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Analogue Hearts, Digital Minds?

An investigation into perceptions of the audio quality of vinyl.

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ABSTRACT

This study investigates the vinyl revival, with particular focus given to the listener's perception of audio quality. A new album was produced using known source material. Subjects then participated in a series of double-blind listening tests, comparing vinyl to established digital formats. Subsequent usability tests required subjects not only to re-appraise the audio, but also to interact with the physical media and playback equipment. Digital vinyl systems were used in order to investigate the influence of non-auditory factors on their perception of sound quality. Both qualitative and quantitative data was also gathered from subjects of the usability tests, with the correlation (or contradiction) between the results being analysed. The study concludes that sound quality is not the sole defining factor and that listener preferences are profoundly influenced by other, non-auditory attributes and that such factors are as much a part of the vinyl experience, as the music etched into the grooves.

1. INTRODUCTION

As is the case with many technologies, innovations in audio have often been met with resistance. This was never more evident than during the early 1980s, when the compact disc was first heralded as the successor to the long-playing album [1]. Remarkably, vinyl sales are on the increase [2], and as a consequence, the debate about the comparative qualities of vinyl and digital formats has re-emerged in journals, music magazines, hi-fi periodicals and all over the web. Research commissioned by the industry suggests that sound quality, or at least its perception, is a primary reason why a seemingly obsolete format has been revived and is gaining new admirers.

Evaluation of sound quality is by definition a subjective matter, which is not only influenced by a person's physiological attributes, but also psychological factors shaped by prior knowledge, experience, cultural surroundings, lifestyle choices and so on [3]. Of course, such perceptions can also be prone to bias and may also be manipulated.

As part of the promotional campaign for his Diamond Disc Phonograph, Edison held a series of public concerts, during which a renowned artist would take to the stage and perform a rendition of a song, alongside a phonograph recording of the same performance [4]. Although these so called 'tone tests' were purported to be authentic listening experiments, they were in actual

fact carefully designed marketing exercises, in which the listener’s perception of sound quality was subtly, yet deliberately influenced by both auditory and non-auditory factors.

2. METHODOLOGY

2.1. Listening Tests

Subjects were invited to take part in a series of double blind listening tests, scoring the perceived quality of excerpts taken from the formats under investigation. Audio used in the trials was prepared using archives of the author’s own material, allowing control over the mixing and mastering processes. Once mastered, files were sent to a reputable manufacturer, to be cut to a ‘one-off’ vinyl dub-plate [5]. It was stipulated that no additional dynamic processing or mastering EQ would be applied to the files and that the only additional adjustments after D/A conversion, would be optimisation of gain to the cutting stylus (which would be normal in any situation) and applying RIAA pre-emphasis - also an integral part of the process.

Although MUSHRA testing would theoretically be possible using physical vinyl, it would be difficult to implement in practice as interaction with the playback equipment would be necessary, by those conducting the tests or the participant themselves. ABX tests conducted under lab conditions have repeatedly demonstrated subjects’ inability to distinguish between an analogue audio signal and one that has been passed through a 16bit/44.1kHz A/D/A loop [6]. It follows that any distinctive, audible differences between a vinyl and digital release of the same material would be a consequence of the mastering and manufacturing, rather than a result of nuances of the A/D/A conversion process [7]. It is therefore argued that comparing a digitised sample of vinyl with the original digital master file, would form valid test and yield meaningful set of data.

Fig. 1 shows the different paths through the signal chain, which two test signals would take, in order to be included in a web-based listening test. Differences between our two files, would arise from various processes required to cut the record (amplifier, lathe, diamond disc-cutting stylus) and then replay it (turntable, stylus and hi-fi amp). Also included in this ‘system’ is the vinyl itself, as any changes or defects

(e.g. static, scratches, warping) would also contribute to the sound of our final files.

Any uncertainty that could be attributed to the D/A converters used at the vinyl cutting stage was eliminated by using an identical set of converters as the first stage in an additional D/A/D loopback chain, added into the ‘digital’ signal path. The final A/D conversion stages were in both cases, also identical.

The newly cut dub-plate was digitised at a sampling rate and bit depth of 24bit/96kHz. Slight mains hum was observed and removed using a suitable comb-filter. Any large click and pops were also removed at this stage, as although it has been suggested that clicks and pops are part of the allure of vinyl records [8], this is by no means a universal view. Such imperfections would also form obvious cues, which could influence perceptions. Variations in speed and pitch were corrected by importing the digitised files back into the original sequencer arrangement. A beat detector was then used to create a tempo map from the sampled vinyl and a suitable algorithm was chosen to re-align to the source files.

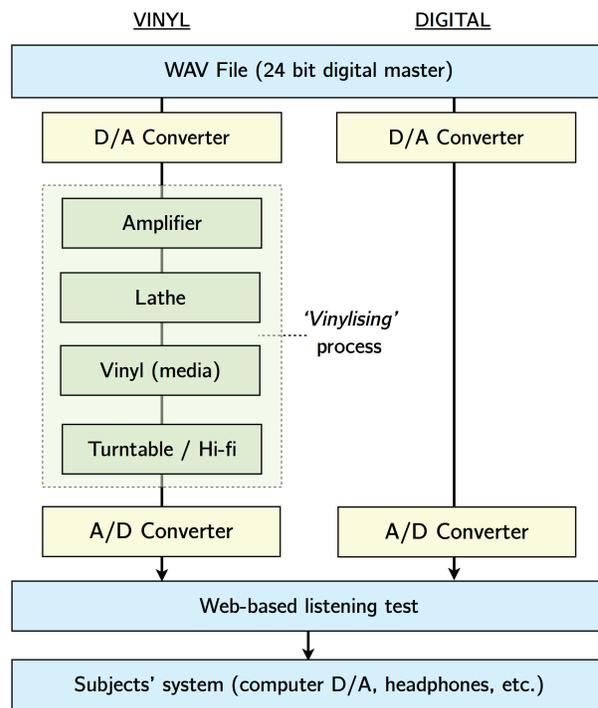


Figure 1 Signal paths of vinyl vs. digital test files

A series of test records (used to calibrate the turntable) were also digitised. Subsequent analysis of broadband noise files enabled estimates of spectral and spatial changes due the ‘vinylising process’ to be made, whilst analysis of the pure tones revealed the amount of harmonic distortion introduced by analogue production processes – that much vaunted quality, often known as ‘warmth’. As a result, it was possible to include ‘emulated vinyl’ versions, by applying plug-ins to the digital masters to match the frequency spectrum, narrow the stereo width and introduce the observed amount of harmonic distortion.

In order to deploy as a web-based listening test, an existing framework, ‘mushraJS’ [9] was adopted. The order of the files and the tests were randomised to remove the possibility of bias due to primary effects and modifications were made to the user interface (e.g. to simplify the numeric scale) to increase its suitability for subjective studies [10]. Clear bullet-pointed instructions were also added on every page. Anchor files were *not* included, as this would have made assumptions as to the listeners’ perception of ‘lowest sound quality’. Indeed, Nokelainen and Dedeheyir [9] found that the imperfections inherent in vinyl are actually favoured by some enthusiasts. Instead, participants were able to rate test files as either equal, better, or worse than the reference, defining the median point on the scale as ‘Equal to reference’ and use similarly non-ambiguous terms for other descriptors.

A total of four tests (two per song) were conducted (Table 2). In tests A and C, vinyl was compared with its source file, and also two other common digital formats. In B and D, the ‘emulated vinyl’ and un-mastered studio mixes were scrutinised. Conducting two separate tests per song, kept the number of files on screen at any one time down to five (four plus hidden reference), whilst also providing us with an additional cross-reference, for post-selection of participants. It was decided to edit the tracks down to one-minute extracts and also dither to 16bit/44.1kHz, confident that this would have no perceptible consequences to the audio [11]. Finally, all files were loudness matched to the integrated LUFS value of the reference file.

| Song 1 | | Song 2 | |
|----------------|----------------|----------------|----------------|
| Test A | Test B | Test C | Test D |
| Digital Master | Digital Master | Digital Master | Digital Master |
| Sampled Vinyl | Sampled Vinyl | Sampled Vinyl | Sampled Vinyl |
| CD Master | Emulated Vinyl | CD Master | Emulated Vinyl |
| MP3 (192kbps) | Studio Mixdown | MP3 (192kbps) | Studio Mixdown |

Table 2 List of files included in listening tests

2.2. Usability Test

In order to investigate the influence of non-auditory factors on the perception of sound quality, a second test based around the use of a digital vinyl system (DVS) was devised. The DVS system comprised of a vinyl ‘control record’ etched with analogue timecode, an audio interface and control software. Timecode picked up at the stylus was digitised and translated to positional information by the DVS software, which would then trigger the playback of an associated digital audio file, at the correct speed and position. The use of such a system was ideal, as it was able to replicate an authentic vinyl user experience, whilst providing an audio output theoretically *identical* to that of the digital system being compared.

For the digital playback system, a standard CD player was chosen. Although declining in popularity, it is a well-established format and it was envisaged that all participants would be familiar with its operation. Playing a compact disc also has its own associated ‘ritual’ and the comparison between loading a disc and cueing up a record, is a valid one to observe. Taylor [2] mentions three attributes through which newcomers to the format will discover the “magic” of the analogue records; *the sound, the artwork and the liner notes*. A sleeve, liner notes and disc labels for the DVS control record in the exact style of the CD sleeve, scaled-up for the 12inch format.

Fig. 3 shows the set-up used in the tests. The turntable fed a DJ mixer, which in turn fed the computer’s audio input. The chosen track was ripped directly from CD as 16bit / 44.1kHz stereo WAV and then dropped onto the first ‘virtual deck’ of the DVS software. Tempo variation between the DVS and CD was corrected using the turntable’s pitch control and once again, loudnesses of the two systems were matched.

An initial cause for concern, was that signals triggered by the DVS were so *completely* free of static, that the beginning of the track was perceived as ‘too clean’ to be vinyl. To disguise this, a small amount of un-modulated groove noise was sampled and placed at the very beginning and end of the digital files.

The structure of the test was straightforward: participants were asked to play (and listen to) a CD, followed by a DVS record and in the process, to observe and interact with the object and the playback system.

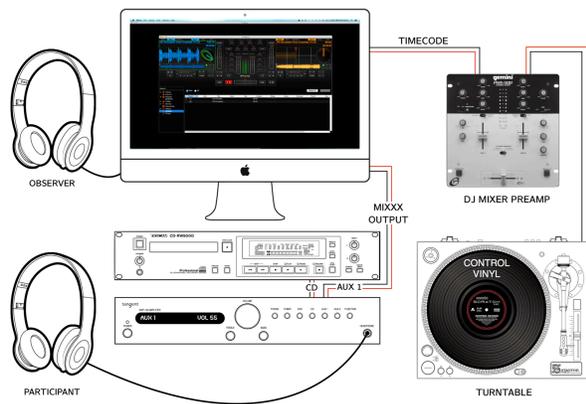


Figure 3 System schematic of vinyl usability test.

The test was in essence a modern ‘twist’ on Edison’s tone tests, the main difference being that we already knew that the audio playback on both occasions would be identical, suggesting that any observations to the contrary would be due to the influence of other non-auditory factors.

3. RESULTS

3.1. Listening Test

The listening test was deployed on-line, with a total of 59 responses gathered. Post-selection of subjects was carried out for each test, disregarding the results for subjects whose scores; i) differed by greater than one point (20%) between reference and hidden reference and ii) differed by greater than one point between the same vinyl sample in subsequent tests. Following post-selection, mean values for ratings of each sample were calculated, with 95% confidence intervals (Fig. 4).

Results from the listening tests suggest that for our sample population, the digitised vinyl was the least favoured of all the formats. Across the tests, mean scores for the vinyl ranged between 2.31 and 2.69, corresponding to the classification ‘worse than reference’, defined on our modified MUSHRA scale. Those who favoured vinyl were in the minority and vinyl was also ranked last more often than any other format. MP3 versions were judged favourably in the tests in which they appeared, surprisingly outscoring the CD versions as both were created using an identical source file. Tests of the ‘emulated’ vinyl also returned some interesting results, as it was preferred to the audio

sampled from the genuine record. Although the mean score is slightly below that of the original unmastered mixdown, the confidence intervals show a considerable amount of overlap, which suggest that there are some who preferred the emulated vinyl over the original stereo mix-downs. One would however, need to undertake a more focussed study, in order to test such an assertion.

Results of the listening tests suggest that transferring the mix to vinyl, did not improve perceived audio quality and that for the majority of users, quality was perceived to have been degraded.

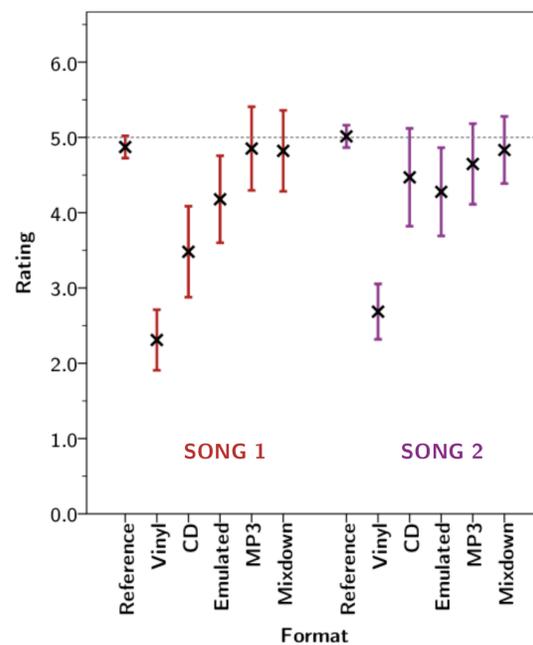


Figure 4 Listening Test Mean Scores ($\alpha = 0.05$)

3.2. Usability Test

The results from the usability tests provide us with an interesting contrast. Only one song was chosen for inclusion in the trials, cross-referencing the first listening test. After interacting with both CD and ‘vinyl’, seven of eleven listeners perceived a difference in sound quality between the formats, five of whom favoured the sound of the ‘vinyl’, whilst only two favoured the CD. Recall that the vinyl used in this test was a DVS timecode disc, the audio files being played back were identical and the outputs of the CD player and computer were loudness-matched.

Table 5 shows direct comparisons between the results given by the eleven subjects who took part in both the listening and usability tests. Viewed side-by-side, the answers suggest some clear contradictions. No subject who chose vinyl in the usability lab, expressed the same preference during the listening tests.

Qualitative interviews give us some further insight. Asked for their reason for preferring the sound of vinyl, our first subject remarked that it *“didn't sound as precise and clean, it added something that made me feel a little bit closer to the song, it made all the synthesisers sound a bit more real”*. Our second respondent commented upon the tone of the record and was adamant that the DVS vinyl, *“felt bassier [...] and you know to use a cliché, sounded warmer”*.

Respondent nine combined all of the above assertions, stating the following; *“No doubt in my mind [vinyl] sounded better... It seemed to be softer in the upper-mids, so less harsh, just more pleasing in that area but certainly more warmth in the bottom end. The way things sit in the mix seems to be more preferable on that kind of record.”*

| Subject | Preferred Sound in Usability Test | Listening Test Ratings | |
|---------|-----------------------------------|------------------------|----|
| | | Vinyl | CD |
| 1 | DVS VINYL | 0 | 5 |
| 2 | DVS VINYL | 0 | 6 |
| 3 | CD | 4 | 6 |
| 4 | NO PREFERENCE | 5 | 6 |
| 5 | CD | 4 | 5 |
| 6 | DVS VINYL | 2 | 2 |
| 7 | DVS VINYL | 2 | 4 |
| 8 | NO PREFERENCE | 3 | 5 |
| 9 | DVS VINYL | 0 | 0 |
| 10 | NO PREFERENCE | 3 | 5 |
| 11 | NO PREFERENCE | 2 | 6 |

Table 5 Comparison of usability lab vs. listening tests

4. CONCLUSIONS

This investigation has given a clear indication that the reasons behind the recent resurgence of the vinyl LP are numerous and rejects the hypothesis that audio quality is the sole defining factor. There does however, appear to be a clear link between subjective audio quality assessments and an individual's appreciation of other attributes of vinyl such as the artwork, sleeve notes, or even their their past experiences, pre-conceptions or memories of the format. It is still clearly a subject which divides opinion and engenders passionate views on all sides but this study has shown that it is possible to delineate auditory and non-auditory influences.

In designing this experiment, some compromises were necessary due to time and budgetary constraints. The use of a ‘one-off’, rather than a commercial pressing remains the greatest cause for concern and in order to have greater confidence in the results of the listening tests, the study will be repeated using better vinyl. The sample population for the on-line tests and the usability testing, will also be expanded.

However, the manner in which the usability tests managed to encourage some participants to eulogise over the *sound* of vinyl, despite the fact that they were actually listening to a CD, clearly suggests that they may have indeed been ‘listening with their hearts’.

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