

# **The Loudness War: Background, Speculation and Recommendations**

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Earl Vickers

STMicroelectronics, Inc.

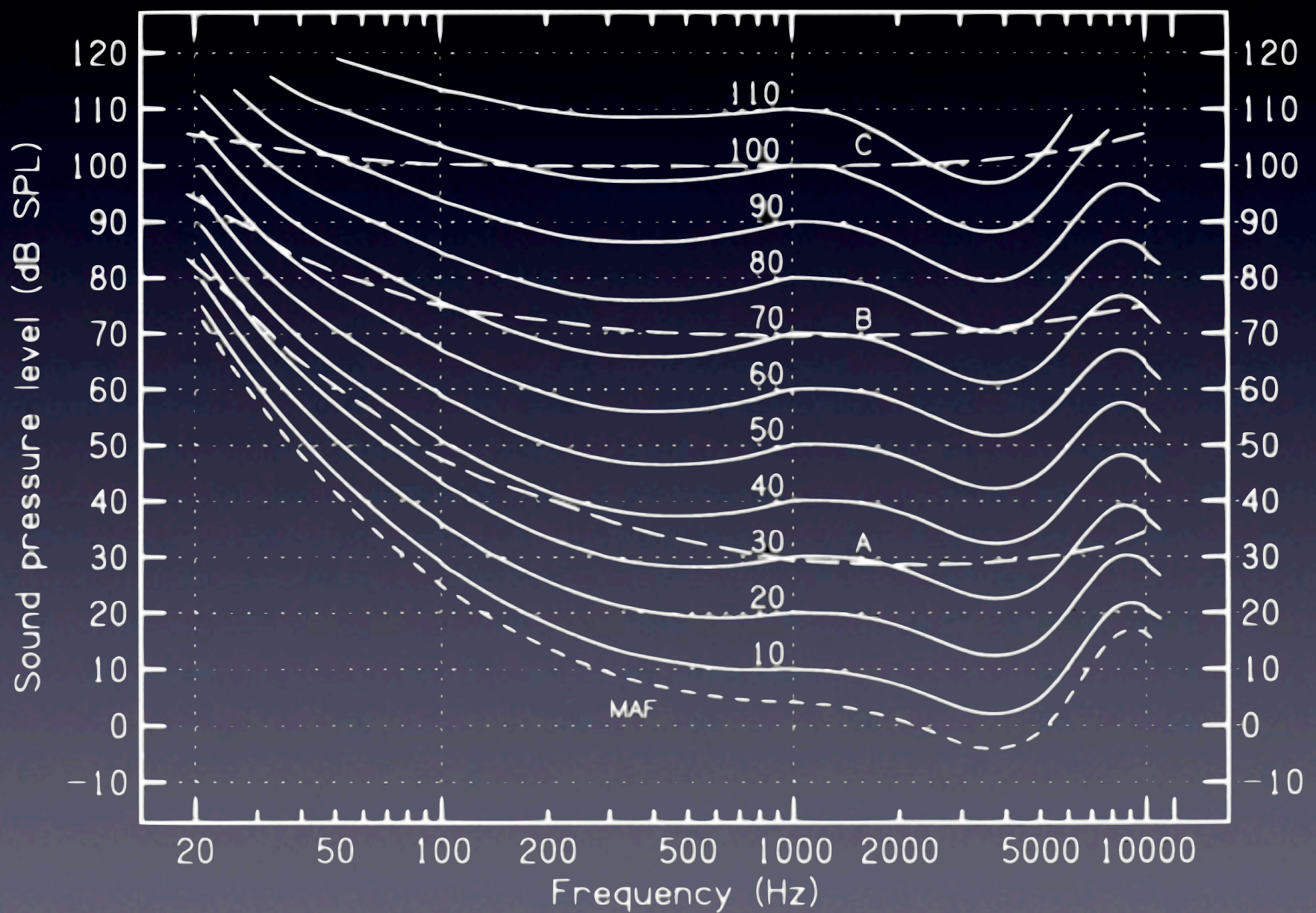
[earl.vickers@st.com](mailto:earl.vickers@st.com)

The belief that louder recordings sell better has driven a trend toward greater and greater use of dynamic range compression. I'll explore some of the effects of the loudness war; then I'll look at the problem in terms of game theory and question some underlying assumptions.

# The Loudness War

When I talk about the loudness war, I'm not talking about the final playback level – that can always be adjusted by the listener. I'm talking about the effects of processing – hyper-compression, limiting and even clipping – used to make recordings sound louder than others with the same peak level.

# The Loudness War



Our hearing curves become flatter at higher playback levels, so – all other things being equal – louder tends to sound better.

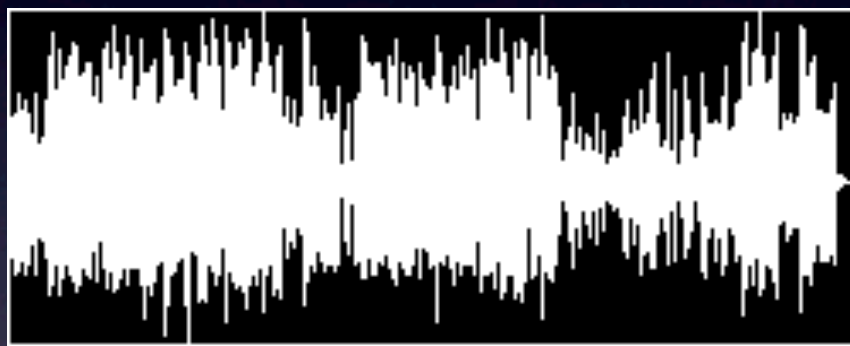
“We’re making popular music recordings that have no more dynamic range than a 1909 Edison Cylinder!”

- Bob Katz



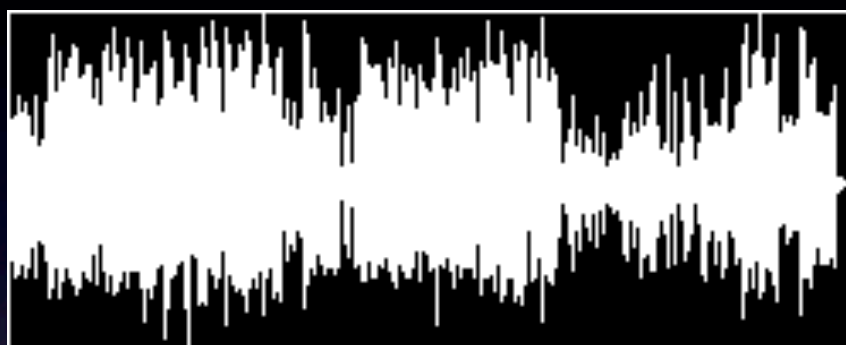
I saw this statement and thought, that can't be right...

Down Where the Big Bananas Grow, 1909



So I found a digitized 1909 Edison cylinder recording. There's some surface noise, but it's got a pretty good range of levels.

Down Where the Big Bananas Grow, 1909

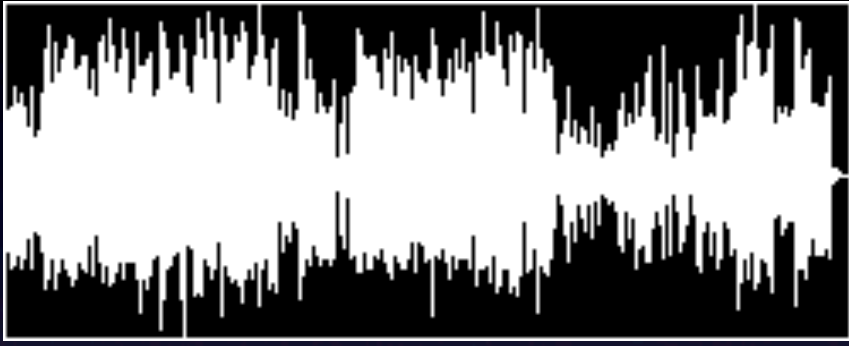


My Apocalypse, 2008



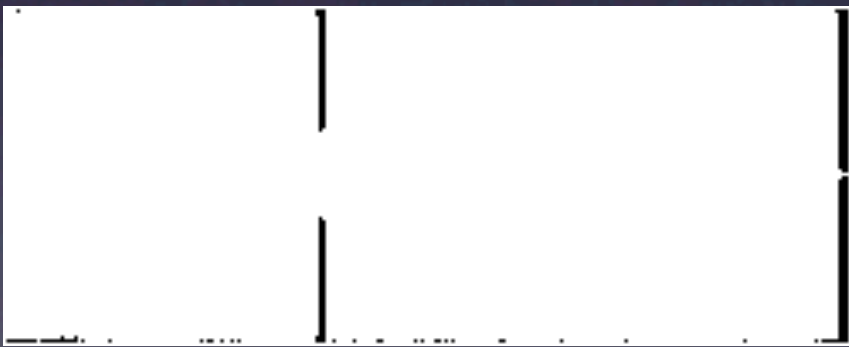
And below that, “My Apocalypse” from Metallica’s Death Magnetic CD.

Down Where the Big Bananas Grow, 1909



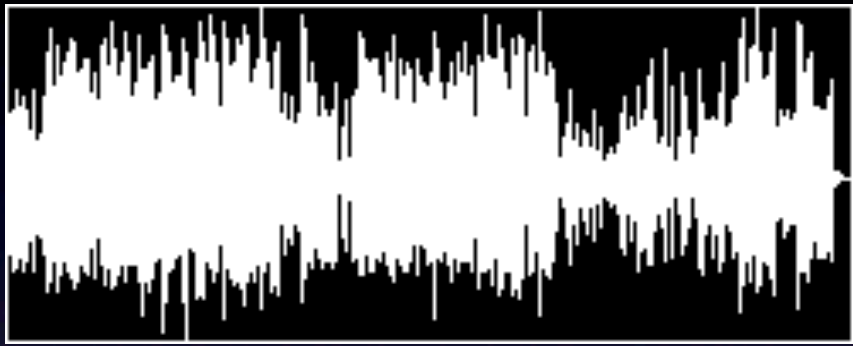
DR=15

My Apocalypse, 2008



If we measure them with a  
“Dynamic Range” meter,

Down Where the Big Bananas Grow, 1909



DR=15

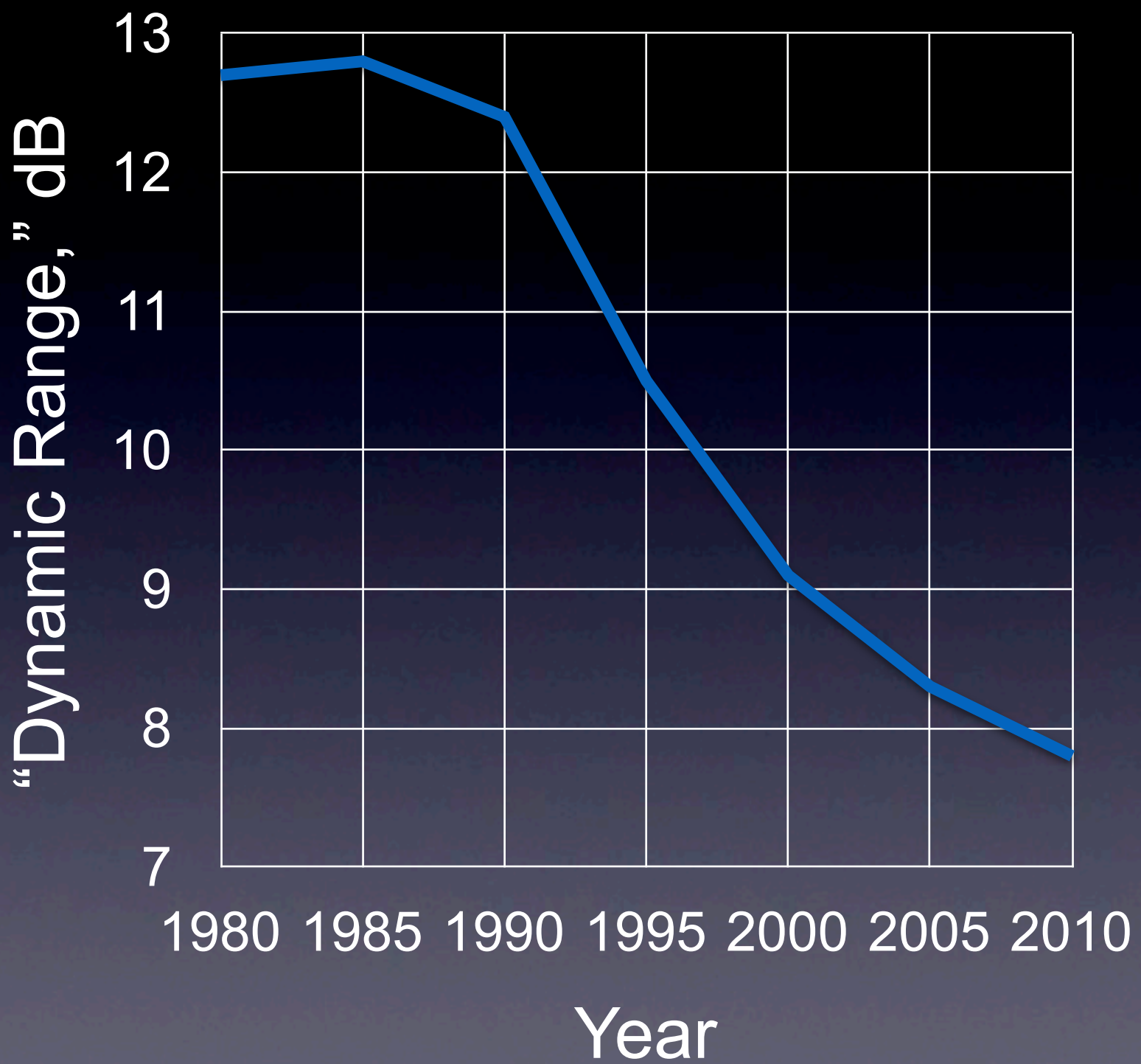
My Apocalypse, 2008



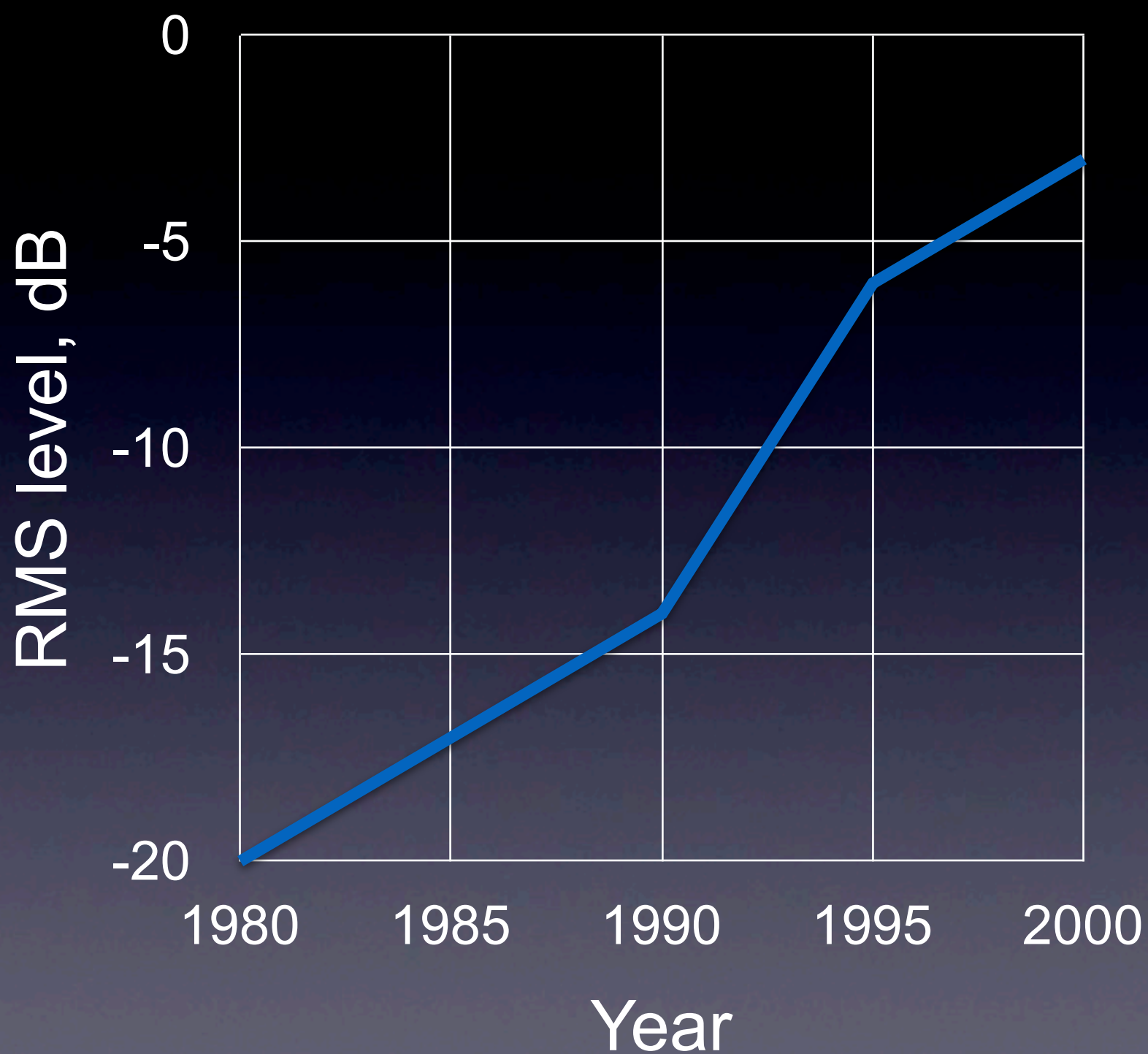
DR=3

we find the cylinder recording had five times the dynamic range of the Metallica song, and about twice the range of a typical 2010 release.





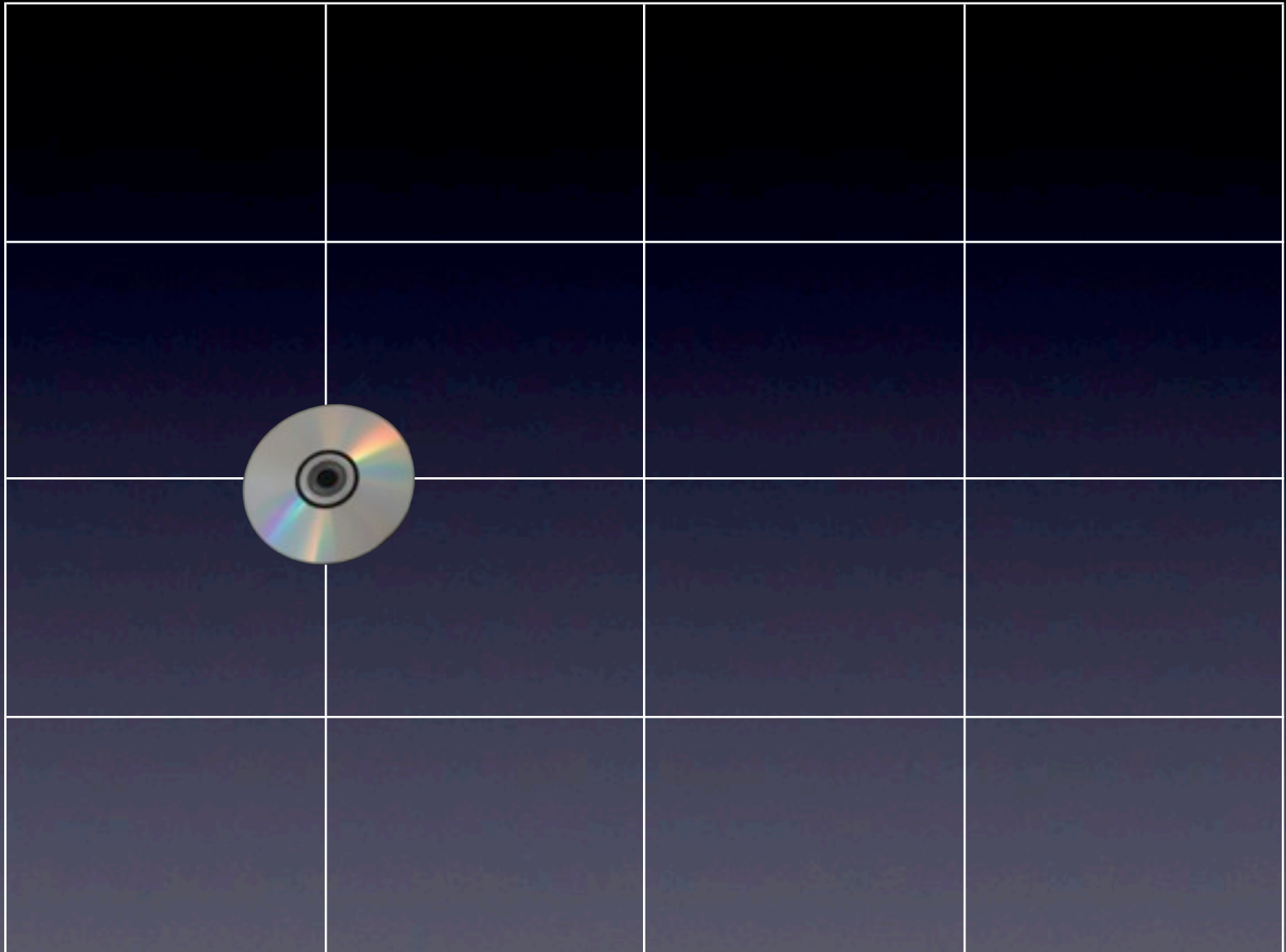
This shows the reduction of dynamic range during the CD era,



and conversely, the ongoing increase in average RMS levels.

# Remastering

Sound Quality

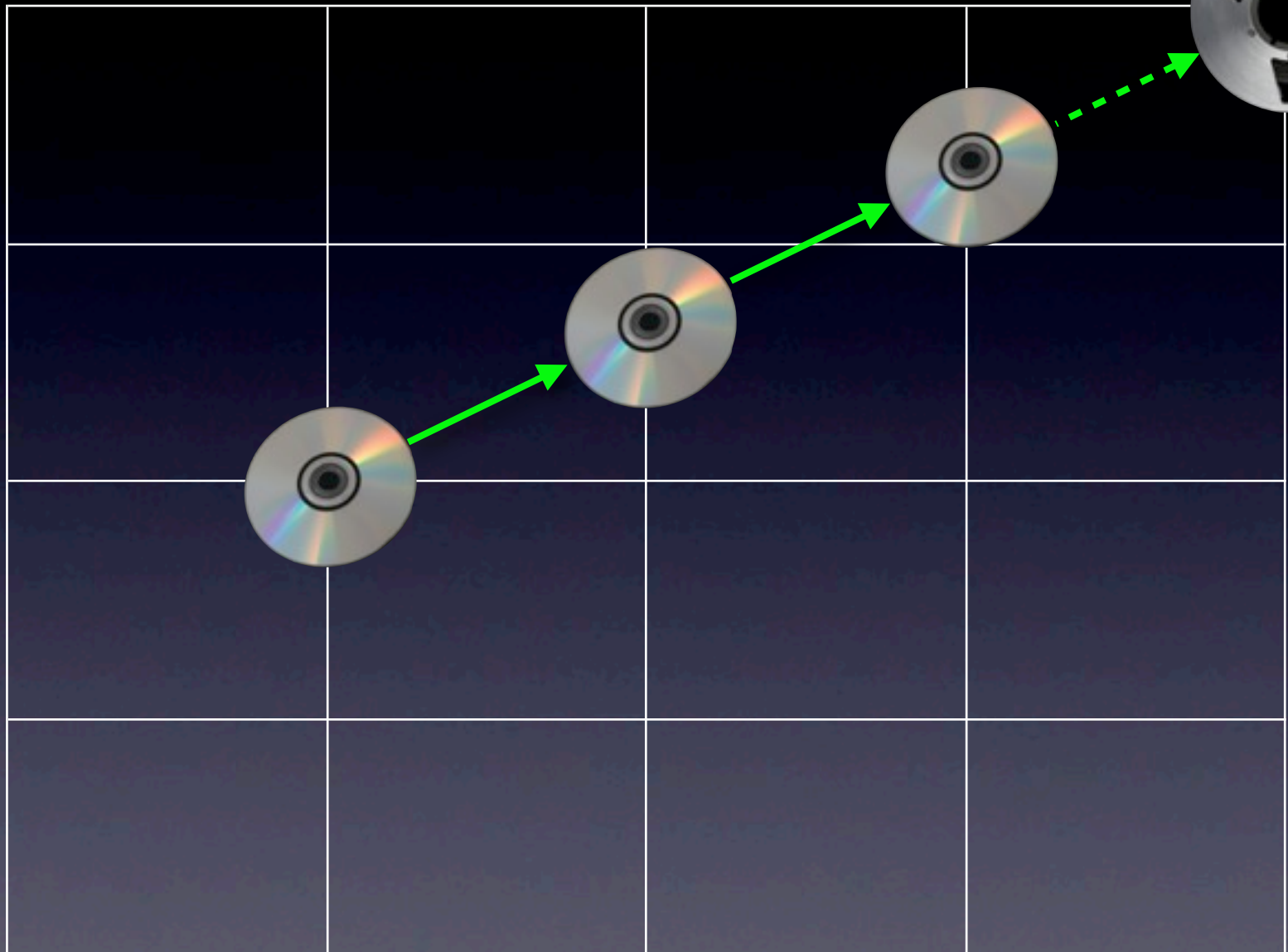


Year

Without access to the original, we may not know how the mastering process affected the audio quality.

## Remastering

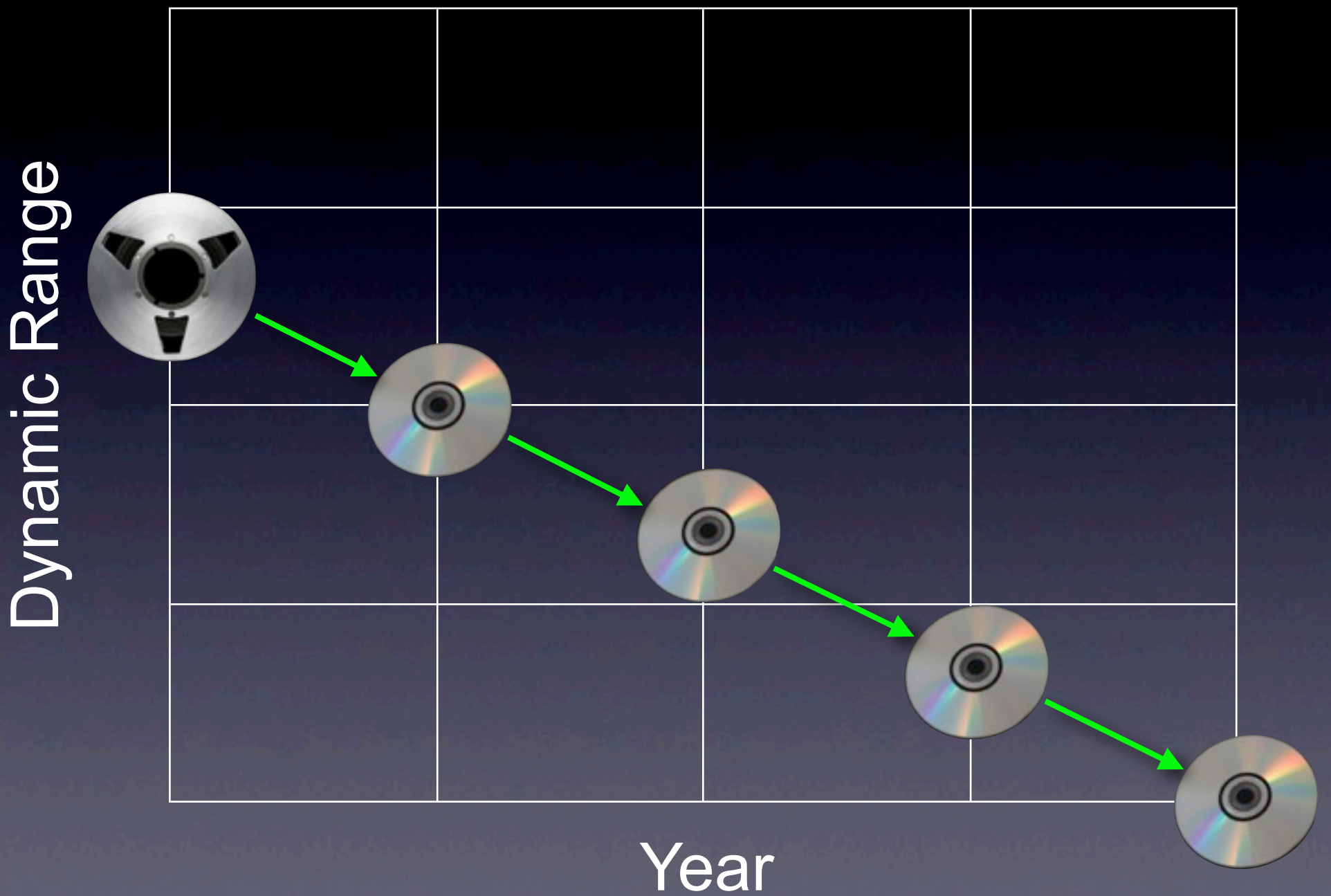
Sound Quality



Year

But when a recording is remastered, we can compare it to previous releases. The marketing message is that we're getting closer to the quality of the original master tape...

# Remastering



The irony of course is that, with each release, we're usually getting further from the original dynamic range.

Is there a problem?

How do we fix it?

Is the loss of dynamic range really a problem, and if so, how do we fix it?

# Possible problems

Aesthetic concerns

Listening fatigue

Hearing damage

Decline of the music industry

We'll look at a number of issues, beginning with sound quality.

Even out levels

Bring out details

Make the mix more coherent

Dynamic range compression has a number of positive uses, but it can be taken too far.

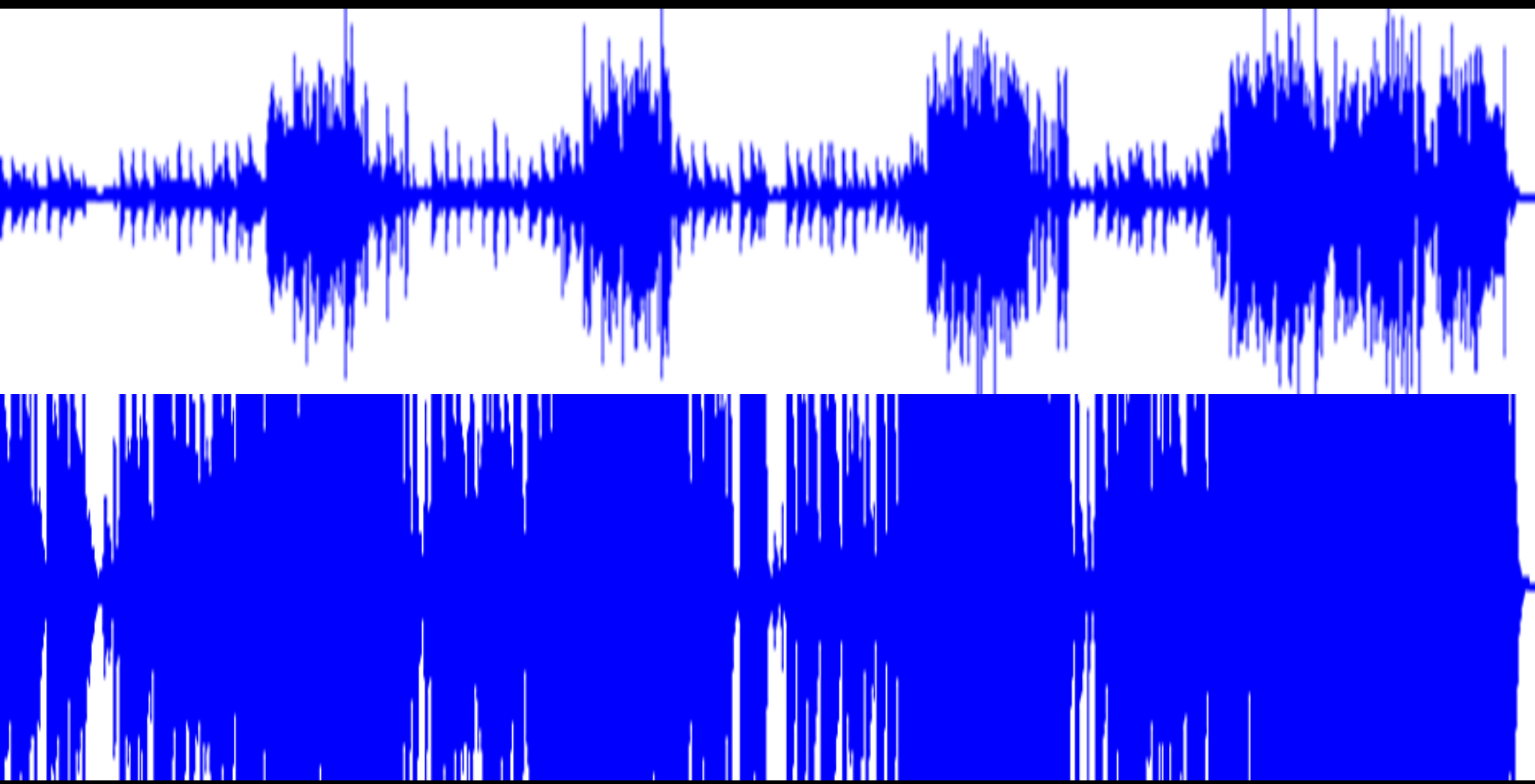


**SQUASHED  
MUSICAL CLUTTER  
REDUCED DEPTH  
AND TEXTURE  
ROBBED OF EMOTIONAL POWER  
UNCOHESIVE  
REDUCED STEREO WIDTH  
LESS PUNCH**

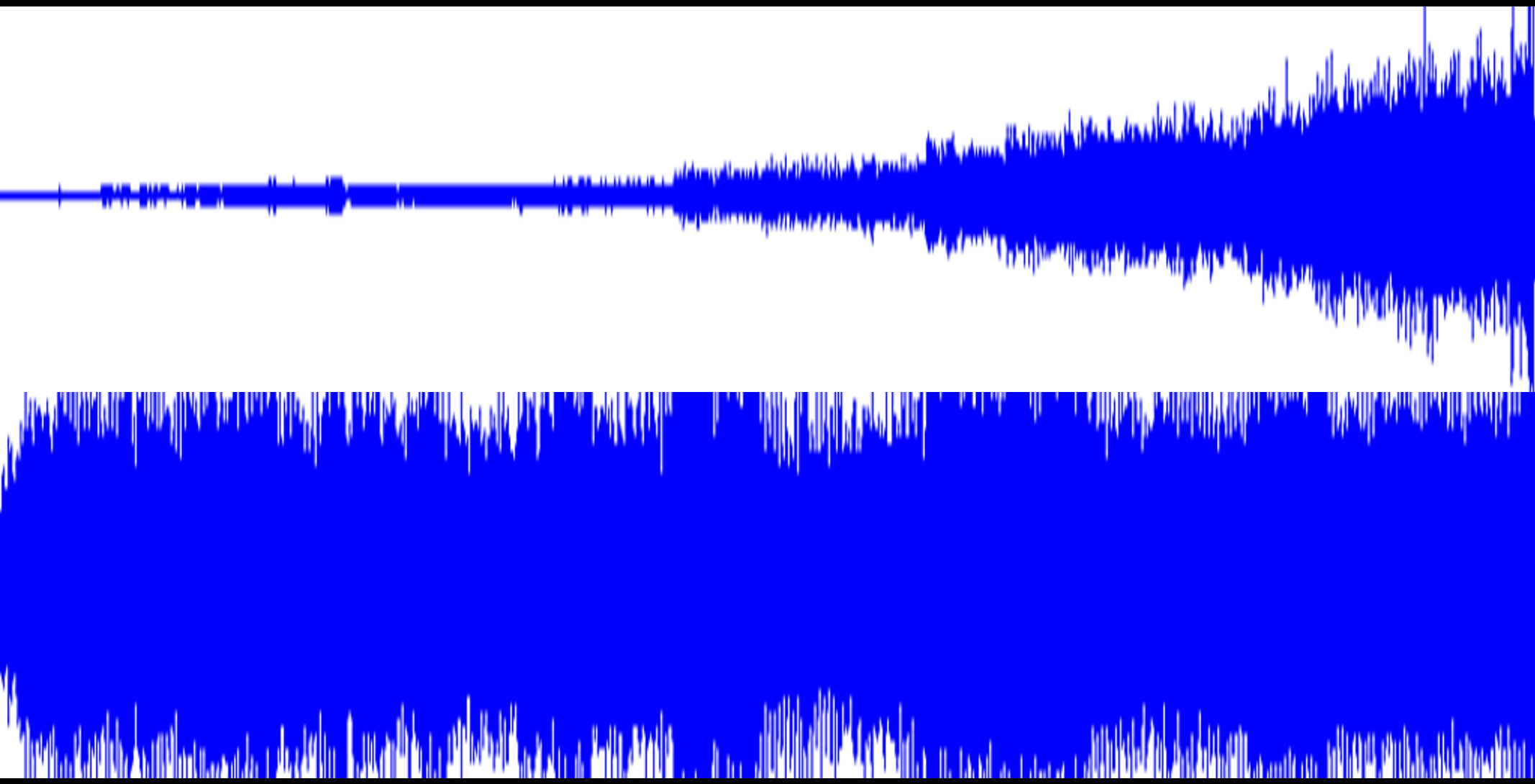
Hypercompression has been accused of removing dynamics, creating musical clutter, reducing the excitement and emotional power, and weakening the punch of transients.

Can listeners hear a difference?

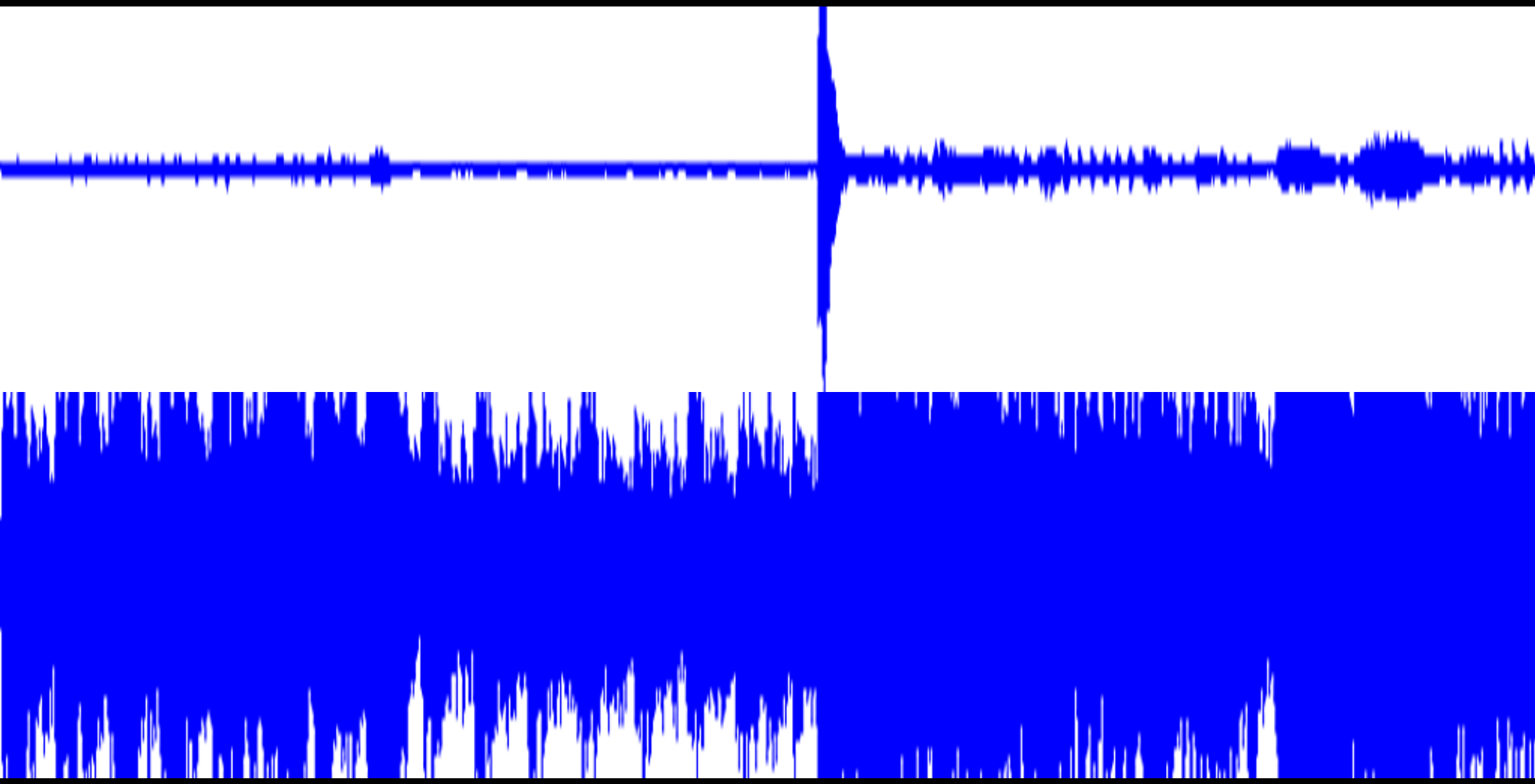
There are few studies, but clearly there's a range of effects, from subtle compression no one would notice to extreme effects almost anyone would hear.



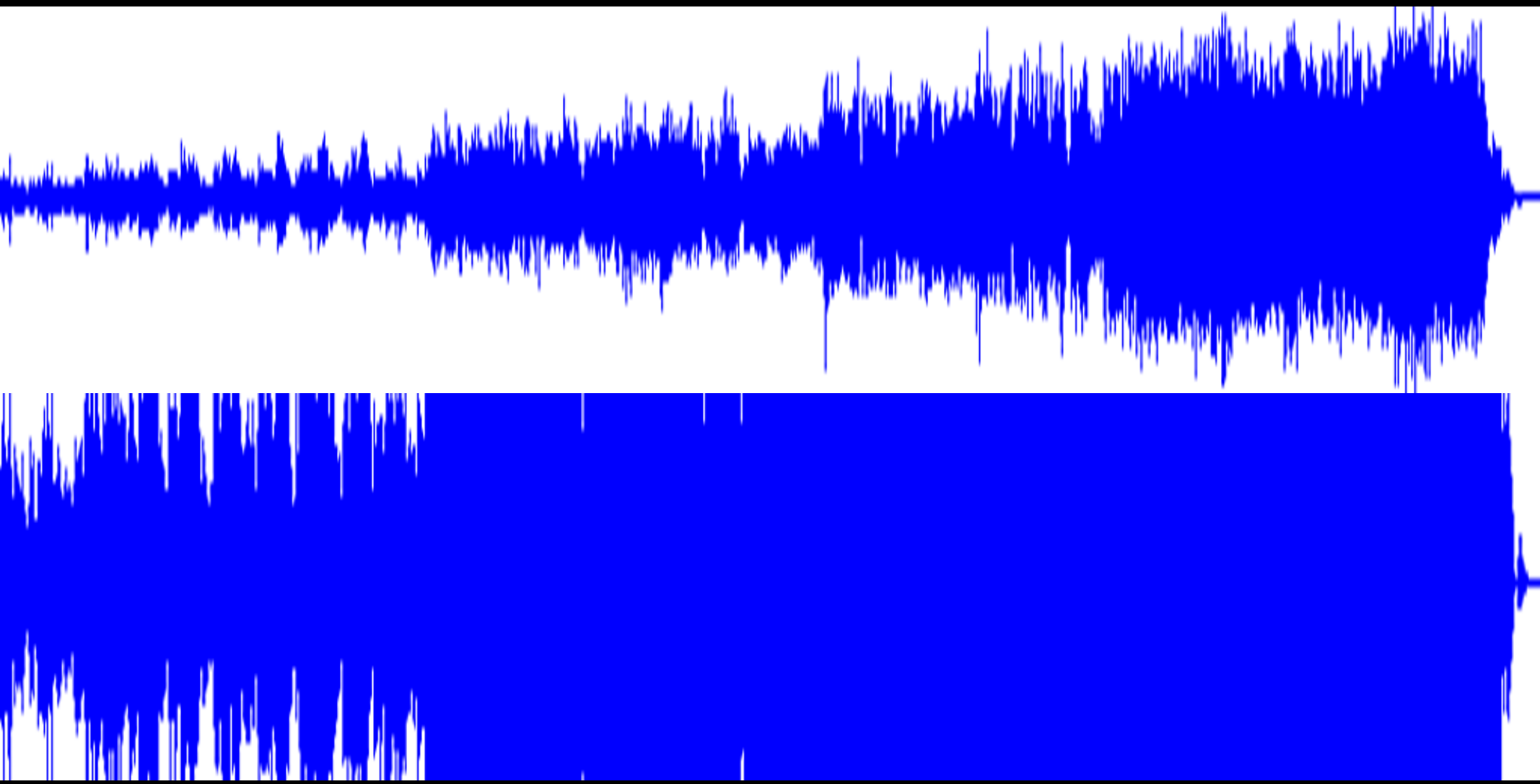
If we look at some extreme examples, created for illustration, we see that hypercompression reduces contrast between verse and chorus;



it takes the crescendo out of  
the Bolero;

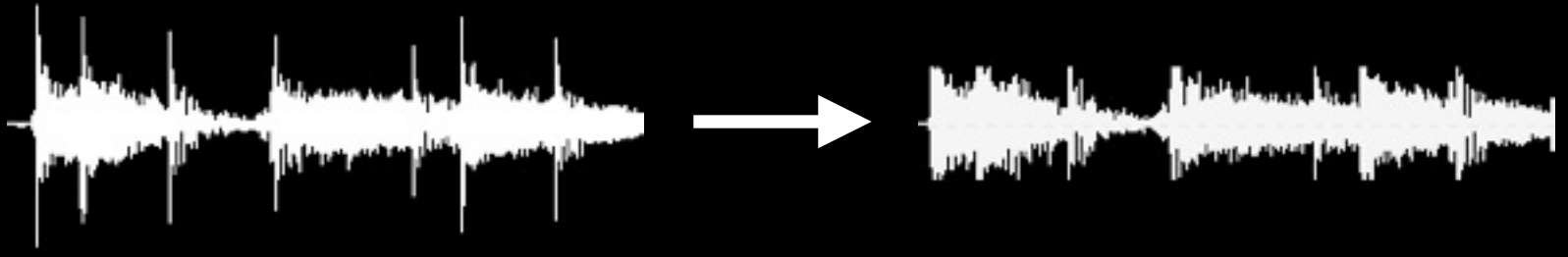


removes the surprise from  
the Surprise Symphony;

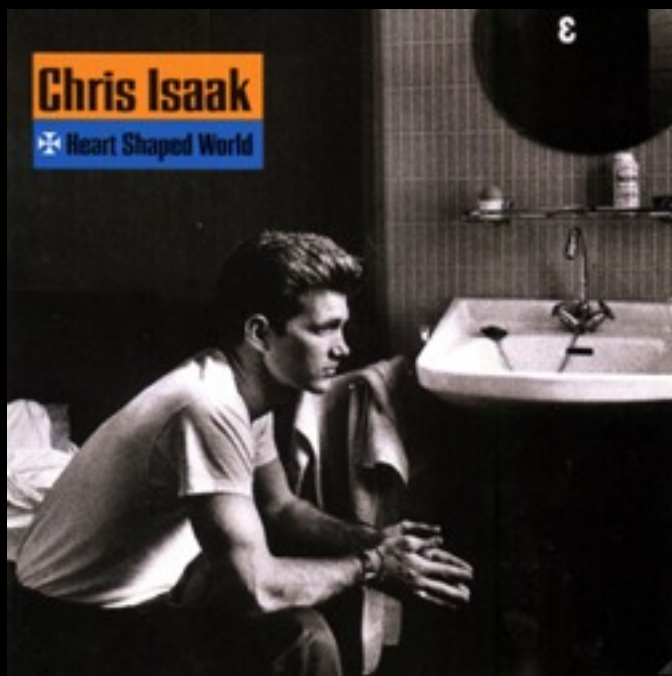


and turns Stairway to  
Heaven into a sidewalk....  
Those are examples of  
macrodynamic compression.

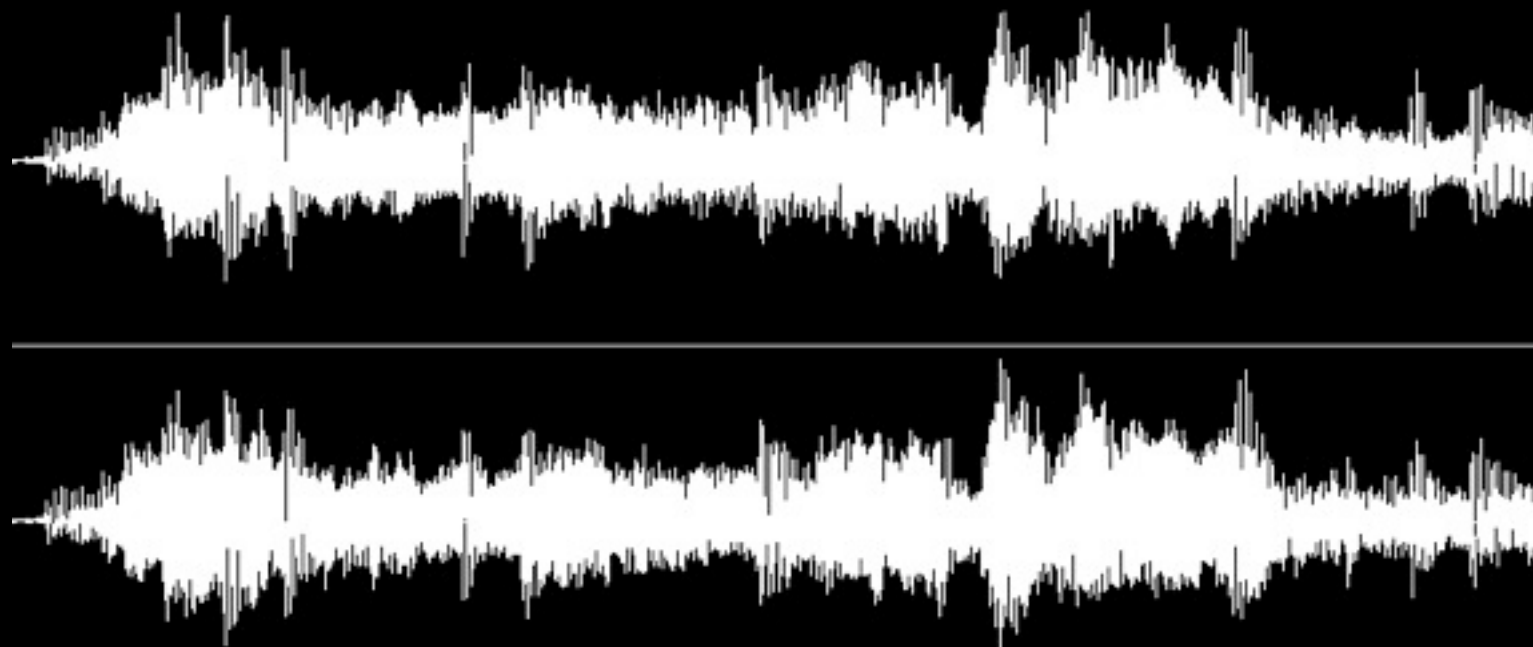
# Microdynamic compression



Fast, microdynamic compression tends to affect the individual transients.



DYNAMIC RANGE  
DR 13



If we compare the original 1989 version of Chris Isaak's "Wicked Game"





DYNAMIC RANGE  
DR 7



to the same song, remastered in 2006, we find the dynamic range has gone from 13 to 7. The new version has some crunch distortion during the chorus due to clipping of the bass, especially on the word “fall,”



DYNAMIC RANGE  
DR 7



and maybe it's my imagination, but it feels like some of the magic's gone with the background vocals. They were so low in the mix in the original, it was a great effect.



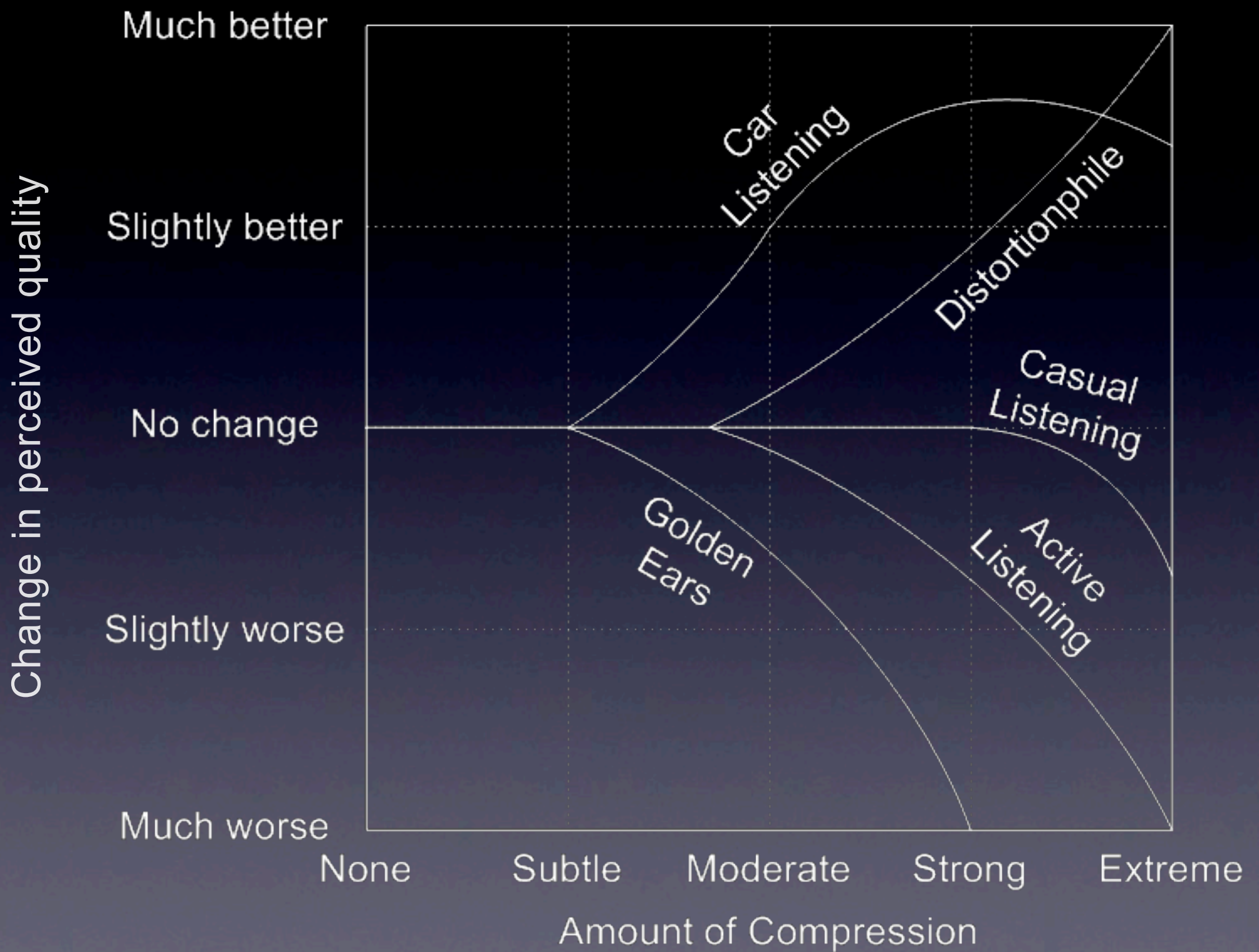
DYNAMIC RANGE  
DR 7



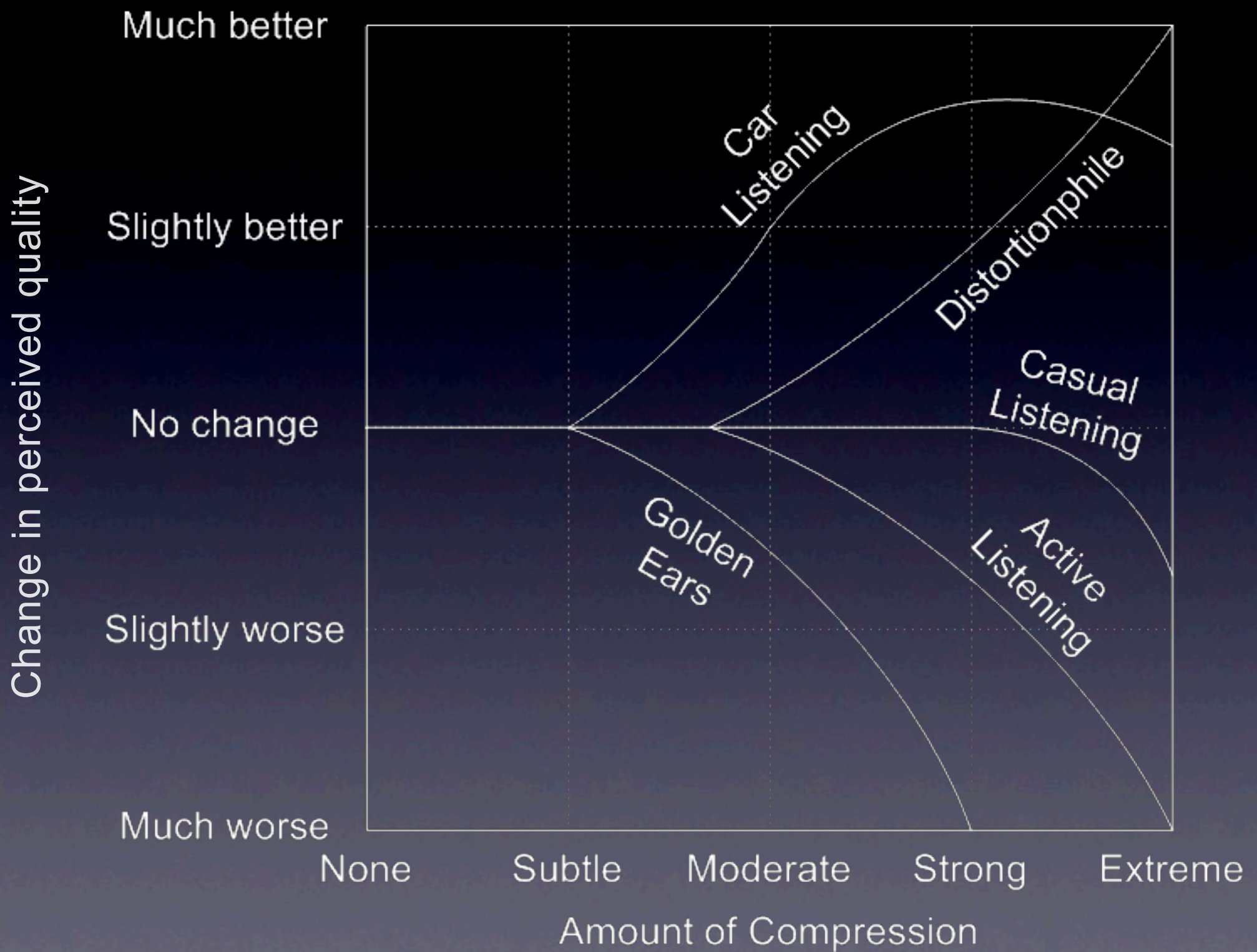
Even if it is my imagination, you can easily imagine that with a little more compression, the background vocals would be right in your face. Not everything needs to be in the foreground.

# Differences between listeners

The impact of hypercompression may vary with different listeners, listening styles and environments.



Again, there's very little actual data, but we could imagine plotting the relationship between amount of compression and perceived quality for different listeners and situations. Audio professionals and Active Listeners may hear a loss of quality even for moderate compression, Casual Listeners may not notice anything short of severe clipping.



and compression may actually improve the listening experience in the car, by making the quiet parts audible over road noise. Keep in mind that if the audio is mastered with a wide dynamic range, it can always be compressed further at the playback stage to satisfy most listeners.



One way to get your message heard is to make it louder, but that can become tiresome.

## Listening fatigue

It's widely believed that hypercompression can cause listening fatigue. Even if people don't consciously notice a problem, the music may become mentally or physically tiring. Listeners may lose interest without knowing why.



“highly compressed or limited music with no dynamic range is physically difficult to listen to for any period of time....”

- Weston

“I never heard the word ‘fatigue’ once when I was cutting vinyl.”

- Calbi

“...but then you just stop listening because they fatigue your ear....”

- Lambert

“the sensory assault simply doesn’t let up.... you end up battered, fatigued by, and disgusted with the music you love....”

- Southall

Again, there’s surprisingly little experimental evidence, but there’s a lot of anecdotal evidence.

Physical fatigue

CNS fatigue

The term “listening fatigue” may have multiple meanings, such as physical ear fatigue and central nervous system fatigue.



Fatigue is often mentioned as a problem with long listening tests, which raises the not entirely facetious question of whether experiments designed to measure listening fatigue might in fact corrupt their own results due to listening fatigue.

## Hearing damage

There's some concern over whether hypercompression may increase the potential for hearing damage,

$$\text{harm} \propto \overline{\text{SPL}}$$

$$\overline{\text{SPL}}(\text{compressed}) > \overline{\text{SPL}}(\text{normal})$$

because the harm from excessive exposure is a function of the average sound level, and hyper-compressed music has higher average levels. There's also speculation that, just as we need frequent breaks from the keyboard



to avoid carpal tunnel, we  
may need frequent rest  
periods from peak sound  
levels to protect



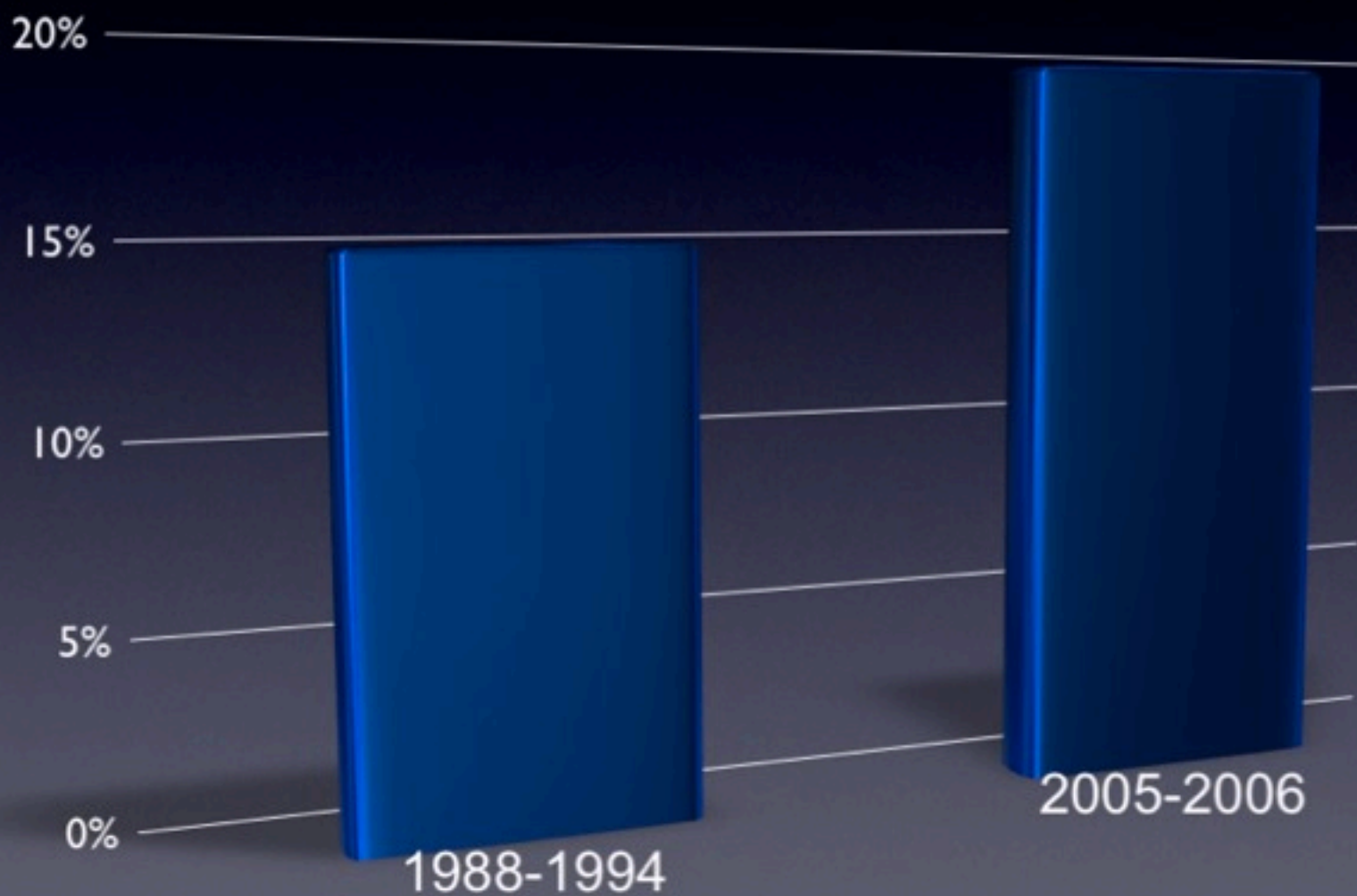
our ears...



(Same illustration, but with less dynamic range...)



## Prevalence of hearing loss among U.S. adolescents



A recent study found a significant increase in hearing loss among adolescents over a 15-year period. The losses are often slight, but may be permanent and may get worse with continued exposure. Many experts think the main cause may be the use of earbuds and headphones with portable music players.

## Earbud / headphone listening

Faster adaptation to loud sounds

Poor bass response

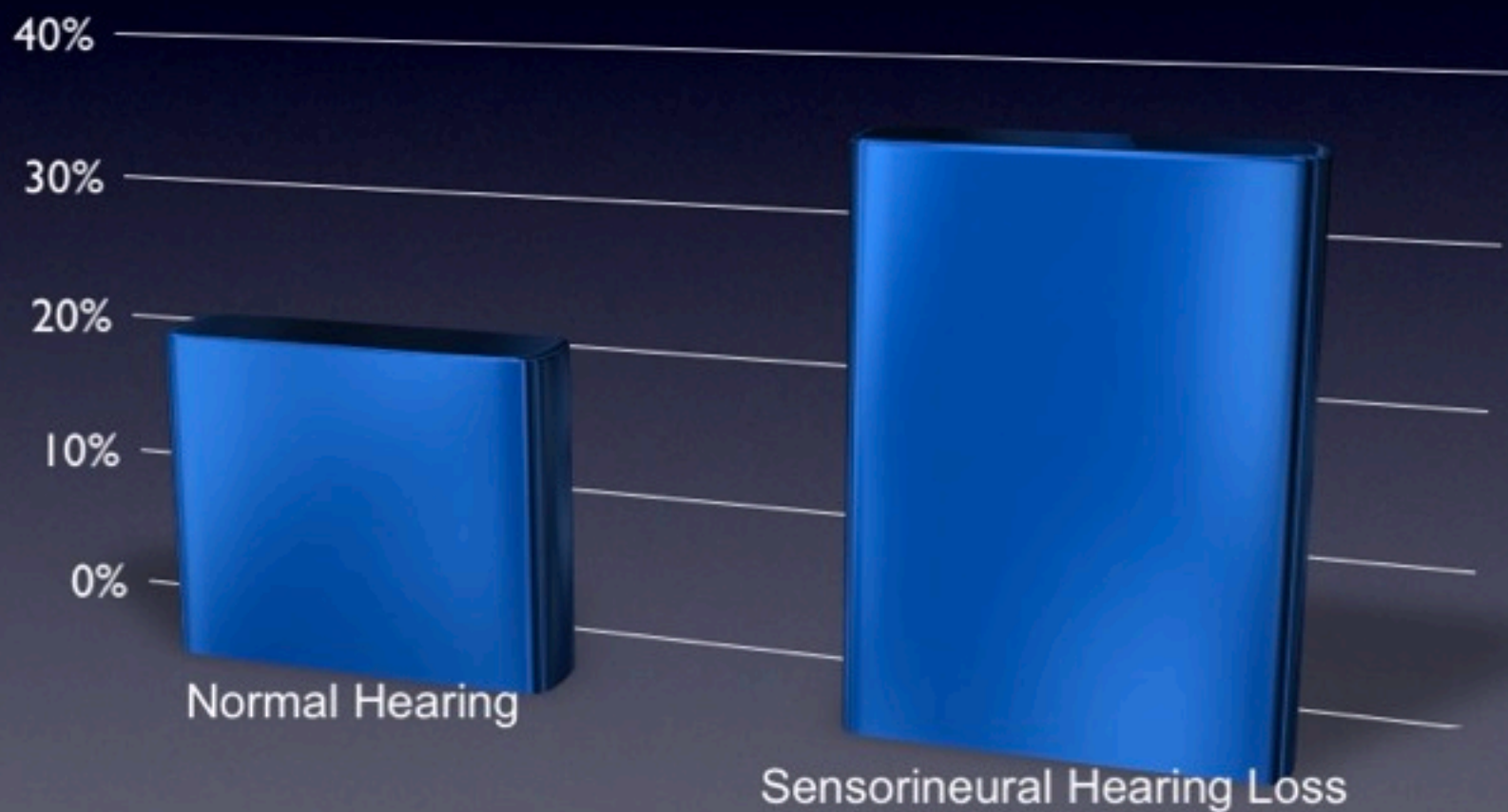
We don't feel the bass

Less air absorption at HF



The ears adapt to loud sounds faster over headphones, so we turn up the volume. The bass is often weak, and our bodies don't feel the pumping bass that tells us the music's really loud, so we turn it up even more. And there's less air absorption at the damaging high frequencies, because the sound doesn't have to travel across the room.

## Personal stereo usage of Australian elementary school children with and without hearing loss



A study of Australian children found that personal stereo usage was associated with a 70% increase in the risk of hearing loss.



**CAUTION**

**HIGH INTENSITY NOISE**

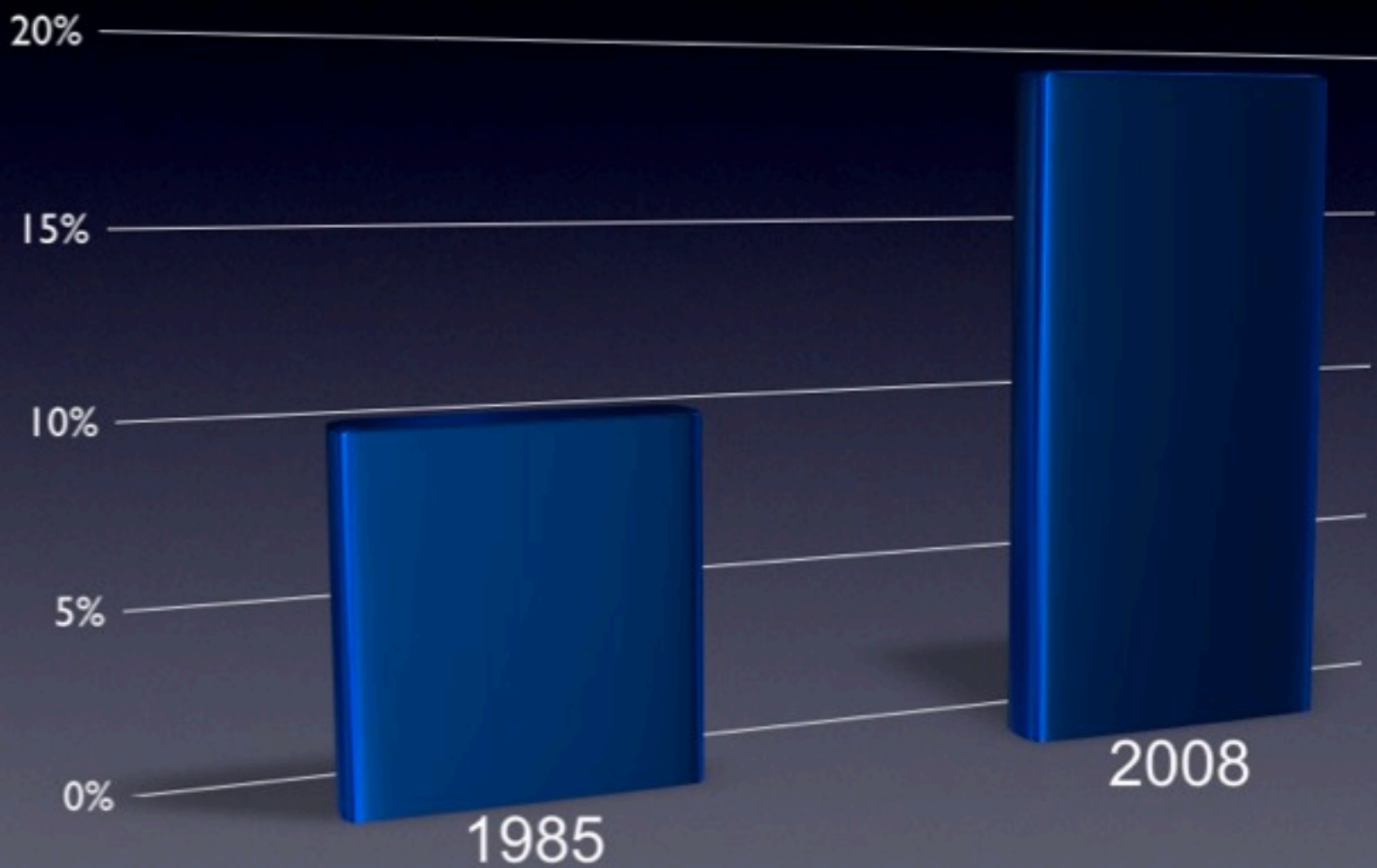
**HEARING**

**PROTECTION**

**REQUIRED**

Another study found that those who listen at high volumes for five hours a week – less than an hour a day – receive more noise exposure than permitted in the loudest factories.

## High-frequency hearing loss among adolescent females

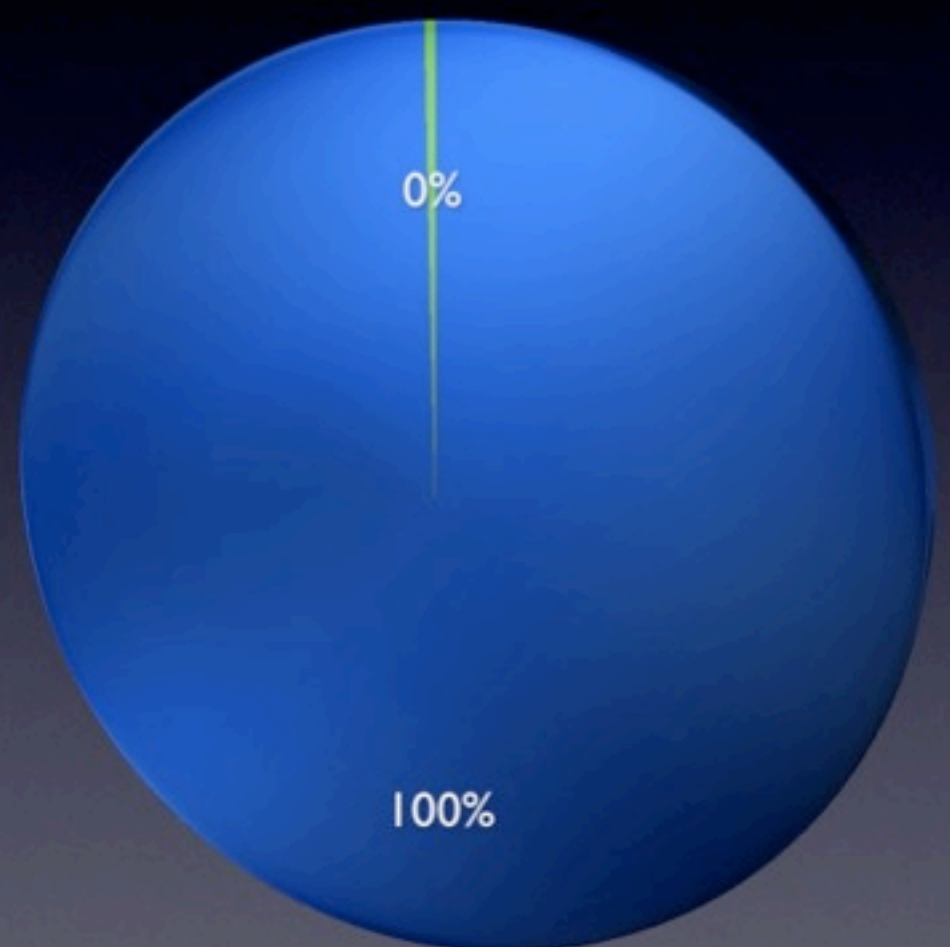
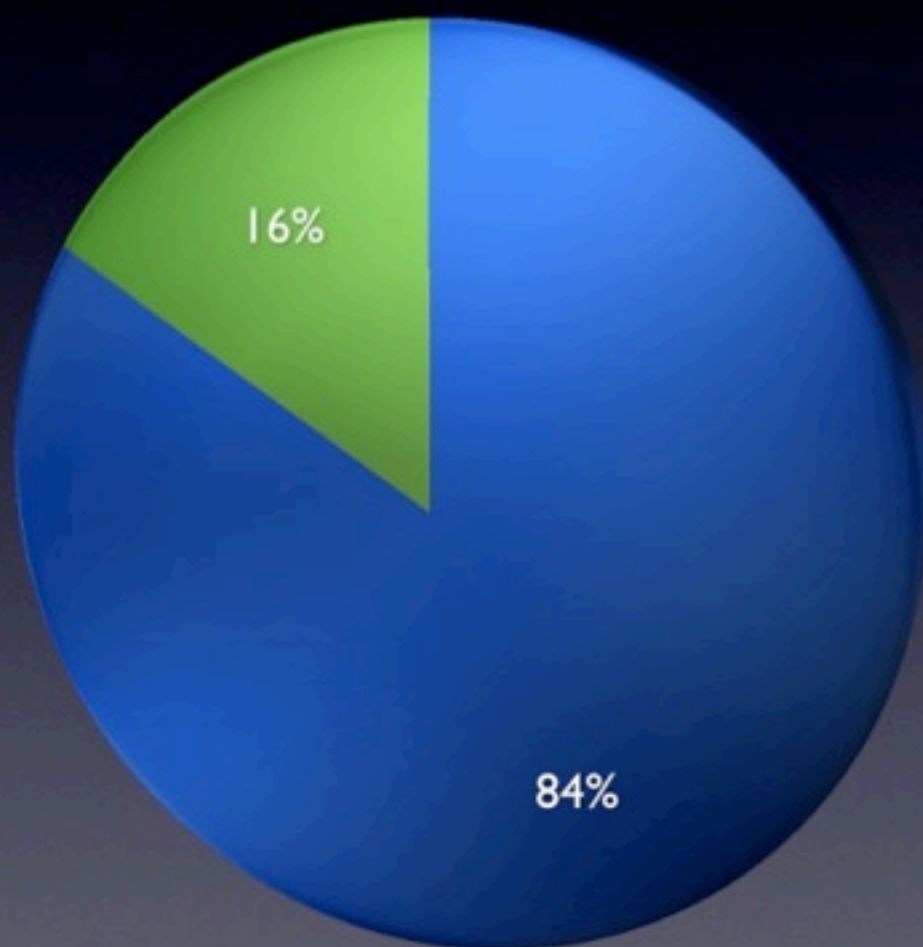


And another one – I found this one shocking – showed that high frequency hearing loss among adolescent females doubled over a 24 year period.

# High-frequency Hearing Loss & Tinnitus by Use of Personal Listening Devices

Subjects with HF hearing loss

Subjects with tinnitus



● PLD users

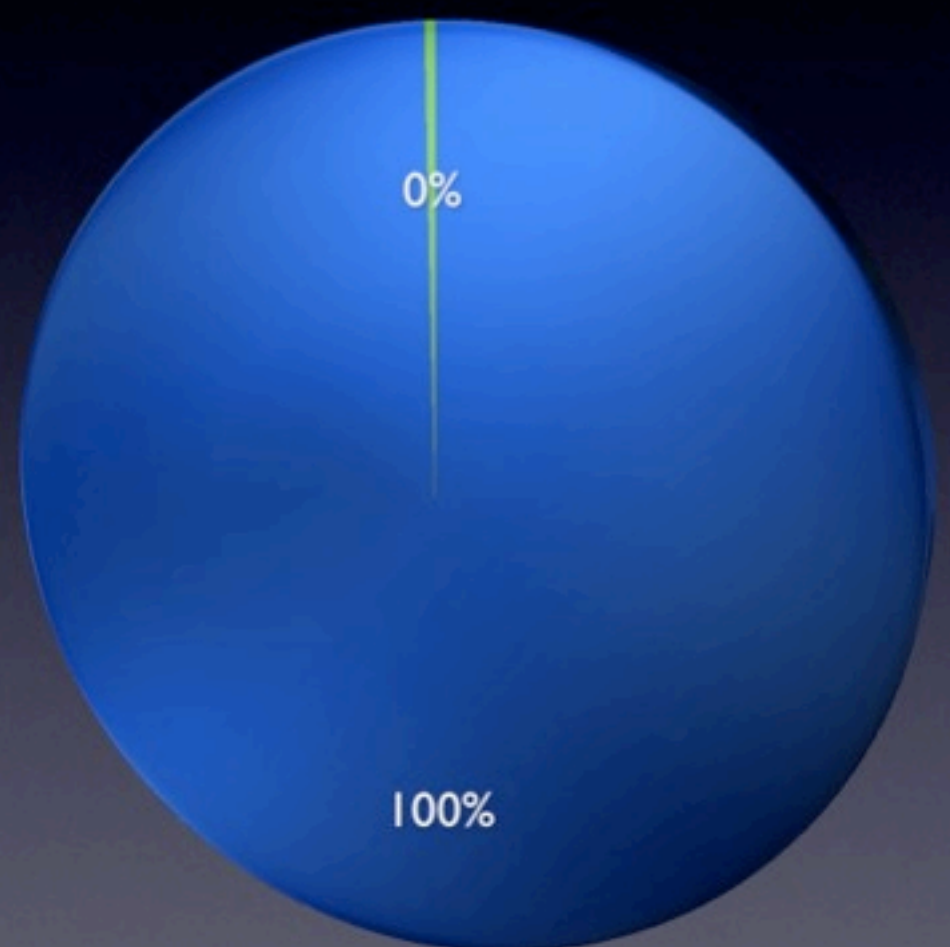
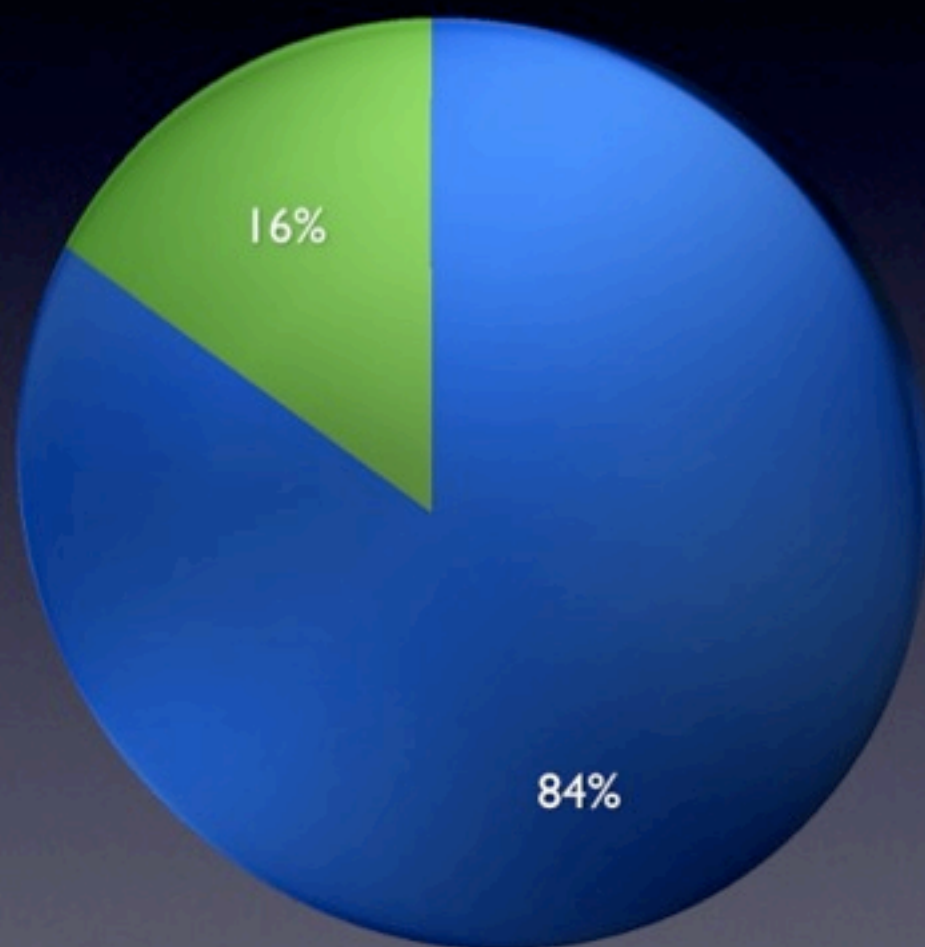
● PLD non-users

During the last decade of the study, about half the subjects used personal stereos, half didn't. But of those with HF hearing loss, 84% were regular users of personal stereos, and all but one of the subjects with tinnitus – 99.7% – used personal stereos.

# High-frequency Hearing Loss & Tinnitus by Use of Personal Listening Devices

Subjects with HF hearing loss

Subjects with tinnitus



● PLD users

● PLD non-users

Ringling of the ears is often a precursor to hearing loss, and it seems to be strongly correlated with use of personal stereos. Now, does this have anything to do with hyper-compression?



That may depend on how listeners typically set the volume.



## Long-term average

Normalizes for equal hearing damage

If they set it according to average long-term loudness, they may essentially normalize for equal hearing damage.

## **Long-term average**

Normalizes for equal hearing damage

## **Peak level**

More exposure with compressed music

But if they set it by the highest peak level they're comfortable with, they'll receive more sound exposure with compressed music, which spends more time at the peak levels. So that needs to be studied.

## Hearing damage

This combination of hyper-compression and earbud listening may be a perfect storm for hearing damage. A link between compression and hearing loss is hard to prove; on the other hand, the stakes are high.



**Most people don't give it much thought until the damage is done, and teens, in particular, tend to consider themselves invulnerable.**

## Decline of the music industry

I'm on shaky ground with this next one – it's hard to prove a causal relationship, and certainly there are major factors like online piracy –

## Decline of the music industry

“Far less mega-million selling records are occurring... and I think this is because the clamour to make music louder has made it less loveable, and in the long run loveable sells more.”

- Nick Southall

but it's at least conceivable that overcompression is one factor that has contributed to the decline of the music industry. Many of the best-selling albums had excellent dynamics, and maybe that's part of what people liked about them.

## A game theory view of the loudness war

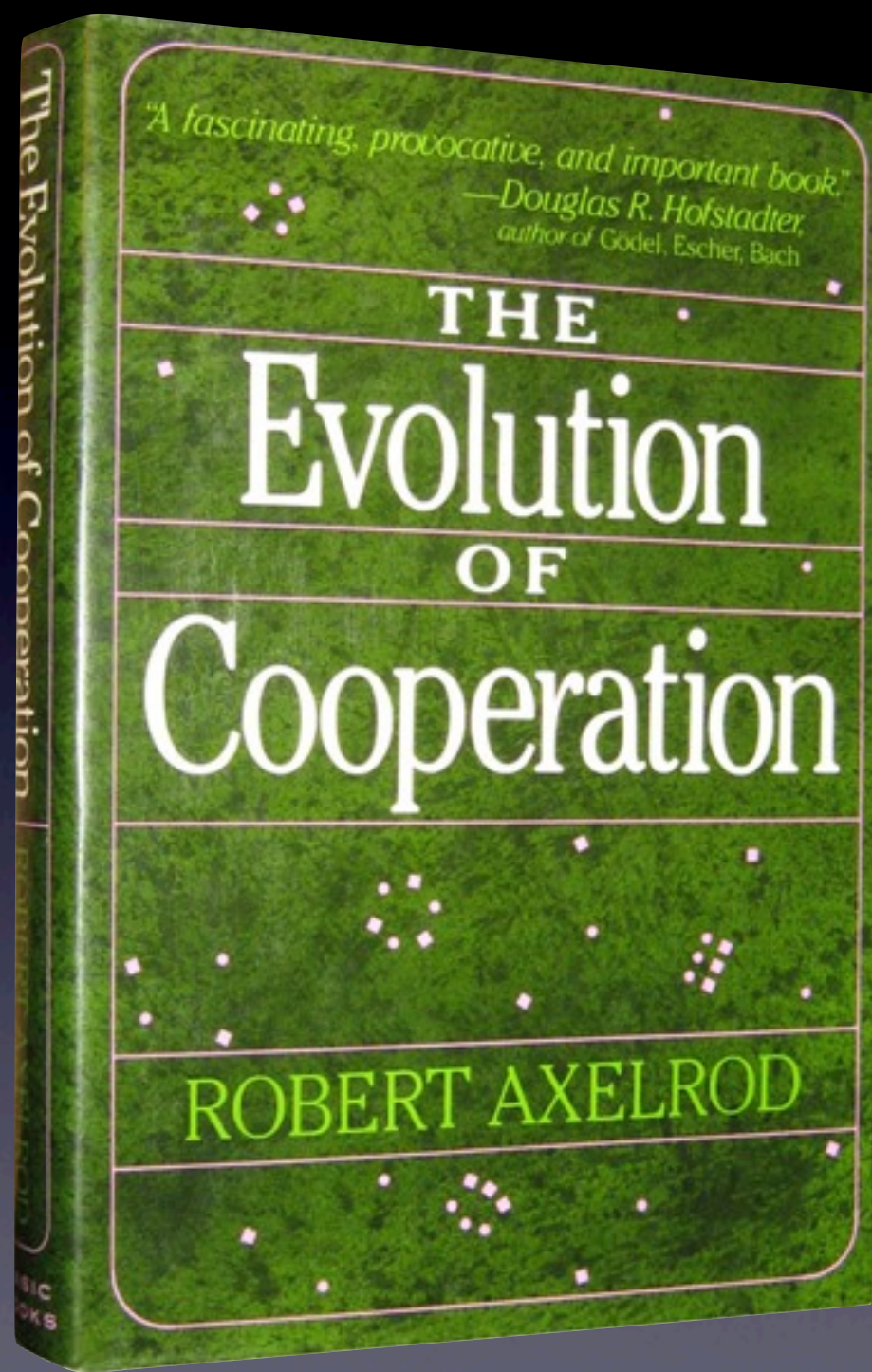
The terms “loudness race” and “loudness war” remind us of the similarity to an arms race. But just as actual war is not fundamentally a chemical or nuclear engineering problem, the loudness war is not primarily an audio engineering problem.

# A game theory view of the loudness war

		Player B	
		Cooperate	Defect
Player A	Cooperate	+1 → +3	-1
	Defect	+3	-1 → 0

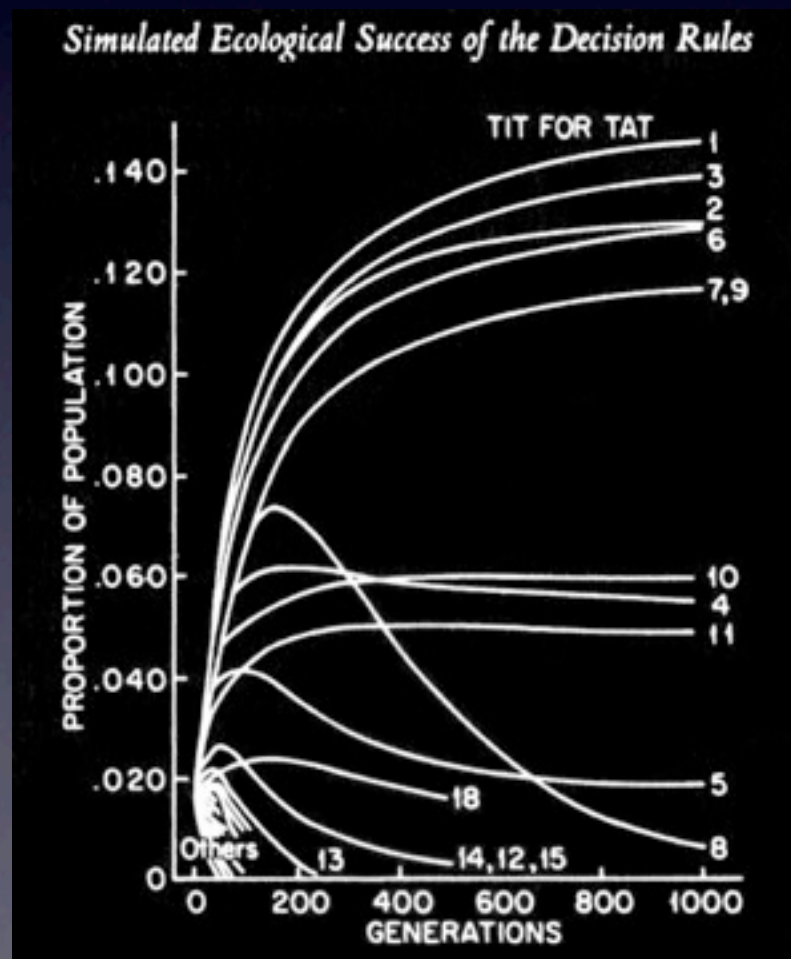
We can view the underlying problem in terms of game theory, a branch of mathematics that applies the study of games to topics like war and business. Some of the more interesting topics involve non-zero-sum games – partly competitive, partly cooperative. For example, during the cold war, the US and USSR had a shared interest in avoiding mutual destruction.





In 1984, Axelrod published a hopeful and influential book called *The Evolution of Cooperation*. He used Prisoner's Dilemma computer tournaments to show how cooperation could emerge from competition between greedy individuals, even with no central authority to police their actions.

The winning strategies  
focused on their own success,  
not on beating their competitors



He found that the strategies that did best were the ones that focused on their own success, instead of comparing themselves to others.

“The practice of overcompression  
is part of a vicious circle of  
**loudness envy....”**

- Katz

In the case of the loudness war, the underlying problem has been referred to as “loudness envy,” which says it pretty well.

“If the only metaphor you have is the zero-sum game, you tend to treat everything as if it were a war.”

- Kollock



If our mental model is based on zero-sum games, we think in terms of beating the other guy. And maybe the easiest way to beat the other guy's song is just to make our song louder.

## Understanding the actual payoffs

In game theory, if players are misinformed about the costs and benefits, they can end up playing the wrong game. In the loudness war, there are a couple of areas where the payoffs can be misunderstood.

Is hypercompressed music any louder on the radio?



First, one of the motivations behind the loudness war has been to make your song sound louder on the radio. But typical FM processing adds so much additional compression that hyper-compressed music just ends up sounding small and distorted.

Does louder, hypercompressed music sell better?



And here's the core issue... the main thing driving the loudness war has been this idea that hyper-compressed music sells better, which in turn is based on the idea that listeners prefer louder songs.

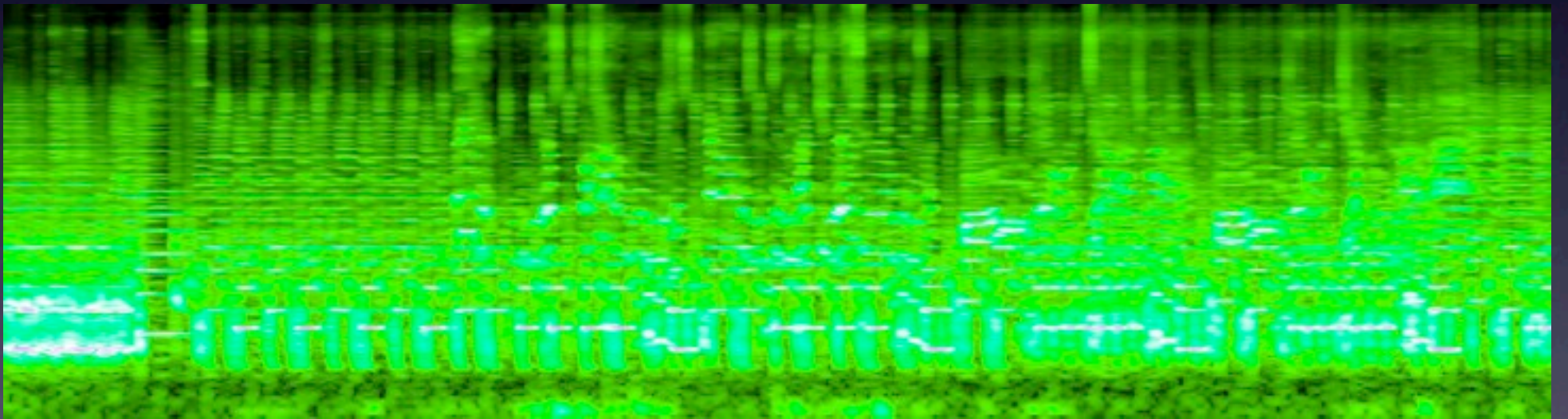
Does louder, hypercompressed music sell better?



I want to question both of these assumptions – and I think they are assumptions, because it's hard to release two versions of the same song and see which sells better. But we do have some data. Let's look at four studies.



# The Evergreen Project



In the Evergreen Project, Chris Johnson analyzed spectrograms from a number of the most commercially important albums of the last few decades.

“The more strongly they sell,  
the more likely it is that they will have  
High Contrast characteristics,”  
i.e., a wide dynamic range

He found that the all-time  
best selling albums were the  
ones with wide dynamic  
range. For example, he said



“The Eagles Greatest Hits was the most commercially important album in RIAA history and has some of the most striking dramatic contrasts pop music’s ever seen.... People want dynamic contrasts.”

# **“The Obsession with Compression”**

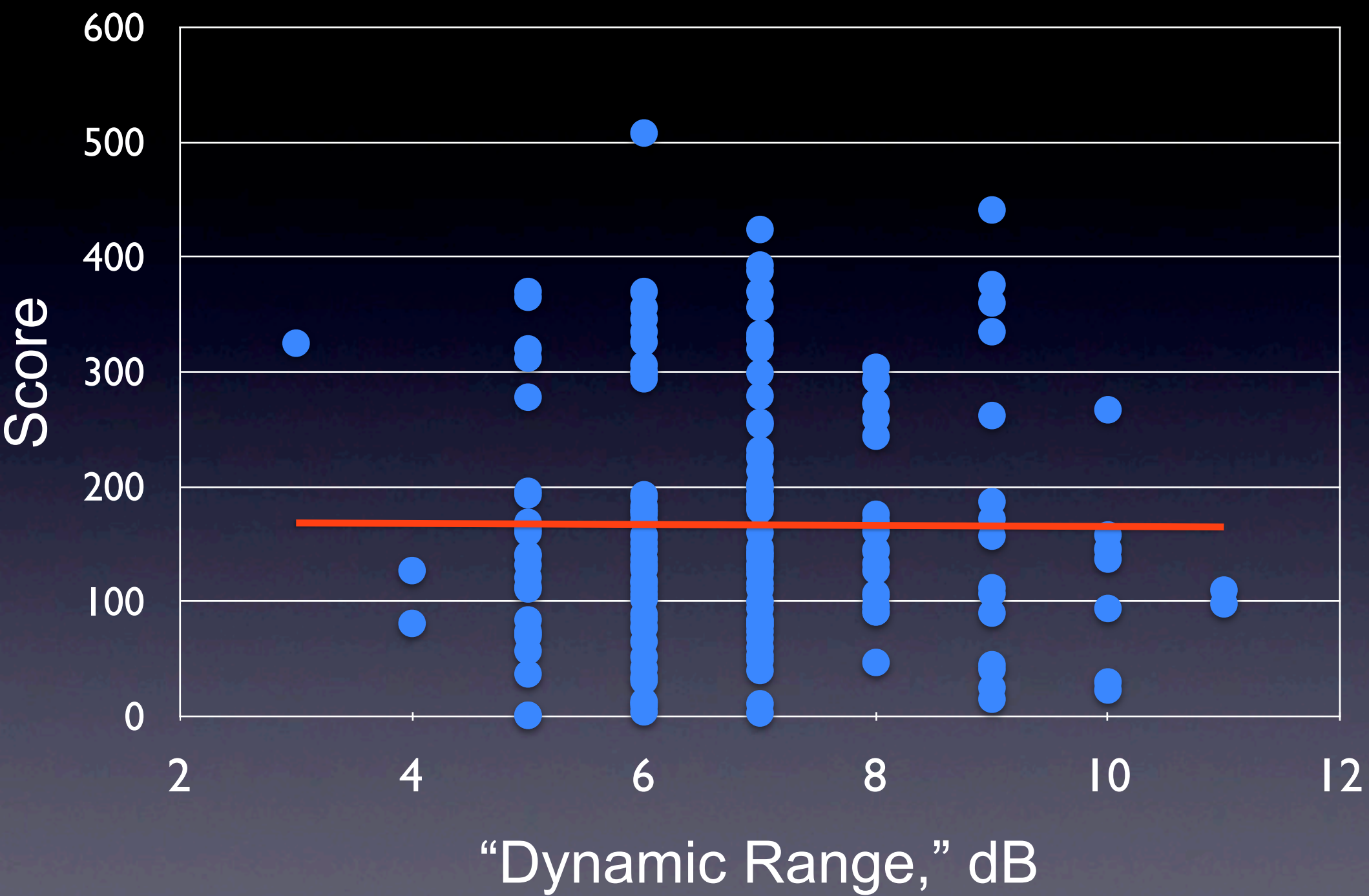
A dissertation by Dave Viney looked at 30 recent CD singles on the UK charts

No significant correlation  
between measured loudness  
and sales chart position  
or weeks in chart

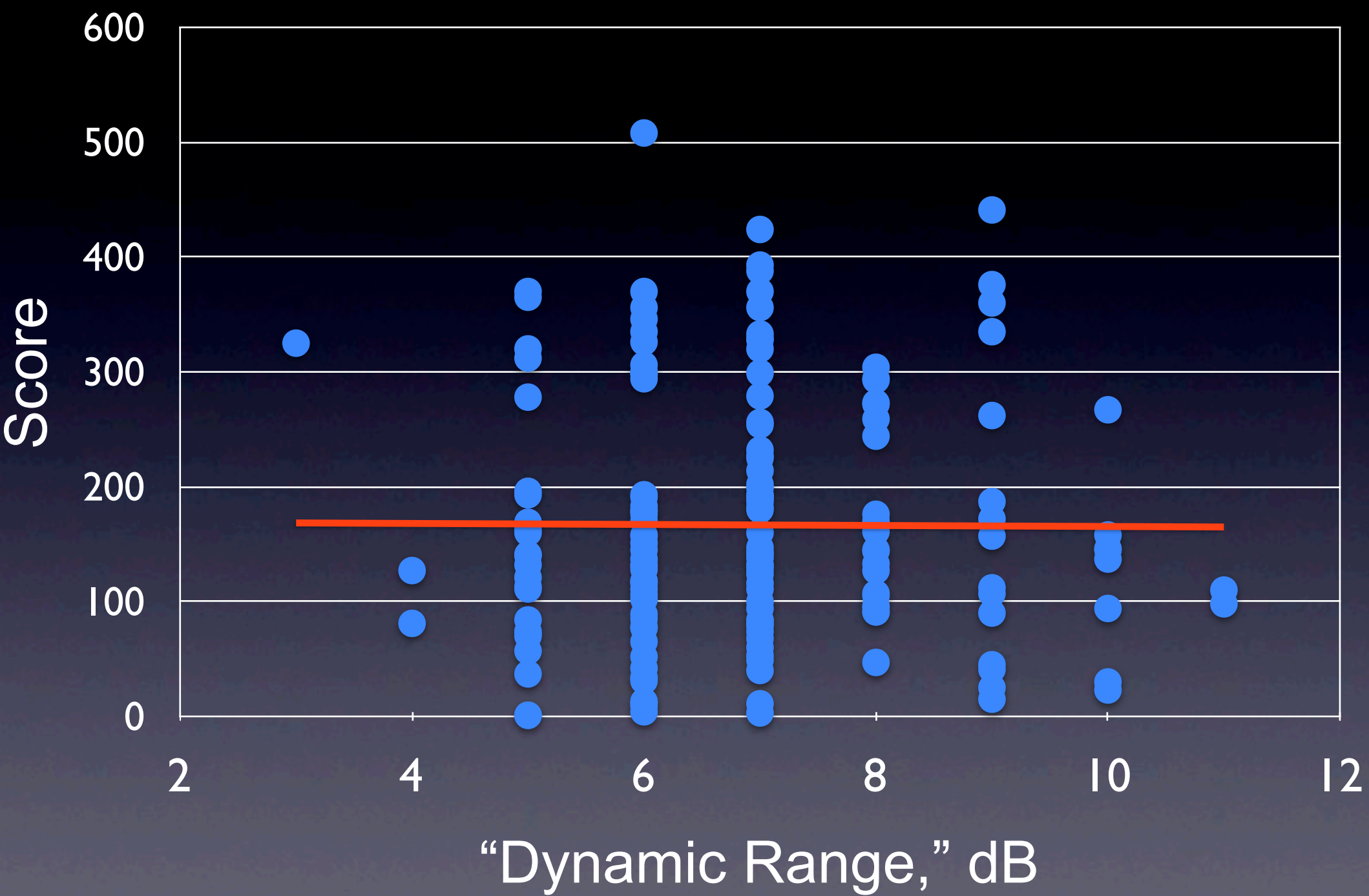
and found no significant  
correlation between  
loudness and sales.

## **Sales rankings vs. dynamic range**

I made a scatter plot of sales rankings from the Billboard year-end charts, 2002–9, vs. dynamic range data from an online database. 173 albums appeared in both databases.



The dots represent individual albums. (The vertical bands are because the dynamic range data was quantized to 1 dB....) The red trendline is almost horizontal, which means that a large change in dynamic range corresponds to a very small change in sales.



The data points are scattered all over, and the correlation is not statistically significant. So the data fails to support a link between dynamic range (presumably correlated to loudness) and the Billboard rankings.



**“The influence of sound processing on listener’s program choice...”**

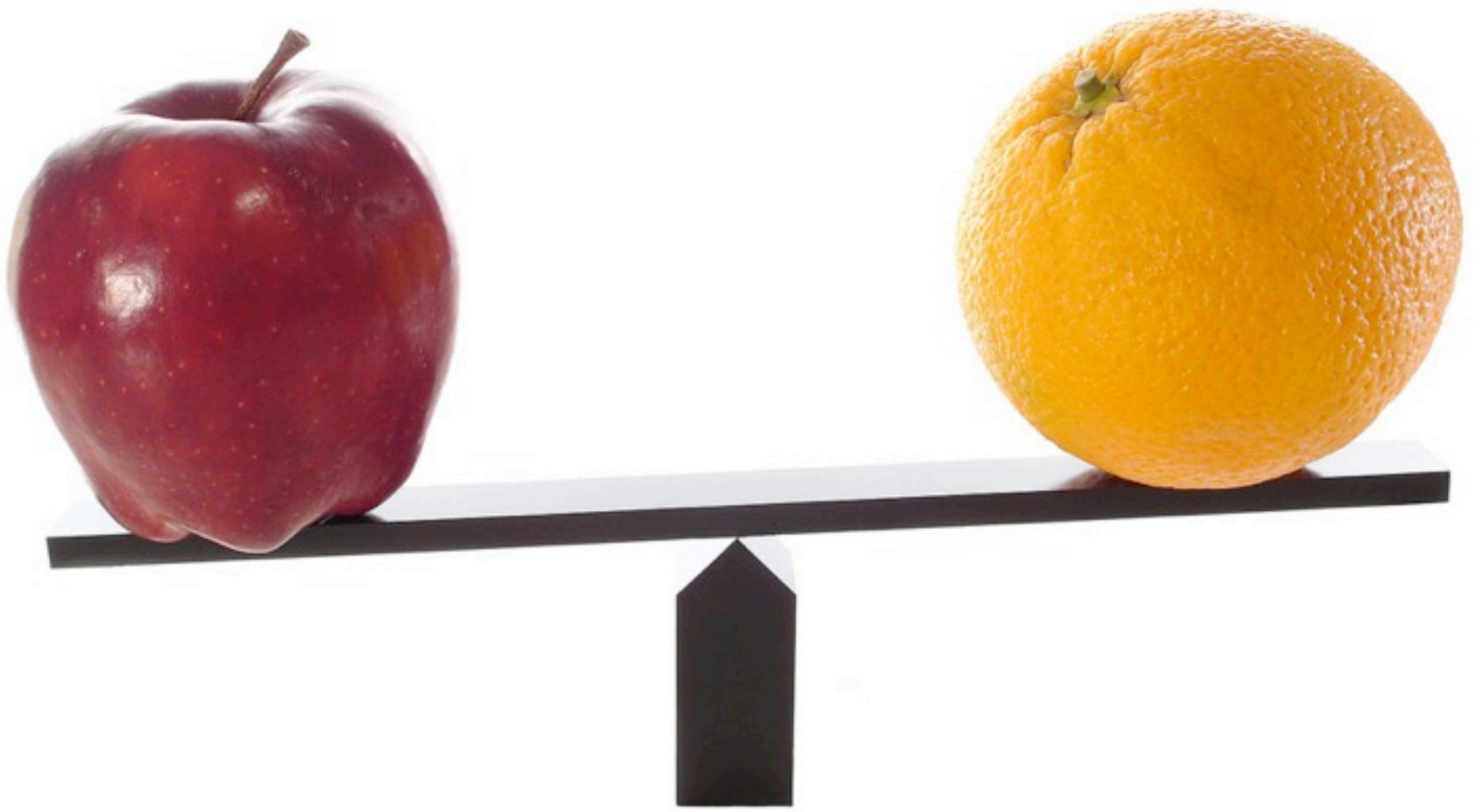
Next, a recent and important study looked at the effects of radio sound processing on listener preference. Maempel and Gawlik tested a number of music pieces and a variety of typical radio processing settings that varied in loudness and crest factor.

Listeners prefer the louder of two otherwise identical recordings

One experiment was a conventional test, where you compare different types of processing using the same piece of music. To no one's surprise, listeners preferred the louder one. In an A-B test with the same song, you're straining to hear the slightest difference, and the only difference is the processing.

But with 2 different songs,  
the processing has a  
**marginal and statistically  
insignificant effect**  
on listener preference

But in real life, we don't choose between two versions of the same song. If I change stations, I hear a different song, with a different type of processing. When they systematically co-varied the source material and processing, they found the type of processing had very little effect on listener preference, which was strongly determined by the choice of source material.



It's like: Hey, I don't care if the apple's heavier, I want an orange!

Loudness  
doesn't trump  
everything

So maybe loudness doesn't  
trump everything.

Content  
trumps  
loudness

It looks like content largely swamps any differences in listener preference due to changes in loudness and compression. And differences due to loudness disappear the minute the listener adjusts the volume.

**vocals**  
**melody** **texture** **spaciousness**  
**instrumentals** **style**  
**emotion** **dynamics**  
**lyrics** **pitch** **genre**  
**rhythm** **harmony**  
**timbre** **loudness** **effects**

We judge music based on many different factors. The brain may be more interested in things like melody, vocals, emotion, whether it's got a beat and you can dance to it, than it is in small loudness changes.

What if  
people buy music  
because they like it,  
not because of how loud it is?

People buy music (steal music) for any number of reasons, and loudness may play a very minor role.



What if  
we went to loudness war  
based on a lie?

So maybe we've  
overextrapolated from  
studies that compare the  
same song at different  
playback levels.

## Understanding the actual payoffs

Loudness may already have minimal effect on listener preference and commercial success, but this idea is contrary to firmly held assumptions, possibly driven by loudness envy and groupthink.

# Changing the payoffs

To **change** the payoffs, we can reduce the relevance of loudness even more by

Making loudness irrelevant

Loudness normalization

building loudness  
normalization into the  
playback devices,

# Making loudness irrelevant

## Loudness normalization as default setting

Sound Check

Automatically adjusts song playback volume to the same level.

and equally important, making that the default. Then, if you compress your music to make it louder, the normalizer just says, “Ha-ha, too loud,” and sets it back to the standard loudness.

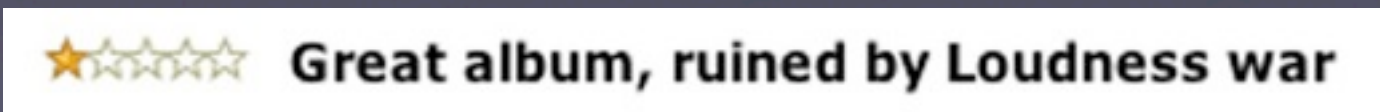
“High Dynamic Range” label



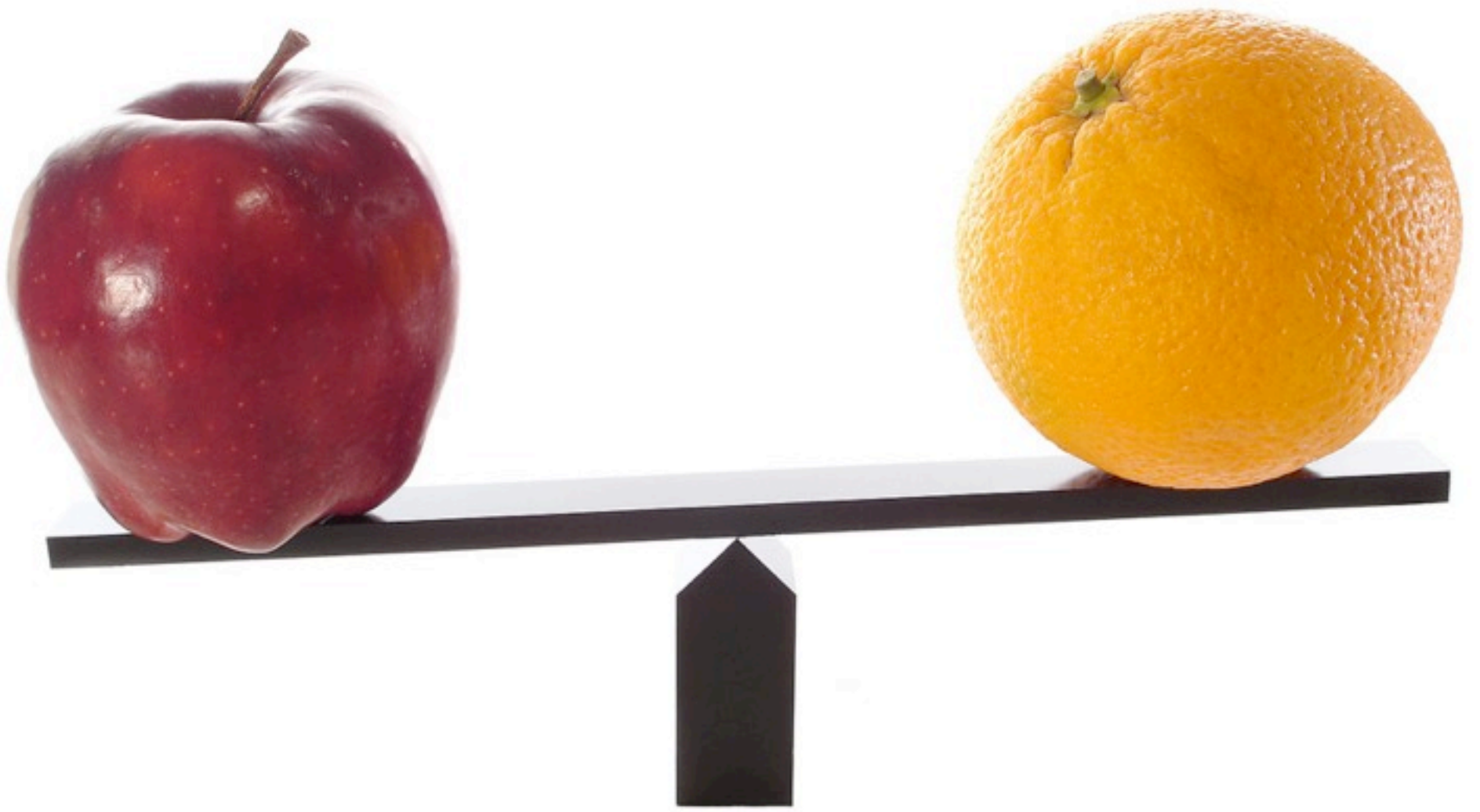
Recognize outstanding achievement



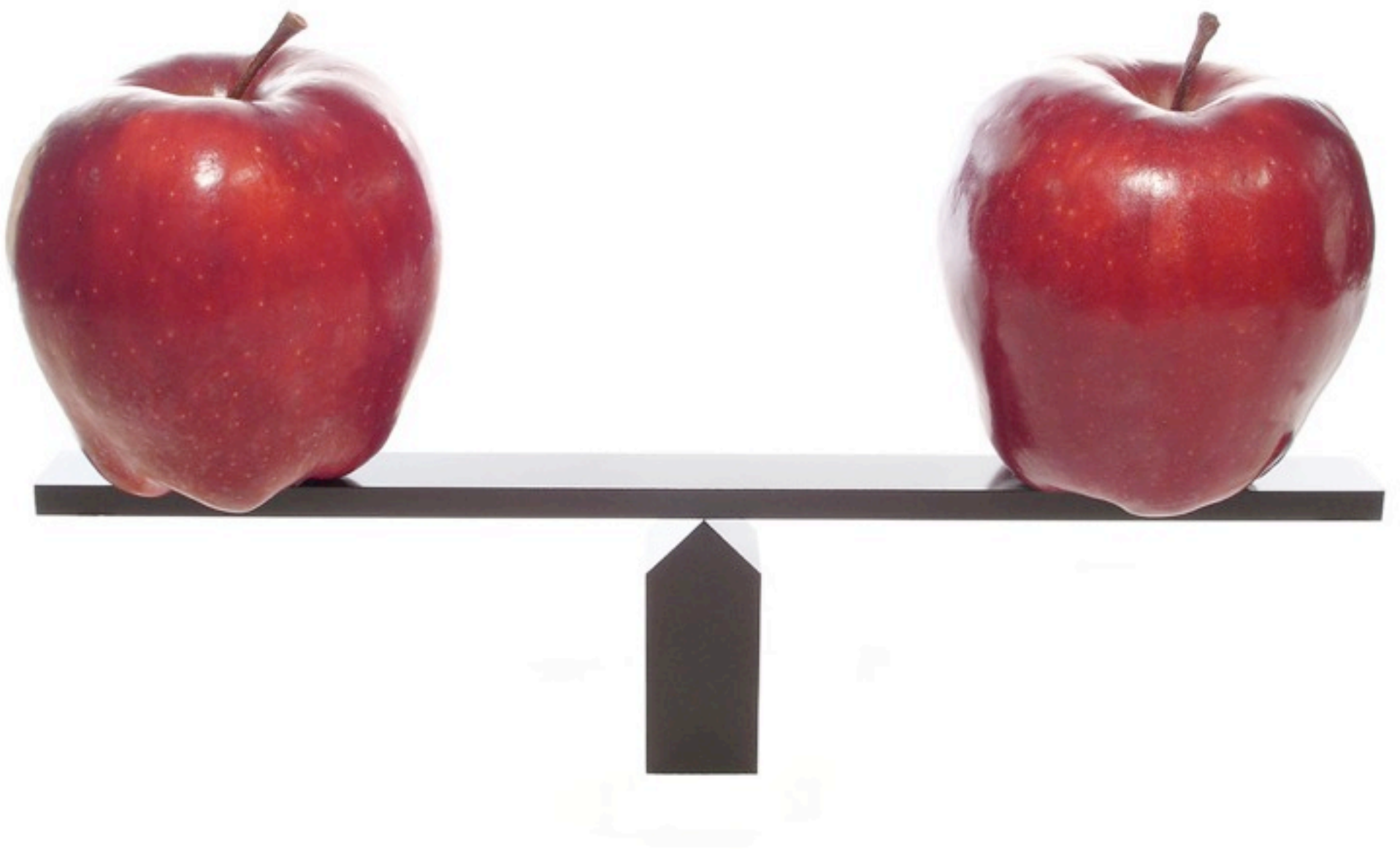
Post audio quality reviews



Some other ways of changing the payoffs could include providing a “high dynamic range” certification, giving awards for excellent mastering and engineering, and posting reviews on sites like iTunes and Amazon.



But let's back up a second...  
This idea that loudness plays  
an minor role when  
comparing two different  
songs – wouldn't the same  
argument apply to the  
audibility of compression  
artifacts?



In other words, if I go back and forth between two versions of the same song, sure, I can tune in to subtle differences due to compression, maybe hear some loss of punch – but if you play





**two different songs in a casual setting and ask me which one was compressed, I'm not sure I could tell you, because there are so many other differences.**

# Hypercompression



It looks like, as long as the compression is not too extreme – for example, no clipping – the side effects may not be immediately apparent to the casual listener...

# Hypercompression



But the commercial advantage of hypercompression – the whole reason for doing it in the first place – may also be small, or even non-existent! So, what to do?



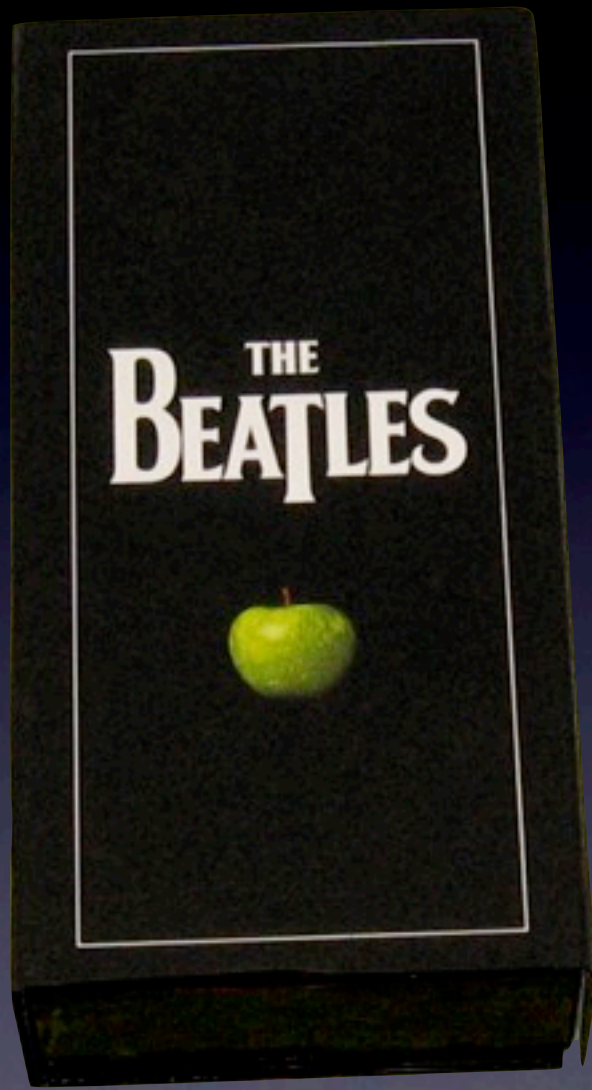
**Should we cater to active listeners who want to discern musical subtleties?**



Or do we use the old loudness nonlinearity trick to try to con people into buying our songs, given that the trick may not even work?



My personal feeling is:  
master it the way you'd like  
to hear it – preserve the  
dynamics. It shouldn't have  
much effect on the sales. \*  
Or we could try to make  
everyone happy. Sell the  
cheap, hypercompressed  
version, but also

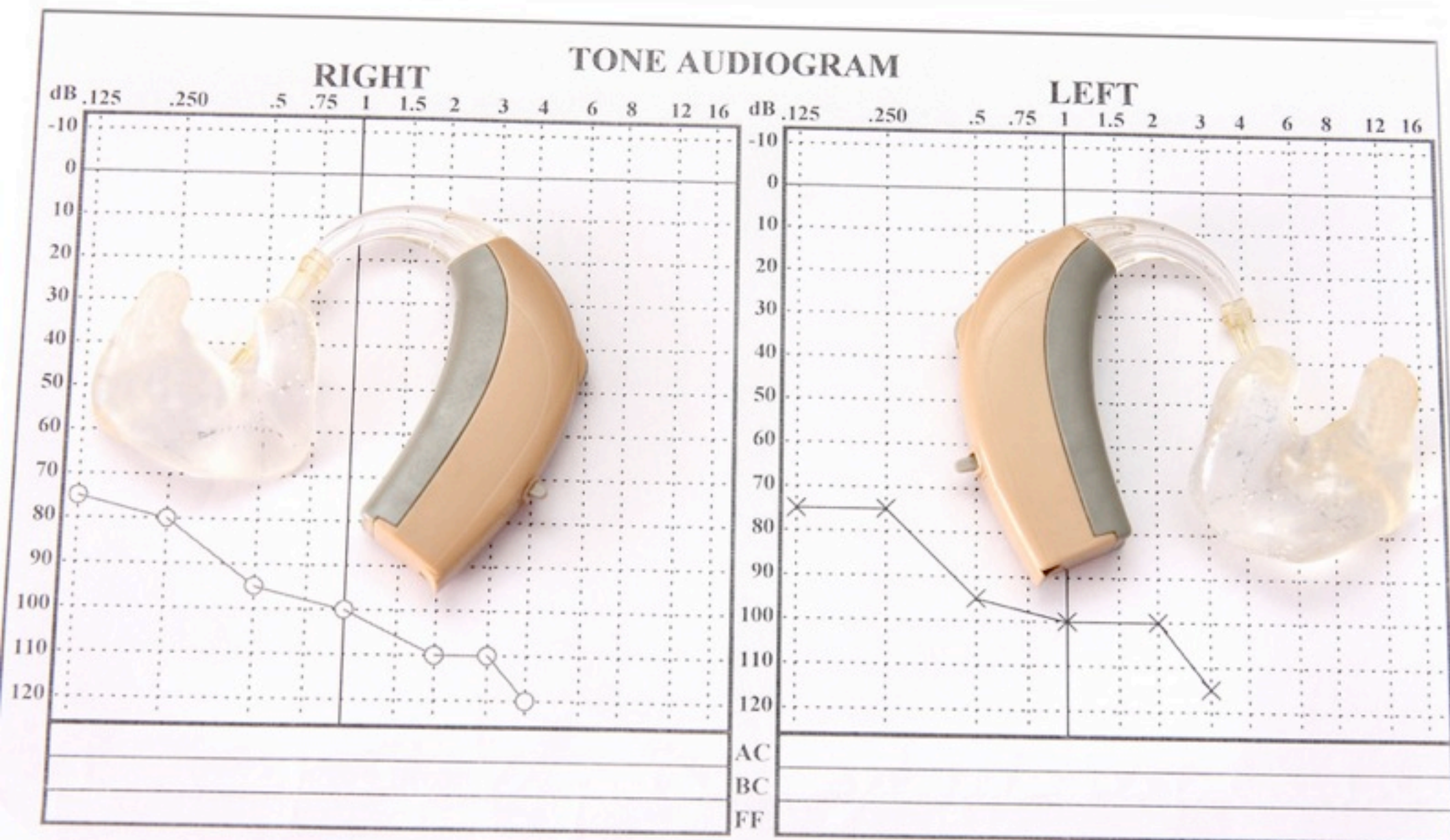


provide a premium, wide dynamic range version for the audiophile.



Record companies could even use the loudness war as a kind of copy protection, so they can upgrade us to the high-dynamic range version later.





Now there's still the issue of possible hearing damage, and that's where we really need some research – How do people set the levels? Do they get more sound exposure with compressed music?



The loudness war is a relatively minor issue in a world with financial meltdown, environmental destruction, real wars. People aren't dying from hypercompression;



they're not marching in the streets, singing anti loudness-war songs. But maybe it's all part of the same big picture,



the vast human capacity to use our brainpower to outsmart ourselves. I mean, who foresaw what mp3s and the internet would do to the industry, by making music so easy to steal, it wouldn't feel like stealing?



Who anticipated that portable music players would be associated with increased hearing loss among young people?



Max: 0.0dB 44.1kHz 16-bit Stereo raw WAVE [67.21MB]

And who saw that digital audio, with its huge dynamic range, would lead to a dramatic reduction of musical dynamics?



The music business is often more about business than it is about music.

# **LOUDNESS WAR IS OVER!**

**IF YOU WANT IT**

But if culture's important, if music's important, then how we produce and preserve our music may be important. I think it might be time to let go of the obsession with loudness, and back off a little on the compressor.



Additional information available at

<http://sfxmachine.com/docs/loudnesswar>