PG Research Methods - Assignment 1 'Article Commentary'

Name: Josh Fairhead (21056775), **Lecturer:** Dr. Robert Scholl

Distortion and Subjective Audio Quality – Mark Irwin

In the paper Distortion and Subjective Audio Quality, Mark Irwin[1] talks about various types of audio processing, the resulting types of distortion in both the analog and digital domains and the subjective viewpoints of people within the audio industry.

Irwin starts the article with a broad definition of linear and non-linear distortion from the paper: The Effect of Nonlinear Distortion on the Perceived Quality of Music and Speech Signals.[2] This paper defines linear distortion as changes to the relative amplitudes and phases of a complex signal and defines non-linear distortion as being the introduction of frequency components that were no present in the input signal.

Although fitting with the provided definitions, Irwins examples of these distortions could lead to confusion; the frequency response of the ear, dependent on volume, is non-linear in behaviour. However these distortions produced at specific volumes could be viewed as linear in that they can be directly correlated to the input level at a given volume.[3] Aside from this lack of clarity; Irwins main point is that given the complexities in our hearing and audio equipment makes capturing sonic events is a complex task.

Irwin then gives a brief history of amplifier design and the different properties of valve and transistor technology and their relative distortions, which leads to the question: what is musical distortion?

Due to such a subjective question, Irwin summarises findings in the paper Tubes vs. Transistors-Is There an Audible Difference? by Russell O. Hamm.[4] According to these tests valves have strong 2nd & 3rd harmonics with the 4th & 5th present but at reduced level and that transistors have a strong 3rd harmonic with others being present but at a greatly reduced level.

These harmonic profiles could be correlated with the acoustic properties of various instruments and the subjective viewpoints of how we relate this to pleasing harmonic distortion. However Irwin points out that despite the majority of subjective evidence (i.e. peoples opinions) is in favour of tubes having a more 'musical' sound; some designers feel that results are dependent on design philosophy.[5]

Irwin then goes on to discuss phase distortion, which can be described as a shift in time to the input signal due to inherent circuit resistance. Here Irwin makes the point that the 'shape' of the distortion envelope over time could be just as important as harmonic

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[1] Irwin, M. (2009) - *Distortion and Subjective Audio Quality* - Journal on the Art of Record Production [ISSN 1754-9892].

[2] Tan et al (2003) - *The Effect of Nonlinear Distortion on the Perceived Quality of Music and Speech Signals* - Audio Engineering Society.

[3] Holman & Kampmann (1977) - *Loudness Compensations Use and Abuse* p8 - Audio Engineering Society.

[4] Hamm, R. (1973) - *Tubes vs. Transistors-Is There an Audible Difference* - Audio Engineering Society.

[5] These designers and their opinions are quoted in Irwins paper. Its also worth noting that construction could determine application; for instance using a transistor design where detachment is desirable in the music.

distortion in our perception of warmth. This is then related to our hearing and the accepted psychoacoustic theory of Head Related Transfer Functions (our spatial hearing mechanisms). Irwin argues that distortions in phase and frequency response will lead to less realistic reproduction in the recording chain due to these functions; Inter-aural Timing Differences are dependent on phase to localise sound, while Inter-aural Intensity Differences rely on difference in frequency energy between signals for localisation.[6] A valid point however Irwin then states 'valve designs can be guaranteed to add predicable and pleasant colouration to the recording chain.'

Although popular opinion holds the belief that valves impart musical distortion; 'pleasant colouration' is still a subjective evaluation and as such cannot be guaranteed. This however should not distract from the main point that producers and engineers rely on phase and harmonic distortion to achieve a desirable outcome.[7]

This subject gravitates to the underlying question: Is analogue better than digital?

Its been shown that there are complex non-linearities in analog equipment that effect the signal such as phase and harmonic distortion and that these distortions are characterised in the perception of a 'warm' sound. However these distortions in the digital domain are hard to emulate; as frequencies tend towards a Nyquist limit at 22.05Khz the phase shift becomes increasingly severe and often perceived as unnatural.[8] This is bad news to people that hold Rupert Neve's point of view: "frequencies well outside of the normally accepted limits of human hearing can be perceived".[9]

Despite this phase shift, a digital EQ/Compressors gain stage is more transparent in harmonic distortion often causing engineers to over apply the effect in an attempt to compensate, introducing further phase shifts.[10]

Irwin presents several points of view on the subject of re-issues and why they don't sound the same as an original. An electronic reissue has components are usually different from the original and therefore the distortion caused by these components has changed. In digital emulations its essentially a necessary simplification of the original unit (limited by processor cycles) which in turn changes the distortion characteristics.

When discussing tape distortion Irwin points out the limited dynamic range of tape in comparison to our hearing and even low bit rate digital systems (16bit). He goes on to point out that engineers will commonly record at higher input levels to avoid the noise floor inherent in the format, leading to colouration. As Irwin states:

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[6] In Robert Jourdains book, *Music, the Brain & Ecasty* (1997) p203, it's stated 'The whole point of the brain is to move', this lends further credibility to Irwins point. If this statement is taken as true, phase distortions (based in the time domain, the same as motion) could correlate to our perception of natural sound and therefore could be just as important as harmonic distortions in relation to our subjective judgement.

[7] From reading Dr Robert Toulsons paper *Can We Fix It? – The consequences of 'fixing it in the mix' with common equalisation techniques are scientifically evaluated* - Journal on the Art of Record Production, its clear that over use of colouration/phase distortion can seriously degrade audio quality.

[8] Kemp, M. (2003) - *Sampling Equalisers* - Resolution, S2 Publications Ltd.

[9] Irwin, M. (2009) - *Distortion and Subjective Audio Quality*, p4 quoted Neve, R. (1991) - *Analogue Audio EQ* p6 - Line Up Magazine, October.

[10] Kemp, M. (2003) - *Sampling Equalisers* - p66, Resolution, S2 Publications Ltd.

...tape naturally compresses the signal particularly when overdriven. This effect generally results in the loss of high frequency information, resulting in a 'thicker' and 'warmer' sound than the original source.[11]

The importance of non-linear distortion is a hot topic in mastering and broadcast industries today, commonly known as the ‘loudness wars’. Engineers are limiting the peak values in digital audio to achieve higher levels resulting with the introduction of subjectively ‘unpleasant’ non-linear distortion. Due to this Irwin calls for the establishment of a metering system that takes into account distortion, stating that ‘The problem of course, will be, persuading manufacturers to adopt this new measurement system’.[12]

In summary distortions are highly subjective and can range from subtle and pleasing to obvious and irritating, the main issue is more how they are used to achieve an end result. To do this knowledge and understanding of how they are introduced is extreamly important.

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[11] This explanation is somewhat simplified, in reality there are a combination of the components distorting phase/frequency response which are then further phase shifted by the non-linear mapping of the magnetic tape causing further frequency distortion; this is what leads to the high frequency response Irwin describes.
[12] Such a system exists already with the K-System developed by Bob Katz; although not widely established it is slowly gaining popularity as a metering option that also measures distortion. This system is discussed over chapter 15 in his book: Katz, B. (2006) - Mastering Audio; The Art and the Science - 1st Edition, Focal Press, US.