Measuring Dynamics

Comparing and Contrasting Algorithms for the Computation of Dynamic Range

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Motivation

It has been argued that:

- An increased use of dynamic range compression is directly related to (or even a cause of) the "loudness war"
- Reduced dynamic range is related to poor audio quality

However, these statements are difficult to defend without a solid method for measuring dynamic range

Definition for this study

- Dynamic Range is
  - Not the range from lowest to highest energy *possible*…
  - But rather, the range that is actually *used* by the *audible* program material
- This definition should be relevant for any metric that claims to be related to some aspect of perceptual quality

Ways to measure dynamic range

- Loudness Range
  - EBU Technical Document 3342
- TT Dynamic Range Meter
  - Pleasurize Music Foundation
- Dynamic Spread
  - Vickers (AES 111th Convention)
- pfpf Software
  - Tollerton (http://audiamorous.blogspot.com)

Loudness Range (LRA)

EBU Technical Document 3342, published August 2010

- Based on ITU-R Bs.1770 loudness
- Integrated using a 3sec sliding window
- Values are gated at -20LU re the loudness level
  - (to focus on foreground sounds)
- A histogram is created
- LRA is the range from 10% to 95%
  - *"The lower percentile of 10%, can, for example, prevent the fade-out of a music track from dominating Loudness Range. "*
  - *"The upper percentile of 95%, ensures that a single unusually loud sound, such as a gunshot in a movie, cannot by itself be responsible for a large Loudness Range."*

Loudness Histogram

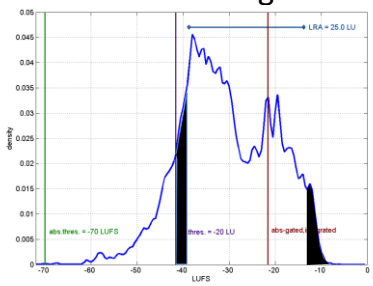


Figure 1. Loudness distribution, with gating thresholds and Loudness Range for the film The Matrix (DVD version). Adopted from Skovenborg & Lund (2009) "Loudness Descriptors to Characterize Wide Loudness-Range Material", 127th AES Conv.

TT Dynamic Range Meter

- For each 3sec window, calculate peak and RMS
- Sum the RMS over the top 20%
- DR = mean($Peak_2$ / ΣRMS)
- The authors argue that using just the top 20% :
  - allows them to compare a variety of program types (e.g., genres of music, speech, etc.), and…
  - is more likely to measure the effects of dynamic range compression since gain reduction is usually greatest for high-level signals.

Dynamic Spread

- Just use the P-norm of the signal

$$d = \left(\frac{1}{M} \sum_{i=0}^{M-1} \left| V_{dB}(i) - \overline{V} \right|^p \right)^{\frac{1}{p}}$$

- Vickers recommended p=1
  - Mean absolute deviation
- We also calculated p=2,3,4
  - Standard deviation, skewness, kurtosis

pfpf

- Based on BS.1770 loudness
- Three time scales
  - 10ms
  - 200ms
  - 3sec
- Histogram from 50% to 97.7%

Source Material

- 10 music clips from released albums
  - Chosen to represent a variety of dynamic ranges
  - Various genres (jazz, electronic, metal, pop, etc.)
- Each was 10-20sec long
- All normalized to the same BS.1770 loudness

Dynamic Range Metrics

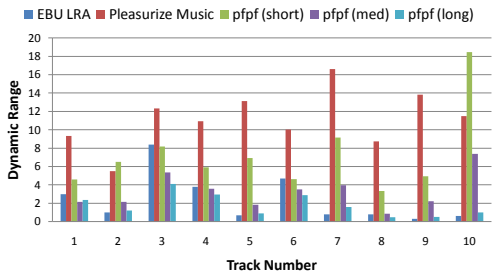
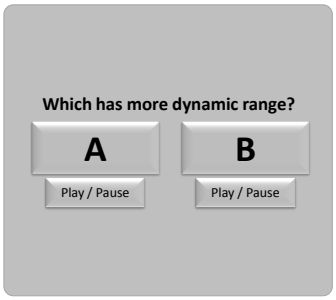


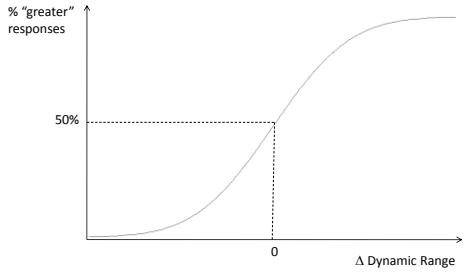
Table of Paired Comparisons

	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

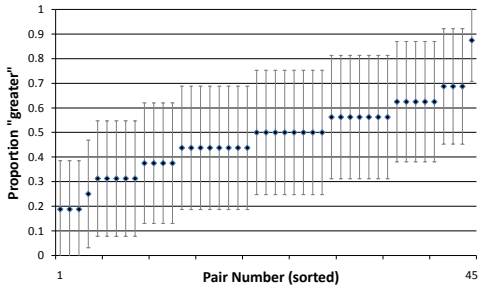
Psychoacoustics GUI



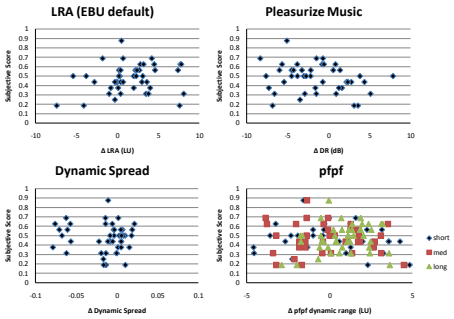
Psychometric function



Perceptual Results (N = 16 listeners)



Perception vs. Metrics



LRA permutations

- Window size
  - 100ms
  - 200ms
  - 400ms
  - 800ms
  - 1500ms
  - 3000ms
- Percentile range
  - Every combination, in steps of 5%
  - (e.g., 0-5%, 0-10%, …, 55-60%, …, 5-100%, 0-100%)

Perception vs. LRA

Top Ten Correlations:

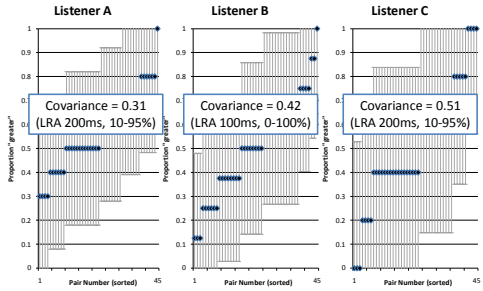
1	0.409604	3000ms	30-35%
2	0.399333	1500ms	35-40%
3	0.341461	1500ms	35-45%
4	0.307979	1500ms	35-50%
5	0.305513	3000ms	30-40%
6	0.297876	1500ms	35-55%
7	0.294927	3000ms	30-45%
8	0.290928	1500ms	30-40%
9	0.272833	1500ms	35-60%
10	0.272404	1500ms	30-50%

Perception vs. LRA

Top Ten Covariances:

1	0.16575	400ms	0-100%
2	0.155111	1500ms	0-100%
3	0.154583	1500ms	0-95%
4	0.154028	400ms	0-95%
5	0.15275	1500ms	0-90%
6	0.148806	400ms	0-90%
7	0.148083	1500ms	0-85%
8	0.146167	1500ms	0-80%
9	0.145556	800ms	0-100%
10	0.145444	800ms	0-95%

Individual Listeners



Concerns to be addressed

- Listening tests have too much variability
  - More extensive listening tests needed
- Musical clips may have been too short (10-20s) to get a meaningful metric from some of these algorithms
  - However, there certainly was a meaningful dynamic range for our listeners
- Use material with more DR