The Cambridge Companion to

POP AND ROCK

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1 'Plugged in': technology and popular music

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Any discussion of the role of technology in popular music should begin with a simple premise: without electronic technology, popular music in the twenty-first century is unthinkable. As a point of departure, however, such a premise demands that one develop an understanding of music technology as more than a random collection of instruments, recording and playback devices. Technology is also an environment in which we experience and think about music; it is a set of practices in which we engage in making and listening to musical sounds; and it is an element in the discourses that we use in sharing and evaluating our experiences, defining, in the process, what music is and can be. In this sense, the ensemble of electronic devices that are used to make, distribute and experience contemporary music are not simply a technical 'means' through which we experience music. Technology has become a 'mode' of music production and consumption: that is, technology has become a precondition for music-making, an important element in the definition of musical sound and style, and a catalyst for musical change (Blacking 1977). However, technology does not simply determine music-making. Pop artists and consumers have often used technology in ways unintended by those who manufacture it. In this way, pop practices constantly redefine music technologies through unexpected or alternative uses.

This chapter presents an overview of several parallel yet interconnected evolutions in music technology: the development and continued importance of electro-magnetic technologies; the evolution of studio recording technologies and techniques; the rise of new musical instrument technologies; and the evolution of consumer audio devices and formats, including recent innovations in digital formats for music distribution on the Internet. The brief survey of musical instruments, reproduction devices and technical formats presented here will be treated as an inquiry into musical concepts, techniques, and social and aesthetic values as much as a history of technology *per se*. In this regard, it is essential to recognise, firstly, that conflicts in musical aesthetics and values have accompanied virtually every development in music technology and, secondly, that the possibilities offered by new musical technologies are never exploited equally, or even accepted, in every sphere of music-making. Indeed, different uses of technology reflect different aesthetic and cultural priorities (Rose 1994).

The specific uses, abuses, or the explicit rejection of various technologies are thus instrumental in defining a particular 'sound' – a pop aesthetic – and contribute to a sense of 'distinction' between popular music genres.

Fundamental technologies

By the second half of the twentieth century, the technologies of sound recording and reproduction, and the industries associated with them, were already firmly established and had become a central component in all of Western musical culture and, increasingly, throughout the world. But the vast array of technical devices that came into use in popular music after the Second World War, and the intensity of the economic and aesthetic debates which often surrounded their introduction, tended to mask the continued importance of a number of other, ancillary technologies developed during the early years of the twentieth century. Specifically, the microphone, electrical amplification and loudspeakers must be considered as absolutely fundamental to contemporary popular music. Their character is underscored, ironically, by the degree to which they have become 'naturalised' and their effects rendered invisible to us. Even in the digital age, however, these technologies remain the beginning and end points of virtually every act of musical production and reproduction, thus giving the lie to the very idea that pop music can be 'unplugged'. The aesthetics of 'high-fidelity' have reinforced the idea that microphones, amplifiers and speakers are *reproductive* technologies, that they are, by design, transparent in their operation. However, such an ideology only serves to efface the impact that these technologies continue to have on our experience of popular music, even in the twenty-first century.

Curiously, these fundamental technologies were developed initially neither within nor for the record industry. Microphones, for example, were first developed by the telephone and broadcast industries and only later adopted for use in music recording and in film production. During the early 1920s, the record industry hesitated in adopting electrical methods of recording in favour of protecting the large investments already made in the production and stockpiling of acoustical recordings. The microphone, in conjunction with electrical amplification, soon proved to be more powerful in its ability to render the subtleties of both the human voice and instrumental sounds than acoustical methods and the industry was forced to convert to electrical technologies in order to compete with the new medium of radio.

The impact of the microphone on musical style was both subtle and profound: for example, the string bass could be heard clearly, for the first

time, in jazz recordings and the instrument quickly replaced the tuba which had often been used in earlier recorded jazz. More importantly, a new, intimate style of singing, known as 'crooning', evolved in response to the introduction of the microphone in popular music practice and spurred immediate controversy. As Simon Frith (1986) has pointed out, crooners were regarded by early critics as effeminate and their singing style as both technically and, by extension, emotionally 'dishonest'.

Despite such criticisms, what had become clear for the early crooners was that it was now necessary not only to sing but to develop a technique suited to the microphone. No performer of the period appears to have realised this more than Bing Crosby, who exploited the intimacy offered by the microphone to great effect: his more 'masculine', 'husky' sounding baritone voice not only differed from the style of singing adopted by many of the other early crooners but its low register was also particularly enhanced by the microphone through the physical phenomenon known as the 'proximity effect'.

In this sense, while pop performers sing to an audience, real or imagined, they always sing first and foremost *to* the microphone. In return, the microphone reveals, in intimate detail, every nuance of the performer's vocal style. But it does not do so in a transparent fashion: every microphone has its own characteristics and colours the sound in subtle yet unmistakable ways. Pop performers have become exceptionally sensitive to the manner in which the microphone can flatter the voice and even musicians who publicly denounce the excesses of modern instrument and recording technologies can be found, in interviews, waxing rhapsodically about the ability of a certain microphone to lend 'warmth' to a vocal performance.

As listeners, our experience of the 'grain' (Barthes 1990) of the voice in popular music (not to mention our notions of how an acoustic guitar or other traditional instrument 'should' sound) has been subtly influenced by the intercession of the microphone. The sensuous pleasures that we derive from listening to the sounds produced by pop performers – from the ironic, conversational tones of Brad Roberts (Crash Test Dummies), to the over-the-top ballad styles of Céline Dion or Whitney Houston, to the tortured screams of Axl Rose – are essentially erotic in character (Frith 1981). These pleasures are made all the more powerful by the extraordinary sense of 'presence' (an aesthetic, metaphorical and quasi-technical term used by recording engineers) afforded by the microphone.

In contemporary live performance and recording the microphone is never a singular technology, it is always plural. Indeed, the evolution of multi-microphone techniques have been central to the development of popular music since the advent of rock'n'roll during the 1950s. Prior to

this time, it was unusual to find more than a handful of microphones used in live performance contexts or in recording studios. But innovative engineers and producers, in search of a new 'sound' for the emerging music, began to experiment with microphones and their placement: at Atlantic records, for example, 'Tommy [Dowd] did revolutionary things with how he would mike the bass and drums. Nobody used to mike drums in those days [the 1950s] . . . later on he started using multiple miking. We learned all the advantages of remixing and sweetening' (producer Jerry Wexler, quoted in Fox 1986: 146). In this way, engineers gradually took over much of the responsibility for achieving musical balances within the overall sound of first the recording, and later, live performance. Experiments in multi-microphone technique, which involve the selective placement and isolation of instrumental sounds, were among the first steps taken towards the creation of the modern multitrack studio and continue to be an essential factor in the production of the transparent sound and instrumental separation characteristic of most popular music today (Schlemm 1982).

Microphones (and related electro-magnetic technologies such as guitar pickups and the stylus of a turntable), however, would be useless without the ability to amplify electrically the signals they produce. The development of the 'Audion Tube' by Lee DeForest, in 1904, laid the basis for amplification, radio broadcasting, and other electric technologies of the early twentieth century. Since the 1950s, however, amplification has become more than a technical necessity, it has become a crucial element in the evolution of the sound of popular music, particularly rock music. From the outset, rock'n'roll established itself as loud, raucous music by virtue of its emphasis on the sound of amplified electric guitars and, in the decades that followed, rock became synonymous with both volume and distortion. When an amplifier is pushed beyond its normal capacities the electronic components become overdriven, resulting in a brighter sound, rich in harmonic content unrelated to the original sound source. Rob Walser (1993) has argued that the sound of amplified guitar distortion has become a key aural sign of heavy metal and hard rock genres and an important signifier of power and emotional intensity in the music.

Even when tube amplifiers are not overdriven, however, they have a distinct sound, valued by many musicians and engineers, that is difficult to reproduce through other means. In this regard, there is perhaps no more curious an example of the fact that the production of popular music is essentially an aesthetic project, not simply a technical one, than the survival of tube technology. Decades after the introduction of solid state transistors and, more recently, digital circuitry, the vacuum tube remains a viable technology. Throughout the 1990s and into the twenty-first century, equipment manufacturers have done a brisk business in the production of

tube-based microphone preamps, guitar amplifiers, compressors and other signal processors. Similarly, as computers became increasingly important in music production, programmers attempted to simulate, in software form, the particular distortion characteristics, buzz and 'warmth' of tube technology in order to cash in on the 'retro' aesthetic prevalent in various genres of pop music.

It is in combination with loudspeakers, however, that amplification makes its most significant contribution to popular music culture. Since its introduction during the 1950s, amplification through transistor circuitry has lent itself to both the economies of power and miniaturisation, thus making it possible to meet the acoustic demands of public venues such as dance clubs and sports stadiums, on the one hand, and the more intimate spaces of automobiles, portable transistor radios and Sony Walkmans, on the other. 'Power' is again in this instance both a description of a physical phenomenon and a cultural value: for it is only through the application of electrical amplification to loudspeakers (or headphones) that we are able to invest both our public and private spaces with a musical intensity unprecedented in cultural history. It could be argued that no other technology affects our subjective experience of popular music more than the amplified loudspeaker: the loudness of rock or the booming bass of hip-hop are sounds that can only be produced and experienced through technological means. Studio engineers recognise the importance of loudspeakers in music consumption and routinely employ two or three different speaker systems in an attempt to approximate the effects of different listening conditions on a given mix.

Loudspeakers were first introduced in radio and public address systems during the 1920s but their most significant development occurred during the early days of sound cinema. Some of the most respected names in the audio industry, such as J. B. Lansing, began their careers developing speaker systems for film theatres during the 1930s and only later oriented their efforts towards meeting the demands of the recording studio, stage performance, and home listening. It was during the 1960s, however, that popular music began to make special demands on speaker technology. As pop bands, such as the Beatles, the Who, and others, turned increasingly to sports stadiums as performance venues, their primitive guitar amplifiers and PA systems proved inadequate. Manufacturers responded to these new demands by creating ever more powerful sound systems and, in the process, created the technical infrastructure of modern live performance. More importantly, amplifiers and loudspeakers became part of a complex social technology: they facilitated the coming together of ever-larger crowds for popular music, thus supporting both the needs of fans and those of the expanding music industry.

As noted above, however, loudness in rock music was only partly dictated by necessity, it was also a fundamental component in an evolving rock aesthetic. And, as in the case of amplifier distortion, rock musicians soon learned that loudspeakers, as the functional source of musical sound, could be employed for musical ends. When a microphone or guitar pickup is placed in close proximity to a highly amplified loudspeaker the phenomenon known as 'feedback' occurs. Rock guitarists, such as Jimi Hendrix, learned to play *to* their amplifier speakers, coaxing novel sounds from them, and making them a true extension of their musical instruments.

Outside guitar-based rock, the loudspeaker must also be considered as central to the experience of a range of pop music genres from reggae to the whole gamut of genres associated with modern dance music. From the early reggae 'sound system' – or mobile discotheque – to the dance club, to the rave party, a premium has been placed on the ability of amplifiers and loudspeakers to produce an artificially loud, or 'heavy' bass sound. Subsonic speaker systems create tones that are felt as much as they are heard, thus supporting the movement of dancers as much as the rhythm of the music itself. Furthermore, the exaggerated emphasis on bass frequencies found in various genres of African–American music, such as hip-hop and rap, has come to be perceived by fans and pop commentators alike as a marker of not only musical genre but cultural identity as well (Rose 1994).

Certainly, microphones, amplifiers and loudspeakers have been important to virtually all recorded music: classical, folk, jazz, or popular. But it is only in popular music and in rock that these technologies can be regarded as truly essential to the processes of both musical expression and experience.

Sound recording

Magnetic recording, in one form or another, has also been a central element in the development of production practices in popular music since the 1950s. While the first magnetic recorder was developed as early as 1898 and wire and steel-band magnetic recorders found limited use in radio broadcasting during the 1930s, it was not until the Second World War that German engineers were able to perfect tape-based recording. In 1948, working from German prototypes, the first commercially successful tape machines were introduced in the United States and were soon put to general use in radio, film and record production. The overall improvement in sound fidelity, duration of recording time and, above all, the ability to edit and splice together different 'takes' of a performance, contributed to a

quality and flexibility previously impossible with conventional disk recording methods. Singer Bing Crosby was again one of the first performers to exploit these possibilities: from the late 1940s onward, he insisted that his radio programmes be pre-recorded (first on disk and, later, on tape), thus ensuring 'perfect' performances. The ease and relative low cost of production were also significant factors in the rise of independent, entrepreneurial production (especially in the emerging genres of rhythm and blues and rock'n'roll) during the 1950s and contributed to an overall reorganisation of the recording industry.

From the outset, entrepreneurial producers and engineers experimented with the technical possibilities of tape technology in order to create new sounds. For example, echo, originally produced by the physical gap that exists between the record and playback heads on a tape recorder, was employed as a novelty effect in pop recording from the early 1950s onward (it can be heard prominently, for example, in some of the early rock'n'roll recordings, such as Elvis Presley's version of 'Hound Dog') and later became a standard part of pop recording practice. Similarly, during the late 1960s, an experimental technique known as 'flanging', which can be described as a kind of 'whooshing' effect created by phase cancellations that occur when the speed of two tape recorders is manipulated relative to one another, became a distinctive part of the sound of many psychedelic rock recordings. Audio manufacturers quickly responded by creating electronic devices that could reproduce the effect of such experimental techniques but with greater control and precision; these effects remain part of the standard repertory found in digital effects processors and software today. Thus, in what has become characteristic of the commercial context in which many pop practices originate, what begins as experimentation is soon packaged and sold back to pop practitioners in commodity form.

Beyond such novelties, however, there is perhaps no more salient example of the intimate relationship between popular music and technology than the development of the multitrack tape recorder. Indeed, while the technology of multitrack tape recording was developed in response to the needs of popular music, the evolution of pop and rock from the 1960s onward was, at the same time, predicated on the very existence of the technology and the practices associated with it. Multitrack recording is not simply a technical process of sound production and reproduction; it is also a *compositional* process and is thus central to the creation of popular music at the most fundamental level (Eno 1983).

Multitrack recording techniques were first used in mainstream pop of the 1950s when a third track was added to the stereo pair of tracks found on professional recorders. The extra track was used as a means of isolating and enhancing the vocal sound of pop singers, such as Frank Sinatra and

Nat King Cole, in relation to the backing orchestra. Such applications can be regarded as a simple technical expedient in the service of commercial ends. Overdubbing was put to a much more extensive and creative use, however, in the multiple guitar and voice recordings of Les Paul and Mary Ford during the 1950s (Les Paul is also credited with having created the design for the first 8-track tape recorder; see Sievert 1978). The fusion in timbre created by a single vocalist performing multiple harmony parts, a technique pushed to its limits by artists such as Joni Mitchell during the late 1960s and early 1970s, can only be achieved through overdubbing. By the time that four-track recorders became available during the early 1960s, producers such as Phil Spector were using the technology as an integral component in an overall strategy for the creation of a new pop sound. During the late 1960s and early 1970s, track capacity expanded rapidly from 4-, to 8-, to 16- and 24-track recording, offering greater possibilities for the control and layering of sounds; performers such as Stevie Wonder made use of these enhanced capabilities and released recordings in which they played and sang all the musical parts.

The multitrack tape recorder is one of the principal technical devices within an overall technical environment – the multitrack studio – that needs to be understood as a 'technology' in larger terms. The studio is an environment made up of a specifically designed set of acoustic spaces within which one finds a wide range of technical devices: microphones, tape recorders, mixing console, signal processors, monitors, headphones and, more recently, digital samplers, synthesisers and computers. Furthermore, the multitrack studio comprises a flexible, though well-defined organisation of musical labour and a rational division of specific technical practices: the use of multiple microphones, overdubbing and other techniques to maximise separation, signal processing, and mixing (Théberge 1989). Mixing has become such a complex and specialised task that different engineers (and different studios) are often employed at this stage of the recording process. The work of creative engineers and producers, from the disco producers of the 1970s (such as Freddie Perren and Giorgio Moroder) to the dance remixers of the1980s and 1990s (such as Shep Pettibone), has highlighted the capacity of the studio to act as a tool in reworking pre-existing material in order to meet the needs of different consumer contexts. Such practices also clearly fit within the economic imperatives of the record industry as they allow for the profit potential of every song to be exploited to its fullest (Tankel 1990). Not surprisingly, prominent remix engineers, based on their ability to deliver marketable hits, have been signed to long-term contracts with major labels.

Taken together, the ensemble of technical spaces, devices and practices

that constitutes the process of multitrack recording has become the primary mode of production in popular music. It has resulted in both a particular 'sound' – dynamically compressed and spatially separated (Schlemm 1982) – that is characteristic of most contemporary recording, and a new approach to the creative process. Whereas, in the early 1960s, a band would not ordinarily enter a studio without having a selection of material rehearsed and ready to record, less than a decade later it was normal for bands to compose in the studio, spending weeks and months experimenting with the various creative possibilities inherent in the multitrack process. In this regard, 'overdubbing', an essentially additive process in which the various instrumental sounds are layered in temporal succession and then later combined (or stripped away) at the time of mixdown, is a central technique of the studio when used as a compositional tool (Eno 1983). As a compositional tool, the multitrack studio has perhaps been most fully exploited in various genres of dance music, where the contributions of musicians have become little more than raw material which is manipulated, transformed and re-composed in the studio itself.

Initially, the prerogative of 'composing' with the new medium was not given equally to all who participated in the multitrack enterprise: it was the producer, more than anyone else, whose judgement prevailed within the studio environment (on the role of the producer, see Hennion 1989). And, indeed, it is the status of the producer that is valorised in modern copyright law: as far as mechanical rights to the recording are concerned, it is the producer (or the record company) who holds all rights of reproduction. Increasingly, however, popular musicians insisted on having greater control over the multitrack recording process and, ultimately, the sound of their music. Edward R. Kealy (1979) has described in detail the changing patterns of collaboration that came about in the recording of rock music during the period between 1965 and 1975. According to Kealy, an 'art mode' of production evolved during this period where the recording artists themselves were responsible for aesthetic decision-making in the studio. In this, pop musicians have come to rely heavily on the technical expertise and growing artistic contributions of recording engineers with whom they have developed creative relationships. Such relationships often allow musicians to experiment with the technology in unorthodox ways: for example, Tricia Rose (1994) has described how rap musicians and producers (not unlike rock guitarists of the sixties) often work 'in the red', pushing the capacity of tape recorders in order to create a more distorted sound.

From the 1970s onward, many successful artists invested tens of thousands of dollars in constructing their own studios, where they could experiment freely without the pressures of paying for commercial studio

time at hourly rates. As an understanding of the basic technologies, routines and practices of studio recording has gradually become an essential part of every musician's store of knowledge and skill – as essential as knowing how to tune a guitar – semi-professional and amateur musicians also began setting up their own studios using low-cost equipment specifically designed by manufacturers for the 'home studio' market. In an effort to simplify the design of multitrack equipment for amateur recordists, manufacturers such as Tascam created the consumer-oriented 'Portastudio', which integrated tape recorder and mixer functions in a single device. Aspiring young musicians now regularly produce demo tapes even before they have learned to play before an audience; as Steve Jones (1992) has pointed out, 'paying your dues' in the music business is no longer simply a matter of playing night after night in bars, it also means working in (and making payments on) your home studio. The sound quality of home equipment has improved to the point where it can often rival that found in commercial studios: by the mid-1990s, digital multitrack recorders, in both tape and hard disk/computer software formats, had become available at modest prices.

This continuous 'democratisation' of the audio marketplace is significant in that it allows for a level of do-it-yourself recording activity (and an associated aesthetic) that is unusual in contemporary cultural production. Punk musicians of the 1970s and 'alternative' bands of the 1980s developed an aggressive, 'lo-fi' approach to the recording medium that both rejected the dominant practices and aesthetics of the record industry and played a role in defining these genres, in ideological terms, as more 'authentic' than other forms of mainstream pop and rock . This type of low-cost, independent production that co-exists with more commercial recording practices is characteristic of the music industry and is significantly different from the type of 'independent' production that takes place in other cultural sectors, such as the film and television industries.

At a very different level, the significance of multitrack recording has also become evident as the next generation of technology – digital technology – has entered into studio practice. MIDI (Musical Instrument Digital Interface) is a hardware/software protocol, introduced into the synthesiser market in 1983, that allows digital synthesisers, samplers, drum machines and computers to be networked together. Sequencers, software programs that allow MIDI data to be recorded, have adopted the multitrack tape recorder as a metaphor for the user interface even though MIDI does not carry sound data, only data related to performance gestures. In this way, software manufacturers have built upon, and thus reproduced, an already existing base of technical knowledge and practice

(Théberge 1997). Similarly, as high-fidelity, digital audio recording has become viable on home computers, the entire multitrack studio has become the object of software simulation: including simulations of multi-track tape recorder functions, mixing consoles and signal processors.

This technical reproduction is not without its social consequences. The technologies of rock and pop music production have long been a male-dominated terrain, and this has been as true for the most basic of rock technologies, the electric guitar, as it is for the wider range of electronic technologies associated with stage and studio (see Bayton 1990). Recent studies conducted by the music instrument industry have suggested that even among women with computer and music instrument skills, the use of music software is extremely limited. In reproducing the multitrack studio in software form, programmers implicitly assume that users *already* have the knowledge required for its use, thus reproducing, perhaps, the social inequalities associated with access to the earlier technology as well.

Musical instruments

Musical instruments are often the centre of controversy in pop and rock because their use is so intimately tied with musicians' notions of personal expression, on the one hand, and audience concerns for the 'authenticity' of music, on the other. Even Bob Dylan's adoption of the electric guitar in folk music of the 1960s was looked upon with derision by his fans. Historically however, rock music has been inextricably associated with the electric guitar in terms of its sound, performance gestures (fans often mimic, on 'air guitar', the exaggerated gestures of rock performers) and iconography. Because of the way in which specific sounds (and images) are linked to musical genres and the way in which nostalgia works in both pop and rock music, guitars of a certain type or vintage – the Gibson Les Paul or the Fender Stratocaster and Telecaster models, for example – have attained a special status among guitarists. The Stratocaster in particular, first introduced in 1954, has been copied by many manufacturers and its distinctive form has become, through commercial advertising and other avenues, one of the musical icons most commonly associated with rock.

But perhaps most important for rock and popular music are the wide variations in sound that can be produced by the electric guitar. In addition to the distortion and feedback techniques described above, the sound of the electric guitar has become increasingly integrated with electronic tech-nologies: from the 'wah-wah' pedals of the 1960s to the elaborate, multiple digital effects employed in the 1990s, our notions of what the guitar is, and can be, have been transformed. It could be argued that the guitar is no

longer simply 'electric' – that is, an instrument that has been amplified – but that its sound has become truly 'electronic' in nature.

Similarly, our experience of even the most 'primitive' of musical instrument technologies – the drums – has been altered by the processes of sound recording and electronic manipulation. The multitrack recording process allows for the sound of the drums and cymbals to be spatially separated in the stereo mix, thus creating an artificially enhanced, spatialisation of the rhythmic structure of the music itself (Théberge 1989). The sound of the voice and other instruments and, ultimately, the listener are placed *within* this spatial/rhythmic field. Furthermore, the drums are usually subjected to high levels of dynamic compression and other signal processing which serve to increase the overall impact of the sound of the beat in the final mix. Phil Collins' trademark snare sound – a sound that dominated many pop recordings of the 1980s – was created through a combination of microphone placement and signal processing: including compression, artificial reverberation and noise gating. Despite the controversy created by the introduction of drum machines during the late 1970s and instruments such as the Simmons Electronic Drums during the early eighties, the difference between the sound of processed acoustic drums and their sampled and electronic counterparts can be quite negligible.

Filling the same role as the guitar in rock music, the drum machine has become perhaps one of the most important instruments in the production of a wide variety of pop and dance music genres. The drum machine has its origins in the rhythm accompaniment boxes associated with home organs of the 1950s and 1960s, thus demonstrating that musical innovations do not always flow from the top down (that is from professional to consumer markets); but rather, significant innovations can originate in almost any market sector. These humble origins extend to even some of the manufacturers of drum machines: Ikutaro Kakehashi, founder of Japan's Roland Corporation, which is today one of the major suppliers of electronic musical instruments in the world, began his career in the music instrument industry designing home organs and rhythm boxes.

Both the sounds and the characteristic ways in which rhythm patterns are constructed on drum machines have been important elements in defining pop aesthetics. The Roland TR-808 drum machine (introduced in 1980), for example, became the instrument of choice among many hip-hop, rap and house music producers. Both the ability to detune the bass drum, creating a sound akin to a low-frequency hum, and the necessity of building rhythm patterns in a precise grid-like framework, have been cited as influences on the musical style of these genres. The instrument has achieved its own 'vintage' status: it continues to fetch a high price on the used instrument market, its sounds have often been sampled by producers

of dance music, and it has even been reincarnated in the form of a computer software program (Steinberg's 'ReBirth', released in 1997).

Most audiences, however, have never seen a TR-808, and if there is any instrument that has achieved both the musical and the iconic status of the guitar in dance music, it is the phonograph turntable. Using innovative techniques such as mixing and 'scratching', dance club deejays transformed the turntable, a quintessentially reproductive device, into a *productive* one, a musical instrument of the first order. Similarly, one might consider the art of the deejay as founded, initially, upon a type of consumer knowledge – a knowledge of musical style based in judgement and connoisseurship – which is then combined with a particular set of musical skills: the ability to sequence and mix together a series of songs and rhythmic breaks (Straw 1993). Along with the turntable, the form of the vinyl record was also transformed: the twelve-inch single had been developed specifically for dance use as early as the 1970s and, later, specialised distribution networks evolved to serve the needs of professional deejays (often catering to their penchant for secrecy by distributing the records in unmarked, 'white label' editions). Not unlike the preference among rock guitarists for tube amplification, many deejays continued to champion the turntable and vinyl records over CD technology well into the late 1980s and early 1990s.

The evolution of deejay aesthetics and practices – beginning with the Jamaican-inspired work of deejay Kool Herc in the early 1970s and its influence on the New York hip-hop scene and the later development of house music in Detroit and Chicago – created the conditions in which other, more advanced technologies, such as the digital sampler, could be introduced into dance music production. Arguing against crude technological determinist notions of how technology influences musical style, Ross Harley (1993) has suggested that it was the dance floor context, and the deejay practices associated with it, that led to the adoption of digital sampling technology and the particular manner in which it was put to use in house music of the 1980s.

The digital sampler is a hybrid device – a device for recording sound *and* a musical instrument – that was designed to reproduce the sounds of conventional musical instruments, thereby making studio production more economical by eliminating the need for backing musicians. The Mellotron, an analogue keyboard instrument that used tape loops, was introduced during the 1960s for similar purposes; the sound of its taped string ensembles were popularised by bands such as the Moody Blues and King Crimson during the late 1960s and early 1970s, and used on individual cuts by the Beatles, the Rolling Stones, and many others. In many commercial recordings, the digital sampler is used specifically for the mundane

purposes for which is was designed: as an inexpensive replacement for grand piano, drum sounds, string and brass ensembles and, more recently, the sounds of traditional instruments from around the world.

However, in the hands of house music producers and remix engineers, the sampler was used to cut sound fragments and loop together rhythmic grooves from a wide variety of sources: especially commercial recordings of soul, funk and heavy metal music but, also, from an increasingly diverse range of sources including film and television sound tracks. By using samplers to extend the possibilities of isolating break beats and mixing together passages from various recordings, sampling artists created a crisis within the music industry with regards to copyright infringement during the 1980s (Frith 1993). While the perceived threat to copyright law was relatively short-lived – the industry essentially bringing would-be samplers into line primarily through intimidation and the threat of litigation – the influence of this chaotic moment in the history of pop should not be underestimated. By the 1990s, sampling had become a tolerated, if not fully accepted, part of musical practice: for example, in 1993, the acid jazz group US 3 was given extensive sampling access to the back catalogue of Blue Note recordings in order to create their particular mix of jazz and rap styles.

The rise of sampling technology must be considered within the overall development and use of keyboard synthesisers within popular music. Prior to the 1960s, the use of electronically synthesised sound had been largely the province of avant-garde and, to a lesser extent, film music composers. While modular analogue synthesisers were already being used in commercial studios by the late 1960s, it was the introduction of the Minimoog, in 1970, that shifted the emphasis of synthesiser design towards the needs of live performance, thus paving the way for the wider acceptance of synthesiser technology within popular music. Despite the reaction to synthesisers mounted by the musicians' unions (who regarded them as a threat to the livelihood of conventional studio musicians) and opponents of disco music during the late 1970s, the sound of analogue synthesisers became central to a wide range of pop and rock styles throughout the decade: from the funky, soul/rhythm and blues style of Stevie Wonder, to the driving, progressive rock sound of Emerson, Lake and Palmer, and the ironic, electro-pop styles of Kraftwerk and Devo, to name only a few.

A number of significant developments occurred during the early 1980s that changed the nature of the modern synthesiser. Manufacturers began to make use of digital circuitry in order to make synthesiser technology more stable, economic, and easier to use. They pursued an aggressive economic and technological strategy that saw the lowering of the cost of syn-

thesisers and samplers, the expansion of synthesiser capabilities, and an ever-increasing capacity to store and reproduce pre-fabricated sound programs. The development of this latter capacity coincided with a subtle shift in the way in which musicians were regarded by manufacturers: no longer thought of as programmers of original sounds, musicians were increasingly viewed as consumers of prefabricated sounds and a small cottage industry developed to meet the supposed 'needs' of this new market. By the 1990s, synthesiser users had become largely dependent upon pre-fabricated synthesiser programs and prerecorded, CD libraries of digitally sampled sounds, thus placing them in a new relationship to instrument and software manufacturers (Théberge 1997).

With the introduction of MIDI (Musical Instrument Digital Interface) in 1983, the ability to use multiple synthesisers, drum machines and samplers in conjunction with one another and with personal computers was greatly enhanced, thus stabilising the synthesiser marketplace and offering greater creative possibilities to musicians. More important, it allowed electronically generated music to become part of a complete production *system*, modelled (as mentioned above) on the multitrack studio, and to become more fully integrated with conventional sound recording than ever before. While electronic pop music was still regarded by many, particularly the rock press, as 'cold' and 'inhuman', the sound of digital synthesisers began to appear in a surprising number of genres: for example, the eighties folk-derived style of Suzanne Vega's music was defined by a combination of acoustic guitar and synthesisers – a combination that would have been unheard of a decade earlier.

At the same time that these developments were taking place in the field of pop production, large music and consumer electronics corporations, such as Yamaha and Casio, were introducing portable electronic keyboards into the consumer marketplace. While regarded by many as mere toys, the impact of these instruments on the musical tastes of an entire generation of musical consumers should not be underestimated. Furthermore, as digital sampling methods became more commonplace, the market for home organs and upright pianos has gradually been displaced by electronic keyboards and digital pianos. In this way, not only has popular music become increasingly electronic in nature, but so too has much of amateur music culture in the West.

Consumer audio

As the above comments suggest, the relationship between the professional and semi-professional worlds of popular music-making and the world of

consumer electronics is extremely intimate and complex. Indeed, the economics of technological innovation are such that even the professional world of music production has become dependent, in part, upon the success of home computers and the consumer audio industry to ensure the availability of affordable digital components. At the same time, the record industry has become increasingly hostile towards audio manufacturers (which, in many cases, are only partly independent of the record industry) and, more recently, the computer industry because they supply consumers with the tools with which they can violate copyright in recorded music, thus challenging the record industry's power to control patterns of distribution and consumption.

Quite apart from issues of copyright, however, consumer technologies and audio formats must be understood as being intricately interwoven with the structures of music marketing and distribution. In this regard, historical conflicts between the record and audio industries have often been accompanied by larger, structural changes within the music industry and changes in the character of music consumption. For example, shortly after Columbia Records launched the 12-inch, 33⅓-rpm, long-playing record in 1948, RCA countered with its own 7-inch, 45-rpm format, with the hope of ensuring consumer loyalty by making its own technology incompatible with the LP. A number of reasons contributed to the premature end of the so-called 'Battle of the Speeds' that ensued, not least among them the fact that small, independent manufacturers of high-fidelity equipment decided to develop turntables that could play not only both of the new formats but the older, 78-rpm records as well, thus undercutting the record companies' strategy of exclusivity. Eventually, the 45-rpm format would have been doomed to failure had RCA not aggressively promoted it as the new standard for popular music singles. The 45-rpm record quickly became the preferred format among young consumers of the 1950s and helped to establish the youth market as a powerful force within the popular music industry (the LP did not become a mainstay of youth consumption until the late 1960s).

A different set of conflicts greeted the arrival of Compact Discs during the 1980s. Launched in 1983 after a lengthy collaboration between Japanese (Sony) and European (Philips) electronics manufacturers, CD technology was still not guaranteed success in the marketplace unless the majority of record companies agreed to make music available in the new format, which they were reluctant to do at first. It was only after audio manufacturers dropped the price of CD players to a fraction of their initial retail value that consumer demand for the new technology began to grow. The loss of profits suffered by the audio industry is often cited as one of the reasons for the acquisition of Columbia Records by Sony: the introduction

of future innovations in hardware, it was hoped, would not be hampered by the unavailability of music 'software'. Once the CD format was adopted, the record industry soon halted production of LPs on most new releases and began to capitalise on CDs through reissues of their enormous back catalogues of popular (and other) music. In this way, the loyalty of fans and the nostalgia for pop music of the past can be seen to have strategic value for the record industry. The LP has, nevertheless, survived in a kind of half-life in deejay practice and, curiously, among both hi-fi and lo-fi (alternative music) enthusiasts, as well as in various developing nations where consumers have been less inclined to invest in CD technology.

Perhaps the most significant conflict between the record and audio industries and, indeed, the public in the second half of the twentieth century can be found in the controversies surrounding popular uses of cassette tape. Whether made in the form of attacks on 'home taping' (in the industrialised world) or on 'piracy' (just about everywhere else), the record industry has conducted a long campaign against the unauthorised taping of its copyrighted music. Given the difficulties of gaining direct compensation for such uses, the industry has, in recent decades, managed to persuade many Western governments to impose levies on the sale of cassette recorders and blank tapes. This industry-dominated public discourse concerning the supposed abuses of cassette technology has tended to mask the broader social and cultural significance of the medium; economically too, industry lobbying has largely obscured the fact that pre-recorded cassettes outsold both LPs and CDs throughout the 1980s and were thus one of the pillars of the record industry during this period.

As the first recordable audio medium to have gained widespread acceptance among consumers in nearly a century (since the demise of the early Edison wax cylinder; reel-to-reel tape technology never having taken hold outside of the high-end, audiophile market), cassette tape recording offered a form of potential empowerment to users that was unprecedented. Popular musicians and consumers alike used the cassette as an alternative medium of distribution for forms of music that would not otherwise gain the support of the record or radio industries (see Pareles 1987). Cassette technology spread rapidly in the form of devices designed for use in the home, in automobiles, and in portable applications. Given its durability, ease of use, and the huge base of installed hardware, cassettes have been able to fend off other competing technologies and will likely remain a viable format for consumer audio well into the first decade of the twenty-first century (its possible replacement by Digital Audio Tape was effectively blocked by record industry lobbying during the 1980s and other digital audio formats emerging in the 1990s, such as Sony's MiniDisc, met

with limited acceptance by the public; digital file formats, such as MP3, are still confined primarily to computer enthusiasts).

Equally important, the low cost and portability of cassette technology contributed to its diffusion throughout the non-industrialised world during the 1970s where its impact on local music cultures has been as profound as it is widespread (Wallis and Malm 1984). Often contradictory in its effects, the cassette has enabled local popular music cultures to thrive, offering greater diversity of content than is available through industry or state-controlled media, while at the same time, it has contributed to the spread of Western pop music. Nevertheless, many commentators agree that the cassette has been a democratising agent in the popular music of the non-industrialised world and has effectively led to the restructuring of the music industry in many countries (see, for example, Regev 1986 and Manuel 1993). Digital technology notwithstanding, the cassette continues to be, on a global scale, one of the most significant audio technologies of our time.

At the dawn of the twenty-first century, many of the debates concerning piracy and home taping that had appeared decades earlier, with the advent of the cassette, have been revived and given a new sense of urgency within the world of online culture – the world of computers and network communications. While a relatively small number of musicians, independent record labels and fans had, at least since the late 1980s, made use of specialised computer networks for sharing and distributing music and information, their efforts were hampered by the sheer size of digital audio files and the relatively slow speed of data transfer. By the late 1990s, the appearance of various file compression techniques and increases in the overall speed of computer networking allowed the digital distribution of music (both legally and illegally obtained) to become a mass phenomenon. The speed with which music can be copied and distributed among, potentially at least, millions of users on an international scale, has become a pressing concern for the record industry.

In particular, the sudden rise in popularity of the MP3 file format – short for Moving Picture Experts Group (MPEG) 1, Layer 3, a digital file format that reduces audio files to a fraction of their normal size while retaining reasonable audio quality – during the 1990s, is a case study in the complex relationships between audio formats, entrepreneurial capital and consumer interests, on the one hand, and the marketing and distribution structures of the record industry, on the other. From the outset, MP3 was recognised, by individual fans and audio pirates alike, as a viable format for sharing and distributing music over the Internet. While the record industry was able, beginning around 1996, to prosecute some of the larger sites offering pirated music, dealing with individual consumers proved to

be more difficult. The problems associated with policing individual beha-
viour on the Net became even greater with the appearance, in 1999, of a
software program known as 'Napster'. Based on a decentralised, distrib-
uted model that allows users to access sound files located on the computers
of thousands of other individuals, Napster immediately became popular
among students on college campuses in the United States and elsewhere.
While many fans (and even some musicians) regard the sharing of copy-
righted songs over the Internet as being relatively harmless – a form of
social interaction that may ultimately act in such a way as to promote and
increase record sales – the record industry regards it as a form of theft and
quickly brought legal proceedings against Napster.

The popularity of the MP3 file format also gave rise to a number of web
sites dedicated to offering alternative forms of music distribution and con-
sumer services. For example, MP3.com was founded in 1997 as a site for
the distribution of independently produced music. Funded essentially by
advertising revenues and, more significantly, large sums of venture capital,
MP3.com expanded quickly and, by the year 2000, represented over 50,000
independent artists. In an attempt to diversify its operations, MP3.com
also began to offer new music services, one of which allowed subscribers to
access thousands of copyrighted music files from a centralised data bank.
Once again, the record industry brought suit against MP3.com on the
grounds that the creation of such a data base was in violation of copyright
laws.

While the outcome of both these legal proceedings is, as of this writing,
yet to be determined, it is important to recognise that what is at stake in the
various controversies surrounding the MP3 file format is not simply the
issue of copyright *per se*. The case of Napster needs to be understood as a
clash between radically different value systems – between a particular
notion of what constitutes a legitimate form of social interaction between
fans, on the one hand, and the commercial needs of the industry, on the
other. For its part, MP3.com represents a new type of business model
based on the possibilities offered by digital technology and computer net-
works (see National Research Council 2000). In taking legal action against
MP3.com, the record industry is, in part, using copyright law to prevent
entrepreneurial competitors from gaining an upper hand in what is, in
essence, a new marketplace. In the meantime, the industry is attempting to
adapt its own marketing and distribution structures to meet the demands
of online commerce.

Aside from the technical formats that support sound reproduction –
vinyl, cassettes, CDs and MP3 – and the possibilities they offer to consu-
mers and industry alike, the various forms of consumer 'hardware' asso-
ciated with sound reproduction have also played an increasingly

important role in the experience of popular music since the middle of the twentieth century. Above all, the audio industry's penchant for miniaturisation contributed to the reshaping of pop music sensibilities and the social conditions of listening. During the 1950s, the portable transistor radio was an essential component in the sense of freedom and mobility associated with post-war youth culture. Similarly, the 'ghetto blaster', or 'boom box', of the 1970s and 1980s, while significantly larger than the transistor radio, helped fuel hip-hop street culture. Its territorialising power – its ability to lay sonic claim to the street – has been immortalised in Spike Lee's film, *Do the Right Thing*, where the key dramatic moment is precipitated by a confrontation over the blaster's sonic boom and the clash of cultures that it symbolises.

For the more discreet, the Sony 'Walkman' proposed a new kind of balance in the experience of aural and visual environments in the urban landscape during the 1980s (Hosokawa 1984). More than any other technology, the Walkman seemed to epitomise the sense of mobile, privatised musical experience that had been the promise of sound reproduction technology for a century. With a design philosophy and a marketing campaign that was global in scope and targeted at the youth market, the Sony Walkman rose to popularity during the 1980s and early 1990s, influencing the listening habits of an entire generation (see du Gay et al. 1997). In this context, it is perhaps no accident that when the manufacturers of computer peripherals, such as Diamond Multimedia, and others, introduced audio devices dedicated to the playback of MP3 files during the late 1990s, they concentrated their initial efforts on the creation of Walkman-like portable players. Recognising the potential for the portable players to legitimise MP3 as a mainstream consumer format, thus extending its reach beyond the confines of computer-based communications, the Record Industry Association of America launched a legal battle against Diamond Multimedia – a battle that ultimately failed.

While miniaturisation and mobility has been a significant factor in the design of audio technologies, contributing to a wide range of aesthetic and social practices, so too has the development of an increasingly sophisticated set of technologies designed for domestic music consumption. The rise of the modern audio component system – the 'hi-fi' – took place during the post-war period and, together with television, displaced the role of the parlour piano and radio as the central entertainment technologies of the home. As the primary means of listening to music in the home, the hi-fi needs to be understood in terms of its accommodation within, and its contributions towards the construction of domestic relationships: indeed, the incorporation of the hi-fi system into family life can be regarded as a case study in middle-class culture and gender relations of the

1950s (see Keightley 1996). The discourses surrounding the hi-fi experience emphasised hi-fi reproduction as a means of immersing oneself in music; at the same time, the hi-fi was discursively constructed, in opposition to television, as essentially a male domain.

The aesthetics associated with hi-fidelity reproduction have also contributed to the construction of the perceived opposition (or, as I would argue, a complementarity) between domestic and public forms of entertainment. During the late 1960s and early 1970s, for example, as popular music became increasingly used in film soundtracks, the superior audio quality of domestic hi-fi was cited as one of the forces necessitating increased investments in the improvement of audio in both cinema production and exhibition (similar forces were also at play in the live concert presentation of music, resulting in improvements in PA systems). Coming full circle in the 1990s, the introduction of domestic versions of the Dolby Surround Sound system has given rise to the notion of the 'home theatre' and given a new resonance to the aesthetic (and social) ideal of 'immersion' in the experience of hi-fi reproduction.

While phonograph listening was often regarded by critics of the early twentieth century as a form of 'passive' consumption, it should be clear from the examples cited above that this is no longer the case (if, indeed, it ever was). As a final example, one might also consider the rise of *Karaoke*, a practice originating in Japan but increasingly popular in the West during the late 1980s and early 1990s as well, where consumers were invited not to simply sing along with their favourite songs, but actually to take on the role of lead vocalist performing with pre-recorded arrangements of popular hits. Ethnomusicologist Charles Keil (1984: 94) has suggested that we need to consider this novel form of 'mediated-and-live' performance as a kind of 'humanising or, better still, personalisation of mechanical processes'. Keil's analysis could apply equally well to a number of other technologies cited above and highlights, I think, the importance of understanding consumer audio technology as a significant enabling factor, operating at a number of levels, in a wide range of essentially participatory, social and musical practices.

Conclusion

Technology has been central to the production, distribution and consumption of popular music for over half a century; indeed, it has become a precondition for popular music culture at its broadest and most fundamental levels. The debates that have accompanied the introduction of new technology in popular music have often depended on a rigid set of dichotomies:

for example, the distinction between 'live' and 'recorded' music. However, as I have attempted to demonstrate throughout this essay, such distinctions are often misleading: the live performance of popular music is as dependent upon the technologies of audio production and reproduction (not to mention lighting, video and other technologies) as any studio recording (see Goodwin 1992).

As a precondition for popular music-making, technology must be understood as both an enabling and a constraining factor that acts in complex and contradictory ways in music production, distribution and consumption, blurring, in many cases, the distinctions between these otherwise discreet stages in the circulation of music. While it is in the interests of the record industry to use technology in ways that will enhance, rationalise or control the circulation of music, musicians (in the case of sampling) and consumers (with cassettes and MP3 files) have also used technology to disrupt the operations of the industry, if only temporarily. As outlined briefly above, the Internet is, at the turn of the twentieth century, the ground upon which this play between competing interests is currently being acted out. On the one hand, the Internet is regarded as a potentially lucrative forum for direct marketing strategies, sales and licensing for both the traditional record industry and a new generation of entrepreneurs while, on the other, it has given rise to new consumer formats (such as MP3, among others) and emerged as an alternative distribution network for all forms of independently produced music as well as a potential site of new musical experiences and social interactions among consumers. In the end, the outcome of the exploitation and containment of these various possibilities will depend on the ways in which this technology can be used to mediate the ever-shifting set of power relations that exists between the industry and popular music practices.

Further reading

A comprehensive history of audio technology and its role in the evolution of the sound recording industries can be found in Pekka Gronow and Ilpo Saunio's *An International History of the Recording Industry* (Christopher Moseley, trans., London: Cassell, 1998); less detailed but taking a more polemical stance with regards to the musical and cultural significance of sound recording, including the importance of technologies from the microphone to digital sampling, is Michael Chanan's *Repeated Takes: A Short History of Recording and its Effects on Music* (London: Verso, 1995). William Moylan's *The Art of Recording: The Creative Resources of Music Production and Audio* (New York: Van Nostrand Reinhold, 1992) offers a

good overview of the technical and aesthetic practices associated with studio recording.

A stimulating account of the shifting musical and cultural meanings associated with the electric guitar – one of the most significant of all musical instrument technologies of the jazz and pop/rock eras – can be found in *Instruments of Desire: The Electric Guitar and the Shaping of Musical Experience*, by Steve Waksman (Boston: Harvard University Press, 1999). The influence of digital technologies on musical instrument design and musicians' practices, as well as an account of the industries that create and promote these technologies, is the subject of my own book, *Any Sound You Can Imagine: Making Music / Consuming Technology* (Hanover, NH: Wesleyan University Press, 1997). An insightful case study of the uses of technology in the production of rap music can be found in 'Soul sonic forces: technology, orality, and black cultural practice in rap music', by Tricia Rose (in *Black Noise: Rap Music and Black Culture in Contemporary America*, Hanover, NH: Wesleyan University Press, 1994).

A number of important studies documenting the diffusion of cassette technology, especially as it relates to non-Western cultures, have been published. Among the first, and the most broadly based, is Roger Wallis and Krister Malm's study of the music industry in some twelve countries around the world, entitled: *Big Sounds from Small Peoples: The Music Industry in Small Countries* (New York: Pendragon Press, 1984). Focused on the dramatic changes in popular music wrought by the advent of cassettes in India is *Cassette Culture: Popular Music and Technology in North India*, by Peter Manuel (Chicago: University of Chicago Press, 1993). Taking a slightly different tack, in *Doing Cultural Studies: The Story of the Sony Walkman* (London: Sage, 1997), Paul du Gay and his colleagues offer a wide-ranging account of the design and global marketing of the Sony Walkman and its impact on consumption practices.

Much of what has been written about MP3 files and the Internet in the popular press (and throughout the Internet itself) has been largely naive, partisan, or sensational in character. A recent study that examines the underlying industrial and structural issues raised by the new technologies was conducted by the National Research Council in the United States and published under the title: *The Digital Dilemma: Intellectual Property in the Information Age* (Washington, DC: National Academy Press, 2000).