Use of tactile transducers to reduce the use of low frequency airborne sound in cinema

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Abstract

Aiming to address transmitted low frequency noise between closely situated cinema screens, an installation of tactile transducers mounted to the theatre seating the was developed as a means of replacing low frequency airborne sound with vibration. Without causing determent to the listening experience, it was investigated whether a reduction in subwoofer SPL was enabled, reducing the reliance upon traditional methods of low frequency isolation within partition walls. With vibration, psychoacoustic testing reported an increase in perceived low frequency loudness, while also showing no detrimental effect upon realism, impact or dynamics with a reduced subwoofer SPL. It was concluded a 6.8dB subwoofer level reduction would be perceptually indistinguishable with vibration given directly to the listener.

Introduction

The close proximity of multiplex cinema screens and the permeability of partitions to low frequency sound commonly causes noise disturbance in the adjacent auditorium through system bleed. Low frequency energy forms a vital part of the cinema experience and a reduction in SPL would address noise transmission, but at the consequence of enjoyment . Structure borne vibration is deemed correlated to airborne low frequency sound (Altinsoy and Merchel 2011), and in this project is presented in supplementation to the LFE channel.

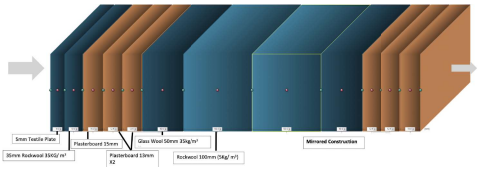

Figure 1: Example partition wall construction (Ottobre et Al. 2016)

Aims

The key aim to report if vibration transmitted directly to the user can supplement the LFE signal, enabling an airborne sound level reduction was tackled using the stages of:

1. Developing a tactile transducer hardware system
2. Specifying and refining input signal generation methods for optimal airborne LFE support (Lofelt 2019)
3. Psychoacoustic testing to investigate the effectiveness of the system

Hardware

Hardware was developed using a focus group of 5 participants to the specification below:

Figure 2: Images showing developed hardware solutions

Transducer placement was optimised to the shoulder blades and sit bones

A floor plate to mimic natural structure borne sound (Lindeman 2015)

Resonances were avoided and vibration transfer optimised through transducer mounting methods

Psychoacoustic Testing

To quantify the precise effect of the tactile system on the listening experience, a 5.1 test loudspeaker system was used. Two participants graded the 'loudness of low frequencies', 'realism', and 'dynamics and impact' on continuous 5 reference grading scales in the format of a questionnaire (ITU-R BS 1116-1). Participants also controlled the LFE level with and without vibration. Audio and video clips of between 10 and 20 seconds were used and repeated for each variable.

A	B	C	D	E
Subwoofer Only	Vibration Only	Vibration, Subwoofer -6dB	Vibration, Subwoofer -10dB	Vibration and Subwoofer

Table 1: Playback repeats (variables) with the manipulated parameters

In addition to 5 step grading scales, participants controlled the output gain of the LFE signal to the subwoofer with and without vibration, and with vibration reduced in intensity by 6dB.

Results

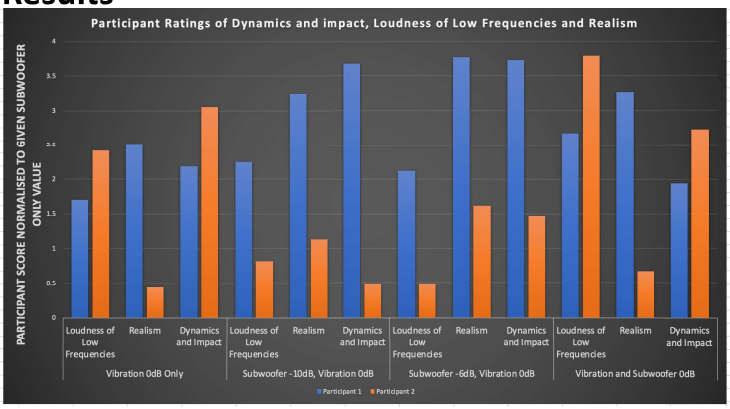

Figure 3: Participant scores with vibration, normalised to their subwoofer only rating

Key results were:

- The subwoofer only condition was rated lowest in all tests
- Vibration improved ratings in 'loudness of low frequency', 'realism' and 'impact and dynamics' by 32.3%, 19.7% and 23.7%
- A 6dB reduction in subwoofer level produced a 19% reduction in LF loudness with vibration, but this is still 14% higher than with the subwoofer only
- A 10dB reduction in subwoofer level produced a 17% reduction in LF loudness with vibration, but this is still 15% higher than with the subwoofer only
- With full intensity vibration, the LFE signal was set 6.8dB lower than without
- With vibration reduced by 6dB, results varied greatly between participants between a 11.97 and 0.93dB reduction so are inconclusive

Conclusions

It was concluded that with vibration, a reduction in subwoofer level was perceptible to listeners, but still rated higher in all conditions than with the subwoofer at the calibration level without vibration. 'Realism' and 'dynamics and impact' were not impeded by a reduction in subwoofer level with vibration active. In conclusion, it was stated approximately a 7dB reduction in subwoofer level would be imperceptible, and that if the LFE subwoofer was replaced completely with vibration, ratings of low frequency loudness would be higher than with standard subwoofer systems.

References

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Demonstration

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