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An investigation into the efficacy of methods commonly employed by mix engineers to reduce frequency masking in the mixing of multitrack musical recordings

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ABSTRACT

Studio engineers use a variety of techniques to reduce frequency masking between instruments when mixing multi-track musical recordings. This study evaluates the efficacy of three techniques, namely mirrored equalization, frequency spectrum sharing and stereo panning, against their variations to confirm the veracity of accepted practice. Mirrored equalisation involves boosting one instrument and cutting the other at the same frequency. Frequency spectrum sharing involves low pass filtering one instrument and high pass filtering the other. Panning involves placing two competing instruments at different pan positions. Test subjects used eight tools comprising a single unlabeled slider to reduce frequency masking in several two instrument scenarios. Satisfaction values were recorded. Results indicate subjects preferred using tools that panned both audio tracks.

1. INTRODUCTION

Frequency masking is a phenomenon in which the perceived audibility of one sound is affected by the presence of another sound which has a similar spectral content [1]. The two sounds can be considered as competing with each other. This is of particular concern in the mixing of multi-track recordings where many tracks may have similar spectral content and appear to compete for the listener's attention, resulting in a lack of clarity and undefined mix.

There has been extensive research by Glasberg & Moore [2] and Zwicker [3] on frequency masking.

Generally this research has focused on the study of broadband, narrowband noise and pure tones which has led to the development of the auditory filter model [4] and critical listening bands [5]. There has been little research, however, that considers the veracity of the methods and strategies commonly employed by audio mix engineers when treating real-world multi-track musical recordings.

2. STRATEGIES COMMONLY EMPLOYED TO REDUCE FREQUENCY MASKING

In the development of a tool that quantitatively measures the level of masking between the different tracks of a multitrack recording Vega and Janer [5] began their study by identifying the techniques employed by mix engineers to reduce frequency masking. These included:

- mirrored equalization (EQ)
- frequency spectrum sharing
- stereo panning

Mirrored EQ involves boosting one instrument at a particular frequency and cutting the other instrument at the same frequency [6]. Mirrored EQ is seen as advantageous over simply boosting the frequency in one instrument. Another alternative is to cut the frequency in one instrument in order to allow the other to be heard at that frequency.

Frequency spectrum sharing involves low pass filtering one instrument and high pass filtering the other. Alternatives would be to only high pass filter one instrument or conversely only low pass filter the other.

Stereo panning involves panning two instruments that are competing in the frequency spectrum to different pan positions. Variations on this technique are panning both instruments away from each other or keeping one instrument central and panning the other away.

The aim of this paper is to explore the use of these three techniques in controlled experiments with real-world multitrack audio recordings. In particular this paper aims to evaluate the efficacy of each technique against its variations to confirm the veracity of accepted practice for future integration into assisted mixing tools.

3. THE EXPERIMENTS

Eleven test subjects who were either second or third year undergraduate students on Music Technology or Music Production courses and deemed suitably experienced in mixing music took part in these experiments. The subjects were asked to use their own headphones during the experiments. This meant that each subject could use a means of monitoring the audio with which they were familiar. This approach also had the advantage of allowing the subjects to be tested in one session.

The subjects undertook a total of three two-track mixing experiments which included the following seven scenarios:

- bass guitar and kick drum
- bass guitar and lead electric guitar
- rhythm and lead electric guitar
- distorted and clean electric guitar
- electric guitar and synthesizer
- two synthesisers
- two electric guitars

These scenarios were similar to those used by Vega and Janer [5] and represent a range of masking situations commonly encountered by mix engineers.

The order of experiments, scenarios and tools were randomised.

3.1. Experiment 1

The first experiment investigated mirrored EQ. The subjects were provided with three different tools but were unaware of each tool's functionality. For each tool the test subject had a single unlabeled slider. The first tool boosted a frequency in the first track, the second cut the same frequency in the second to the same extent and the third boosted the first and cut the second simultaneously (i.e. Mirrored EQ). The frequency and Q (7) were fixed in each tool and two different frequencies were considered in each scenario, i.e. six tools were presented in each scenario. These two frequencies were characteristic frequencies present in the target track and were identified during development by an experienced mixing engineer, as listed in Table 1.

Scenario	Target Instrument	Masker Instrument	First Frequency Considered (Hz)	Second Frequency Considered (Hz)
1	Bass Guitar	Kick Drum	202	89
2	Electric Guitar	Bass Guitar	987	123
3	Electric Guitar	Electric Guitar	220	493
4	Distorted Electric Guitar	Distorted Electric Guitar	415	220
5	Electric Guitar	Synthesiser	880	422
6	Synthesiser	Synthesiser	552	1570
7	Electric Guitar	Electric Guitar	369	220

Table 1 Mirrored EQ details

Value	Subjective Descriptor
1	Not satisfied at all
2	Slightly satisfied
3	Moderately satisfied
4	Very satisfied
5	Extremely satisfied

Table 2 The five-point Likert used to measure satisfaction

The subjects were asked to use each unlabeled tool by moving a slider until the sound sources started to become unmasked i.e. became distinguishable. This method of testing is termed just noticeable difference (JND) and was previously used by Pulkki [7] in a series of listening tests that considered spatial panning. Each test subject's level of satisfaction with each tool was captured on a second slider. The subjects were also asked to record their satisfaction with each tool in performing the task using a five-point Likert scale as shown in Table 2. This method is commonly employed in usability studies [8].

3.2. Experiment 2

Scenario	Target Instrument	Target Average Spectral Centroid (Hz)	Masker Instrument	Masker Average Spectral Centroid (Hz)	Maximum Cut-off Frequency (Hz)
1	Bass Guitar	1189	Kick Drum	60	329
2	Electric Guitar	444	Bass Guitar	395	415
3	Electric Guitar	239	Electric Guitar	247	246
4	Distorted Electric Guitar	362	Distorted Electric Guitar	553	466
5	Electric Guitar	520	Synthesiser	759	622
6	Synthesiser	637	Synthesiser	953	783
7	Electric Guitar	1155	Electric Guitar	418	699

Table 3 Mirrored EQ details

The second experiment was similar to the first experiment and investigated frequency spectrum sharing. The average spectral centroid was calculated for each track and is shown in Table 3 and used to determine which track was high pass filtered (HPF) and which was low pass filtered (LPF). The average spectral centroid value of target and masker track was also used to determine the maximum HPF/LPF cut-off frequency possible with each tool. A slope of 0.7 was used in the HPF/LPF filters. This equated to a frequency mid-way between the two track's spectral centroids, as illustrated in Figure 1. Moving the tool's slider altered the HPF cut-off frequency from 0Hz towards the maximum cut of frequency and altered the LPF cut-off frequency from 22kHz towards the maximum cut-off frequency.

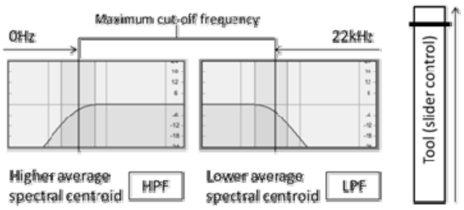

Figure 1 Diagram showing how the frequency spectrum sharing tool worked

The test subjects were provided with three tools in each scenario. The first tool applied a LPF to the track with the lower spectral centroid. The second tool applied a HPF to the track with the higher spectral centroid. The third tool applied HPF and LPF respectively to the two tracks. An unlabeled slider controlled the cut-off frequency of the filter or filters. Again, subjects were asked to use the tool until the two tracks became distinguishable. Satisfaction values were recorded on a second slider as in experiment 1.

3.3. Experiment 3

The third experiment considered using pan position to reduce frequency masking and featured two tracks panned to the centre position. Subjects were provided with two tools. The first tool panned one track to the right and the other equally to the left using the standard constant power panning algorithm. With the second tool the target track remained central while the masker track panned to the right. A single unlabeled slider that modified the pan position or positions was provided for each tool with satisfaction values recorded on a slider as in the other experiments.

4. RESULTS

Figure 1 presents the average satisfaction scores across all scenarios and shows 95% confidence intervals. Figure 2-8 similarly present the average satisfaction scores for each scenario.

The results show that the tool which pans the target left and masker right is the tool most favoured by the subjects overall, having the highest satisfaction score in all but one of the scenarios considered. Furthermore, the results for all scenarios indicate that this tool is statistically significantly favoured by the subjects in comparison to all other tools.

The tool which performs a variation of mirrored EQ by only cutting the masking track is least favoured overall and has the lowest satisfaction score in all of the scenarios considered. Furthermore, the results for all scenarios indicate that this tool is statistically significantly favoured least by the subjects in comparison to all other tools. This result is interesting as some mix engineers are known to favour this technique when treating masking but in blind testing with unlabeled sliders this technique does not appear to be supported in terms of user satisfaction with the tools It is possible that this low level of subject satisfaction may be due to the selected frequencies, and potentially further exacerbated by the Q being fixed to a fairly narrow bandwidth.

The subjects appear to have no preference over the remaining two tools that perform a variation of mirrored EQ with each tool having similar average satisfaction values recorded in all scenarios. Overall, both tools appear to be statistically more satisfying to use than the target: none masker: cut tool.

With regard to experiment 2 there does not appear to be any significant (statistical or otherwise) difference in satisfaction with the three tools. In different scenarios it appears that all three may be preferred.

With regards to experiment three which considers pan the target: left masker: right tool has a statistically significant higher satisfaction score than the tool that left the target track panned to the centre and panned the masker track to the right.

5. CONCLUSIONS

Three experiments were devised to investigate the three most commonly used techniques to treat masking in multi-track mixing. These techniques include mirrored EQ, sharing the frequency spectrum and panning competing tracks apart. A range of tools were developed and tested in a range of real-world popular music two track mixing scenarios. Crucially the sliders in each tool were unlabeled and their function hidden from the subjects tested.

With regard to mirrored EQ the subjects preferred the tools that boosted the target and cut the masker or only boosted the target at characteristic frequencies over the tool that only cut the masker track, which was the least preferred tool of all tools considered. We might have expected boosting the target and cutting the masker to be the most favoured based on most favoured industry practice. This experiment does appears to confirm this is a favoured approach under blind testing with an unlabeled slider however suggests that it is no more favoured than simply boosting the target. When sharing the frequency spectrum subjects there was no discernable user preference between the three variations with the preferred variation changing between scenarios. Based on industry favoured practice, it might have expected that the test subjects would have been more satisfied with a tool that affected both the masker and target but this experiment appears to show that in blind testing with unlabeled sliders this is not the case (within the limitations of the scenarios and experimental setup explored here).

When competing tracks were panned apart the subjects preferred the tool that panned the target track to the right and the masker track to the left. Overall this tool had a significantly higher satisfaction score than all other tools considered. One experienced mix engineer did tell us informally that pan was always his first choice of technique to tackle masking and these experiments with blind testing using unlabeled sliders appear to support this view. Obviously it should be noted that panning is only possible with stereo mixing (and where mono compatibility is not a concern) whereas the other techniques are applicable in mono as well as stereo. It should also be noted that panning both target and masker may not be appropriate if the target is a key track in the mix, for example the lead vocal.

6. FURTHER WORK

Similar tests should be conducted with a more subjects to validate the findings of this experiment.

More experiments should be conducted to examine subject satisfaction with differing frequencies and Q values to those presented in the first mirrored EQ tool experiment. Differing cut-off frequencies limits to those used in the second shelving EQ tool experiment should also be considered.

To validate the findings of these experiments final Pro Tools session files for mixes by professional producers should be examined to identify appropriate EQ settings for further experiments.

In these experiments we also collected the unlabeled slider settings and further work could involve analysing these settings to try to determine thresholds for when the target becomes distinguishable from the masker and whether there is consistency between test subjects.

7. REFERENCES

[1] Moore, B. C. (Ed.). (2012). An introduction to the psychology of hearing. Brill.

[2] Glasberg, B. R., & Moore, B. C. (1990). Derivation of auditory filter shapes from notched-noise data. Hearing research, 47(1), 103-138.

[3] Zwicker, E. (1970). Masking and psychological excitation as consequences of the ear’s frequency analysis. Frequency analysis and periodicity detection in hearing, 376-396.

[4] Moore, B. C., & Glasberg, B. R. (1983). Suggested formulae for calculating auditory-filter bandwidths and excitation patterns. The Journal of the Acoustical Society of America, 74(3), 750-753.

[5] Vega, S., & Janer, J. (2010). Quantifying Masking in Multi-track Recordings. In Proceedings of SMC Conference.

[6] Mynett, M., Wakefield, J. P., & Till, R. (2010). Intelligent Equalisation Principles and Techniques for Minimising Masking when Mixing the Extreme Modern Metal Genre.

[7] Pulkki, V., & Karjalainen, M. (2001). Localization of amplitude-panned virtual sources I: stereophonic panning. Journal of the Audio Engineering Society,49(9), 739-752.

[8] Norman, D. A. (2002). The design of everyday things. Basic books.

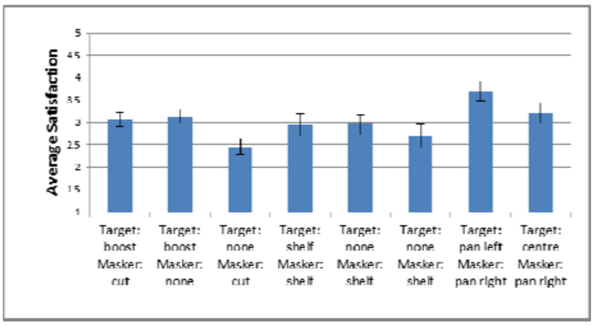

Figure 1 Average subject satisfaction for all scenarios considered

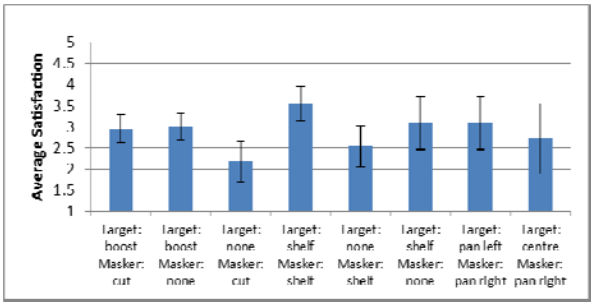

Figure 2 Average tool satisfaction scores in scenario 1

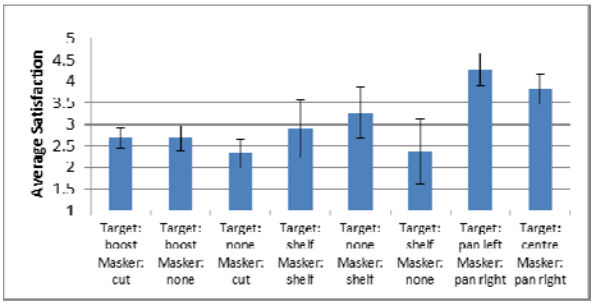

Figure 3 Average tool satisfaction scores in scenario 2

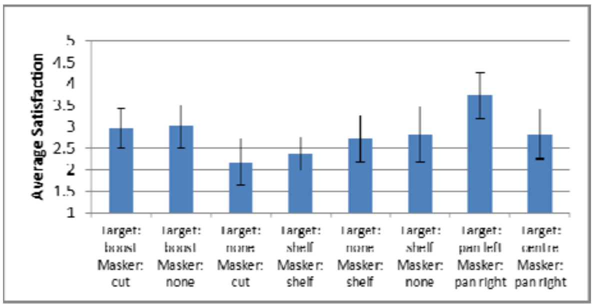

Figure 4 Average tool satisfaction scores in scenario 3

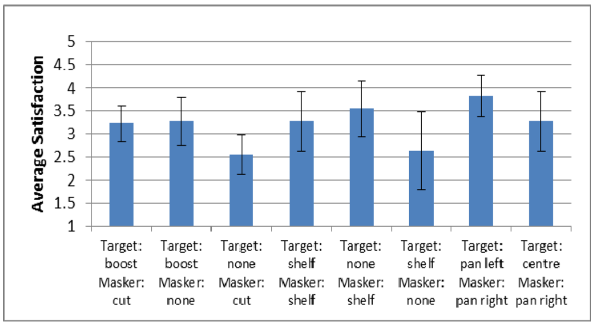

Figure 5 Average tool satisfaction scores in scenario 4

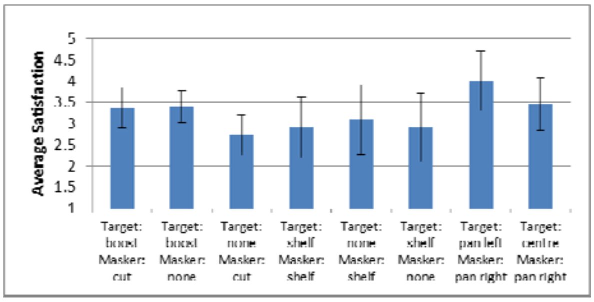

Figure 6 Average tool satisfaction scores in scenario 5

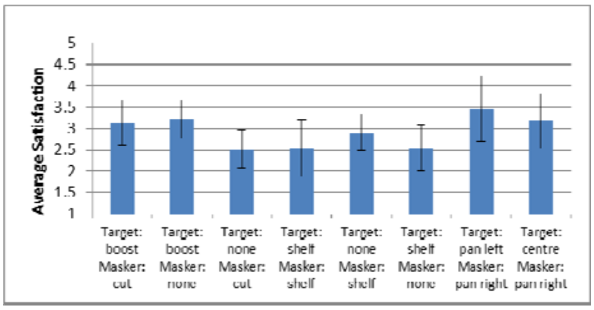

Figure 7 Average tool satisfaction scores in scenario 6

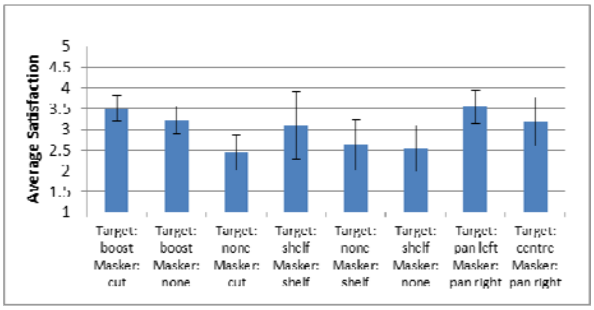

Figure 8 Average tool satisfaction scores in scenario 7