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**Song Dynamics:
The *chiaroscuro* of Loudness
in Selected Pop/Rock Recordings, 1971 – 2021**

Robert Toft

Over the past fifteen years, discussions of loudness¹ in pop/rock recordings have centered on the dramatic increases in average level that occurred during the 1990s and early 2000s,² and the analyses authors have used to establish the details of this upward trend generally employ a single global measurement, often an integrated value, to represent the loudness characteristics of an entire track or album. Algorithms dedicated to calculating the average loudness of a complete program, such as the one developed by the International Telecommunication Union (ITU),³ certainly generate essential information for audio engineers, broadcasters, and streaming services, yet the application of this type of measurement tool will inevitably conceal localized variations in loudness. Indeed, the distinctive treatment mix engineers give each section of a song (intro, verse, chorus, bridge, instrumental interludes, outro, etc.) cannot be captured by a solitary calculation, and the *chiaroscuro*⁴ or song dynamics of a track, that is, the ways in which recordists organize light and shade to provide contrast and create variety, remain hidden. An investigation into loudness procedures within individual tracks not only places song dynamics at the heart of loudness practices but also brings the *chiaroscuro* of recordings into focus, for many tracks, even those with the highest integrated values (that is, above -10.0 LU), juxtapose light and shade.⁵

Although this study does not directly consider the polemic surrounding the so-called “loudness war,” the issue cannot be ignored, as loudness seems to have become a flashpoint for a number of commentators.⁶ In fact, people who invoke the metaphor of a battlefield tend to write

¹ In 2013, the Advanced Television Systems Committee (ATSC) in Washington, D.C. defined loudness as a perceptual quantity, that is, the magnitude of the physiological effect produced when a sound stimulates the ear (ATSC 2013: 14). These physiological reactions can be quantified (measured) by digital meters employing an algorithm designed to approximate the human perception of level. For further information on this metering system, see ITU 2015 and EBU 2016.

² See, in particular, Mayfield [M] 2007; Katz 2009a, b, c; Vickers 2010; Deruty 2011; Katz 2011; Lund 2011; Croghan, Arehart & Kates 2012; Stjernholm 2012; Deruty, Pachet & Roy 2014; Deruty & Tardieu 2014; Deruty & Pachet 2015; Shepherd 2015a, b; Shepherd 2019; and Third 2022.

³ As described in ITU-R BS.1770-4 (10/2015).

⁴ The Italian term *chiaroscuro* may be translated as light and shade.

⁵ This paper complements work undertaken by Emmanuel Deruty and his co-researchers, especially Deruty, Pachet & Roy 2014.

⁶ See, in particular, Katz 2009a, b, c; Katz 2011; Stjernholm 2012; Shepherd 2015a, b; Shepherd 2019; and Third 2022. For a somewhat more balanced view of increased loudness, see the video by Dane Holmes (2022).

from an old versus new perspective, and listeners/audio engineers who prefer the loudness customs in vogue before 1990 regularly complain about the lack of dynamic range in later recordings, as well as the harshness of digital distortion.⁷ These sorts of controversies have been common throughout history, and the current battle does not, on the surface, look much different from previous ones.⁸ For instance, in mid-eighteenth-century France, a pamphlet “war” took place between two groups of Parisian intellectuals over which was superior, Italian or French opera, and the debate has been dubbed the “Querelle/Guerre des Bouffons” (Quarrel/War of the Comic Actors).⁹ Similarly, in early seventeenth-century Italy, a dispute over musical style erupted between Giovanni Maria Artusi and Claudio Monteverdi. Monteverdi, in his later books of madrigals, had adopted a new method of composing that did not sit well with critics like Artusi, who preferred sixteenth-century compositional principles, as codified by Gioseffo Zarlino in 1558, to Monteverdi’s audacious treatment of dissonance, amongst other things. In response to Artusi’s criticisms, Claudio, and his brother Giulio Cesare, proposed that instead of claiming the superiority of one compositional style over another, the two conflicting approaches should be regarded as first and second practices.¹⁰

When viewed from this historical perspective, today’s loudness “querelle” seems to be more about musical preference than measurable listener experience, and individual predilections undoubtedly shape each commentator’s perception of audio quality.¹¹ Artistic expression clearly was changing in the 1990s, and the introduction of digital tools that permitted the loudness of recordings to be increased in an unprecedented manner¹² substantially transformed the practices of recordists.¹³ This emerging loudness paradigm soon became the norm in the audio industry, so much so that in the early 2000s, when record companies reissued older material, they frequently

⁷ Dynamic range is defined in the Audio Engineering Society’s technical document AESTD1008.1.21-9 (2021) as “the difference in loudness between the loudest and softest passages of content, excluding silence.” On the harshness of digital distortion, see Katz 2009b, at 3:57, when he uses the word “egregious” to describe this form of dissonance, and at 4:42, when he characterizes it as “horrendous.”

⁸ In addition to the controversies mentioned here, see Devine 2013 on loudness in the earliest days of commercial sound production.

⁹ A summary of this “querelle” may be found in Cook 2001.

¹⁰ For further information on this dispute, see Palisca 2001.

¹¹ As revealed in comments, such as: “loudness is a drug” (Katz 2009a, at 3:32); “loudness-normalized media reveals that over-compressed masters sound wimpy, small, and distorted” (Katz 2011, at 14:20); “people think you need to be loud to make it sound better” (Shepherd 2015a, at 1:44); and “don’t think loudness, think quality” (Third 2022, at 13:47).

¹² For example, Waves’ L1 Ultramaximizer (1994) and L2 Ultramaximizer (hardware unit: 2000; software: 2001) [dates from the Waves Sales Team, private communication, 1 February 2023] and TC Electronic’s Finalizer (1996; date from Rudolf Ortner’s interview with Florian Camerer in Ortner 2012: 132).

¹³ The history of these changes has been traced in Katz 2011 and Ortner 2012.

used the latest digital technology to modernize the sound of those recordings, processes that paralleled the way Richard Wagner refreshed Christoph Willibald Gluck's eighteenth-century operas in the mid nineteenth century (Wagner updated Gluck's orchestrations and added newly composed music¹⁴). In 1995, a similar approach was taken during the remastering of Elton John's *Goodbye Yellow Brick Road* (1973), and in the liner notes of the reissued album, Gus Dudgeon, the original producer, not only reflected on the sonic limitations of transferring analogue recordings to vinyl discs in the early 1970s but also endorsed the use of the latest digital processing equipment to enhance the sound of the album:

“All the tapes used to create these new masters are the original mixes. However, due to the fact that many of the tapes are at least 25 years old, they have ‘softened up’ to varying degrees. So, the sound has been passed through the most up to date digital processing equipment, at 20 Bit Resolution; namely The Sadie Digital System and Prism Super Noise Shaper. The effect is purely to ‘enhance’ rather than ‘colour’ the sound. As the original producer, I would have used this equipment at the time, had it been available for mastering. The very nature of analogue recordings being transferred to vinyl demanded major compromises. With the benefits of digital sound these constraints are removed, and the recordings can be heard much closer to the reproduction we had originally intended. Gus Dudgeon.” (John 1995: unpaginated).

In my view, the modernization of *Goodbye Yellow Brick Road* comfortably maps on to the idea of a first and second practice, for the sound of the original album was shaped by the technology of its day, the first practice, while the digital processing available in the 1990s allowed the music to be presented through a “new” second practice. In other words, technological innovation ushered in the next prevailing taste in sound recording, a sonic style that could not be realized in the 1970s. If this argument is extended to the so-called “loudness war,” one might be tempted to suggest that limitations of technology conditioned the first practice (before the 1990s), and digital signal processors facilitated a second, much more audacious (and dissonant) practice. However, even though pop/rock recordings became louder in the 1990s, the degree of *chiaroscuro* present is often identical or similar to that of tracks produced in the 1970s and 1980s. To exemplify this point, and with the “loudness war” polemic as a backdrop, I will examine localized loudness in selected recordings from 1971 to 2021, beginning with Jenny Tolman's “So Pretty.”

I quantify loudness through measurement tools developed by the International Telecommunication Union (algorithms published in 2006; see ITU 2015 for the latest revision), which in 2010 were organized into a metering system by the European Broadcasting Union (see EBU 2016 for the latest revision), and then implemented by Steinberg in their mastering

¹⁴ Wagner's treatment of Gluck's operas is discussed in Wagner 2010: vii-xii.

software WaveLab Pro. From the options available in WaveLab Pro 11.1’s “Global Analysis” feature, I have chosen the following criteria for analyzing loudness (adapted and/or quoted from Steinberg 2022b: 212-13, 216-17):

Sample Peak / True Peak

Displays the highest peak in the analyzed selection.

Integrated Loudness

Displays the integrated loudness of the analyzed selection ... This indicates the average loudness of the audio.

Short-Term Loudness

Maximum

Displays the level of the loudest 3 second section in the analyzed selection.

I also employ the “Dynamic Range” measurement in the Youlean Loudness Meter to approximate the dynamics of a song, particularly the meter’s graphic representation of variations in *chiaroscuro* across an entire track. Youlean determines the dynamic range of an audio signal by calculating the difference between true-peak and short-term loudness, as averaged over a three-second window.¹⁵



Jenny Tolman’s “So Pretty” (*There Goes the Neighborhood*, 2019) illustrates the significant role mixing plays in creating the *chiaroscuro* of recorded music and serves as an introduction to the treatment of light and shade. John Mayfield mastered the track and subsequently discussed his approach to the song in Adam Audio’s video series “Mastering Masterclass” (episode 6). In recognizing that he was dealing with a fairly “musical arrangement,” Mayfield chose to preserve the “dynamics” of the original mix, while fulfilling his obligation to produce a reasonably loud master for commercial distribution:

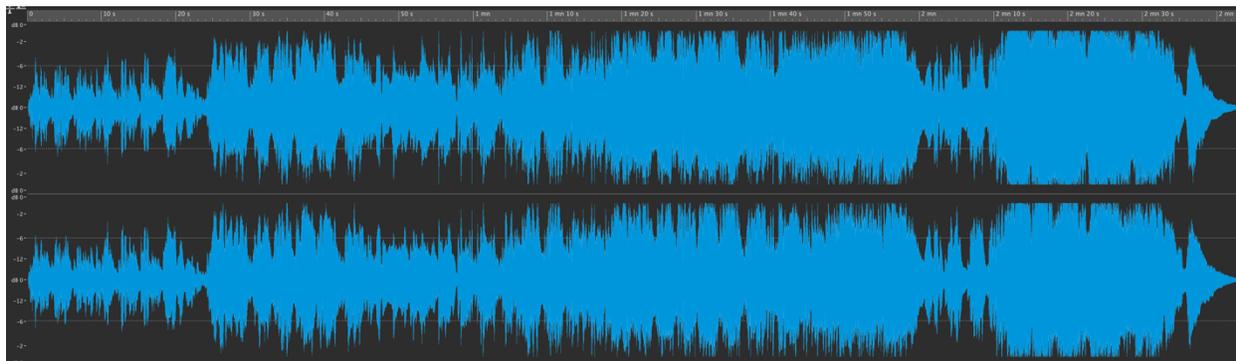
“[28:06] this track is ... quite musical in it’s arrangement, [and] it’s got dynamics. ... [28:52] [Yet] the dynamic in this song ... [has] been changed from the original mix, because I had to master it loud. But I didn’t smash it, and I didn’t alter the original dynamic from top to bottom, because musically it made sense. ... [30:12] [But] it’s a compromise between dynamics and art. ... [29:50] If you’re driving down the road at 70 miles per hour, you’ve got a

¹⁵ Youlean calls the resulting peak to short-term (PSR) measurements the real-time dynamics of a recording (Désard 2022). A growing number of software developers believe PSR calculations provide a better insight into track “dynamics,” as PSR measures shorter time frames, instead of calculating an average range for a complete program of material. For example, in the manual to true:level, Sonible states: “true:level is using the median of all measured PSR (peak to short-term loudness ratio) values for measuring the dynamics of a track. Compared to the well-known PLR (peak to long-term loudness ratio) value used by other tools, our experiments showed that our PSR based descriptor better traces the actual dynamics of a track, including short-term dynamics.” (Sonible 2022: 7). See also Meterplugs n.d., “Why Loudness Doesn’t Matter.”

lot of road noise. You try to listen to classical music, you're going miss a lot of it. So, it's part of my responsibility to make sure that the dynamics built in to the piece ... will work logistically in a car. ... There's got to be a happy medium.¹⁶ ... [30:33] I try to maintain as much dynamic as possible, such that the art that was originally intended by the producers is still there.” (Mayfield [J] 2022).

The juxtaposition of light and shade across “So Pretty” may be visualized through the three images shown in Figure 1 – a depiction of the song’s waveform, a graph plotting the integrated and short-term measurements, and an illustration of the recording’s dynamic range (as defined by Youlean). Clearly, the line representing average loudness in the second image does not reflect the multitude of localized variations that actually comprise the track’s loudness profile, whereas the line representing short-term fluctuations meticulously captures these details. The third image, derived from the ratio between true-peak and short-term values, provides another useful way of showing loudness variation over time. The taller portions of the graph correspond to areas with a larger dynamic range, while the vertically shorter segments depict parts of the track with a smaller dynamic range. In fact, when one measures the loudness of each section, the *chiaroscuro* of “So Pretty” spans 9.9 LU, from -16.3 in the quietest section to -6.4 in the loudest (see Figure 2 for the complete set of measurements).

Figure 1. Loudness variations in Jenny Tolman, “So Pretty” (screenshots, WaveLab Pro 11.1 and Youlean).



¹⁶ Mastering engineer John Greenham also speaks of the importance of the listening environment, especially the playback device, for the loudness characteristics of a recording: “That little phone speaker doesn’t want a lot of dynamic range. It’s gonna sound really weak if it’s not ... fairly, sort of, blown up ...” (Shepherd 2021, at 32:24).

Red = integrated measurement; Green = short-term measurement

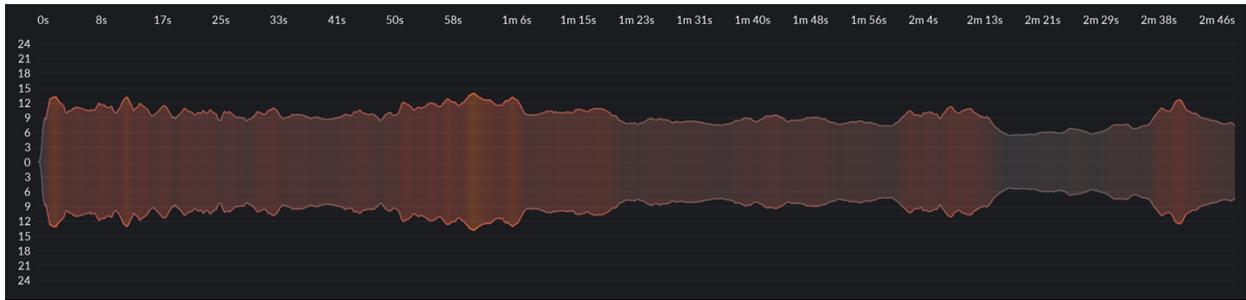
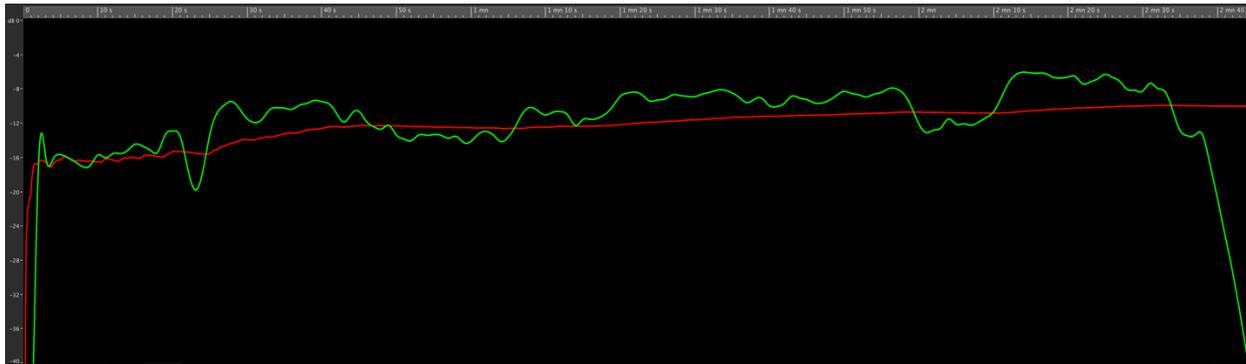


Figure 2. Loudness measurements in Jenny Tolman, “So Pretty” (SP = sample peak, TP = true peak, S = short term, I = integrated).

	<i>Time</i>	<i>SP</i>	<i>TP</i>	<i>S</i>	<i>I</i>
<i>Complete Track</i>	2:45	-0.59	-0.55	-6.0	-9.9
<i>Sections</i>					
Verse 1	0:00	-2.92	-2.92	-15.5	-16.3
Verse 2	0:12	-2.40	-2.40	-12.8	-14.7
Chorus 1, 1st half	0:24	-0.61	-0.60	-9.6	-10.5
Chorus 1, 2nd half	0:36	-0.62	-0.61	-9.3	-10.6
Interlude 1	0:49	-1.18	-1.18	-13.3	-13.7
Verse 3	0:55	-0.62	-0.62	-12.9	-13.3
Verse 4	1:06	-0.60	-0.60	-10.3	-10.9
Chorus 2, 1st half	1:17	-0.60	-0.59	-8.4	-8.8
Chorus 2, 2nd half	1:29	-0.60	-0.60	-8.1	-8.9
Interlude 2	1:43	-0.60	-0.58	-9.3	-9.3
Bridge	1:49	-0.60	-0.55	-7.9	-8.8
Chorus 3, 1st half	2:00	-0.63	-0.61	-9.9	-11.2
Chorus 3, 2nd half	2:11	-0.59	-0.56	-5.9	-6.4
Outro	2:26	-0.59	-0.58	-7.4	-9.7

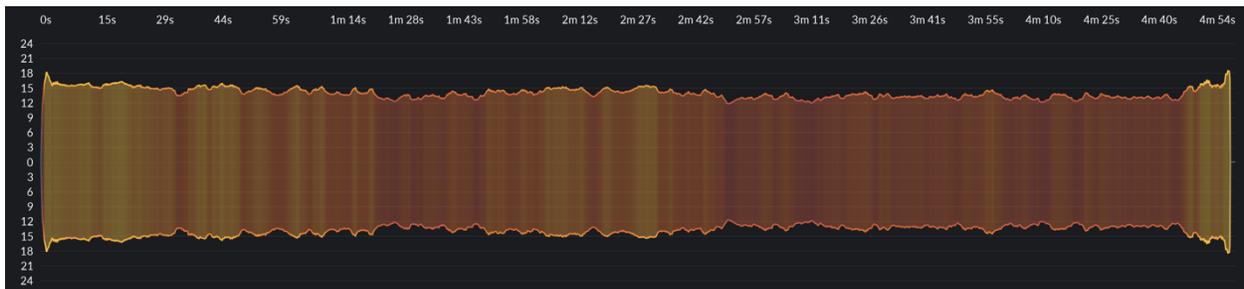
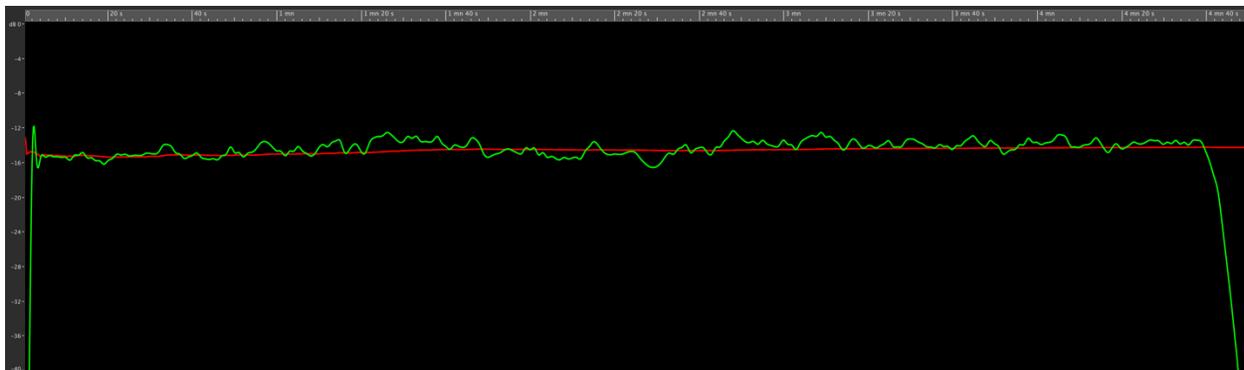
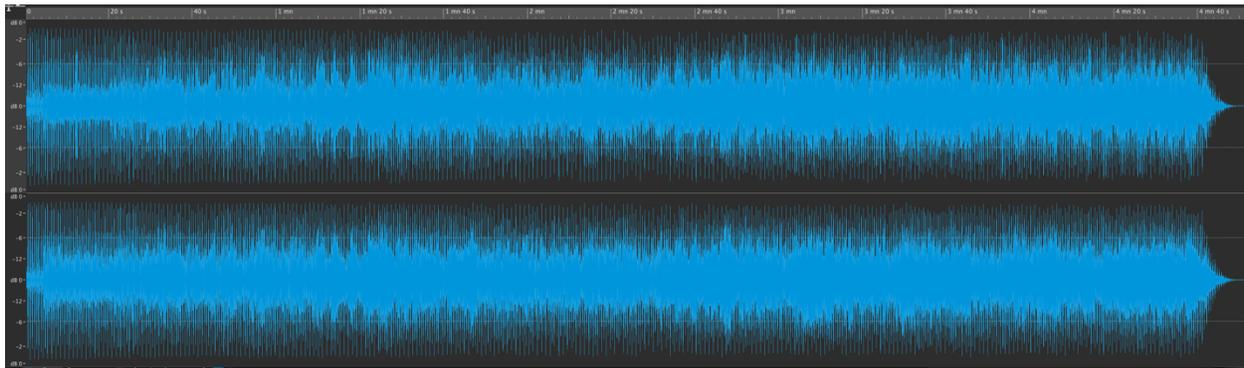
The song opens with singer and acoustic guitar in the first two verses (-16.3 and -14.7 LU respectively), with other instruments (piano, bass guitar, pedal steel, and drums) augmenting the texture in the first chorus (the two halves measuring -10.5 and -10.6 LU). The chorus's increased loudness is a natural by-product of its thicker texture, and while this instrumentation is maintained in the third and fourth verses, the loudness of the third verse drops to -13.3 LU, before the fourth verse returns to the -10 LU range. The two halves of the second chorus are presented at -8.8 and -8.9 LU, with the bridge retaining this level (-8.8 LU), but the most intense part of the mix is reserved for the latter part of the third chorus (-6.4 LU), just before the close of the song.

The song dynamics, then, encompass almost 10.0 LU, and when the single integrated measurement of 9.9 LU is used to represent the recording's loudness, the fine degrees of light and shade that confirm the track's diversified *chiaroscuro* are obscured. With its fairly broad loudness span, the recording obviously does not have restricted song dynamics, even though the track as a whole averages on the louder side of things. In fact, when one measures individual sections of songs, a less monolithic understanding of loudness emerges, for these calculations reveal not only that recordings with narrower and wider song dynamics coexisted throughout the time frame of this study but also that tracks with a less diversified *chiaroscuro* were being released well before the dramatic loudness increases of the later 1990s.

Michael Jackson's "Billie Jean" (*Thriller*, 1982) and Billy Joel's "Movin' Out" (*The Stranger*, 1977) restrict differences between sections to 1.8 and 2.2 LU respectively, and when the loudness variations within each song are examined, another style of mixing comes to light (see Figures 3 and 4). Both tracks have integrated values in the mid teens (-14.2 and -15.1 LU), yet the recordists did not create mixes with a wide *chiaroscuro*. Indeed, the individual sections of "Billie Jean" range from -13.5 to -15.3 LU and "Movin' Out" from -14.2 to -16.4 LU. Moreover, the integrated and short-term loudness plots for the two songs deviate far less from each other than do the plots drawn from Jenny Tolman's "So Pretty".¹⁷ This mixing style, one in which recordists prefer a more uniform presentation of loudness, is relatively common (see the dynamic-range graphs of Figures 3 and 4 for two examples), and as the chart in Figure 5 illustrates, smaller dynamic ranges, that is, those below 6.0 LU, predate the era of higher average levels, notably the tracks by Billy Joel (1977), Michael Jackson (1982), Peter Gabriel (1986), and Tori Amos (1991).

¹⁷ The four loudness dips in "Movin' Out" coincide with a brief thinning of the textures immediately before the interludes and at the beginning of the outro.

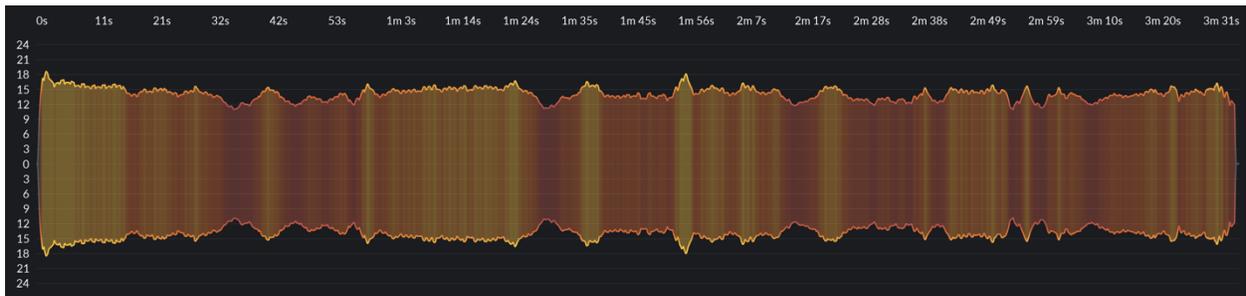
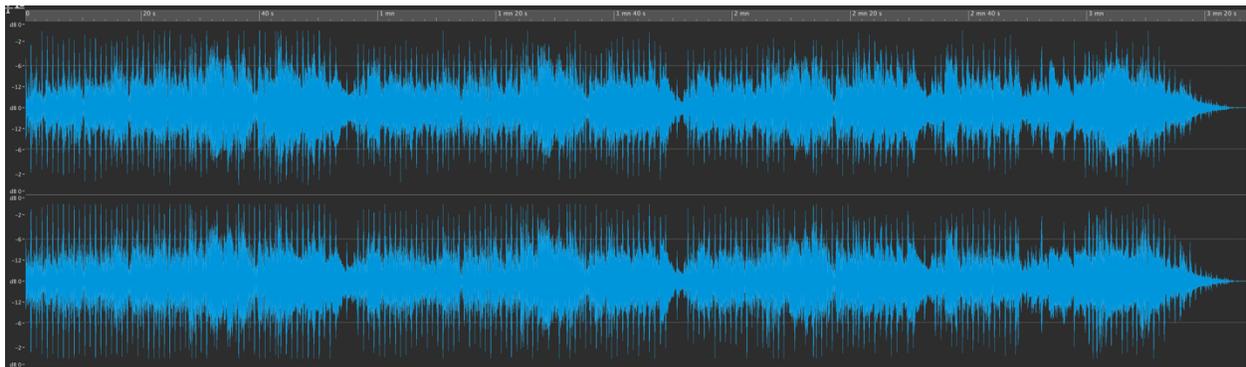
Figure 3. Loudness variations in Michael Jackson, “Billie Jean.”



	<i>Time</i>	<i>SP</i>	<i>TP</i>	<i>S</i>	<i>I</i>
<i>Complete Track</i>	4:54	-0.29	+0.59	-12.3	-14.2
<i>Sections</i>					
Intro, 1st half	0:00	-0.29	+0.59	-14.7	-15.3
Intro, 2nd half	0:20	-0.51	+0.38	-15.0	-15.2
Verse 1	0:29	-0.52	+0.23	-13.7	-14.7
Pre-Chorus 1	1:09	-0.54	+0.12	-12.8	-13.7
Chorus 1	1:25	-0.62	+0.08	-12.6	-13.6

Verse 2	1:51	-0.67	-0.06	-13.5	-15.0
Pre-Chorus 2	2:31	-0.63	+0.40	-13.5	-14.2
Chorus 2	2:47	-0.88	-0.26	-12.9	-13.5
Chorus 3	3:04	-0.68	-0.18	-12.5	-13.6
Interlude	3:29	-0.60	+0.03	-12.9	-13.8
Chorus 4	3:54	-0.71	-0.30	-12.7	-13.6
Outro	4:16	-0.65	-0.20	-13.2	-14.1

Figure 4. Loudness variations in Billy Joel, “Movin’ Out.”



	<i>Time</i>	<i>SP</i>	<i>TP</i>	<i>S</i>	<i>I</i>
<i>Complete Track</i>	3:30	-0.60	-0.20	-12.4	-15.1
<i>Sections</i>					
Intro	0:00	-0.60	-0.39	-15.7	-16.4
Verse 1	0:14	-0.60	-0.33	-12.5	-14.2
Chorus 1	0:43	-0.60	-0.48	-12.5	-14.3
Interlude 1	0:56	-0.60	-0.57	-14.8	-15.8
Verse 2	1:10	-0.60	-0.20	-12.5	-15.1
Chorus 2	1:39	-0.60	-0.53	-13.9	-15.1
Interlude 2	1:52	-0.60	-0.55	-15.7	-16.0
Verse 3 (partial)	2:06	-0.60	-0.53	-13.3	-14.7
Chorus 3	2:20	-0.85	-0.84	-13.7	-14.7
Interlude 3	2:34	-0.60	-0.24	-14.3	-15.4
Outro	2:48	-0.60	-0.52	-13.1	-15.7

Figure 5. Loudness measurements in selected recordings 1971 – 2021, listed according to the difference between the loudest and softest sections.¹⁸

<i>Year</i>	<i>Track</i>	<i>I</i>	<i>Loudest Section</i>	<i>Softest Section</i>	<i>Loud to Soft Difference</i>
1999	Backstreet Boys – <i>I Want It That Way</i>	-9.6	-7.3	-25.7	18.4
2009	Mumford & Sons – <i>The Cave</i>	-11.7	-7.3	-24.2	16.9
1973/1983	Elton John – <i>Goodbye Yellow Brick Road</i>	-19.6	-16.9	-32.9	16.0
1973/1995	Elton John – <i>Goodbye Yellow Brick Road</i>	-11.7	-9.3	-24.9	15.6
1972/1990	Neil Young – <i>Old Man</i>	-20.0	-15.5	-30.9	15.4
1995	Oasis – <i>Wonderwall</i>	-11.6	-10.5	-25.8	15.3
1981/1988	Phil Collins – <i>In the Air Tonight</i>	-20.0	-15.0	-29.8	14.8
2019	Billie Eilish – <i>Xanny</i>	-9.5	-6.9	-21.7	14.8
2002	Avril Lavigne – <i>I’m With You</i>	-9.7	-6.8	-20.3	13.5
2002	Faith Hill – <i>Cry</i>	-7.6	-5.7	-18.7	13.0
2021	Adele – <i>Easy on Me</i>	-9.4	-8.1	-20.7	12.6
1989	Aerosmith – <i>Water Song/Janie’s Got a Gun</i>	-13.1	-11.0	-22.7	11.7
2019	Billie Eilish – <i>Bad Guy</i>	-7.8	-6.8	-17.8	11.0
2001	Puddle of Mudd – <i>She Hates Me</i>	-8.1	-5.9	-16.8	10.9
1997	Shania Twain – <i>From This Moment On</i>	-12.2	-9.4	-20.1	11.0
2019	Jenny Tolman – <i>So Pretty</i>	-9.9	-6.4	-16.3	9.9
1998	Shania Twain – <i>From This Moment On</i>	-8.4	-5.4	-14.8	9.4
1997	Shania Twain – <i>That Don’t Impress Me Much</i>	-12.0	-9.9	-19.2	9.3

¹⁸ Double dates indicate the release of the LP and CD versions, except for the remastered releases of Barenaked Ladies, Michael Jackson, and Shania Twain. The measurements for songs originally recorded before the advent of digital tracking have been taken from the earliest CD releases, that is, at a time when digital limiting was not possible. A number of the first CD re-releases carried a statement identical or similar to the following: “The sound of the original recording has been preserved as closely as possible, however due to its high resolution, the compact disc can reveal limitations of the source tape.” See, for example, Carole King, Billy Joel, and Meatloaf.

1977/1990	Meatloaf – <i>You Took the Words</i>	-16.0	-14.8	-24.0	9.2
1971/1985	Carole King – <i>It's Too Late</i>	-17.5	-15.8	-24.9	9.1
2006	Trisha Yearwood – <i>Georgia Rain</i>	-9.1	-6.7	-15.8	9.1
1984	Bryan Adams – <i>Summer of '69</i>	-14.6	-13.3	-21.5	8.2
2001	The Smashing Pumpkins – <i>Landslide</i>	-15.4	-13.4	-21.5	8.1
2002	Norah Jones – <i>Don't Know Why</i>	-13.0	-9.4	-17.3	7.9
2005	Michael Bublé – <i>Home</i>	-10.7	-8.9	-16.7	7.8
2003	Jet – <i>Are You Gonna Be My Girl</i>	-6.5	-4.4	-11.9	7.5
1991	Tori Amos – <i>Crucify</i>	-17.4	-15.8	-21.5	5.7
1997/1998	Shania Twain – <i>That Don't Impress Me Much</i>	-8.5	-7.1	-12.7	5.6
1986	Peter Gabriel – <i>Sledgehammer</i>	-13.0	-11.5	-16.9	5.4
1997	Spice Girls – <i>Spice Up Your Life</i>	-8.6	-7.2	-10.7	3.5
1998	Barenaked Ladies – <i>It's All Been Done</i>	-8.8	-7.5	-10.3	2.8
1998/2001	Barenaked Ladies – <i>It's All Been Done</i>	-5.9	-4.6	-7.4	2.8
1977/1987	Billy Joel – <i>Movin' Out</i>	-15.1	-14.2	-16.4	2.2
1982	Michael Jackson – <i>Billie Jean</i>	-14.2	-13.5	-15.3	1.8
1982/2003	Michael Jackson – <i>Billie Jean</i>	-9.1	-8.5	-10.0	1.5

Figure 5 also shows that some of the largest dynamic contrasts (differences in light and shade above 9.0 LU) occur in tracks released in 1995 or later:

- 1995 Oasis – 15.3
- 1997 Shania Twain – 9.3 and 11.0
- 1998 Shania Twain – 9.4
- 1999 Backstreet Boys – 18.4
- 2001 Puddle of Mudd – 10.9
- 2002 Faith Hill – 13.0
- 2002 Avril Lavigne – 13.5
- 2006 Trisha Yearwood – 9.1
- 2009 Mumford & Sons – 16.9
- 2019 Billie Eilish – 11.0 and 14.8
- 2019 Jenny Tolman – 9.9
- 2021 Adele – 12.6.

In fact, these recordings have a *chiaroscuro* similar to or larger than tracks dating from earlier eras, particularly the pre-1990 recordings by:

- 1971 Carole King – 9.1
- 1972 Neil Young – 15.4
- 1973 Elton John – 16.0
- 1977 Meatloaf – 9.2
- 1981 Phil Collins – 14.8
- 1984 Bryan Adams – 8.2
- 1989 Aerosmith – 11.7.

Even the remastered versions included in the chart (Elton John – 1995, Barenaked Ladies – 2001, and Michael Jackson – 2003) do not reduce dynamic contrast significantly, either by no more than 0.4 LU or not at all, despite average levels increasing by as much as 7.9 LU (Elton John).

An exception is Shania Twain’s “From This Moment On.” After the initial release of *Come on Over* in 1997, the album was reissued in 1998, and the new CD contained the “smash pop radio mixes” of “From This Moment On,” “That Don’t Impress Me Much,” “You’re Still the One,” and “You’ve Got a Way.” In the case of “From This Moment On,” the average level of the re-recorded track rose by 3.8 LU, from -12.2 to -8.4, while the amount of *chiaroscuro* decreased by 1.6 LU, from 11.0 to 9.4 (see Figure 6 for visualizations of the tracks).

Figure 6. Short-term and integrated loudness plots, along with dynamic range (as defined by Youlean), in Shania Twain, “From This moment On.”

1997



1998



In the later 1990s and early 2000s, digital peak limiters were available for mastering and remastering tracks to higher average levels, and before true-peak detection became possible (post 2010), recordists had to rely on sample-peak measurements if they wished to prevent signals from clipping. But because sample-peak devices measure audio only at sample points, any peaks occurring between those points will not be discovered. Hence, if the maximum output level of a limiter is set near 0.0 dBFS, undetected overs may occur. For instance, in Shania Twain’s “That Don’t Impress Me Much” (*Come On Over*), output settings of probably -0.2 dB (album mix of 1997) and 0.0 dB (radio mix of 1998) resulted in true-peak maximums of +1.24 and +2.66 dB (see Figure 7). Clipping occurs in every section of Twain’s song (see Figure 8),¹⁹ but for tracks that exceed full scale to a lesser degree, clipping is often more sporadic, appearing in just a handful sections (see Figure 9, in which 6 of the 25 song sections have overs ranging from +0.01 to +0.12 dB).

¹⁹ See also Jet’s “Are You Gonna Be My Girl” (2003) with overs between +0.09 and +0.41 dB; Michael Bublé’s “Home” (2005), between +0.02 and +0.26 dB; and Barenaked Ladies “It’s All Been Done” (1998), between +0.02 and +0.56 dB.

Figure 7. Maximum sample-peak, true-peak, and integrated values in Shania Twain, “That Don’t Impress Me Much,” album and radio versions (complete tracks).

	<i>SP</i>	<i>TP</i>	<i>I</i>
<i>Album Mix (1997)</i>	-0.24	+1.24	-12.0
<i>Radio Mix (1998)</i>	-0.02	+2.66	-8.5

Figure 8. Maximum true-peak values in Shania Twain, “That Don’t Impress Me Much” (by section).

	<i>Time 1997</i>	<i>TP 1997</i>	<i>Time 1998</i>	<i>TP 1998</i>
Intro	0:00	+0.52	0:00	+0.92
Verse 1	0:13	+0.22	0:15	+0.96
Chorus 1	0:28	+0.23	0:30	+0.96
Verse 2	0:39	+0.56	0:41	+1.70
Refrain 1	0:55	+0.25	0:57	+0.71
Verse 3	1:06	+0.12	1:08	+1.16
Chorus 2	1:21	+0.40	1:23	+1.56
Verse 4	1:33	+0.63	1:35	+1.15
Refrain 2	1:49	+0.33	1:51	+0.73
Interlude	1:53	+1.24	1:55	+0.81
Verse 5	2:08	+0.30	2:10	+1.02
Chorus 3	2:23	+0.21	2:25	+1.42
Verse 6	2:34	+0.37	2:36	+2.66
Verse 7	2:50	+0.25	2:52	+1.28
Refrain 3	3:08	+0.88	3:10	+0.87
Outro	3:19	+0.64	3:21	+0.97

Figure 9. Maximum true-peak values in Avril Lavigne, “I’m With You” (2002) and Trisha Yearwood, “Georgia Rain” (2006) (by section).

I’m With You

	<i>Time</i>	<i>TP</i>
Intro	0:00	-6.94
Verse 1	0:18	-1.62
Pre-Chorus 1	0:37	-1.25
Chorus 1	0:47	-0.22
Transition 1	1:05	-0.43
Verse 2	1:15	-0.52
Pre-Chorus 2	1:34	-0.03
Chorus 2	1:44	+0.04
Transition 2	2:02	-0.27
Bridge	2:11	+0.12
Chorus 3	2:32	-0.72
Transition 3	2:48	+0.11
Verse/Chorus 1	3:00	0.00
Verse/Chorus 2	3:19	+0.03
Outro	3:28	-0.71

Georgia Rain

	<i>Time</i>	<i>TP</i>
Intro	0:00	-2.88
Verse 1	0:10	-0.22
Chorus 1	0:49	-0.05
Verse 2	1:29	-0.09
Chorus 2	2:09	+0.01
Interlude	2:47	-1.13
Verse 3	2:54	-0.11
Chorus 3	3:33	+0.06
Chorus 4	4:07	-0.05
Outro	4:45	-1.72

Since questions surrounding the audibility of the digital distortion associated with overs have yet to be addressed adequately, particularly the comparison of the high-end equipment found in mixing and mastering facilities to modest consumer playback systems, this form of distortion, especially when the overs are both small and infrequent, may be neither “egregious” nor “horrendous” (Katz 2009b, at 3:57 and 4:42). Dissonance of this type might simply be part of a second practice, a custom in which the champions of the style do not find moderate amounts of distortion disagreeable.

In one of the tracks analyzed for this study, Billie Eilish’s “Xanny” (*When We All Fall Asleep, Where Do We Go?*, 2019) distortion can certainly be heard, but it results from the artist’s desire to reflect the emotional qualities of the text sonically and not from processing the mastering engineer applied. Although loudness in “Xanny” has already been discussed a number of times,²⁰ particularly the audible distortion, the song is worthy of further consideration, for it is an example of a track with a fairly high average level (-9.5 LU) that utilizes an expansive *chiaroscuro* (14.8 LU) as one of its strategies for evoking a strong emotional response in listeners. The integrated values shown in Figure 10 detail the changes of light and shade across the recording, variations of loudness that range from -6.9 in the bridge and -8.0 / -8.1 in the choruses to -14.9 / -15.1 / -21.7 in the verses, with a short instrumental interlude measuring -16.9. No true peak exceeds -0.25 dB, and the distortion portraying the distasteful atmosphere produced by second-hand smoke was part of the mix received by mastering engineer John Greenham, who said in an interview with Simon Götz,

“... as the mastering engineer, you always get the blame for everything. ... ‘Xanny’ ... has that big kind of broken-up bass thing. ... That apparently came about because they [Billie and Finneas] were listening to it on a boom box, and they just turned it all the way up, ... and Billie was like, yeah, I want it to sound like that. ... When it came out, ... I actually had haters, ... people ... who post stuff on Facebook and things, about how ... I did this and I did that. ... If you ever get into that position, ... people saying stuff about your work, do not respond to any of it. Just let it go, don’t comment on it, don’t try and correct it, it’s a losing battle ...” (Götz 2022, at 43:41).

On another occasion, in a discussion with video blogger Ian Shepherd, Greenham explained his approach to loudness:

“[When] Rob Kinelski [who mixed *When We All Fall Asleep, Where Do We Go?*] sends me a loud mix and a mix with more headroom, ... I use the mix with more headroom more often than not. But I don’t generally clip it. I just bring it back up to the level that the reference mix was or maybe a little bit higher. ... I’m not really adding, ... at least not that I’m aware of, ... distortion or any sort of artifacts that aren’t already there.” (Shepherd 2021, at 16:28).

Later in the interview, Shepherd commented “[‘Xanny’] has really extreme dynamics. You have very, very quiet verse sections and very, very loud chorus sections, and to be honest, I think if it had been passed on to me to master, I would have been tempted to experiment with reducing that

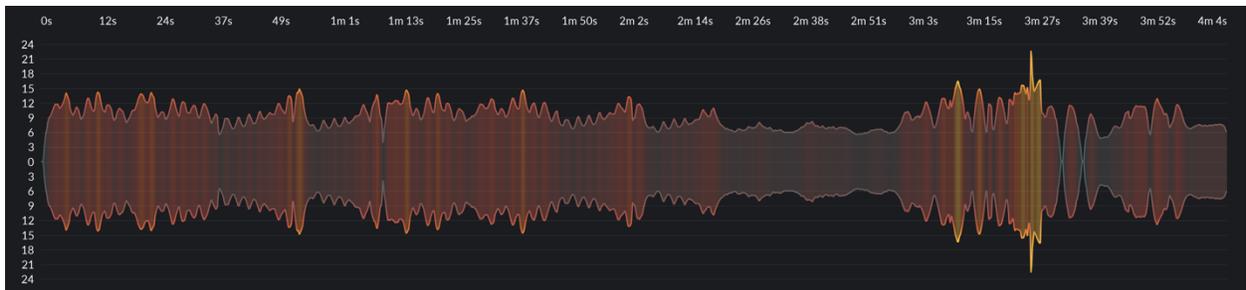
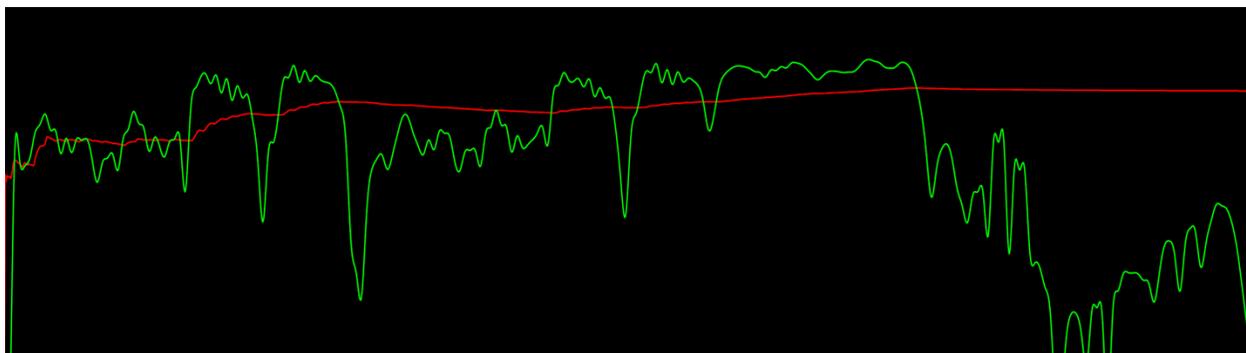
²⁰ See, in particular, Shepherd 2019, Shepherd 2021, Götz 2022 (at 43:39), and Indovina 2022 (at 37:41).

contrast somewhat ...” (at 20:40). He then asked “I was just curious whether you had been tempted to do that yourself” (at 21:08). Greenham responded:

“No, in general, when you work with people who are really talented, ... they’ve already sorted all that stuff out. The rough mix, or the mix, is basically what they want, so you’re just trying to ... improve on it a bit, ... just whatever you can find ... that they possibly hadn’t thought of, which isn’t much. ... You’re not going to go screwing around with the dynamics or any of that stuff. That probably would not be a good idea. It’s all very carefully thought out.” (at 21:16).

Figure 10. Loudness measurements in Billie Eilish, “Xanny,” along with short-term and integrated loudness plots, and dynamic range (as defined by Youlean).

	<i>Time</i>	<i>SP</i>	<i>TP</i>	<i>S</i>	<i>I</i>
<i>Complete Track</i>	4:03	-0.29	-0.25	-5.8	-9.5
<i>Sections</i>					
Verse 1	0:00	-0.45	-0.45	-11.8	-15.1
Chorus 1	0:35	-0.29	-0.28	-6.5	-8.1
Verse 2	1:10	-0.31	-0.31	-11.7	-14.9
Chorus 2	1:45	-0.29	-0.25	-6.6	-8.0
Bridge	2:16	-0.29	-0.29	-5.8	-6.9
Interlude	2:56	-0.31	-0.30	-15.6	-16.9
Verse 3	3:03	-0.50	-0.50	-15.2	-21.7



The dynamics to which Shepherd and Greenham refer provide strong contrast between the verses and choruses. The verses quietly reflect on party-goers, while the loud choruses detail Billie’s reaction to both second-hand smoke and people who need a “xanny” to enhance their sense of well-being. The loudest part of the song occurs in the bridge, when the singer recalls the experience of an attempted kiss she did not want. The method Billie and Finneas use to portray the distastefulness of these situations centres on a heavily distorted bass sound, or as John Greenham describes it, “that big kind of broken-up bass thing” (Götz 2022, at 43:53), which sonically depicts the sentiments expressed in the lyrics.

Musical devices that serve to illustrate the text have been used for centuries to heighten the emotional impact of words, and Billie and Finneas have tapped into a tradition dating back to at least the early seventeenth century. Through the rhetorical figure *hypotyposis*, writers and orators of the past vividly presented a thought or image to readers and listeners, and musicians paralleled these verbal procedures with equally vivid musical representations of textual images, so as seemingly to paint the ideas before the eyes of hearers (Bartel 1997: 307-11). Although this approach to composition was fashionable in the seventeenth and eighteenth centuries, it is not common in today’s popular music, and perhaps the “haters,” who mistakenly blamed Greenham for the distortion in “Xanny,” reacted so negatively to this form of dissonance, because they were unfamiliar with the concept of musical illustration. Furthermore, this carefully planned production technique, and the backlash to it, is reminiscent of the Artusi-Monteverdi controversy from the early seventeenth century, especially Artusi’s dislike of the dissonant intervals in Monteverdi’s brash, new compositional style.

Nonetheless, one of the benefits of “Xanny’s” loud-soft style of mixing has been noted by John Greenham, who speaks about the importance of *chiaroscuro* for giving the impression of loudness on streaming platforms. Lengthy soft sections intermingled with very loud passages can produce a lower overall integrated value, so services such as Spotify will not turn down a track by any significant amount during the normalization process:

“... the average of [“Xanny”] is not that great. But the loud parts are ... super loud. ... It comes down to, if you want your stuff to be loud on Spotify, it’s an arrangement thing. You have to put quiet bits in your song. ... If you have a quiet intro that goes on for 30 seconds, [Spotify] won’t turn [the song] down that much because [of the] average. The thing [the normalization algorithm] is stupid. It can’t figure out that ... the loud part’s gonna be ... louder than the next song, which goes all the way through at a high level. The loud parts of the songs with the quiet bits in [them] are gonna be louder than the whole [of the] ... other [track].” (Indovina 2022, at 38:19).

“Xanny,” with its wide dynamic range, undoubtedly lies at one end of the *chiaroscuro* continuum, and although a track such as Barenaked Ladies’ “It’s All Been Done,” with its much narrower dynamic range, would be placed at the other end of the mixing spectrum, it still

exhibits a modicum of light and shade.²¹ Figure 11 compares the original release of “It’s All Been Done” on the album *Stunt* (1998) to the remastered version on *Barenaked Ladies: All Their Greatest Hits, 1991 – 2001* (2001). Despite the fact that the integrated level of the track rose by 2.9 LU when it was remastered (from -8.8 to -5.9), the *chiaroscuro* of the two recordings remained 2.8 LU.

In the quieter sections of the song, particularly the bridge (-10.3 LU, 1998) and first half of the third verse (-9.7 LU, 1998), the texture thins when the instrumentation changes. This adjustment to the arrangement provides the middle of the track with a degree of light and shade, and even though the alteration in dynamics is small (1.4 and 2.0 LU; 1998), textural modifications of the type employed in this track can increase the perceived differences between sections. Nevertheless, despite modest amounts of *chiaroscuro*, “It’s All Been Done” typifies the way recordists maintain a relatively constant loudness throughout a song (see the visualizations in Figure 12), a consistency which includes persistent true-peak overs. Setting the sample-peak limiter to a maximum output of -0.20 dB (1998) and -0.10 dB (2001) led to true-peaks ranging from +0.02 to +0.61 dB in the original album release and from +0.94 to +1.38 in the greatest-hits remaster. However, on my computer-based playback system,²² the distortion brought about by these overs is not noticeable when listening to 16 bit, 44.1 kHz AIFF files, especially since the track contains an overdriven electric guitar, the sound of which may mask the clipping.

²¹ Varying degrees of light and shade are present in many louder recordings. For tracks in Figure 5 with integrated values less than 10.0 LU that contain a 7.5 LU or more difference between loud and soft sections, see Backstreet Boys’ “I Want It That Way” (1999) at 18.4 LU, Avril Lavigne’s “I’m With You” (2002) at 13.5, Faith Hill’s “Cry” (2002) at 13.0, Adele’s “Easy on Me” (2021) at 12.6, Billie Eilish’s “Bad Guy” (2019) at 11.0, Puddle of Mudd’s “She Hates Me” (2001) at 10.9, Trisha Yearwood’s “Georgia Rain” (2006) at 9.1, and Jet’s “Are You Gonna Be My Girl” (2003) at 7.5.

²² Sonic Studio, Amarra Luxe player; Merging Technologies, Hapi converter; Grace Design, M905 analog monitor controller; ATC, SCM20 Pro ASL loudspeakers; and Audeze, MM-500 headphones.

Figure 11. Loudness Measurements in Barenaked Ladies, “It’s All Been Done.”

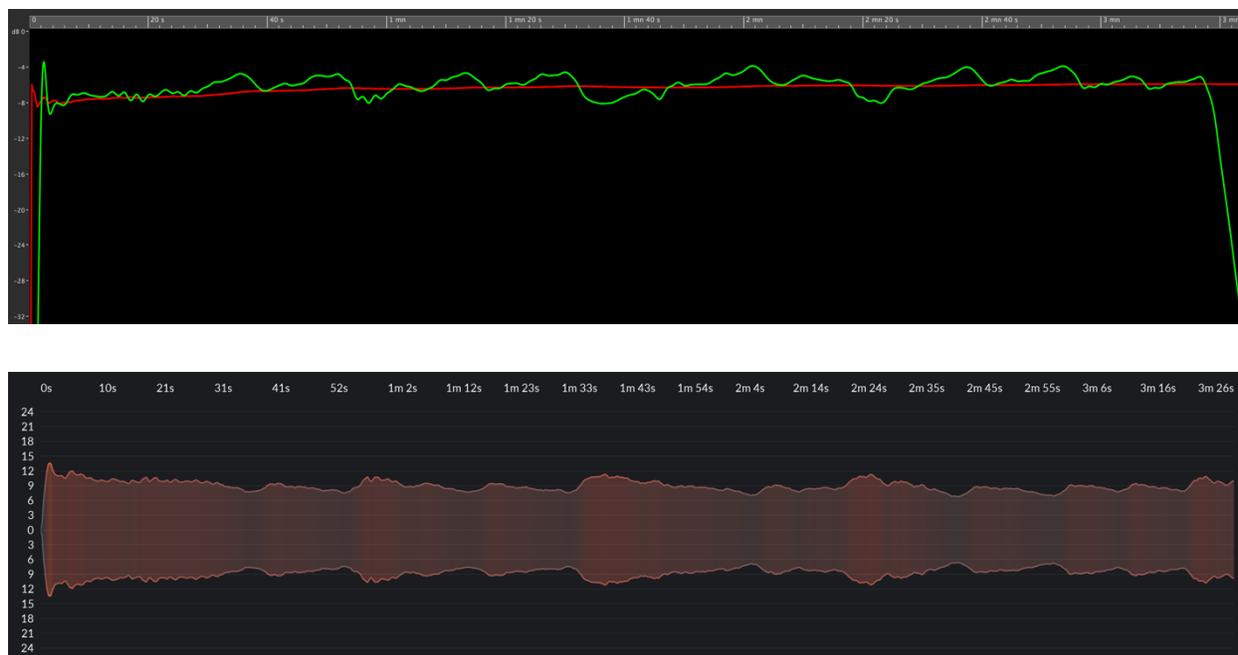
1998

	<i>Time</i>	<i>SP</i>	<i>TP</i>	<i>S</i>	<i>I</i>
<i>Complete Track</i>	3:26	-0.15	+0.61	-6.7	-8.8
<i>Sections</i>					
Intro	0:00	-0.15	+0.47	-9.9	-10.3
Verse 1	0:14	-0.20	+0.29	-7.6	-9.2
Chorus 1	0:37	-0.20	+0.30	-7.7	-8.4
Verse 2	0:53	-0.20	+0.14	-7.5	-9.0
Chorus 2	1:15	-0.20	+0.28	-7.5	-8.3
Bridge	1:31	-0.20	+0.37	-9.4	-10.3
Chorus 3	1:46	-0.20	+0.56	-7.0	-8.0
Guitar solo	2:01	-0.20	+0.21	-7.9	-8.3
Verse 3, 1st part	2:16	-0.20	+0.42	-8.9	-9.7
Verse 3, 2nd part	2:30	-0.20	+0.61	-6.8	-7.5
Chorus 4	2:39	-0.20	+0.22	-6.7	-7.9
Outro	2:55	-0.20	+0.02	-7.8	-8.9

2001

	<i>Time</i>	<i>SP</i>	<i>TP</i>	<i>S</i>	<i>I</i>
<i>Complete Track</i>	3:26	-0.10	+1.38	-3.9	-5.9
<i>Sections</i>					
Intro	0:00	-0.10	+1.38	-6.9	-7.4
Verse 1	0:14	-0.10	+1.12	-4.7	-6.3
Chorus 1	0:37	-0.10	+1.13	-4.9	-5.5
Verse 2	0:53	-0.10	+1.35	-4.6	-6.1
Chorus 2	1:15	-0.10	+1.16	-4.7	-5.4
Bridge	1:31	-0.10	+1.18	-6.5	-7.3
Chorus 3	1:46	-0.10	+1.27	-4.2	-5.2
Guitar solo	2:01	-0.10	+1.23	-4.9	-5.3
Verse 3, 1st part	2:16	-0.10	+1.38	-6.0	-6.8
Verse 3, 2nd part	2:30	-0.10	+1.17	-4.0	-4.6
Chorus 4	2:39	-0.10	+1.35	-3.9	-5.0
Outro	2:55	-0.10	+0.94	-4.9	-5.9

Figure 12. Short-term and integrated loudness plots, as well as dynamic range (as defined by Youlean), in Barenaked Ladies, “It’s All Been Done” (1998).



Song dynamics, whether restrained (Barenaked Ladies, Billy Joel, and Michael Jackson in Figure 5) or expansive (Billie Eilish, BackStreet Boys, Mumford & Sons, Elton John, Neil Young, Oasis, Phil Collins), provide light and shade for listeners, and of the thirty-five tracks analyzed for this study (listed in Figure 5), twenty-one have dynamic ranges larger than 9.0 LU and nine restrict differences in *chiaroscuro* to less than 6.0 LU. In fact, some of the narrower dynamic ranges predate the advent of digital limiters, so instead of viewing the dramatic increases in loudness during the latter 1990s as the product of some sort of envy amongst artists and audio engineers,²³ I would prefer to place the upward expansion of overall levels in the context of new technology that captured the imaginations of recordists. Digital limiters, such as Waves’ L1 Ultramaximizer, allowed audio engineers to elevate the two main mixing styles to unprecedented heights, and even though this development quickly became the “norm” of artistic expression, song dynamics were not sacrificed in the process (after all, restricted *chiaroscuro* existed long before digital limiters were invented). Unquestionably, this louder mode of delivery continues to dominate pop/rock record production, and it will probably persist until, as history teaches, another “radical” fashion prevails.

²³ The notion of “loudness envy” has been raised in Katz 2011, at 12:19.

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