5th October 2011 from <http://www.nme.com/news/ash/28918>.

Nyquist, H. (1928). 'Certain topics in telegraph transmission theory'. *Transactions of the American Institute of Electrical Engineers*, 47 (2): 614–644.

Olson, H. (1954). 'A review of twenty five years of sound reproduction'. *The Journal of the Acoustical Society of America*, 26 (5): 637–643.

Olson, H. (1972). *Modern sound reproduction.* Van Nostrand Reinhold: New York, NY.

Ondo, W., Sutton, L., Vuong, K., Lai, D., and Jankovic, J. (2003). 'Hearing impairment in essential tremor'. *Neurology*, 61 (8): 1093–1097.

Oord, G. (1977, 18 April). 'Signals beyond the dreams of Edison'. *The Times*: 16.

Osborne, H. (2012). 'Do you own your digital content?', *Guardian*. Retrieved 20th November 2012 from <http://www.guardian.co.uk/money/2012/sep/03/do-you-own-your-digital-content>.

Oxford Dictionaries (2012). 'File-sharing: definition', *Oxford Dictionaries*. Retrieved 23rd May 2012 from <http://oxforddictionaries.com/definition/english/file-sharing?q=file-sharing>.

Palombini, C. (1993). 'Machine songs V: Pierre Schaeffer—from research into noises to experimental music'. *Computer Music Journal*, 17 (3): 14–19.

Patokos, T. (2008). 'A new era for the music industry: how new technologies and the Internet affect the way music is valued and have an impact on output quality'. *Panoeconomicus*, 2 (1): 233–248.

Pavlov, I. (1910). *The work of the digestive glands.* Charles Griffin and Co.: London.

Peitz, M., and Waelbroeck, P. (2004). 'Piracy of digital products: a critical review of the theoretical literature'. *Information Economics and Policy*, 18 (4): 1–27.

Perlman, M. (2003). 'Consuming audio: an introduction to tweak theory' in Lysloff, R. and Gay, L. (eds) *Music and technoculture*. Wesleyan University Press: Middletown, CT.

Petersen, J. (2005). 'Comment', *Wired blog network*. Retrieved 10th July 2012 from <http://longtail.typepad.com/the_long_tail/2005/01/definitions_fin.html#comment-3415583>.

Philips, C. (2001). 'Record label chorus: high risk, low margin', *Los Angeles Times*. Retrieved 3rd October 2012 from <http://articles.latimes.com/2001/may/31/news/mn-4713>.

Pinch, T., and Bijsterveld, K. (2004). 'Sound studies: new technologies and music'. *Social Studies of Science*, 34 (5): 635–648.

Pohlmann, K. (1989). *The Compact Disc: a handbook of theory and use.* Oxford University Press: Oxford.

Poulsen, V (1899). 'Apparatus for effecting the storing up of speech or signals'. *United States Patent Office* no. 822,222.

Poulsen, V (1906). 'Magnetizable body for the magnetic record of speech &c'. *United States Patent Office* no. 836,339.

Power, D., and Jansson, J. (2004). 'The emergence of a post-industrial music economy?: music and ICT synergies in Stockholm, Sweden'. *Geoforum*, 35 (4): 425–439.

Price, D. (ed.) (1912). *The notebooks of Samuel Butler.* A.C. Fifield: London.

Rainie, L., and Madden, M. (2004). 'Preliminary findings from a web survey of musicians and songwriters', *Pew Internet and American Life Project*. Retrieved 18th April 2011 from <www.pewinternet.org/pdfs/PIP_Musicians_Prelim_ Findings.pdf>.

Ratazzi, P. (2004). *MiniDisc: successful innovation or just cool technology? An analysis of Sony's decade-long quest for success* [Masters dissertation]. Air Force Research Laboratory: Rome, NY.

Read, O., and Welch, W. (1959). *From tinfoil to stereo: the acoustic years of the recording industry, 1877–1929.* Howard W. Sams and Co.: New York, NY.

Robertshaw, N. (1982, 6th November). 'The world turns to tape'. *Billboard*: WC-3.

Rogers, E. (2003). *Diffusion of innovations.* Free Press: New York, NY.

Rohlfs, J. (2001). *Bandwagon effects in high-technology industries.* MIT Press: Cambridge, MA.

Rohr, D. (2001). *The careers of British musicians, 1750–1850: a profession of artisans.* Cambridge University Press: Cambridge.

Rolling Stone (2003, 1st May). 'Untitled'. *Rolling Stone*: 36.

Rosenberg, N. (1982). *Inside the black box: technology and economics.* Cambridge University Press: Cambridge.

Rosenberg, N. (1996). 'Uncertainty and technological change' in Landau, R., Taylor, T., and Wright, G. (eds) *The mosaic of economic growth*.

Stanford University Press: Palo Alto, CA.

Rosheim, M. (1994). *Robot evolution: the development of anthrobotics.* John Wiley and Sons: Chicago.

Roth, E. (1966). *The business of music.* Cassell: London.

Rothenbuhler, E., and Peters, J. (1997). 'Defining phonography: an experiment in theory'. *Musical Quarterly*, 81 (2): 242–264.

Rubin, D. (1997). *Memory in oral traditions: the cognitive psychology of epic, ballads, and counting-out rhymes.* Oxford University Press: New York, NY.

Rupp, S. (2003). 'John Dowland's strategic melancholy and the rise of the composer in early modern England' in Schülting, S., Döring, T., and Greiner, N. (eds) *Shakespeare jahrbuch 139*. Verlag und Druckkontor Kamp GmbH: Bochum.

Russell, D. (1987). *Popular music in England, 1840–1914: a social history.* Manchester University Press: Manchester.

Ryan, M. (1998). *Knowledge diplomacy: global competition and the politics of intellectual property.* Brookings Institution: Washington, DC.

Sadler, D. (1997). 'The global music business as an information industry: reinterpreting economies of culture'. *Environment and Planning*, A (29): 1919–1936.

Sandoval, G. (2007). 'Free beats fee for Radiohead's *In Rainbows*', *CNET*. Retrieved 13th July 2002 from <http://news.cnet.com/8301-10784_3-9811013-7.html>.

Sanjek, R., and Sanjek, D. (1988). *American popular music business in the 20th century* [three volumes]. Oxford University Press: New York.

Saunders, J. (1951). 'The stigma of print: a note on the social bases of Tudor poetry'. *Essays in Criticism*, 1 (1): 139–164.

Savage, M. (2010). 'How commonplace is auto-tune?', *BBC*. Retrieved 23rd October 2012 from <http://www.bbc.co.uk/news/entertainment-arts-11056840>.

Schick, K., and Toth, N. (1993). *Making silent stones speak: human evolution and the dawn of technology.* Simon and Schuster: New York, NY.

Schmidt Horning, S. (2004). 'Engineering the performance: recording engineers, tacit knowledge, and the art of controlling sound'. *Social Studies of Science*, 34 (5): 703–731.

Schofield, J. (2005). 'Andreas Pavel, inventor of the portable personal stereo', *Guardian*. Retrieved 27th November 2012 from <http://www.guardian.co.uk/technology/blog/2005/dec/18/andreaspaveli>.

Schroeder, M., Atal, B., and Hall, J. (1979). 'Optimizing digital speech coders by exploiting masking properties of the human ear'. *The Journal of the Acoustical Society of America*, 66 (6): 1647–1652.

Schuller, D. (2001). 'Preserving the facts for the transfer of analog audio documents into the digital domain'. *Journal of the Audio Engineering Society*, 49 (7/8): 618–621.

Scott de Martinville, E. (1857). 'Phonautograph'. *French Patent Office* no. 31470.

Shaw, G. (1889, 21st February). 'Music in Bow'. *Star*: 7.

Sherburne, P. (2003). 'Digital DJing app that pulls you in'. *Grooves*, 10 (1): 46–47.

Shields, R. (2009). 'Illegal downloaders "spend the most on music", says poll', *Independent*. Retrieved 10th March 2011 from <http://www.independent.co.uk/news/uk/crime/illegal-downloaders-spend-the-most-on-music-says-poll-1812776.html>.

Shure (2013). 'SM58 vocal microphone', *Shure*. Retrieved 5th January 2013 from <http://www.shure.com/ProAudio/Products/WiredMicrophones/us_pro_SM58-CN_content>.

Smith, O. (1888). 'Some possible forms of phonograph'. *The Electrical World*, 9 (1): 116.

Somajo, S. (2012). 'Hello lover', *You Can Call Me SoSo*. Retrieved 31st May 2012 from <http://www.youcancallmesoso.com/letter.html>.

Sony (1999). 'Sony celebrates Walkman 20th anniversary', *Sony*. Retrieved 20th January 2010 from <http://www.sony.net/SonyInfo/News/Press_Archive/199907/9

9-059/>.

Sony (2007). 'Sony CONNECT Europe', *Sony*. Retrieved 18th December 2011 from <http://www.connect-europe.com/>.

Sony (2011a). 'Product and technology milestones: personal audio', *Sony*. Retrieved 10th March 2011 from <http://www.sony.net/sonyinfo/corporateinfo/history/sonyhistory-e.html>.

Sony (2011b). 'PRMD-74: overview/features', *Sony*. Retrieved 10th March 2011 from <http://www.sony.co.uk/biz/product/apm-professional-minidisc/prmd-74/overview>.

Sony (2011c). 'ATRAC overview', *Sony*. Retrieved 10th March 2011 from <http://www.sony.net/products/ATRAC3/overview/index.html>.

Spotify (2013). 'What is Spotify?', *Spotify*. Retrieved 22nd January 2013 from <http://www.spotify.com/uk/about-us/press/ information/>.

Sterne, J. (1997). 'Sounds like the Mall of America: programmed music and the architectonics of commercial space'. *Ethnomusicology*, 41 (1): 22–50.

Sterne, J. (2003). *The audible past: cultural origins of sound reproduction.* Duke University Press: London.

Sterne, J. (2006). 'The MP3 as cultural artifact'. *New Media Society*, 8 (5): 825–842.

Stuckenschmidt, H. (1927). 'Machines: a vision of the future'. *Modern Music*, 4 (2): 8-14.

Sturman, J. (2003). 'Technology and identity in Colombian popular music: "tecno-macondismo" in Carlos Vives's approach to "Vallenato"' in Lysloff, R. and Gay, L. (eds) *Music and technoculture*. Wesleyan University Press: Middletown, CT.

Terhardt, E., Stoll, G., and Seewann, M. (1982). 'Algorithm for extraction of pitch and pitch salience from complex tonal signals'. *The Journal of the Acoustical Society of America*, 71 (3): 679–687.

The Pirate Bay (2008). '25 Million!', *The Pirate Bay*. Retrieved 31st January 2011 from <http://thepiratebay.org/blog/138>.

Thiele, H. (1988). 'Magnetic sound recording in Europe up to 1945'. *Journal of the Audio Engineering Society*, 36 (5): 396–408.

Thompson, G. (2006). *American culture in the 1980s.* Edinburgh University Press: Edinburgh.

Thompson, S., and Sinha, R. (2008). 'Brand communities and new product adoption: the influence and limits of oppositional loyalty'. *Journal of Marketing*, 72 (6): 65–80.

Torrent Freak (2012). 'Pirate Bay enjoys 12 million traffic boost, shares unblocking tips', *Torrent Freak*. Retrieved 5th May 2012 from <http://torrentfreak.com/pirate-bay-enjoys-12-million-traffic-boost-shares-unblocking-tips-120502/>.

Towse, R. (2001). 'Quis custodiet? Or managing the management: the case of the Royal Opera House, Covent Garden'. *International Journal of Arts Management*, 3 (3): 38–50.

Treitler, L. (1981). 'Oral, written, and literate process in the transmission of medieval music'. *Speculum*, 56 (3): 471–491.

United States Bureau of Labor Statistics (2012). 'Occupational employment and wages: 27-4014 sound engineering technicians', *United States Bureau of Labor Statistics*. Retrieved 7th November 2012 from <http://www.bls.gov/oes/current/oes274014.htm>.

United States Patent and Trademark Office (2012). 'Patents', *United States Patent and Trademark Office*. Retrieved 5th January 2012 from <http://www.uspto.gov/inventors/patents.jsp#heading-5>.

van Loon, J. (2008). *Media technology: critical perspectives.* Open University Press: Buckingham.

van Wijk, F., Staecker, H., Keithley, E., and Lefebvre, P. (2006). 'Local perfusion of the tumor necrosis factor α blocker Infliximab to the inner ear improves autoimmune neurosensory hearing loss'. *Audiology and Neurotology*, 11 (6): 357–365.

Vonnegut, K. (1987). *Bluebeard.* Delacorte Press: New York, NY.

Wallis, R., and Malm, K. (1984). *Big sounds from small peoples: the music industry in small countries.* Constable: London.

Watkinson, J. (2001). *The art of digital audio.* Focal Press: Oxford.

Weber, W. (2004). 'Musical culture and the capital city: the epoch of the beau monde in London 1700–1870' in Wollenberg, S. and McVeigh, S. (eds) *Concert life in eighteenth-century Britain.* Ashgate: Aldershot.

Wegman, R. (2005). 'Musical offerings in the Renaissance'. *Early Music*, 33 (3): 425–437.

Wente, E. (1917). 'A condenser transmitter as a uniformly sensitive instrument for the absolute measurement of sound intensity'. *Physical Review*, 10 (1): 39–63.

Wente, E. (1922). 'The sensitivity and precision of the electrostatic transmitter for measuring sound intensities'. *Physical Review*, 19 (5): 498–503.

Westaway, L. (2012). 'Pirate Bay claims record number of visitors following ISP ban', *CNET*. Retrieved May 5th 2012 from <http://crave.cnet.co.uk/software/pirate-bay-claims-record-number-of-visitors-following-isp-ban-50007855/>.

Westcott, W. (1998). 'Bells and their music', *Michigan State University*. Retrieved 9th December 2009 from <https://www.msu.edu/~carillon/batmbook/>.

Wex Photographic (2012). 'LaCie 5big Network 2 10 terabyte hard drive', *Wex Photographic*. Retrieved 13th November 2012 from <http://www.wexphotographic.com/buy-lacie-5big-network-2-10tb-hard-drive/p1530219?cm_mmc=GoogleBase-_-hard-drives-_-external-hard-drives-_-lacie-5big-network-2-10tb-hard-drive_1530219&utm_source=googlebase>.

Wierzbicki, J. (1985). 'Music in society', *Personal Website*. Retrieved 31st May 2009 from <http://pages.sbcglobal.net/jameswierzbicki/dinner.htm>.

Wollenberg, S. and McVeigh, S. (eds) *Concert life in eighteenth-century Britain.* Ashgate: Aldershot.

Xiph (2008). 'Homepage', *Xiph*. Retrieved 14th March 2012 from <http://www.vorbis.com/>.

Zhang, M. (2002). *A review of the economic properties of music distribution* [doctoral dissertation]. Massachusetts Institute of Technology, Cambridge, MA.

Bibliography

A&M Records v. Napster (2001). *United States Court of Appeals for the 9th Circuit*, 239 F 3d 1004.

Ahlkvist, J., and Fisher, G. (2000). 'And the hits just keep on coming: music programming standardization in commercial radio'. *Poetics*, 27 (6): 301–325.

Aksoy, A. (1992). 'Mapping the information economy: integration for flexibility' in Robins, K. (ed.) *Understanding information: business, technology and geography*. Belhaven Press: London.

Allen, K. (2009, 24 November). 'Money, money, money. Swedish music sales rise after anti-piracy laws passed'. *The Guardian*: 24.

Anderson, R., and Moore, T. (2006). 'The economics of information security'. *Science*, 314 (5799): 610–613.

Andreasen, A., and Belk, R. (1980). 'Predictors of attendance at the performing arts'. *The Journal of Consumer Research*, 7 (2): 112–120.

Anheier, H., and Isar, Y. (eds) (2008). *The cultural economy.* Sage Publications: London.

Anon. (1887). 'Tenth statistical abstract: population'. *United States Census*: 1–254.

Arewa, O. (2006a). 'Copyright on Catfish Row: musical borrowing, *Porgy and Bess*, and unfair use'. *Rutgers Law Journal*, 37 (2): 277–354.

Arewa, O. (2006b). 'From J.C. Bach to hip hop: musical borrowing, copyright and cultural context'. *North Carolina Law Review*, 84 (2): 547–642.

Arnould, E. (1989). 'Toward a broadened theory of preference formation and the diffusion of innovations: cases from Zinder province, Niger Republic'. *The Journal of Consumer Research*, 16 (2): 239–267.

Aronson, A. (1946). 'The anatomy of taste'. *Modern Language Notes*, 61

(4): 228–236.

Attali, J. (1983). 'Interview with Jacques Attali'. *Social Text*, 7 (1): 3–18.

Banks, M., Lovatt, A., O'Connor, J., and Raffo, C. (2000). 'Risk and trust in the cultural industries'. *Geoforum*, 31 (4): 453–464.

Barabási, A., and Albert, R. (1999). 'Emergence of scaling in random networks'. *Science*, 286 (5439): 509–512.

Barbalet, J. (2001). *Emotion, social theory, and social structure: a macrosociological approach.* Cambridge University Press: Cambridge.

Battani, M., and Hall, J. (2000). 'Richard Peterson and cultural theory: from genetic, to integrated, and synthetic approaches'. *Poetics*, 28 (3): 137–156.

Becker, H. (2008). *Art worlds.* University of California Press: Berkeley, CA.

Beckman, G. (2001). *Disciplining the arts: teaching entrepreneurship in context*. Rowman and Littlefield: Plymouth.

Belfiore, E., and Bennett, O. (2007). 'Determinants of impact: towards a better understanding of encounters with the arts'. *Cultural Trends*, 16 (3): 225–275.

Belk, R. (1988). 'Possessions and the extended self'. *The Journal of Consumer Research*, 15 (2): 139–168.

Benjamin, W. (1935). *Illuminations: essays and reflections* [English translation by Harry Zohn, 1968]. Schocken: New York, NY.

Bennett, A., and Kahn-Harris, K. (eds) (2004). *After subcultures: critical studies in contemporary youth culture.* Palgrave Macmillan: London.

Bennett, T. (2006). 'Cultural capital and inequality: refining the policy calculus'. *Cultural Trends*, 15 (2): 239–244.

Bennett, T., and Savage, M. (2004). 'Cultural capital and cultural policy'. *Cultural Trends*, 13 (2): 7–14.

Bennett, T., and Silva, E. (2006). 'Introduction cultural capital and inequality: policy issues and contexts'. *Cultural Trends*, 15 (2): 87–106.

Bentley, A., Lipo, C., Herzog, H., and Hahn, M. (2007). 'Regular rates of popular culture change reflect random copying'. *Evolution and Human Behaviour*, 28 (3): 151–158.

Berberich, K., Bedathur, S., Vazirgiannis, M., and Weikum, G. (2006). 'BuzzRank . . . and the trend is your friend'. *Proceedings of the 15th International Conference on World Wide Web*: 937–938.

Berger, J., and Heath, C. (2007). 'Where consumers diverge from others: identity signaling and product domains'. *Journal of Consumer Research*, 34 (2): 121–134.

Berry, D. (2008). *Copy, rip, burn: the politics of copyleft and open source.* Pluto Press: London.

Berry, S., and Waldfogel, J. (1999). 'Public radio in the United States: does it correct market failure or cannibalize commercial stations?'. *Journal of Public Economics*, 71 (2): 189–211.

Bhattacharjee, S., Gopal, R., Lertwachara, K., and Marsden, J. (2006). 'Whatever happened to payola?: an empirical analysis of online music sharing'. *Decision Support Systems*, 42 (1): 104–120.

Bhattacharjee, S., Gopal, R., Lertwachara, K., and Marsden, J. (2007). 'Stochastic dynamics of music album life-cycle: an analysis of the new market landscape'. *International Journal of Human-Computer Studies*, 65 (1): 85–93.

Bhattacharjee, S., Gopal, R., Marsden, J., and Sankaranarayanan, R. (2009). 'To theme or not to theme: can theme strength be the music industry's "killer app"?'. *Decision Support Systems*, 48 (1): 141–149.

Biagi, S. (2002). *Media/impact: an introduction to mass media.* Wadsworth: Kentucky.

Bikhchandani, S., Hirshleifer, D., and Welch, I. (1992). 'A theory of fads, fashion, custom, and cultural change as informational cascades'. *The Journal of Political Economy*, 100 (5): 992–1026.

Blanton, H., and Christie, C. (2003). 'Deviance regulation: a theory of action and identity'. *Review of General Psychology*, 7 (2): 115–149.

Boldrin, M., and Levine, D. (2008). *Against intellectual monopoly.* Cambridge University Press: Cambridge.

Booth, G., and Kuhn, T. (1990). 'Economic and transmission factors as essential elements in the definition of folk, art, and pop music'. *The Musical Quarterly*, 74 (3): 411–438.

Bourdieu, P. (1979). *Distinction: a social critique of the judgement of taste* [English translation by Richard Nice, 2006]. Routledge: Oxford.

Bourdieu, P. (2005). *The social structures of the economy* [English translation by Chris Turner, 2005]. Polity Press: Cambridge.

Boyd, J. (2005). *White bicycles: making music in the 1960s*. Serpent's Tail: London.

Breen, M., and Forde, E. (2004). 'The music industry, technology and utopia: an exchange between Marcus Breen and Eamonn Forde'. *Popular Music*, 23 (1): 79–89.

Brewer, J., and Porter, R. (eds) (1993). *Consumption and the world of goods.* Routledge: London.

Brown, A., O'Connor, J., and Cohen, S. (2000). 'Local music policies within a global music industry: cultural quarters in Manchester and Sheffield'. *Geoforum*, 31 (4): 437–451.

Brown, S., and Volgsten, U. (eds) (2006). *Music and manipulation: on the social uses and social control of music*. Berghahn Books: Oxford.

Broyles, M. (1991). 'Music and class structure in antebellum Boston'. *Journal of the American Musicological Society*, 44 (3): 451–493.

Bryson, B. (1996). 'Anything but heavy metal: symbolic exclusion and musical dislikes'. *American Sociological Review*, 61 (5): 884–899.

Bunting, C. (2005). 'Social stratification of cultural consumption: a policy response from Arts Council England'. *Cultural Trends*, 14 (3): 213–216.

Burkart, P., and McCourt, T. (2004). 'Infrastructure for the celestial jukebox'. *Popular Music*, 23 (3): 349–362.

Burrows, R., and Marsh, C. (eds) (1992). *Consumption and class.* Macmillan: London.

Callahan, M. (2005). *The trouble with music.* AK Press: Edinburgh.

Carlton, R. (1995). 'The public marketing of music'. *International Review of the Aesthetics and Sociology of Music*, 26 (1): 123–132.

Chan, T., and Goldthorpe, J. (2007). 'The social stratification of cultural consumption: some policy implications of a research project'. *Cultural Trends*, 16 (4): 373–384.

Cherrier, H., and Lego-Munoz, C. (2007). 'A reflection on consumers' happiness: the relevance of care for others, spiritual reflection, and financial detachment'. *Journal of Research for Consumers*, 12 (1): 1–19.

Choi, D., and Perez, A. (2007). 'Online piracy, innovation, and legitimate business models'. *Technovation*, 27 (4): 168–178.

Chopyak, J. (1987). 'The role of music in mass media, public education and the formation of a Malaysian national culture'. *Ethnomusicology*, 31 (3): 431–454.

Chung, S., Singh, H., and Lee, K. (2000). 'Complementarity, status similarity and social capital as drivers of alliance formation'. *Strategic Management Journal*, 21 (1): 1–22.

Churchill, N. (2007). 'The golden age of the arts?'. *Cultural Trends*, 16 (4): 357–359.

Clair, C. (1965). *A history of printing in Britain.* Cassell and Co.: London.

Clark, K., and Maeer, G. (2008). 'The cultural value of heritage: evidence from the Heritage Lottery Fund'. *Cultural Trends*, 17 (1): 23–56.

Collins, D. (1985). 'Ritual sacrifice and the political economy of music'. *Perspectives of New Music*, 24 (1): 14–23.

Comor, E. (2000). 'Household consumption on the Internet: income, time, and institutional contradictions'. *Journal of Economic Issues*, 34 (1): 105–116.

Cook, D., and Wang, W. (2004). 'Neutralizing the piracy of motion pictures: reengineering the industry's supply chain'. *Technology in Society*, 26 (4): 567–583.

Coulangeon, P., and Lemel, Y. (2007). 'Is "distinction" really outdated?: questioning the meaning of the omnivorization of musical taste in contemporary France'. *Poetics*, 35 (3): 93–111.

Cowell, B. (2007). 'Measuring the impact of free admission'. *Cutural Trends*, 16 (3): 203–224.

Coyle, J., Gould, S., Gupta, P., and Gupta, R. (2009). 'To buy or to pirate: the matrix of music consumers' acquisition-mode decision-making'. *Journal of Business Research*, 62 (10): 1031–1037.

Crain, M., and Tollison, R. (1997). 'Economics and the architecture of popular music'. *Journal of Economic Behavior and Organisation*, 32 (2): 185–205.

Crane, D., Kawashima, N., and Kawasaki, K. (eds) (2002). *Global culture: media, arts, policy, and globalization.* Routledge: New York, NY.

Cruz, J. (2002). 'Nineteenth-century United States religious crisis and the sociology of music'. *Poetics*, 30 (2): 5–18.

Daniel, E., and Klimis, G. (1999). 'The impact of electronic commerce on market structure: an evaluation of the electronic market hypothesis'. *European Management Journal*, 17 (3): 318–325.

Davidson, M. (2000). 'Copyright'. *Notes*, 56 (3): 598–604.

DeFreitas, D. (1989). 'Copyright and music'. *Journal of the Royal Musical Association*, 114 (1): 69–79.

Deighton, J. (1992). 'The consumption of performance'. *The Journal of Consumer Research*, 19 (3): 362–372.

Demers, J. (2006). 'Dancing machines: "Dance Dance Revolution", cybernetic dance, and musical taste'. *Popular Music*, 25 (3): 401–414.

DeNora, T. (1999). 'Music as a technology of the self'. *Poetics*, 27 (1): 31–56.

DeNora, T. (2004). 'Historical perspectives in music sociology'. *Poetics*, 32 (4): 211–221.

DeNora, T., and Witkin, R. (2001). 'Configuring the classics: musical experience and musical consciousness'. *Poetics*, 29 (2): 71–74.

Dent, E. (1917). 'Music in university education'. *The Musical Quarterly*, 3 (4): 605–619.

DeVoss, D., and Porter, J. (2006). 'Why Napster matters to writing: file-sharing as a new ethic of digital delivery'. *Computers and Composition*, 23 (2): 178–210.

DeWolf, R. (1943). 'Copyright in music'. *Notes*, 1 (1): 3–13.

Dickson, P. (2000). 'Understanding the trade winds: the global evolution of production, consumption, and the Internet'. *The Journal of Consumer Research*, 27 (1): 115–122.

DiMaggio, P. (1996). 'Are art-museum visitors different from other people?: the relationship between attendance and social and political attitudes in the United States'. *Poetics*, 24 (4): 161–180.

DiMaggio, P. (2000). 'The production of scientific change: Richard Peterson and the institutional turn in cultural sociology'. *Poetics*, 28 (3): 107–136.

DiMaggio, P., and Mukhtar, T. (2004). 'Arts participation as cultural capital in the United States, 1982–2002: signs of decline?'. *Poetics*, 32 (2): 169–194.

DiMaggio, P., and Useem, M. (1978). 'Social class and arts consumption: the origins and consequences of class differences in exposure to the arts in America'. *Theory and Society*, 5 (2): 141–161.

Doane, R. (2006). 'Digital desire in the daydream machine'. *Sociological Theory*, 24 (2): 150–169.

Dowd, T. (2002b). 'Introduction: explorations in the sociology of music'. *Poetics*, 30 (1): 1–3.

Duchêne, A., and Waelbroeck, P. (2006). 'The legal and technological battle in the music industry: information-push versus information-pull technologies'. *International Review of Law and Economics*, 26 (4): 565–580.

Durrant, J., and Lovrinic, J. (1995). *Bases of hearing science.* Williams and Wilkins: Baltimore, MD.

Dynan, K. (2000). 'Habit formation in consumer preferences: evidence from panel data'. *The American Economic Review*, 90 (3): 391–406.

Eargle, J. (1990). *Music, sound, and technology.* Van Nostrand Reinhold: New York, NY.

Eargle, J. (2004). *The microphone book.* Focal Press: Oxford.

Ehrlich, C. (1977). 'Economic history and music'. *Proceedings of the Royal Music Association*, 103 (1): 188–199.

Eisenstein, E. (1983). *The printing revolution in early modern Europe.* Cambridge University Press: Cambridge, MA.

Ekström, K., and Brembeck, H. (eds) (2004). *Elusive consumption.* Berg: Oxford.

Elborough, T. (2008). *The long-player goodbye: the album from vinyl to* *iPod and back again*. Sceptre: London.

Ellul, J. (1954). *The technological society* [English translation by John Wilkinson, 1964]. Vintage Books: New York, NY.

Etzkorn, P. (1964). 'Georg Simmel and the sociology of music'. *Social Forces*, 43 (1): 101–107.

Evans, G., and Foord, J. (2008). 'Cultural mapping and sustainable communities: planning for the arts revisited'. *Cultural Trends*, 17 (2): 65–96.

Fairchild, C. (2008). *Pop idols and pirates: mechanisms of consumption and the global circulation of popular music.* Ashgate: Aldershot.

Fetscherin, M. (2005). 'Movie piracy on peer-to-peer networks: the case of Kazaa'. *Telematics and Informatics*, 22 (2): 57–70.

Field, A., Hartel, P., and Mooij, W. (2001). 'Personal DJ: an architecture for personalized content delivery'. *Proceedings of the 10th International Conference on World Wide Web*: 1–7.

Fine, T. (2008). 'The dawn of commercial digital recording'. *Journal of the Association for Recorded Sound Collections*, 39 (1): 1–18.

Fischer, M. (2007). 'Culture and cultural analysis as experimental systems'. *Cultural Anthropology*, 22 (1): 1–65.

Fisher, L. (1988). 'Removing the static from old recordings', *New York Times*. Retrieved 8th September 2010 from <http://www.nytimes.com/1988/12/21/business/business-technology-removing-the-static-from-old-recordings.html?pagewanted=1>.

Flora, J. (1998). 'Social capital and communities of place'. *Rural Sociology*, 63 (4): 481–506.

Forte, D. (2001). 'Peer-to-peer file-sharing is here to stay: Napster's definitive shift to a pay service means more problems for system administrators. Meanwhile, other similar systems are gaining a foothold'. *Network Security*, 2001 (1): 9–11.

Foy, J., and Schlereth, T. (eds) (1992). *American home life, 1880–1930: a social history of spaces and services.* University of Tennessee Press: Knoxville, TN.

Fraser, A., and Ettlinger, N. (2008). 'Fragile empowerment: the dynamic cultural economy of British drum and bass music'. *Geoforum*, 39 (5): 1647–1656.

Fuld, J. (1973). 'Early copyright'. *The Musical Times*, 114 (1559): 32.

Gagnier, R. (2000). *The insatiability of human wants: economics and aesthetics in market society.* University of Chicago Press: Chicago, IL.

Gainer, B. (1995). 'Ritual and relationships: interpersonal influences on shared consumption'. *Journal of Business Research*, 32 (2): 253–260.

Garofalo, R. (1987). 'How autonomous is relative: popular music, the social formation and cultural struggle'. *Popular Music*, 6 (1): 77–92.

Garofalo, R. (1999). 'Music publishing to MP3: music and industry in the twentieth century'. *American Music*, 17 (3): 318–354.

Gasser, U., and Ernst, S. (2006). 'From Shakespeare to DJ Danger Mouse: a quick look at copyright and user creativity in the digital age'. *Berkman Centre for Internet and Society Research Publication*, 5 (1): 1–19.

Geels, F. (2007). 'Analysing the breakthrough of rock 'n' roll (1930–1970): multi-regime interaction and reconfiguration in the multi-level perspective'. *Technological Forecasting and Social Change*, 74 (8): 1411–1431.

Gelfand, S. (1998). *Hearing: an introduction to psychological and physiological acoustics.* Marcel Dekker: New York, NY.

Giles, D., Pietrzykowski, S., and Clark, K. (2007). 'The psychological meaning of personal record collections and the impact of changing technological forms'. *Journal of Economic Psychology*, 26 (4): 429–443.

Gitlin, T. (2002). *Media unlimited: how the torrent of images and sounds overwhelms our lives*. Henry Holt and Co.: New York, NY

Gladstone, F. (1879). 'Copyright'. *The Musical Times and Singing Class Circular*, 20 (440): 544–545.

Glock, C. (1953). 'The comparative study of communications and opinion formation'. *The Public Opinion Quarterly*, 16 (4): 512–523.

Glynn, M., Bhattacharya, C., and Rao, H. (1996). 'Art museum membership and cultural distinction: relating members' perceptions of prestige to benefit usage'. *Poetics*, 24 (4): 259–274.

Golden, M. (1982, 6th November). 'Walkman'. *Billboard*: WC-6.

Gopal, R., and Bhattacharjee, S. (2006). 'Do artists benefit from online music sharing?'. *Journal of Business*, 79 (3): 1503–1533.

Grayling, A. (2009, 8 October). 'Art: whether you love it or hate it, the purpose is to elicit a response'. *Times Higher Education*: 26–27.

Grenfell, M. (2004). *Pierre Bourdieu: agent provocateur.* Continuum: London.

Griscom, R. (2003). 'Distant music: delivering audio over the Internet'. *Notes*, 59 (3): 521–541.

Grolleau, G., Mzoughi, N., and Sutan, A. (2008). 'Please do not pirate it, you will rob the poor!: an experimental investigation on the effect of charitable donations on piracy'. *Journal of Socio-Economics*, 37 (6): 2417–2426.

Gronow, J. (1997). *The sociology of taste.* Routledge: New York, NY.

Groot, L. (2000). 'Roger Caillois, games of chance, and the superstar'. *Diogenes*, 48 (2): 33–42.

Guha, R., Kumar, R., Raghavan, P., and Tomkins, A. (2004). 'Propagation of trust and distrust'. *Proceedings of the 13th International Conference on World Wide Web*: 403–412.

Guterman, J. (1997). 'How home taping fuels the record industry', *Forbes*. Retrieved 10th March 2011 from <http://www.forbes.com/1997/07/11/taping.html>.

Hahn, M., and Bentley, A. (2003). 'Drift as a mechanism for cultural change: an example from baby names'. *Proceedings of the Royal Society B: Biological Sciences*: 120–123.

Hakanen, E. (1998). 'Counting down to number one: the evolution of the meaning of popular music charts'. *Popular Music*, 17 (1): 95–111.

Hall, P. (1999). 'Social capital in Britain'. *British Journal of Political Science*, 29 (3): 417–461.

Hall, S. (1992). 'Cultural studies and its theoretical legacies' in Grossberg, L., Nelson, C., and Treichler, P. (eds) *Cultural studies*.

Routledge: New York, NY.

Halvey, M., and Keane, M. (2007). 'Exploring social dynamics in online media sharing'. *Proceedings of the 16th International Conference on World Wide Web*: 1273–1274.

Hannon, E., and Trainor, L. (2007). 'Music acquisition: effects of enculturation and formal training development'. *Trends in Cognitive Sciences*, 11 (11): 466–472.

Hansman, H. (1996). *Life course experience and music consumption* [Doctoral dissertation]. Utrecht University: Utrecht.

Harker, R., Mahar, C., and Wilkes, C. (eds) (1990). *An introduction to the work of Pierre Bourdieu: the practice of theory.* Macmillan: London.

Harrow, J., Palmer, P., and Bogdanova, M. (2006). 'Business giving, the tsunami and corporates as rock stars: some implications for arts funding?'. *Cultural Trends*, 15 (4): 299–323.

Hartley, J. (2008). 'YouTube, digital literacy and the growth of knowledge' in Burgess, J. and Green, J. (eds) *YouTube: online video and participatory culture*. Polity Press: Cambridge.

Hartline, J., Mirrokni, V., and Sundararajan, M. (2008). 'Optimal marketing strategies over social networks'. *Proceedings of the 17th International Conference on World Wide Web*: 189–198.

Haruvy, E., Mahajan, V., and Prasad, A. (2004). 'The effect of piracy on the market penetration of subscription software'. *Journal of Business*, 77 (2): 81–108.

Haydu, J. (2002). 'Business citizenship at work: cultural transposition and class formation in Cincinnati, 1870–1910'. *The American Journal of Sociology*, 107 (6): 1424–1467.

Hedström, P. (2006). 'Experimental macro sociology: predicting the next best seller'. *Science*, 311 (5762): 786.

Hegel, G. (1821). *Elements of the philosophy of right* [English translation by Hugh Nisbet, 1991]. University of Berlin: Berlin.

Hegselmann, R., and Krause, U. (2002). 'Opinion dynamics and bounded confidence models, analysis, and simulation'. *Journal of Artificial Societies and Social Simulation*, 5 (3): 1–33.

Hemetsberger, A. (2001). 'Fostering cooperation on the Internet: social exchange processes in innovative virtual consumer communities'. *Advances in Consumer Research*, 29 (1): 354–356.

Hennion, A. (2001). 'Music lovers: taste as performance'. *Theory, Culture, Society*, 18 (5): 1–22.

Hermeking, M. (2005). 'Culture and Internet consumption: contributions from cross-cultural marketing and advertising research'. *Journal of Computer-Mediated Communication*, 11 (1): 1–23.

Hesmondhalgh, D. (1998). 'The British dance music industry: a case study of independent cultural production'. *The British Journal of Sociology*, 49 (2): 234–251.

Hesmondhalgh, D. (2002). *The cultural industries.* Sage Publications: London.

Hetzler, S. (1969). *Technological growth and social change.* Routledge and Kegan Paul: London.

Hirsch, P., and Fiss, P. (2000). 'Doing sociology and culture: Richard Peterson's quest and contribution'. *Poetics*, 28 (3): 97–105.

Holbrook, M., and Addis, M. (2007). 'Taste versus the market: an extension of research on the consumption of popular culture'. *The Journal of Consumer Research*, 34 (3): 415–424.

Holbrook, M., and Hirschman, E. (1982). 'The experiential aspects of consumption: consumer fantasies, feelings, and fun'. *The Journal of Consumer Research*, 9 (2): 132–140.

Holt, D. (1995). 'How consumers consume: a typology of consumption practices'. *The Journal of Consumer Research*, 22 (1): 1–16.

Holt, D. (1997). 'Distinction in America?: recovering Bourdieu's theory of taste from its critics'. *Poetics*, 25 (3): 93–120.

Holt, D. (1997). 'Poststructuralist lifestyle analysis: conceptualizing the social patterning of consumption in postmodernity'. *The Journal of Consumer Research*, 23 (4): 326–350.

Holt, D. (1998). 'Does cultural capital structure American consumption?'. *The Journal of Consumer Research*, 25 (1): 1–25.

Huhn, T. (2002). 'Burke's sympathy for taste'. *Eighteenth Century Studies*, 35 (3): 379–393.

Hunter, D. (1986). 'Music copyright in Britain to 1800'. *Music and Letters*, 67 (3): 269–282.

Hutton, L., Bridgwood, A., and Dust, K. (2004). 'Research at Arts Council England'. *Cultural Trends*, 13 (4): 41–64.

Ibrahim, M. (2009). 'Rebel voices and radio actors: in pursuit of dialogue and debate in northern Uganda'. *Development in Practice*, 19 (5): 610–620.

IEC (1981). 'IEC 60908: technical specification for CD-DA', *International Electrotechnical Commission*. Retrieved 20th January 2010 from <http://webstore.iec.ch/webstore/webstore.nsf/artnum/023623>.

Jacke, C. (2009). 'Locating intermediality: socialization by communication and consumption in the popular-cultural third places of the music club and football stadium'. *Culture Unbound*, 1 (1): 331–348.

Jarvenpaa, S., and Todd, P. (1996). 'Consumer reactions to electronic shopping on the world wide web'. *International Journal of Electronic Commerce*, 1 (2): 59–88.

John, A., Adamic, L., Davis, M., Nack, F., Shamma, D., and Seligmann, D. (2008). 'The future of online social interactions: what to expect in 2020'. *Proceedings of the 17th International Conference on World Wide Web*: 1255–1256.

Johnson, J. (2002). *Who needs classical music?: cultural choice and musical value.* Oxford University Press: Oxford.

Johnson, O., Bapst, F., Sudan, C., Stotzer, S., Cavaglieri, S., and Pellizzari, P. (2003). 'VisualAudio: an optical technique to save the sound of phonographic records'. *International Association of Sound and Audiovisual Archives Journal*, 21 (1): 38–47.

Johnstone, J., and Katz, E. (1957). 'Youth and popular music: a study in the sociology of taste'. *The American Journal of Sociology*, 62 (6): 563–568.

Jones, C. (2009). 'Intermediate goods and weak links: a theory of economic development'*. American Economic Journal*, 3 (2): 1–28.

Jones, R. (1842, 2nd November). 'Taste' [Lecture delivered at the opening of the 8th season of the Literary Scientific Institution]. *Hume Tracts*. Longman, Brown and Co.: London.

Kanazawa, S. (2001). 'De gustibus *est* disputandem'. *Social Forces*, 79 (3): 1131–1163.

Kapr, A. (1996). *Johann Gutenberg: the man and his invention* [English translation by Douglas Martin, 1996]. Scolar Press: Aldershot.

Kärjä, A. (2006). 'A prescribed alternative mainstream: popular music and canon formation'. *Popular Music*, 25 (1): 3–19.

Katsikides, S., Campbell, M., and Hochgerner, J. (eds) (1994). *Patterns of social and technological change in Europe.* Ashgate: Aldershot.

Kaufman, J., Edlund, S., Ford, D., and Powers, C. (2002). 'The social contract core'. *Proceedings of the 11th International Conference on World Wide Web*: 210–220.

Keaney, E. (2008). 'Understanding arts audiences: existing data and what it tells us'. *Cultural Trends*, 17 (2): 97–113.

Keaney, E., and Oskala, A. (2007). 'The golden age of the arts?: taking part survey findings on older people and the arts'. *Cultural Trends*, 16 (4): 323–355.

Kelty, C. (2005). 'Geeks, social imaginaries, and recursive publics'. *Cultural Anthropology*, 20 (2): 185–214.

Kenney, W. (1999). *Recorded music in American life: the phonograph and popular memory, 1890–1945.* Oxford University Press: New York, NY.

Klaes, M. (1997). 'Sociotechnical constituencies, game theory, and the diffusion of compact discs: an inter-disciplinary investigation into the market for recorded music'. *Research Policy*, 25 (8): 1221–1234.

Klarreich, E. (2003). 'Small world after all'. *Science News*, 164 (7): 103.

Klein, B., Lerner, A., and Murphy, K. (2002). 'The economics of copyright "fair use" in a networked world'. *The American Economic Review*, 92 (2): 205–208.

Knack, S., and Keefer, P. (1997). 'Does social capital have an economic payoff? A cross-country investigation'. *The Quarterly Journal of Economics*, 112 (4): 1251–1288.

Korsmeyer, C. (1976). 'Hume and the foundations of taste'. *The Journal of Aesthetics and Art Criticism*, 35 (2): 201–215.

Kracman, K. (1996). 'The effect of school-based arts instruction on attendance at museums and the performing arts'. *Poetics*, 24 (4): 203–218.

Krueger, A. (2005). 'The economics of real superstars: the market for rock concerts in the material world'. *Journal of Labour Economics*, 23 (1): 1-30.

Kubacki, K. (2008). 'Making music in transitional societies: a case study of Poland'. *Cultural Trends*, 17 (2): 115–127.

Kuhl, J., and Beckman, J. (eds) (1985). *Action-control: from cognition to behaviour.* Springer: Heidelberg.

Kusek, D., and Leonhard, G. (2005). *The future of music: manifesto for the digital music revolution.* Berklee Press: Boston, MA.

Laing, D. (1987). 'Review of "Noise: the political economy of music" by Jacques Attali [translated by Brian Massumi]'. *Popular Music*, 6 (1): 102–103.

Laing, D. (1994). 'Review of "Producing pop: culture and conflict in the popular music industry" by Keith Negus and "Media policy and music activity" by Krister Malm and Roger Wallis'. *Popular Music*, 13 (2): 223–227.

Lamont, M. (1992). *Money, morals, and manners: the culture of the French and American upper class*. University of Chicago Press: Chicago, IL.

Larsen, G., Lawson, R., and Todd, S. (2009). 'The consumption of music as self-representation in social interaction'. *Australasian Marketing Journal*, 17 (1): 16–26.

Lawrence, K., and Schraefel, M. (2006). 'Bringing communities to the semantic web and the semantic web to communities'. *Proceedings of the 15th International Conference on World Wide Web*: 153–162.

Laycock, G. (1966). 'Copyright'. *The Musical Times*, 107 (1475): 41.

Lee, M. (1993). *Consumer culture reborn: the cultural politics of consumption.* Routledge: London.

Lee, S. (2004). 'Predicting cultural output diversity in the radio industry, 1989–2002'. *Poetics*, 32 (4): 325–342.

Lena, J. (2004). 'Meaning and membership: samples in rap music, 1979–1995'. *Poetics*, 32 (4): 297–310.

Leppert, R. (1989). 'Music, representation, and social order in early-modern Europe'. *Cultural Critique*, 12 (1): 25–55.

Leppert, R. (2005). 'Music "pushed to the edge of existence": Adorno, listening and the question of hope'. *Cultural Critique*, 60 (1): 92–133.

Leskovec, J., Lang, K., Dasgupta, A., and Mahoney, M. (2008). 'Statistical properties of community structure in large social and information networks'. *Proceedings of the 17th International Conference on World Wide Web*: 695–704.

Lessig, L. (1996). 'Reading the constitution in cyberspace'. *Emory Law Review*, 45 (3): 869–910.

Lessig, L. (2001). 'The Internet under siege'. *Foreign Policy*, 127 (2): 56–65.

Levin, T. (1990). 'For the record: Adorno on music in the age of its technological reproducibility'. *October*, 55 (1): 23–47.

Levitas, R. (2004). 'Let's hear it for Humpty: social exclusion, the third way and cultural capital'. *Cultural Trends*, 13 (2): 41–56.

Lewis, G. (1977). 'Taste cultures and culture classes in mass society: shifting patterns in American popular music'. *International Review of the Aesthetics and Sociology of Music*, 8 (1): 39–48.

Leyshon, A. (2001). 'Time-space (and digital) compression: software formats, musical networks, and the reorganization of the music industry'. *Environment and Planning, A* (33): 49–77.

Lieberson, S., and Bell, E. (1992). 'Children's first names: an empirical study of social taste'. *The American Journal of Sociology*, 98 (3): 511–554.

Lipset, S. (1953). 'Opinion formation in a crisis situation'. *The Public Opinion Quarterly*, 17 (1): 20–46.

Livingstone, S. (2004). 'The challenge of changing audiences: or, what is the researcher to do in the age of the Internet?', *London School of Economics*. Retrieved 15th February 2010 from

<http://eprints.lse.ac.uk/archive/00000412>.

Looseley, D. (2004). 'The development of a social exclusion agenda in French cultural policy'. *Cultural Trends*, 13 (2): 15–27.

Lopes, P. (1992). 'Innovation and diversity in the popular music industry, 1969–1990'. *American Sociological Review*, 57 (1): 56–71.

Lynes, R. (1949). *The tastemakers.* Grosset and Dunlap: New York, NY.

Lynes, R. (1985). *The lively audience: a social history of the visual and performing arts in America, 1890–1950*. Harper and Row: New York, NY.

Lysloff, R. (2003). 'Musical life in Softcity: an Internet ethnography' in Lysloff, R. and Gay, L. (eds) *Music and technoculture*. Wesleyan University Press: Middletown, CT.

Lysloff, R., and Gay, L. (eds) (2003). *Music and technoculture.* Wesleyan University Press: Middletown, CT.

Machan, D. (1995, 5 June). 'Sharing Victoria's secret'. *Forbes*: 132–133.

Mackay, H. (ed.) (1997). *Consumption and everyday life.* Sage Publications: London.

Mansell, R. (ed.) (2002). *Inside the communication revolution: evolving patterns of social and technical interaction.* Oxford University Press: Oxford.

Marques, J., and Paez, D. (1994). 'The "black sheep effect": social categorization, rejection of in-group deviates, and perception of group variability'. *European Review of Social Psychology*, 5 (1): 37–68.

Mason, W., Conrey, F., and Smith, E. (2007). 'Situating social influence processes: dynamic, multidirectional flows of influence within social networks'. *Personality and Social Psychology Review*, 11 (3): 279–300.

Matsuo, Y., Mori, J., Hamasaki, M., Ishida, K., Nishimura, T., Takeda, H. et al. (2006). 'POLYPHONET: an advanced social network extraction system from the web'. *Proceedings of the 15th International Conference on World Wide Web*: 397–406.

McClellan, J., and Dorn, H. (2006). *Science and technology in world* *history: an introduction.* Johns Hopkins University Press: Baltimore, MD.

McCracken, G. (1986). 'Culture and consumption: a theoretical account of the structure and movement of the cultural meaning of consumer goods'. *The Journal of Consumer Research*, 13 (1): 71–84.

McIntosh, I. (ed.) (1997). *Classical sociological theory: a reader.* Edinburgh University Press: Edinburgh.

McLuhan, M. (1962). *The Gutenberg galaxy: the making of typographic man.* Routledge and Kegan Paul: London.

Merges, R. (2008). 'IP rights and technological platforms'. *Berkeley Center For Law and Technology Papers*, 64 (1): 1–30.

Miles, S. (1998). *Consumerism: as a way of life.* Sage Publications: London.

Misnikov, Y. (2008). 'Civic engagement in the digitally-mediated political debate: a democratization perspective', *London School of Economics*. Retrieved 2nd April 2009 from <http://eprints.lse.ac.uk/21579/>.

Moore, G. (1965). 'Cramming more components onto integrated circuits'. *Electronics*, 38 (8): 3–6.

Moore, W. (ed.) (1972). *Technology and social change.* Quadrangle Books: Chicago, IL.

Mosquera, G. (1986). 'Bad taste in good form'. *Social Text*, 15 (1): 54–64.

Mulgan, G., and Worpole, K. (1986). *Saturday night or Sunday morning?: from arts to industry—new forms of cultural policy.* Comedia: London.

Myhrvold, N. (2006). 'Moore's law corollary: pixel power', *New York Times*. Retrieved 14th January 2011 from <http://www.nytimes.com/2006/06/08/technology/08iht-cameras.1928986.html>.

Negus, K., and Román-Velázquez, P. (2002). 'Belonging and detachment: musical experience and the limits of identity'. *Poetics*, 30 (2): 133–145.

Newman, M. (2003). 'The structure and function of complex networks'. *Journal of the Society for Industrial and Applied Mathematics*

Review, 45 (2): 167–256.

Nowak, A., Szamrej, J., and Latané, B. (1990). 'From private attitude to public opinion: a dynamic theory of social impact'. *Psychological Review*, 97 (3): 362–376.

O'Connell, J. (2000). 'Fine art, fine music: controlling Turkish taste at the Fine Arts Academy in 1926'. *Yearbook for Traditional Music*, 32 (1): 117–142.

O'Guinn, T. (2000). 'Touching greatness: the central midwest Barry Manilow fan club' in Schor, J. and Holt, D. (eds) *The consumer society reader*. New Press: New York, NY.

Oakley, K. (2006). 'Include us out: economic development and social policy in the creative industries'. *Cultural Trends*, 15 (4): 255–273.

Oberholzer-Gee, F., and Strumpf, K. (2007). 'The effect of file-sharing on record sales: an empirical analysis'. *Journal of Political Economy*, 115 (1): 1–42.

Ostrower, F. (1998). 'The arts as cultural capital among elites: Bourdieu's theory reconsidered'. *Poetics*, 26 (1): 43–53.

Parakilas, J. (1984). 'Classical music as popular music'. *The Journal of Musicology*, 3 (1): 1–18.

Park, C., and Lessig, V. (1977). 'Students and housewives: differences in susceptibility to reference group influence'. *The Journal of Consumer Research*, 4 (2): 102–110.

Passman, D. (2004). *All you need to know about the music business*. Penguin: London.

Peek, H., Bergmans, J., van Haaren, J., Toolenaar, F., and Stan, S. (2009). *Origins and successors of the Compact Disc.* Springer: Amsterdam.

Peitz, M., and Waelbroeck, P. (2006). 'Why the music industry may gain from free downloading: the role of sampling'. *International Journal of Industrial Organisation*, 24 (5): 907–913.

Pellerin, L., and Stearns, E. (2001). 'Status honour and the valuing of cultural and material capital'. *Poetics*, 29 (1): 1–24.

Perlman, M. (2004). 'Golden ears and meter readers: the contest for epistemic authority in audiophilia'. *Social Studies of Science*, 42 (2): 783–807.

Perritt, H. (2006). 'New architectures for music: law should get out of the way'. *Hastings Communications and Entertainment Law Journal*, 29 (5): 259–358.

Peterson, R. (2004). 'Making music sociology: an introduction'. *Poetics*, 32 (3): 195–196.

Peterson, R., and Kern, R. (1996). 'Changing highbrow taste: from snob to omnivore'. *American Sociological Review*, 61 (5): 900–907.

Pettit, B. (1999). 'Cultural capital and residential mobility: a model of impersistence in place'. *Poetics*, 26 (3): 177–199.

Pettit, B. (2000). 'Resources for studying public participation in and attitudes towards the arts'. *Poetics*, 27 (6): 351–395.

Philips, L., and Sanz-Ferrer, R. (1975). 'A taste-dependent true index of the cost of living'. *The Review of Economics and Statistics*, 57 (4): 495–501.

Pinnock, A. (2007). 'The Gramppian hills: an empirical test for rent seeking behaviour in the arts'. *Cultural Trends*, 16 (3): 277–294.

Pinnock, A. (2007). 'The infrastructural aspect of social capital: suggestions for a bridge between concept and policy'. *Public Money and Management*, 27 (5): 345–350.

Pinnock, A. (2009). 'The measure of all things: on the use of time as a value indicator in arts impact assessment'. *Cultural Trends*, 18 (1): 47–74.

Pohlmann, K. (1995). *Principles of digital audio.* McGraw-Hill: New York, NY.

Porter, D. (2000). 'Review: rethinking the aesthetic in the century of taste'. *Eighteenth Century Studies*, 33 (4): 587–592.

Putnam, R. (1995). 'Tuning in, tuning out: the strange disappearance of social capital in America'. *PS: Political Science and Politics*, 28 (4): 664–683.

Radano, R. (1989). 'Review of "Noise: the political economy of music" by Jacques Attali [translated by Brian Massumi]'. *Ethnomusicology*, 33 (1): 161–163.

Radcliffe, M. (2006). 'Grokster: the new law of third party liability for copyright infringement under United States law'. *Computer Law* *and Security Report*, 22 (2): 137–149.

Rajala, A., and Hantula, D. (2000). 'Towards a behavioral ecology of consumption: delay-reduction effects on foraging in a simulated Internet mall'. *Managerial and Decision Economics*, 21 (3): 145–158.

Ramrayka, L. (2009, 13 November). 'Is arts funding surviving the squeeze?'. *Guardian*: 2.

Richards, J. (2009, 13 November). 'Is piracy really killing the music industry?'. The *Times*: 40.

Ringer, A. (1994). 'Musical taste and the industrial syndrome: a socio-musicological problem in historical analysis'. *International Review of the Aesthetics and Sociology of Music*, 25 (1): 79–92.

Robbins, D. (2000). *Bourdieu and culture.* Sage Publications: London.

Roberts, D. (2009, 13 November). 'The show's not over yet'. *Guardian*: 7.

Roberts, K. (2004). 'Leisure inequalities, class divisions and social exclusion in present-day Britain'. *Cultural Trends*, 13 (2): 57–71.

Romer, P. (2002). 'When should we use intellectual property rights?'. *The American Economic Review*, 92 (2): 213–216.

Rook, D. (1985). 'The ritual dimension of consumer behaviour'. *The Journal of Consumer Research*, 12 (3): 251–264.

Rosen, S. (1981). 'The economics of superstars'. *The American Economic Review*, 71 (5): 845–858.

Ryan, J. (2000). 'The production and consumption of culture: essays on Richard A. Peterson's contributions to cultural sociology: a prolegomenon'. *Poetics*, 28 (3): 91–96.

Ryan, M. (1982). 'Behavioural intention formation: the interdependency of attitudinal and social influence variables'. *The Journal of Consumer Research*, 9 (3): 263–278.

Saarikallio, S., and Erkkilä, J. (2007). 'The role of music in adolescents' mood regulation'. *Psychology of Music*, 35 (1): 88–109.

Sacks, O. (2007). *Musicophilia: tales of music and the brain.* Alfred A. Knopf: Toronto.

Salganik, M., Dodds, P., and Watts, D. (2006). 'Experimental study of inequality and unpredictability in an artificial cultural market'. *Science*, 311 (5762): 854–856.

Savage, M. (2006). 'The musical field'. *Cultural Trends*, 15 (2): 159–174.

Saxby, S. (2000). 'Recording industry launches several law suits to protect music copyrights on the Web'. *Computer Law and Security Report*, 16 (5): 352–353.

Scheckter, J. (2006). *A holistic approach to consumption analysis in the popular music market* [Masters dissertation]. Rhodes University: Rhodes.

Scherzinger, M. (2005). 'Music, corporate power, and unending war'. *Cultural Critique*, 60 (1): 23–67.

Schouten, J. (1991). 'Selves in transition: symbolic consumption in personal rites of passage and identity'. *The Journal of Consumer Research*, 17 (4): 412–425.

Scott, M. (2001). 'Music copyright on the Internet: the Ninth Circuit rules in the Napster controversy'. *computer Law and Security Report*, 17 (3): 192–193.

Scruton, R. (2007). *Culture counts: faith and feeling in a world besieged.* Encounter Books: New York, NY.

Selwood, S. (2005). 'John Holden's "Capturing cultural value: how culture has become a tool of government policy"'. *Cultural Trends*, 14 (1): 113–128.

Shachar, R. (2003). 'Party loyalty as habit formation'. *Journal of Applied Econometrics*, 18 (3): 251–269.

Shamma, D., Owsley, S., Hammond, K., Bradshaw, S., and Budzik, J. (2004). 'Network arts: exposing cultural reality'. *Proceedings of the 13th International Conference on World Wide Web*: 41–47.

Sigurdsson, H., Halldorsson, U., and Hasslinger, G. (2007). 'Potentials and challenges of peer-to-peer based content distribution'. *Telematics and Informatics*, 24 (4): 348–365.

Simmel, G. (1903). *The metropolis and mental life* [English translation by Edward Shils, 1936]. Petermann: Dresden.

Sinclair, A. (1990) *The need to give: the patrons and the arts*. University of California Press: Berkeley, CA.

Singla, P., and Richardson, M. (2008). 'Yes, there is a correlation: from social networks to personal behaviour on the web'. *Proceedings of the 17th International Conference on World Wide Web*: 655–664.

Smith, P., and Riley, A. (2009). *Cultural theory: an introduction.* Blackwell Publishing: Oxford.

Solomon, M. (1983). 'The role of products as social stimuli: a symbolic interactionism perspective'. *The Journal of Consumer Research*, 10 (3): 319–329.

Soroka, V., and Rafaeli, S. (2006). 'Invisible participants: how cultural capital relates to lurking behaviour'. *Proceedings of the 15th International Conference on World Wide Web*: 163–172.

Stanziola, J. (2007). 'Measuring the size and concentration of business funding of culture in the UK: closing the gap between advocacy and theory'. *Cultural Trends*, 16 (2): 75–98.

Staubmann, H. (1991). 'The concept of norm in sociological theory and its application to music'. *International Review of the Aesthetics and Sociology of Music*, 22 (2): 119–125.

Streatfeild, R. (1906). *Modern music and musicians.* Methuen: London.

Sumera, M. (2004). 'The completist syndrome, part 1: official recordings', *One Final Note*. Retrieved 10th March 2011 from <http://www.onefinalnote.com/features/2004/completist01/>.

Suo, S., and Chen, Y. (2008). 'The dynamics of public opinion in complex networks'. *Journal of Artificial Societies and Social Simulation*, 11 (4): 1–11.

Tainter, C. (1888). 'Graphophone'. *United States Patent Office* no. 380,535.

Tallis, R. (1995). *Newton's sleep: the two cultures and the two kingdoms.* Palgrave Macmillan: London.

Temkin, K., and Rohe, W. (1998). 'Social capital and neighbourhood stability: an empirical investigation'. *Housing Policy Debate*, 9 (1): 61–88.

Temperley, N. (ed.) (1989). *The lost chord: essays on Victorian music.* Indiana University Press: Bloomington, IN.

Théberge, P. (2004). 'The network studio: historical and technological paths to a new ideal in music making'. *Social Studies of Science*, 34 (5): 759–781.

Thompson, M. (1979). *Rubbish theory: the creation and destruction of value.* Oxford University Press: Oxford.

Throsby, D. (2003). *Economics and culture.* Cambridge University Press: Cambridge.

Tramonte, L., and Willms, D. (In press). 'Cultural capital and its effect on education outcomes'. *Economics of Education Review*, 29 (2): 200–213.

Traube, E. (1996). '"The popular" in American culture'. *Annual Review of Anthropology*, 25 (1): 127–151.

Treitler, L. (1982). 'The early history of music writing in the West'. *Journal of the American Musicological Society*, 35 (2): 237–279.

Turino, T. (2003). 'Are we global yet?: globalist discourse, cultural formations and the study of Zimbabwean popular music'. *British Journal of Ethnomusicology*, 12 (2): 51–79.

Turner, R. (1964). *The social context of ambition.* Chandler Publishing: San Francisco.

van den Berg, B. (2008). 'I-object: intimate technologies as reference groups in the construction of identities', *London School of Economics*. Retrieved 2nd April 2009 from <http://www.lse.ac.uk/collections/media@lse/Conference/Conference_Papers_Keep_them_here/ArticleVandenBergIObjectshortdefJuly2008.pdf>.

van Eijck, K. (2001). 'Social differentiation in musical taste patterns'. *Social Forces*, 79 (3): 1163–1184.

van Eijck, K., and Knulst, W. (2005). 'No more need for snobbism: highbrow cultural participation in a taste democracy'. *European Sociological Review*, 21 (5): 513–528.

van Lente, H., and Rip, A. (1998). 'Expectations in technological developments: an example of prospective structures to be filled in by agency' in Disco, C. and van der Meulen, B. (eds) *Getting new technologies together*. Water de Gruyter: New York, NY.

van Wijk, J. (2002). 'Dealing with piracy: intellectual asset management in music and software'. *European Management Journal*, 20 (6): 689–698.

Varian, H. (2005). 'Copying and copyright'. *The Journal of Economic Perspectives*, 19 (2): 121–138.

Veblen, T. (1899). *The theory of the leisure class.* Macmillan: New York, NY.

Volz, I. (2006). 'The impact of online music services on the demand for stars in the music industry'. *Proceedings of the 15th International Conference on World Wide Web*: 659–667.

Voss, D. (2000). 'Scientists weave new-style webs to tame the information glut'. *Science*, 289 (5488): 2250–2251.

Wakita, K., and Tsurumi, T. (2007). 'Finding community structure in mega-scale social networks'. *Proceedings of the 16th International Conference on World Wide Web*: 1275–1276.

Wallace, R., and Wolf, A. (1995). *Contemporary sociological theory: continuing the classical tradition.* Prentice Hall: Englewood, NJ.

Wallendorf, M., and Arnould, E. (1991). '"We gather together": consumption rituals of Thanksgiving Day'. *The Journal of Consumer Research*, 18 (1): 13–31.

Warde, A., and Martens, L. (2000). *Eating out: social differentiation, consumption and pleasure.* Cambridge University Press: Cambridge.

Watson, M., and Anand, N. (2006). 'Award ceremony as an arbiter of commerce and canon in the popular music industry'. *Popular Music*, 25 (1): 41–56.

Weber, W. (1977). 'Mass culture and the reshaping of European musical taste'. *International Review of the Aesthetics and Sociology of Music*, 8 (1): 5–22.

Weitzner, D. (2006). 'Broken links on the web: local laws and the global free flow of information'. *Proceedings of the 15th International Conference on World Wide Web*: 489.

White, H., and White, D. (1980). *Physics and music: the science of musical sound.* Saunders College Press: Philadelphia, PA.

Williams, C., and Paddock, C. (2003). 'The meaning of alternative consumption practices'. *Cities*, 20 (5): 311–319.

Wilson, C. (2007). *Let's talk about love: a journey to the end of taste.* Continuum: New York, NY.

Wilson, E. (1988). 'Picasso and pâte de foie gras: Pierre Bourdieu's sociology of culture'. *Diacritics*, 18 (2): 47–60.

Wolfe, A. (2004). '"Over to you": can Europe restrain Microsoft's threat to freedom of musical expression in computer-mediated communication?'. *Popular Music*, 23 (1): 63–78.

Wong, D. (2003). 'Plugged in at home: Vietnamese-American technoculture in Orange County' in Lysloff, R. and Gay, L. (eds) *Music and technoculture*. Wesleyan University Press: Middletown, CT.

Wright, R. (2000). '"I'd sell you suicide": pop music and moral panic in the age of Marilyn Manson'. *Popular Music*, 19 (3): 365–385.

Yoon, K. (2002). 'The optimal level of copyright protection'. *Information Economics and Policy*, 14 (3): 327–348.

Yoshida, H. (2001). 'Eduard Hanslick and the idea of "public" in musical culture: towards a socio-political context of formalistic aesthetics'. *International Review of the Aesthetics and Sociology of Music*, 32 (2): 179–199.

Yúdice, G. (2003). *The expediency of culture: uses of culture in the global era.* Duke University Press: Durham, NC.

Zhou, D., Manavoglu, E., Li, J., Giles, C., and Zha, H. (2006). 'Probabilistic models for discovering e-communities'. *Proceedings of the 15th International Conference on World Wide Web*: 173–182.

Zwaan, K., ter Bogt, T., and Raaijmakers, Q. (2009). 'So you want to be a rock 'n' roll star?: career success of pop musicians in the Netherlands'. *Poetics*, 37 (3): 250–266.