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Imperfect sound forever: loudness wars, listening formations, and the history of sound reproduction

Abstract

The purpose of this paper is to provide some historical perspective on the so-called loudness war. Critics of the loudness war maintain that the average volume level of popular music recordings has increased dramatically since the proliferation of digital technology in the 1980s, and that this increase has had detrimental effects on sound quality and the listening experience. My point is not to weigh in on this debate, but to suggest that the issue of loudness in sound recording and playback can be traced back much earlier than the 1980s. In fact, loudness has been a source of pleasure, a target of criticism, and an engine of technological change since the very earliest days of commercial sound reproduction. Looking at the period between the turn-of-the-century format feud to the arrival of electrical amplification in the 1920s, I situate the loudness war within a longer historical trajectory, and demonstrate a variety of ways in which loudness and volume have been controversial issues in – and constitutive elements of – the history of sound reproduction. I suggest that the loudness war can be understood in relation to a broader cultural history of volume.

Introduction

> There's no denying that music is louder today than ever before.
> - Sarah Jones, *Mix Magazine*, 2005

For a hundred years, loudness was part of the solution to the problem of 'fidelity'.[1] In order for recording companies to bolster the claims of realism and presence and truth-to-the-original that pervade the history of sound reproduction, playback had to be faithful (utilizing a frequency range wide enough to approximate the original sounds) – but it also had to be loud (capturing a dynamic range comparable to that of the original sounds). If the volume was feeble, the overall reproduction was less real, less believable, lower in fidelity. So when journalists like Sarah Jones (2005) claim that 'music today is louder than ever before', we might also assume that music today is more hi-fi than ever before. There is an element of truth to that idea. But Jones is referring to popular music's so-called loudness war, the critics of which maintain that the average volume level of popular music recordings has increased dramatically since the proliferation of digital

technology in the 1980s, and that this increase has actually had *detrimental* effects on recording aesthetics. Lower the average volume of popular music recordings, these critics argue, and the result will be higher fidelity.

From this perspective, the loudness war marks an interesting inversion in the history of sound reproduction: if for a hundred years increased loudness was part of the solution to the problem of fidelity, in the twenty-first century the possibilities of digital recording have turned loudness into a *problem* to which the notion of fidelity is actually the *solution*. Part of what this inversion points to is the contingent, socially constructed and historically variable character of fidelity – an idea that is well known and widely discussed. But the inversion also points to the contingent, socially constructed and historically variable character of another, less thoroughly examined property of sound: loudness. Taken together, these aspects of the loudness war signal a degree of malleability in the relationship between loudness and fidelity, the history of which is the subject of this essay.

My starting point is that the historiography of sound reproduction has been circumscribed by the notion of fidelity. By this I mean that the history of sound reproduction is normally framed in one of two ways: either in terms of popular discourses that accept the notion of fidelity as real and debate which technologies provide the best fidelity; or in terms of critical studies that debunk the notion of fidelity, focusing instead on the historical and cultural settings that allow that category to appear as a 'reality' in the first place. Either way, I argue that the historiography of sound reproduction has orbited primarily in a *problem space of fidelity*. In this problem space, perfect fidelity is either identified as the ultimate goal of sound reproduction, or as a 'logic' central to the

history of sound reproduction. Insightful as this latter work may be, a historiography centred on the critique of fidelity is still a historiography centred on fidelity. Loudness can provide another perspective.

I begin to make this argument by defining the contemporary loudness war, describing the critical discourse that has been developed by musicians, fans and industry personnel in rallying against this phenomenon. While the ins and outs of the loudness war have been covered elsewhere – most readably by Greg Milner (2009) – I review the debates here because my perspective is somewhat different. I engage with the loudness war as an observer, in the sociological sense of that word: my goal is to systematically describe the way this phenomenon is understood in the musical world. As such, although it is possible to argue about this issue with facts and figures (see Deruty 2011), my reason for starting with the loudness war is not that I have an interest in proving that popular music is or isn't getting louder; nor is it because I have an interest in deciding whether loudness is good or bad.

Rather, the loudness war serves as a gateway to a historical discussion. I want to understand the contemporary loudness war as a set of contradictions between practices of listening and ideals of sound reproduction, and I want to view this set of contradictions in relation to a longer history of changing modes of listening and musical mediation. To do so, I offer in the latter stages of this paper a series of studies (1880-1930) in which idealistic preferences for fidelity clash with practical realities of loudness: ear tubes v. horns, cylinders v. cylinders, cylinders v. discs, mechanical v. electrical amplification. Whereas many discourses of sound reproduction emphasise ways in which volume and fidelity function symbiotically (as the pillars of 'good' and 'realistic' sound), these case

studies highlight ways in which volume and fidelity are in some ways and in some cases inversely correlated. What's more, in cases where loudness and fidelity have been inversely correlated, audiences often choose loudness over fidelity, whereas audio enthusiasts tend toward ideals of fidelity. Instead of favouring fidelity, audiences like loudness because of its ability to furnish certain situations with music. This pragmatic orientation often outweighs concern for the minutiae of sonic detail. In other words, a particular form of mediation is preferred because it more readily facilitates a certain mode of listening.

These negotiations between forms of mediation and modes of listening, these sets of contradictions between the practices of audiences and the ideals of audio enthusiasts, can be understood as mutually constitutive functions of fragile coalitions called listening formations. 'Listening formation' is a deliberately broad and inclusive concept, encompassing 'the whole context of audition for historically specific audiences, taking account of expectations formed for them by the whole culture and technology of speech and hearing of which they are a part' (Faulkner 1994, p. 165). Obviously providing a detailed account of the constituent elements of a given listening formation at a given time is beyond the scope of this paper (although the kind of 'total history' that such a project would entail would certainly be valuable). Rather, this paper looks at listening formations as systems of thought and practice that are in constant states of sedimentation and erosion. So my aim is less to provide a complete description of a single listening formation than to say something about how these systems work, to specify something about their logics. In other words, this paper is about seeing the contemporary loudness war as one of a series of 'loudness wars'; and, in turn, it is about understanding these loudness wars as

consequential moments in the history of sound reproduction.

The historical connections between these loudness wars are not matters of absolute sound level. There are, of course, real gaps between recording levels in 1900 and 2000. But despite these material differences, there are discursive continuities in the way that loudness has been appreciated and deprecated in the ongoing negotiation of listening formations. Indeed, in each of my case studies, 'loudness' takes on a different meaning. For example, in the early days of commercial sound reproduction, loudness was needed to facilitate new types of group listening (especially dancing). In the electrically amplified 1920s, loudness retained this practical element but also became a scapegoat for audio enthusiasts who preferred the familiar tone of acoustic reproduction. In the contemporary loudness war, the issues are compression and dynamic range, or consistency of loudness, more than absolute volume. 'Loudness' can thus mean different things to different people at different times.[2] It is this contingency, I argue, that makes a history of loudness possible.

However, while I do suggest the possibility of such a history, and while I will end by saying something about what that history might look like, this article does not pretend to offer a full-blown history of loudness. That story is simply too vast and too complex to cover in the space of this short article (e.g. an effective history of volume would need to take better stock of the relationship between loudness and 'noise').[3] My more modest claim here is that the lens of loudness affords a distinct analytical perspective on the history of sound reproduction, and that this perspective encourages us to rethink some of the ways in which the story of sound reproduction is normally told.

The problem space of fidelity

It is customary in popular discourse and in the advertisements of gramophone companies to cast the history of sound reproduction as a story of progress, a series of refinements on the way to flawless recording and playback – perfect fidelity. The usual academic response has been to deny this teleology by revealing that fidelity is a socially constructed category: less a final destination than a moving target. From this perspective, the category of fidelity is a kind of technical-aesthetic ideal that changes over time – a point which Jonathan Sterne (2003, p. 222) sums up well when he says that 'every age has its own perfect fidelity'. In his more recent work, Sterne (2006, p. 345) reiterates this idea ('The history of sound reproduction in the twentieth century is not, as sales literature might suggest, a story of ever increasing fidelity') but also takes it a step further, noting that the story of sound reproduction 'may very well also not be a history of audiences who really care about greater fidelity'. This is the point I'm making here, although I want to expand Sterne's suggestion in two ways.[4] First, the myth of increasing fidelity is of course more widespread than sales literature: in addition to advertisements, a variety of journalistic and insider histories have contributed to the centrality of fidelity (e.g. Read and Welch 1976, Gelatt 1977). Second, the suggestion that fidelity has mattered less than other factors in the history of sound reproduction has the conceptual potential to move sound reproduction scholarship beyond its now repetitive emphasis on the social construction of fidelity. But the full weight of this idea has not yet been borne out in the scholarly literature. Regardless of whether these writers are inflating or deflating the myth of fidelity, they assign fidelity such a pivotal role in the history of

sound reproduction that it ends up overshadowing other facets – such as loudness.

I would also argue that the history of sound reproduction is not, despite what much academic literature might suggest, a story about the problem space of fidelity. Not exclusively, anyway. Sound reproduction obviously raises some provocative questions about the relationship between originals and copies (Sterne 2003), about speech and writing (Gitelman 2000), presence and absence (Peters 2004), the real and the symbolic (Kittler 1999), otology and ontology (Connor 1997). These are instances and extensions of 'the paradoxes of phonography' (Eisenberg 1987, p. 158). As a term, phonography is difficult to define precisely, and the use of it cannot be assigned to any one scholar. In general, though, it is meant as a shorthand way of pointing to a kind of acoustic modernity, in which the development of sound reproduction offered not only new technological possibilities but also new epistemological problems, both of which helped redefine relationships between human consciousness and communication, on the one hand, and the world of sound, on the other. In other words, phonography refers to 'a period in our relation to music . . . marked by a distinct set of attitudes, practices, and institutions made possible by . . . the phonograph' (Rothenbuhler and Peters 1997, p. 242) as well as 'an anthropological revolution in human history – not just another in a series of technological innovations but one which profoundly interrupts and problematises what it means to be human' (Engh 1999, p. 54).

Such writing has been among the most exciting and interesting developments in the social sciences and humanities during recent years. Through a study of loudness, though, it is possible to show that examining sound reproduction primarily in terms of phonography and the problem space of fidelity, as fruitful as this has been, is also to limit

it as an object of study. Despite fidelity's obvious historical importance, the study of loudness emphasises that the development of sound reproduction is characterised by heterogeneity, by various and sometimes competing ideas and practices. And despite the conceptual allure of phonography, the study of listening formations pushes as much toward historical questions as theoretical conundrums (to an extent, the study of loudness is less interesting for the theoretical questions it poses than for the theoretical preoccupations it exposes). This isn't to say that theory is irrelevant here. But to understand this history in terms of listening formations is to augment the theories of modernity, representation and subjectivity that pervade much sound reproduction scholarship. It's for these reasons that I suggest the historiography of sound reproduction has been circumscribed by histories of fidelity and theories of phonography, and that such circumscription is problematic. So my argument here is offered as a counterweight to the theorists of phonography, who treat sound reproduction principally as a problem of semiotics and post/structuralism and psychoanalysis. And my argument is equally meant to counterbalance the historians of fidelity, who argue above all that the 'logic that has attended the development of recorded sound has been one of high fidelity' (Engh 1999, p. 54).

Because of the extent to which the history of sound reproduction has become synonymous with the history/critique of fidelity – both in the popular imagination and the academic literature – my argument about the relatively minor status of fidelity may seem counterintuitive. But the fact that practicalities of loudness trump ideals of fidelity in so many areas of sound reproduction is perhaps less surprising than the fact that fidelity managed to assume such a prominent and resilient role in the discourses of sound

reproduction in the first place. In many ways, the history/critique of fidelity is the story of a dominant discourse but a minority listening practice. Engaging with the history of sound reproduction is thus not, in this article, primarily an exercise in mythologizing fidelity (the 'perfect sound forever' of ads and popular discourse) or demystifying that category (the 'perfecting sound forever' of critical scholars). Rather, the magnetisms of incongruence between acoustic ideals and auditory practicalities – the logics of listening formations evidenced in this article through the loudness wars – point outside the problem space of fidelity. They tell a different story: more like, imperfect sound forever.[5]

The loudness war

The contemporary loudness war begins to reveal aspects of this other story. The loudness war stems from a step in the process of creating a recording called mastering. This step, which occurs after individual sounds and songs have been recorded, edited and mixed, is the final process before a recording is mass-produced (or not-so-mass-produced, as the case may be); it's the step where mastering engineers finalise the original from which copies will be made. The process involves a variety of tasks, such as transferring data from one medium to another, setting the amount of downtime between songs, limiting unwanted noises like hiss and hum, adjusting the frequency spectrum until it sounds 'full' or 'crisp' (or any other number of hazy descriptors) – and the process can also involve increasing a recording's overall volume.

Increasing a recording's overall volume is achieved using a technique called dynamic range compression, whereby the difference in decibels between the quietest and

loudest sections of a recording is reduced. This is accomplished by electronically squishing the sound signal so that the level of quieter sounds is nearer the level of the loudest ones. Compression thus raises not the peak but the *average* volume level of a recording.

Dynamic range compression is not a new phenomenon, nor is it limited to the world of music recording: it has been an essential element of mediated sound since the early twentieth century (e.g. electronic hearing aids, radio and television broadcasting). And while the reasons for using this kind of compression are as varied as its circumstances of mediation, for the purposes of this paper I simply need to highlight two of the main reasons that audio professionals and musicians involved in the loudness war argue that compression is desirable.[6] First, there is an aesthetic argument. Because of the mechanics of human ears and brains, compression can give the impression that a recording is, simply, louder – which, for the same psychoacoustic reasons, can give the impression that a recording is, simply, 'better'.[7] This is related to a second, practical reason for using compression: professionals and musicians believe that loud music is more ear-catching than quiet music. The argument here is that whereas people 'actually listened' to records in the 1970s, nowadays more listening happens on the go, in the car, at the pub, and so on. In such situations, less compressed and quieter songs can be hard to hear (because the ratio of music to environmental noise is low) and risk being lost in the shuffle, so to speak (see Plambeck 2010, p. B1). As Chicago-based mastering engineer Bob Weston (n.d.) explains in his loudness manifesto: 'In this age, we all do tend to listen to music in much noisier environments and generally, perhaps, pay less attention to the music we hear. In such an environment, it is tempting to try to make your music "shout-out" the

loudest'. And while engineers like Weston resist this temptation (for reasons that I will outline momentarily), producers like Matt Serletic (Levine 2007) embrace it: 'In the Seventies', he says, 'you were expected to pay attention . . . Modern music should be able to get your attention'.

So musicians and audio professionals who support the use of compression to increase the overall volume of a recording tend to do so for two reasons. First, because they believe that loud music sounds 'better'. Second, and more significantly, because they recognise that certain forms of musical mediation (like car stereos and MP3 players) facilitate certain ways of listening (music as background, as soundtrack to everyday life) and that recordings which have been made consistently louder through dynamic range compression tend to fare better in such situations (because they garner more attention and constitute a higher signal-to-noise ratio). Combined, these aesthetic and practical points have contributed to an environment where musicians and industry personnel worry that band *X*'s recording will be quieter than band *Y*'s, which has resulted in a competitive, snowballing drive for loudness. And this snowball effect is otherwise known as the loudness war.

Critics of the loudness war

In the past decade, the loudness war has elicited a strong critical reaction from certain fans, musicians and sound engineers. These critics tend to make two (related) points, one of which is about the listening experience, whereas the other is about musical aesthetics. In terms of the listening experience, critics argue that loud, heavily compressed

recordings exhaust our ears more quickly than quieter, less compressed music. For example, Ethan Smith (2008, p. A1) suggests that the more consistent barrage of sound that results from compression can lead to an effect commonly called 'ear fatigue'.[8] In the words of Abbey Road mastering engineer Peter Mew (Sherwin 2007), 'The brain is not geared to accept buzzing. [Loud, heavily compressed] CDs induce a sense of fatigue in the listeners. It becomes psychologically tiring and almost impossible to listen to'. In this way, according to critics of the loudness war, louder overall recording volumes are detrimental to the listening experience.

Aesthetically, critics argue that over-compression and the resultant loudness can obscure musical detail. Long-time Beatles engineer Geoff Emerick (Sherwin 2007) complains that 'A lot of what is released today is basically a scrunched-up mess. Whole layers of sound are missing', while Bob Dylan (Levine 2007, p. 15) notes in *Rolling Stone* that many contemporary recordings 'have sound all over them. There's no definition of nothing, no vocal, no nothing, just like – *static*'. Critics have singled out 'albums from Springsteen to Fall Out Boy' (anon. 2008, p. 32), from the Flaming Lips to the Arctic Monkeys to the Red Hot Chili Peppers, as particularly compressed and loud, though the issue came to the fore especially in relation to Metallica's *Death Magnetic*, which *Rolling Stone* called 'one of 2008's most earsplitting discs' (ibid.). The sound of *Death Magnetic* was considered so offensive that thousands of fans signed an online petition demanding that the album be remastered: 'It's so loud, they say, you can't hear the details of the music' (Smith 2008, p. A1; see also Hiatt 2008, p. 11). The critics' argument here, then, is that compression and loudness result in a dearth of detail in recordings, and that the loudness war thus has had an adverse effect on sound quality.

To summarise: critics argue that the loudness war – defined as a snowball effect that is the result of pressure from musicians and industry personnel to master recordings at higher overall levels (as an effort to keep up with the Joneses in terms of volume, and as a response to shifts in musical mediation and listening practices) – is having detrimental effects on both the listening experience and recording aesthetics.

Beginnings of the loudness war

Dates vary as to when this phenomenon began, but most critics trace it to the proliferation of digital recording and playback technology in the 1980s – the CD, in other words. There is an element of truth to this: before digital audio formats, vinyl records and electromagnetic tape placed definite physical limitations on the amount of volume that a recording could exhibit (on a record, for example, louder sounds mean wider grooves, which means less playing time). The CD eliminated some of these concerns, and allowed for a wider dynamic range than previous playback media. But while the CD does technically allow for higher highs and lower lows, many audio professionals have focused on packing more loud sound into the larger dynamic space, which means that they actually utilize a *narrower* dynamic range than previous sound media. This contradiction in the potential of digital audio is what, for many, marks the CD as the instigator of the loudness war.

However, there is also a sense in which 'The invention of digital audio and the compact disc became a new fuel for a previously existing loudness race', in the words of Bob Katz (Sreedhar 2007), one of the foremost critics of the loudness war. Indeed, some

of the more historically sensitive critics have recognised that precursors to the loudness wars can be found as far back as the 1960s, when record companies 'observed that louder songs in jukeboxes tended to garner more attention than quieter ones' (Sreedhar 2007), and the 1950s, when producers of 45 rpm singles jockeyed for the attention of Top 40 radio's program directors (anon. 2009). One critic (Southall 2006) even observes that 'The "Loudness War" has been going on almost as long as pop music has existed, and probably longer'. The point I want to make in the rest of this paper is that the loudness war is indeed part of a longer history – and not just a history of popular music production, but a history of sound reproduction and listening formations more generally.

Loud and clear? Volume in the history of sound reproduction

> … it is said by experts that what is gained in volume is lost in fidelity.
>
> - Ogilvie Mitchell, editor *Talking Machine News*, ca. 1922

Speaking of the early days of commercial sound reproduction, Columbia patent attorney Philip Mauro (1900, p. 39) provides some historical perspective on the contemporary loudness war and begins to open up an alternate perspective on the history of sound reproduction. 'The main effort during this period', he says, was not for higher fidelity but 'for *greater volume of sound*' (emphasis in original). What's more, it was understood as a matter of course that higher volume often meant lower fidelity. A reporter in the December 1916 issue of the *Sound Wave* stated flatly that 'We have heard it times without number that the more we increase the volume in a reproduction, the more the true

tone quality will suffer' (James 1998, p. 7). *Talking Machine News* editor Ogilvie Mitchell (ca. 1922, p. 50) noted something similar: 'it is said by experts that what is gained in volume is lost in fidelity'. Loud *and* clear sound was thus something of a grail for manufacturers and certain audiences. And even though much effort was put into disproving this 'law' of inverse correlation between volume and fidelity, companies and customers often had to choose one or the other. When presented with this choice, consumers and audiences tended to favour volume over fidelity.

Part of what is interesting about this relationship is that even today, when the pairing of loudness and clarity as the pillars of hi-fi sound has arguably been achieved, they continue to exist in a relationship of antagonism in areas like the loudness war. This relationship between loudness and fidelity points to a more general trend in the history of sound reproduction, where ideals and media of reproduction are weighed against practicalities and modes of listening.

The onerous ear tube

Already in 1886, the merits of cylinder composition were being weighed against the benefits of sound quality and volume. Although the wax-coated cylinders of Charles Tainter and Chichester Bell's graphophone were 'smoother, better defined and more pleasing' than Edison's tinfoil phonograph cylinders, 'there was a drawback': they were 'considerably lower in volume than the sound generated by the old phonogram. This necessitated the addition to the machine of stethoscopic ear tubes to further amplify the sound level' (Schicke 1974, p. 17).

The word *drawback* is used again and again to describe the necessity of ear tubes in early phonograph reproduction. There are several explanations for why ear tubes were regarded as a problem (they were, for example, said to be uncomfortable, even unsanitary). But perhaps the central reason lies in the mode of listening which they most readily facilitated. The main 'drawback' of this mode of listening is well illustrated by an account of some early, unlicensed phonograph performances in the UK around 1890. Percy Willis, the delinquent entrepreneur who smuggled the machines into the country inside apple barrels, recalls the scene upon landing at Queenstown:

> . . . a splendid start it was. The people came rolling in by dozens and scores. In those days, you know, to hear the record you had to listen with tubes in your ears, and there was no spring motor to drive the machine. . . . These were drawbacks . . . The worst of it was that only one person could listen at a time and, especially with children, there was a good deal of difficulty in subduing the impatience of the waiting crowd. (Mitchell ca. 1922, pp. 27-28)

Spurred by his initial success, Willis continued on, drawing 'shoals' of listeners in Cork, Waterford, Limerick and Dublin, with a repertoire ranging from counterfeited speeches of Prime Minister William Gladstone to music hall celebrity Charles Coborn's rendition of 'The man who broke the bank at Monte Carlo'. Had the technology been available to him, in order to allow these audiences to listen as a group Willis would have almost certainly compromised the 'smoother, better defined and more pleasing' sound of ear tubes in favour of a louder, if less pleasing, amplifying horn. Of course, Willis's

motivation was financial (more listeners at once would have meant more revenue). But audiences were also willing to sacrifice sound quality for volume – and that this push for louder reproduction was not so much financially motivated (although penny-pinching was sometimes a factor)[9] as it was culturally motivated.

By 1888, molding processes had improved cylinder composition to the point that phonograph expositions often featured three modes of reproduction: single ear tubes, multi-tubes and horns.[10] In the 1890s, customers could specify whether they wished to use ear tubes or horns, and some recordings were advertised as good for one or the other, or both (Feaster 2007, p. 182). Single tube reproduction was recommended by manufacturers. Columbia, for example, boasted about the 'wonderful fidelity with which the Graphophone reproduces musical and other sounds' but noted that this 'wonderful' fidelity 'can not be fully appreciated unless the reproductions are listened to through the ear tubes' (Columbia 1897, p. 4). As such, they advised 'the use of the rubber hearing tubes . . . where only two or three are to listen' (Feaster 2007, p. 246). While multi-tube contraptions (like those used in the nickel-in-the-slot phonograph parlours) could be used to extend the listening experience to a handful of people, there is evidence that even these quasi-communal events – for which Sterne (2003, p. 163) borows the term 'alone together' – were not enough. In 1892, for example, the Buffalo *Times* described saloon patrons substituting a liquor funnel for ear-tubes, in order to allow a room to listen together (Feaster 2007, p. 251). Indeed, Columbia begrudgingly admitted that 'Where a large company is to be entertained, of course a horn is necessary, but it is believed the music that is thrown out through the horn loses much of its sweetness' (ibid., 246). The willingness of audiences to sacrifice the quality of tubes for the volume of horns thus

indicates that while they may have possessed the cultural tools necessary for individuated listening (Sterne 2003), they were not always or even usually content to listen to music in that way.

Speak to it in undertones, it repeats in thundertones: cylinder v. cylinder

Even though, as we will see, cylinders were eventually overtaken by the louder medium of disc reproduction, this did not prevent cylinder manufacturers from attempting to solve the volume deficiency of their products. Indeed, Columbia was 'convinced that the market was ripe for a cylinder machine capable of greater sound volume' (Schicke 1974, p. 50) and, in 1898, the firm unveiled its Graphophone Grand, which it believed could 'satisfy the demand for a louder wax-cylinder talking machine' (Gelatt 1977, p. 81). Three months later, Edison joined what would later be described as the 'folly' of large cylinders (Schicke 1974, p. 51), announcing the Edison Concert Phonograph.

The Grand and the Concert played cylinders with diameters of up to five inches, more than twice that of the cylinders used by standard graphophones and phonographs. The larger diameter meant that the surface speed of the cylinder, and thus the playback volume, were increased to the point that ear tubes were not necessary (the Grand used a fifty-six inch reproduction horn; the Concert was apparently able to fill an auditorium). This solution was so basic and so effective that Mauro (1900, p. 43) thought it 'strange indeed that, with so many observers and with so strong an incentive to increase the volume of sound, this simple law has not sooner been discovered'.[11]

As I have suggested, this 'incentive to increase the volume of sound' had

something to do with facilitating a collective listening experience. Indeed, it is interesting that volume received as much emphasis as clarity in advertisements for these machines. For example, casings of both Columbia and Edison cylinders proclaimed that they were 'Extra Loud',[12] while an 1899 ad for the Graphophone Grand read: 'Speak to it in undertones, it repeats in THUNDERTONES' (Feaster 2007, pp. 200-01). One important reason for this emphasis on volume was that a relatively novel form of collective listening was on the rise at the time: the phonograph dance.

Though phonographs had been used at dances before this, the machines were used to provide music *between* numbers. The use of recorded music to accompany live dancing was new, as the apparatus was not previously able to produce a volume suitable for such activity (ibid., p. 465). Following the introduction of Columbia's Graphophone Grand, the *Phonoscope* wrote in 1899 that 'The dream of the dancing master is about to be realized in the mammoth instrument just put upon the market. It is powerful enough to fill any theatre or church for a concert . . . Every dancing teacher in the world who can afford it will shortly possess this machine and if he doesn't get one he will be behind the times' (ibid., p. 473). Such features were emphasised in later ads too. For example, a 1905 ad depicting an Edison Standard Phonograph prompted readers to 'dance to music played by the Edison Phonograph if you like – it plays waltzes, two-steps, lancers, quadrilles and fancy dances. Loud enough for large halls' (Edison Company 1905, p. 1188). What is foregrounded here is not the familiar trope of higher and higher fidelity or the social construction of that category in the first place (although these are aspects of the story)[13] but, rather, the incorporation of newfound volume levels into established forms of collective listening – especially dancing. As I've framed it here, then, the story of

large-diameter cylinders is one in which audiences are less concerned with fidelity than danceability.

I reign supreme, their Queen, the gramophone: cylinder v. disc

Music and song my captives, sound my throne,
I reign supreme, their Queen,
THE GRAMOPHONE
- Berliner ad, 1898[14]

Ultimately, the large cylinder trend was short-lived. Almost as soon as the concert-sized cylinders were introduced, better molding processes were developed which afforded smaller cylinders the same advantages as larger ones, rendering the Graphophone Grand and the Concert Phonograph obsolete. But it wasn't just large cylinders that were being eclipsed during the late 1890s: the decade marked the sunset of cylinder reproduction altogether.

Although experiments with disc reproduction were going on much earlier (Edison had tinkered with revolving dinner plate-sized discs as early as 1878),[15] improvements by Berliner Gramophone and the Victor Talking Machine Company led to the commercial viability of discs around the turn of the century. Discs had several advantages over cylinders: the machines were cheaper, the discs themselves were easier to mass produce and to store and transport, pirating was more difficult (though not impossible),[16] and they were louder – they 'did not require the use of the onerous ear tube' (Schicke 1974, p. 50). But they did *not* necessarily sound better.

One of the benefits of cylinders – and one of the reasons that Edison stubbornly continued producing cylinder machines until 1929 – is that the needle maintains a constant surface speed throughout the entire recording, which makes for a consistent quality of sound. On flat discs, by contrast, the surface speed of the needle slows as it reaches the centre of the record, which can result in a phenomenon known as inner groove distortion. Another benefit of cylinder recording is that the tone of the reproduction was thought to be more pleasing than the wax-coated zinc discs used by Berliner, which were 'raucous-sounding' (Schicke 1974, p. 44) and afflicted with a 'hissing, sissing, scratching sound', as one listener complained to the editor of *The Phonogram* in 1901 (Gelatt 1977, p. 158). *The Phonoscope*, on the other hand, ran downright slanderous editorials on the non-Edison discs, going so far as to compare the gramophone's 'blasty, whang-doodle noises' to 'the braying of a wild ass' (Sterne 2003, p. 279).

But even though, in terms of tone, the odds were stacked against the gramophone, for a confluence of reasons the flat disc became a dominant medium of sound reproduction for much of the twentieth century. Influential among those reasons was the fact that 'Compared with the Berliner method, the recording process then employed by the phonograph and graphophone was unable to compete with the Gramophone in volume' (Read and Welch 1976, p. 122). According to Feaster (2007, p. 474), 'Gramophones were thus more likely than standard cylinder phonographs to generate enough volume to accompany live dancing' – meaning that the gramophone's volume was 'a selling point which cylinder advocates had been trying in vain to dismiss'.

Not surprisingly, then, the loudness of the gramophone was also a catalyst for

change in the wider recording industry: 'It may have been in part due to the introduction of the Berliner Gramophone that shortly thereafter the incising methods used in making cylinders were improved so as to also permit the use of horns for reproduction' (Read and Welch 1976, p. 123). And while it's true that more advanced molding processes (e.g. the gold-molding developed by Edison) did allow the use of horns and produced cylinders that were 'cleaner' and 'more accurate' with 'less surface noise' than the discs (ibid., p. 153), cylinder machines simply never achieved the same level of volume as the gramophone. Cylinders thus fell by the wayside. Volume, again, prevailed over fidelity.

In addition to seeing loudness as an impetus for the technological development of sound recording during this period, I want to emphasise two things. First, the popularity and commercial success of the gramophone depended significantly on the fact that it was louder than other forms of sound reproduction. Second, while Berliner and others eventually refined the tone of disc reproduction, initially the gramophone's increased volume came at the expense of 'sound quality'. What's going on here, as with the cylinder feuds, is that tone was being sacrificed in favour of volume, because a certain mode of listening was deemed more desirable than another. Of course, the desire for extra volume also had something to do with the ongoing negotiation of the technology and discourse surrounding fidelity (reproducing sound at levels that approached the original performance was part of the social construction of the category of 'realism'). But the point I want to make is that professionals and audiences also sought louder recordings for a more straightforward and practical reason: such records could be listened to by groups of people and, even more significantly during the 'crazes' of the 1910s and 1920s, they could be *danced* to. As with turn-of-the-century lancers and quadrilles, when it came to

waltzes and foxtrots, the need to fill a room with sound – the need for volume – outweighed the concern for quality.

A complicated cat fight in a mustard mill: mechanical v. electrical amplification

While sound reproduction levels continued to affect the technological development and increasing dominance of the discs through the 1910s, there is a sense in which playback volume took on a new musical and cultural prominence during the 1920s. This point is thrown into sharp relief by looking at the controversies surrounding the introduction of electrical amplification to the gramophone world.

Edison watched skeptically as electrical amplification flooded the recording market, and by the time he was ready to rival the electrical method, he offered too little, too late. In a last-ditch effort to compete in the new world of electrical amplification and the popular but, he thought, misguided 'volume fad' that it had spawned, Edison developed a Dance Reproducer for his acoustic Diamond Disc Phonograph, based on the principle that more friction between the stylus and the surface of the record begets more volume. The rationale for this product is explained in an ad from the 17 June 1926 edition of *The Saturday Evening Post* (Frow 2001, pp. 70-71): 'It is called the Dance Reproducer because our experience indicates quite conclusively that volume is wanted principally for Dance Records by people who dance'. Unfortunately, for Edison, although the Diamond Disc had a reasonably high output and is recognised as a 'high watermark of the acoustic phonograph' (Millard 2005, p. 132), 'many prospective customers said that the Edison

phonograph was not loud enough' (Read and Welch 1976, p. 270). This is in stark contrast to the 1912-13 introduction of the Edison disc machines, when 'the most common complaint of prospective customers was that the reproduction was too loud' and the machines were sold with wads of fabric that could be jammed down the horn of the machine to muffle the volume (ibid.). To understand this shift in the desire for volume – this so-called volume fad – it is necessary to look at another medium of sound reproduction: radio.

With the proliferation of radio broadcasting through the 1920s, gramophone manufacturers and recording companies faced significant challenges. One aspect of this story is of course financial: by the 1930s leisure spending and industry structure had migrated toward radio, contributing to a massive slump in record sales (Frith 1988). But the introduction of radio also opened up a new chapter in the story of loudness that I've been describing.

'Throughout the 1920s', in the words of Millard (2005, p. 139), 'the phonograph and gramophone manufacturers were aware of the listener's desire for greater volume from their machines'. As I've said, this desire was partly a matter of the widespread popularity of dancing during the 1910s and 1920s. However, the very sound of radio – the sound of vacuum tubes and loudspeakers – also contributed to this so-called volume fad:

> Radio . . . served to change the standards of public taste in music and its idea of what were desirable qualities in reproduction. Before radio, the average purchaser of a phonograph had wanted a soft-toned quality of reproduction. . . . After radio

the demand was for greater volume. (Read and Welch 1976, p. 270)

Although Read and Welch's before-and-after depiction of radio sound isn't entirely accurate or even consistent with their overall argument (as I've shown, and as can be gleaned from *Tin Foil to Stereo* itself, listeners had always been willing to trade tone for volume), it still rings true as a marker of the extent to which volume became an even more prominent concern following the introduction of radio. In Millard's words (2005 p. 139), 'Electronic amplification had a special quality that Americans took to heart and soon wanted to hear from their phonographs'. However, while the 'special' sound of electrical records 'was loud enough to dance to' and while 'its raucous volume suited the music of the Jazz age', the quality of reproduction 'was not as delicate and as well articulated as the reproduction of an Edison Diamond Disc' (ibid.). It was for this reason that many recording companies 'scorned the radio sound', even as the success of radio 'forced them into a desperate search to find a way of increasing the volume of reproduction' (ibid.).[17]

As electrically recorded and reproduced sound spread through the musical world, it became obvious that this new method had several technical advantages over the acoustic method: electrical records were clearer (better signal-to-noise ratio, wider frequency range) and the output was not only louder but also easier to control (turning volume knobs instead of 'putting a sock in it'). But, as with the transition from cylinders to discs, not everyone agreed that electrical records sounded better. Perhaps the most common and most venomous insult for electrical recording was to call it *strident*,[18] although the criticisms were more varied and more amusing than that.

Old-guard gramophiles like Compton Mackenzie called the electrical discs 'abominable', mocking the 'whining infancy of the new recording' and describing the sound of the records as a 'jangle of shattered nerves'; his *Gramophone* columnists and readers complained about 'squeaky tone' and 'unpleasant twang', saying the quality of reproduction was 'more like a complicated cat fight in a mustard mill than anything else I can imagine' (Gelatt 1977, p. 232). The young Adorno (1990, p. 48) was also critical of the new method, admitting in 1927 that electrical recording was quieter, but protesting that 'incidental noises . . . nevertheless survive in the more shrill tone of the instruments and the singing'. Later that same year, a reviewer of Wagner's *Valkyrie* album, released by HMV, 'asks plaintively . . . for something a little quieter than the latest of the new recordings' (Balmain 1928, p. 401). For many readers, *Valkyrie* drew 'attention to the prevailing tendency on the part of recording companies to make their records louder and louder' (Luff 1928, p. 401), and the review thus sparked a six-month squabble in *The Gramophone*'s correspondence columns.[19]

Some letters-to-the-editor were in favour of the increased volume, many were against it, and the debate touched on everything from manufacturing processes to needle hardness, microphone placement to room acoustics. The bottom line, though, was that despite the preference of enthusiasts for the tone of acoustic records over the volume of electrical recording and playback, audiences turned down tone so that they could turn up the volume (partly as an effect of shifts in taste and trends toward radio, and partly to facilitate group listening and dancing). Speaking of 'the controversy concerning the "loud" record', Columbia recording engineer Arthur Brooks (1928, p. 489) sums this all up rather well: he shared the enthusiast sentiment ('mere volume, sans quality, leaves me

stone cold'), but noted that 'the dealers maintain that their customers prefer their records loud'.

Imperfect sound forever: loudness wars and listening formations

This brings us back to the contemporary loudness war where, despite the objections of some musicians and industry personnel, generally loud and heavily compressed recordings prevail because they fare best in the situations in which most people listen to music. The loudness war can thus be seen as one in a series of loudness wars that pervade the history of sound reproduction. And the history of sound reproduction can be understood as a history in which auditory ideals and practicalities are in constant negotiation, where the priorities of audiences and 'audiophiles' drift in and out of synch.

These negotiations and compromises are the logics of listening formations that have been highlighted through this article's focus on loudness. By no means have I been exhaustive: there are many more instances where the importance of loudness in the history of sound reproduction could be demonstrated, both during the period I have been describing and through the rest of the century. For example, loudness was privileged in certain styles of electric guitar performance as early as the 1930s; in the discourse of high-fidelity in the 1950s, volume took on a certain role in the gendered redefinition of domestic space (Keightley 1996) – not to mention the role of loudness in live sound and concertgoing (Percival 2011). Additionally, there are many examples of sound quality's subordination to other concerns, from the fashion of concealed horn machines (MacKenzie 1925) to the portability of MP3 files (Sterne 2006), from intelligibility in

film sound (Lastra 2000) to the fascinating but under-researched case of television sound (Negus 2006). More than the history of a continual search for 'perfect' sound, and more than prompting a constructivist critique of that category, these studies attest to the importance of imperfection. Of course, 'perfect sound forever' and 'perfecting sound forever' have been and should remain significant threads in sound reproduction scholarship. But the tradeoffs between ideals of sound and practices of audition, between forms of mediation and modes of listening – i.e. the logics of listening formations exhibited by the loudness wars – point to a need for histories and theories of sound reproduction that orbit less exclusively in the problem space of fidelity, and which are more attentive to the pragmatics and irreducible ontological pluralism of the audible past (Sterne 2012).

Toward a history of volume

One of the themes circulating in the material examined in this paper is that music is getting louder. Edison, for example, complained about a 'volume fad' (Frow 2001, pp. 70-71). During the electrically amplified 1920s, *Gramophone* readers were conscious of living in an 'age of noise' and were sure that records too were getting 'louder and louder' (Luff 1928, p. 401). Read and Welch (1976, p. 270) 'recall the increasing loudness' of 'the competing loudspeakers of the business streets and residential neighborhoods' during the 1930s. Critics of the contemporary loudness war also assume that 'In this age, we all do tend to listen to music in much noisier environments' (Weston n.d.) and assert that 'music today is louder than ever before' (Jones 2005). Such musical claims are part of a

more general history of loudness.

A perennial belief about the modern soundscape is that it is loud – and that it is getting louder. From sixteenth-century French poets who considered hanging themselves in order to find relief from 'the din of bells' (Corbin 1995, p. 299), to eighteenth-century British cooks who were appalled by the 'hideous din' of London's hawkers and criers (Cockayne 2007, p. 107); from nineteenth-century American journalists who cringed at the 'warlike din' of mobilization and city life (Smith 2001, p. 213), to twentieth-century Dutch citizens who rallied against the 'deafening din' of industry (Bijsterveld 2008, p. 66) – the enduring assumption here is that we live in din. Acoustic ecologist Murray Schafer (1994, p. 3) encapsulates this outlook: 'It would seem that the world soundscape has reached an apex of vulgarity in our time', he claims, 'and many experts have predicted universal deafness as the ultimate consequence unless the problem can be brought quickly under control'. From this perspective, loud music is a straightforward reflection of an increasingly loud world, and the history of volume is one of perennial crisis, teleology, crescendo.

My question is whether it is possible to understand this history in a way that doesn't assume such crisis-teleologies and crescendos. Rather than seeing the loudness war (and, indeed, the loudness wars) as part of a causal historical lineage or in terms of absolute sound level, I've tried to show some of the various ways in which loudness has been constructed as a certain kind of problem in this history, as a part of particular listening formations. Just as sound scholars insist that the history of fidelity is not a straightforward march toward perfection, and just as musicologists contend that the history of harmony is not a hike toward complexity and sophistication, so I would argue

that the history of volume is not simply accretive. Indeed, in the same way that every age has its own perfect fidelity, so does every age believe that its music is the loudest, that its soundscape has reached the apex of vulgarity. This way of thinking about the history of volume is based in the assumption that cultural definitions and experiences of volume remain static over time. But they don't. They are functions of listening formations. Loudness has no objective gauge, and volume has no autonomous history; they are historical variables, not constants against which the movements of history can be plumbed. The history of volume is better measured in discourse than decibels.

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End notes

1. ‘Fidelity’ is of course a problematic term that refers less to an absolute quality of sound or the degree to which a recording is ‘faithful’ to its source than it does a set of historically situated discourses (Sterne 2003). Indeed, ‘fidelity’ is a misnomer: when people speak of fidelity, they are usually describing something closer to a sound recording’s *definition* (Chion 1994, pp. 98*ff*). Mindful of the problematic status of ‘fidelity’, I continue to use the word because it is the operative term in the discourses examined here. But placing ‘fidelity’ (and similar terms like ‘faithful’) in scare quotes throughout this article would be tedious, so I refrain from doing so. This brief introduction, as well as the spirit of the discussions that follow, should establish my epistemological break with the idea of fidelity, and my critical distance from it.

2. Analagously to fidelity, ‘loudness’ could be read as appearing in scare quotes throughout this article. But, again, actually supplying the scare quotes would be tedious for the reader.

3. Not all noise is loud, and not all loudness is noise. Of course, there is overlap between the two categories. Indeed, loudness and noise are often used as synonyms for one another. But loudness doesn’t always fit the everyday definition of noise as unwanted sound, or its anthropological definition as sound out of place. And in the same way that noise is not an exclusively negative cultural category or merely a question of bad taste, so it is with loudness. Certainly, loudness can be construed negatively. Indeed, loud music

has been embroiled in controversies of race, gender and youth, and has been variously constructed as barbaric, manly, deviant. But loudness is also understood positively in a variety of contexts: in many music genres, loudness is seen less as a political issue or a danger to hearing, and more as a prerequisite to particular kinds of musical pleasure. A rigorous history of loudness, which would need to fully account for the complex discursive relationship between loudness and noise, has yet to be written. For outstanding studies of noise, see Hegarty (2007), Bijsterveld (2008) and Schwartz (2011).

4. I also want to make it clear that, contra Guberman (2011), I do not think that the history of sound reproduction has or could transition into what he calls a 'post-fidelity' era. Rather, I am suggesting that 'we have never been faithful', and my concern is with the ways in which fidelity has *always* been a secondary concern in certain contexts.

5. Although I use it to very different ends, I borrow this expression, and my title, from a *Stylus Magazine* article (Southall 2006).

6. There are of course other factors at play in the use of dynamic range compression: such compression is an effect of sound reproduction systems themselves (from microphones to amplifiers), and has deep roots in the history/criticism of radio (e.g. Adorno 2002, pp. 256-61) and musical aesthetics (we expect certain genres to be 'louder' than others). To my knowledge there is no exhaustive history of audio compression, and this is not the place to attempt that monumental but interesting task. For useful starting points, see Kenneth Berger (1984) on hearing aids, Greg Milner (2009) on radio (especially during

the 1980s), Simon Frith (2002) and Keith Negus (2006) on television sound, and Jonathan Sterne (2012) on signal compression.

7. Though the acoustics and psychoacoustics of loudness are complex and fascinating problems, a detailed discussion is beyond the scope of this paper. Readers interested in understanding the science of loudness are referred to any one of a number of acoustics textbooks, such as F. Alton Everest and Ken Pohlmann (2009). The history and sociology of the science of loudness, on the other hand, are topics that I have pursued elsewhere (Devine 2012).

8. 'Ear fatigue' is a colloquial term used by sound engineers to describe a feeling of psychological enervation after long periods of listening. This is not necessarily the same as 'auditory fatigue', which is a technical term that describes a physiological loss of hearing after exposure to sound.

9. See Feaster (2007, p. 251 n. 4).

10. For example, by 1900 Edison Phonographs were sold with a 'two-way hearing tube' and 'a 14-inch polished brass horn' – not to mention other goodies like 'a sapphire shaving knife . . . a camel's hair chip brush, an oil can, a winding crank and an oak carrying case' (National Phonograph Company 1900, p. 51).

11. Technically, it appears that the law *had* 'sooner been discovered' (see Read and

Welch 1976, p. 87). However, my concern here is less about intellectual property and patent battles than simply establishing the importance of volume in the history of sound reproduction.

12. See for example a Columbia Phonograph Company tube from 1894, pictured in a Columbia ad in *Billboard 100th Anniversary Issue, 1894-1994* (01 November 1994), p. 57.

13. The faster surface speeds of the large cylinders did more than increase playback volume: they also enabled these phonograms to capture and reproduce a broader frequency spectrum than could be achieved on regular machines. As such, the development of large cylinders can also be seen, in part, as a chapter in the orthodox version of the history of sound reproduction – which has been well covered in terms of the 'quest for fidelity' (Thompson 1995) and the 'social genesis of sound fidelity' (Sterne 2003).

14. Excerpted from a poem in a Berliner catalogue ('A riddle – read', 16 November 1898), reprinted in Moogk (1975, p. 391).

15. Bizarrely, given the mulish commitment to the cylinder that he later demonstrated, an 1878 phonograph demonstration in Ottawa included talk of perfecting a 'flat instrument' (Moogk 1975, p. 5), and Edison told the *New York Graphic* that he intended to 'abolish this whole cylinder and supersede it with a flat circular steel plate about as big as a dinner

plate' (Frow 2001, p. 2). Equally strange, given Edison's insistence on marketing the phonograph as a dictation machine, is his early enthusiasm for the disc phonograph's entertainment potential, as reported in the *New York World* (ibid.).

16. Henry Seymour, a pioneering British recordist who worked independently (producing the Seymour Superphone) and with the EMG Handmade Gramophones company, was apparently also one of the first music pirates. According to David Phillips, an EMG partner, 'Another thing Seymour did – he used to get records recorded in those days by the Gramophone Company or Columbia. He had a very clever copying machine that he used to copy records and then market the records with different labels and with fake artists' (James 1998, p. 6).

17. It is of course also true that some musicians were happy about the increased volume of electrical amplification (Stokowski 1935), while some critics were unhappy about the contribution of radio loudspeakers to city hubbub (Lambert 1934). Although this complicates the point I'm making here, this messiness supports my overall argument about the contingency of volume and fidelity.

18. For some of the broader historical context here, see Straw (2008).

19. The loudness of Wagner's music had been criticised before the introduction of sound reproduction, which opens up a broader historical discussion about the role of loudness in nineteenth-century musical aesthetics and criticism. It is interesting to note that while

composers like Berlioz (1882) believed the new attention given to instrumentation and orchestration during this period freed music from the slavish reliance on harmonic laws, critics often complained that new orchestration techniques – especially loud ones – were a way of hiding bad compositional technique. In 1835, for example, George Hogarth accused Rossini of using 'the confusion of many loud instruments' to camouflage 'incorrect and slovenly harmony' (Demuth 1947, p. 147). Most famously, Wagner's music was often seen as 'needlessly luxurious in mere loudness and meriticiousness of sound' (ibid., p. 242). Further discussion of this longer history is beyond the scope of this essay.

References

Adorno, T. 1990. ‘The curves of the needle’, *October*, 55, pp. 48-55

Adorno, T. 2002. ‘The radio symphony: an experiment in theory’, in *Essays on Music*, ed. R. Leppert (Berkeley, University of California Press), pp. 251-70

Anderson, T. 2007. ‘How CDs are remastering the art of noise’, *The Guardian*, 18 January. http://www.guardian.co.uk/technology/2007/jan/18/pop.music/print (accessed December 2010)

Anderson, T. 2008. ‘Will the loudness wars result in quieter CDs?’, *The Guardian*, 10 January. http://www.guardian.co.uk/technology/2008/jan/10/digitalmusic (accessed December 2010)

Anon. 2008. ‘Fans Say Rock Music Too Loud’, *Rolling Stone*, 1068/1069, p. 32

Anon. 2009. ‘The loudness wars: why music sounds worse’, *NPR Music*, 31 December. http://www.npr.org/templates/story/story.php?storyId=122114058 (accessed August 2010)

Balmain, C. 1928. ‘Volume’, *The Gramophone*, 5/9, p. 401

Barnett, K. 2006. ‘Furniture music: the phonograph as furniture, 1900-1930’, *Journal of Popular Music Studies*, 18/3, pp. 301-24

Berger, K. 1984. *The Hearing Aid: Its Operation and Development* (Livonia, MI, The National Hearing Aid Society)

Berlioz, H. 1882. *A Treatise on Modern Instrumentation and Orchestration* (London, Novello, Ewer & Co)

Bijsterveld, K. 2008. *Mechanical Sound: Technology, Culture and Public Problems of Noise in the Twentieth Century* (Cambridge, MA, MIT Press)

Brooks, A. 1928. ‘Round the recording studios’, *The Gramophone*, 5/12, pp. 487-90

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

Cockayne, E. 2007. *Hubbub: Filth, Noise and Stench in England* (New Haven, Yale University Press)

Columbia. 1897. *The Graphophone* (Indianapolis: Spear & Co)

Connor, S. 1997. ‘The modern auditory “I”’. In *Rewriting the Self: Histories from the Renaissance to the Present*, ed. R. Porter (London, Routledge), pp. 203-23

Corbin, A. 1998. *Village Bells: Sound and Meaning in the Nineteenth-Century French Countryside* (New York: Columbia University Press)

Demuth, N. 1947. *An Anthology of Musical Criticism* (London, Eyre & Spottiswoode)

Deruty, E. 2011. 'To the limit: "dynamic range" and the loudness war', *Sound on Sound*, September, pp. 174-182

Devine, K. 2012. *Imperfect Sound Forever: Loudness, Listening Formations, and the Historiography of Sound Reproduction* (Ottawa, PhD thesis, Carleton University)

Donahue, M. n.d. 'The loudness war', *Performer Magazine*. http://performermag.com/Archives/loudness.php (accessed March 2009)

Downes, K. 2010. '"Perfect sound forever": innovation, aesthetics, and the re-making of compact disc playback', *Technology and Culture*, 51/2, pp. 305-31

Dunne, J. 1928. 'Volume and quality', *The Gramophone*, 5/10, p. 441

Edison Company. 1905. 'Wonderful Edison offer', *Popular Mechanics*, 7/11, p. 1188

Eisenberg, E. 1987. *The Recording Angel: Explorations in Phonography* (New York, McGraw-Hill)

Engh., B. 1999. ‘After “His Master’s Voice”’, *New Formations,* 38, pp. 55-63

Everest, F.A., and K. Pohlmann. 2009. *Master Handbook of Acoustics, Fifth Edition* (New York, McGraw-Hill)

Everett-Green, R. 2011. ‘This bud’s not for them!’, *Globe and Mail*, 06 August, p. R6

Faulkner, C. 1994. ‘René Clair, Marcel Pagnol and the social dimension of speech’, *Screen,* 35/2, pp. 157-70

Feaster, P. 2007. *The Following Record: Making Sense of Phonographic Performance, 1877-1908* (Bloomington, PhD thesis, Indiana University)

Frith, S. 1988. ‘The industrialization of music’. In *Music for Pleasure* (New York, Routledge)

Frith, S. 2002. ‘Look! Hear! The uneasy relationship of music and television’, *Popular Music*, 21/3, pp. 277-90

Frith, S. 2004. ‘Reasons to be cheerful’, *Popular Music*, 23/3, pp. 363-72

Frow, G, with R. Baumbach. 2001. *The Edison Disc Phonographs and the Diamond*

Discs (Los Angeles, Mulholland Press)

Gelatt, R. 1977. *The Fabulous Phonograph, 1877-1977* (New York, Macmillan)

Ginn, J. 1996. *The Magnificent Music Machine* (Cimplesham, Joe Ginn)

Gitelman, L. 2000. *Scripts, Grooves and Writing Machines: Representing Technology in the Edison Era* (Chicago, University of Chicago Press)

Guberman, D. 2011. 'Post-fidelity: a new age of music consumption and technological innovation', *Journal of Popular Music Studies*, 23/4, pp. 431-54

Hegarty, P. 2007. *Noise/Music: A History* (New York, Continuum)

Hiatt, B. 2008. 'Fans complain Metallica disc is too loud', *Rolling Stone,* 1063, p. 11

Hunt, F. 1954. *Electroacoustics: The Analysis of Transduction, and Its Historical Background* (Cambridge: Harvard University Press)

James, F. 1998. *The EMG Story* (Abertillery, Old Bakehouse Publications)

Jones, S. 2005. 'The big squeeze: mastering engineers debate music's loudness wars', *Mix Magazine*, 01 December. http://mixonline.com/mag/audio_big_squeeze/ (accessed

August 2008)

Keightley, K. 1996. ‘Turn it down! she shrieked: gender, domestic space and high fidelity, 1948-59’, *Popular Music*, 15/2, pp. 149-77

Kittler, F. 1999. *Gramophone, Film, Typewriter* (Stanford, Stanford University Press)

Lambert, C. 1934. *Music Ho! A Study of Music in Decline* (London, Faber & Faber)

Lastra, J. 2000. *Sound Technology and the American Cinema: Perception, Representation, Modernity* (New York, Columbia University Press)

Levine, R. 2007. ‘The death of high fidelity’, *Rolling Stone*, 1042/1043, p. 15

Luff, L. 1928. ‘Volume’, *The Gramophone*, 5/9, p. 401

Maisonneuve, S. 2009. *L’invention du disque, 1877-1949: Genènese de l’usage des médias musicaux contemporains* (Paris, Éditions des archives contemporaines)

Masterson, K. 2008. ‘Loudness war stirs quiet revolution’, *Chicago Tribune*, 01 January. http://articles.chicagotribune.com/2008-01-01/news/0801010011_1_loud-compressed-recording (accessed August 2010)

Mauro, P. 1900. ‘Recent development of the art of recording and reproducing sounds’, *Journal of the Franklin Institute*, 150/1, pp. 35-43

Millard, A. 2005. *America on Record: A History of Recorded Sound* (Cambridge, Cambridge University Press)

Milner, G. 2009. *Perfecting Sound Forever: An Aural History of Recorded Music* (New York, Faber and Faber)

Mitchell, O. n.d. (ca. 1922). *The Talking Machine Industry* (London, Sir Isaac Pitman & Sons)

Moogk, E. 1975. *Roll Back the Years: History of Canadian Recorded Sound and Its Legacy, Genesis to 1930* (Ottawa, National Library of Canada)

National Phonograph Company. 1900. *The Phonograph and How to Use It* (New York, Allen Koenigsberg)

Negus, K. 2006. ‘Musicians on television: visible, audible and ignored’, *Journal of the Royal Musical Association*, 131/2, pp. 310-30

Owinsky, B. 2007. *The Mastering Engineer’s Handbook*, second edition (Boston, Thomson Course Technology)

Percival, M. 2011. ‘Stone deaf forever: discourses of live loudness in popular music journalism’, presented at The Business of Live Music (University of Edinburgh)

Peters, J.D. 2004. ‘Helmholtz, Edison and sound history’. In *Memory Bytes: History, Technology and Digital Culture*, ed. L. Rabinovitz and A. Geil (Durham, Duke University Press), pp. 177-98

Plambeck, J. 2010. ‘In mobile age, sound quality steps back’, *New York Times*, 09 May, p. B1

Read, O., and W. Welch. 1976. *From Tin Foil to Stereo: Evolution of the Phonograph* (Indianapolis, Howard W Sams & Co)

Rothenbuhler, E., and J.D. Peters. 1997. ‘Defining phonography: an experiment in theory’, *The Musical Quarterly*, 81/2, pp. 242-264

Schafer, R.M. 1994. *The Soundscape: Our Sonic Environment and the Tuning of the World* (Rochester, Destiny)

Schicke, C. 1974. *Revolution in Sound: A Biography of the Recording Industry* (Boston, Little, Brown & Co)

Schwartz, H. 2011. *Making Noise: From Babel to the Big Bang and Beyond* (New York, Zone Books)

Sherwin, A. 2007. 'Why music really is getting louder', *The Times*, 04 June. http://entertainment.timesonline.co.uk/tol/arts_and_entertainment/music/article1878724.ece (accessed August 2010)

Smith, E. 2008. 'Even heavy-metal fans complain that today's music is too loud!!!' *The Wall Street Journal*, 26 September, p. A1

Smith, M. 2001. *Listening to Nineteenth-Century America* (Chapel Hill, University of North Carolina Press)

Southall, N. 2006. 'Imperfect sound forever', *Stylus Magazine*, 01 May. http://www.stylusmagazine.com/articles/weekly_article/imperfect-sound-forever.htm (accessed August 2010)

Sreedhar, S. 2007. 'The future of music', *IEEE Spectrum*, August. http://spectrum.ieee.org/computing/software/the-future-of-music (accessed August 2010)

Sterne, J. 2003. *The Audible Past: Cultural Origins of Sound Reproduction* (Durham, Duke University Press)

Sterne, J. 2006. ‘The death and life of digital audio’, *Interdisciplinary Science Reviews*, 31/4, pp. 343-45

Sterne, J. 2012. *MP3: The Meaning of a Format* (Durham, Duke University Press)

Stokowski, L. 1935. ‘New vistas in radio’, *Atlantic Monthly*, 155/1, pp. 1-16

Straw, W. 2008. ‘Squawkies and talkies, *Parallax*, 14/2, pp. 20-30

Thompson, E. 1995. ‘Machines, music and the quest for fidelity: marketing the Edison phonograph in America, 1877-1925’, *Musical Quarterly*, 79, pp. 131-71

Weston, B. n.d. ‘Loudness’, *Chicago Mastering Service*. chicagomasteringservice.com/loudness.html (accessed August 2010)