The Effect of Non-audible Low Frequency, Deep Micro Vibrotactile, DMV Sounds on Music

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Abstract

Much of the research on low frequencies is on biological effects or noise pollution. We have confirmed that adding low frequencies to music increases autocorrelation and enhances the higher frequency components. This paper ensures that the addition of low frequencies to music produces 1/f fluctuations.

Keywords: deep micro vibrotactile, DMV, low-frequency sound, 1/f fluctuation

1. Introduction

Infrasound is a sound generated by vibrations of 20 times or less per second. In general, the sound loses energy owing to vibration as it passes through a medium. Therefore, higher frequencies rapidly lose power and are attenuated, whereas lower frequencies are less attenuated. Consequently, it can travel thousands of kilometres. Low frequency sounds are less directional than high frequency sounds; they proceed in concentric circles from the source, and go around any obstacles [1)]. Low frequency sounds have been examined as noise pollution, and their effects on the human body have been studied [3)]. However, a unified view has not yet culminated as the sensitivity to very low frequency sounds can vary from person to person [2)].

Very low frequencies have long been regarded as noise pollution. However, in nature, low frequency sounds are produced by a variety of natural phenomena, including tectonic movements, such as, volcanoes [5)], celestial movements, such as, asteroids, meteorites, meteors, and fireballs entering the atmosphere [6)], meteorological phenomena, such as, typhoons and lightning [7)], and water movement such as waterfalls and rivers [8)].

In the music industry, inaudible low frequencies below 20 Hz generate vibrations and distort the sound in the audible range. Hence, infrasound is removed from music during production. However, low frequency sounds are not completely eliminated, and may be important; hence, they are coordinated not to overload.

We investigated the case of a 40 Hz sine wave mixed with music [9]. It was confirmed that autocorrelation structures arise when the amplitude of the 40 Hz sine wave is large. When the high-frequency component of the music is small and the amplitude of the mixed 40 Hz sine wave is relatively large, the superposition of the waves strengthens the high-frequency component. This effect did not occur with white noise, which suggesting the effect of wave superposition.

In some natural phenomena or music, we can observe a power spectrum whose distribution is inversely proportional to the frequency. In case the slope of the regression line of the spectrum, λ, is around -1.0, it is called the 1/f fluctuation.

2. *Material*

The music was played by the attached speakers in a MacBook Pro laptop. Low frequency sounds were played using a Denon DSW37K subwoofer. A Zoom H6 handy recorder was used for recording. The sound source was Schuman's *Symphony No. 3 in E-Flat Major, Op. 97 "Rhenish": II. Scherzo*, performed by Sent Luis Symphony orchestra, (from *"Schumann: The 4 Symphonies"* Label: Vox). The low frequency sound of the sine wave was generated using Audacity version 3.0.2.

As the experiment was carried out in a room without soundproofing, the background noise of the room was examined. The frequency spectrum was measured without music and with a 40 Hz sinewave. The number of trials was three and the average intensity of was derived. An interval estimation, with a confidence interval of 95%, showed that the intensities at 40 Hz, 20 Hz, and 16.5 Hz were significantly different from the background noise of the room.

3. *Method*

A comparison was drawn between music from speakers and low frequencies of sine waves from a subwoofer both playing at the same time. The speakers and subwoofer were placed in the same position at a distance of 5.45m from each other during the recording. Owing to the influence of external noise, three measurements were taken: one with music solely and one with music and 40 Hz of sine wave played simultaneously.

We compared the power spectrum of a sound source and a sound source mixed with a 40Hz pure tone. We transform the obtained power spectrum to the logarithmic axis. The envelopes of the power spectra were linearly regressed. The slope of the linear regression was set to λ.

4. *Result*

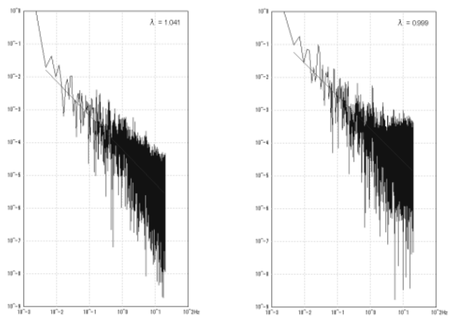

Fig. 1. right) Power spectrum of the sound source. The slope of the regression line, λ=1.041. left) 40 Hz sinusoidal pure tone added to the original. λ=0.999.

We measured the power spectrum of the original sound source and performed a regression analysis of the distribution. The slope of the regression line, λ = -1.041. we also added a pure tone sine wave of 40 Hz to the mixdown. The slope of the regression line of the power spectrum, λ = -0.999. The amplitude of the added sine wave is 0.1; as the amplitude is increased, λ deviates from -1.0.

5. *Discussion*

The role of low frequency sounds in music was studied. We confirmed that low frequency sound enhances the autocorrelative structure of sound. In this study it induces 1/f fluctuation in music.

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References

1. Araújo Alves, J., Neto Paiva, F., Torres Silva, L., & Remoaldo, P. (2020). "Low-frequency noise and its main

effects on human health—A review of the literature between 2016 and 2019." *Applied Sciences*, 10(15), 5205.
2. J. Yuei. (2004). "Outline of the 'Guide to dealing with infrasound problems' (in Japanese)" , *Journal of Enviromental Conservation Engineering*, vol. 33, 10, p. 753-757.
3. Koch, C. (2017). "Hearing beyond the limit: Measurement, perception, and impact of infrasound and ultrasonic noise." In *the 12th ICBEN Congress on Noise as a Public Health Problem, Zurich*.
4. Green, D. N., Neuberg, J. (2006). "Waveform classification of volcanic low-frequency earthquake swarms and their implications for Soufrière Hills Volcano, Montserrat." *Journal of Volcanology and Geothermal Research*, 153(1-2), 51-63.
5. Le Pichon, L. Ceranna, C. Pilger, P. Mialle, D. Brown, P. Herry, and N. Brachet. (2013). "The 2013 Russian fireball was the largest ever detected by the CTBTO infrasound sensors." *Geophysical Research Letters*, 40(14), 3732-3737.
6. Bedard, A. J. (2005). "Low-frequency atmospheric acoustic energy associated with vortices produced by thunderstorms", *Monthly weather review*, 133(1), 241-263. Retrieved on the 17th of July 2021
7. Feng, H. & Yichun, Yang & Chunchuzov, Igor & Teng, Pengxiao. (2014). "Study on infrasound from a water dam Acta Acustica united with Acustica." 100. 10.3813/AAA.918702.
8. Tolonen, T., & Karjalainen, M. (2000). "A computationally efficient multipitch analysis model." *IEEE Transactions on Speech and Audio Processing*, 8(6), 708-716.
9. Morikawa, Masahiro. "Low-Frequency Characterization of Music Sounds--Ultra-Bass Richness from the Sound Wave Beats." arXiv preprint arXiv:2104.08872 (2021).

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