International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V68I10P203
Volume 68 Issue 10, 24-27, October 2020

A Study on Risk Analysis and Prevention of the Noise Cancelling Earphone

Ik-Soo Ahn[1*], Seong-Geon Bae[2], Myung-Jin Bae[3]

[1]*Soong-sil University, Department of Information and telecommunication Engineering, Seoul, 06978, Korea*
[2]*School of Software Application Kangnam University, Gyunggi-do, South Korea*
[3]*Soong-sil University, Department of Information and telecommunication Engineering, Seoul, 06978, Korea*
[1]aisgoodman@ssu.ac.kr
[2]sgbae@kangnam#ac.kr
[3] mjbae@ssu.ac.kr[3]

Abstract *—Recently, as wireless earphones are worn when using a smartphone, the risk of wireless earphones following the Earmbie(Earphone + Zombie) phenomenon has become a more serious social problem. In particular, When used the risk of using earphones with noise cancelling technology is even greater. This is because noise cancelling earphones are made to focus only on the sound heard through earphones because external noise is almost blocked. In this paper, we investigated the principle of noise cancelling earphones, and studied the dangers and prevention methods of wearing the noise cancelling earphones. Hearing test was performed as an experiment on risk. Hearing test was conducted by setting and wearing noise cancelling earphones when wearing both ears and when wearing one ear, listening to music with a normal beat, and listening to the horn and the surrounding distance noise. It is believed that this experiment will help to prevent dangerous situations when using noise cancelling earphones. As a result of the hearing test, the ambient sound could be detected when wearing one ear of the noise cancelling earphone, but almost could not detect the ambient sound when wearing both ears. The horn sound was a sudden and strong warning sound, so even when both ears were using noise cancelling earphones, it could be detected to some extent, but when listening to high-volume music with strong beats, even the loudest horn could not be recognized. . As a result of the experiment, in order to prevent the danger of noise cancelling earphones, noise cancelling earphones should be worn on both ears only in a safe state where you can comfortably concentrate on sound indoors. In addition, when going out on the street, it was found that only one ear should be worn, and the volume of the music or sound being heard should be set to a low level. The enjoyment of video and sound should be done within the range that can cope with the danger.*

Keywords — *the Earmbie phenomenon, earphone, danger, noise cancelling earphone, principle, hearing test*

I. INTRODUCTION

In the multimedia environment of the modern society, because more and more people focus on smartphones and walk, a new term “Smombie (Smartphone + Zombie)” has emerged. Nowadays, interest in sound has increased, so many people use wireless earphones, but the danger is high, and there is a new coined word called Earphone Zombie (Earmbie: Earphone + Zombie). Among earphones, when using a noise cancelling earphone (hereinafter referred to as NCE) with noise cancelling technology, the danger is rising because the surrounding environmental sound and sudden sound can hardly be recognized. If you focus on NCE while using a smartphone, it is very difficult to pay attention to the surrounding environment, so the risk is even greater. If you only use a smartphone, you can recognize the sound of the surroundings, so you can know the dangers such as the sound of a vehicle coming, but if you use up to NCE, you can hardly be prepared for danger because the surrounding sound is hardly heard. Since NCE is becoming more popular as it is also coming out as a wireless earphone, it is becoming very serious as a social problem. Accordingly, in this paper, the principle of NCE was analysed, its dangers and prevention methods were physically studied, and the dangers of use when using NCE were studied through hearing tests for each situation.[1][2][3]

II. OVERVIEW OF NOISE CANCELLING EARPHONE (NCE)

Noise cancelling technology has been developed and is currently being used to cancel or block external noise that interferes with listening activities such as listening to music or monitoring in sound equipment. This noise cancelling technology is said to have originated from a technology that most fighter pilots originally tried to solve the cause of fatigue due to sleep disorders and anxiety symptoms due to noise. Noise-cancelling technology was first studied with headphones, and it was also necessary for aircraft crews who suffered from noise-induced hearing loss due to in-flight noise of almost 80dB. Since then, this noise-cancelling technology was used for passengers in aircraft and then commercialized to the general public. It was also used for personal audio equipment for listening to music to create a quiet background when listening to music. The need for noise cancelling technology has emerged not only for aircraft, but also for the hearing protection of people working on railroads, city streets, factories or construction sites. The noise cancelling method is divided into an active noise cancellation (ANC) method and a passive noise cancellation (PNC) method. However, if you

just call it noise cancelling, it is a term that refers to active noise cancelling (ANC), and passive noise cancelling (PNC) is a technology based on the physical sound insulation of the device itself, and because the sound insulation of noise is low, in this paper, active noise cancelling (ANC) was studied based on technology only.[1][2][3] Since sound is a wave, if the noise from the outside is received and analysed, and a wave in the reverse phase of the noise is generated, the two waves cancel each other and reduce the noise. This principle is called active noise cancelling technology. In other words, active noise cancelling is a technology that artificially creates an inverse phase of the noise coming from the surroundings and covers up the noise. Active noise cancelling technology is largely divided into three steps. First of all, detecting external noise is the first step in performing noise cancelling. In order to detect external noise, it is detected with a sensor attached to the earphone and picked up with an external microphone. The second step is to convert the detected and received external noise into out-of-phase in the noise cancelling circuit. This second step is the core of the active noise cancelling technology. The third step is to generate an artificially generated out-of-phase sound by synchronizing it with external noise that enters the ear through the speaker. [4][5][6] As shown in Figure 1, the active NCE technology receives external noise by installing an external microphone on the earphone, converts the signal into digital data, and converts the signal into an out-of-phase sound through a noise cancelling circuit. It is a structure that the resulting inverse phase wavelength is emitted in synchronization with external noise through the speaker.

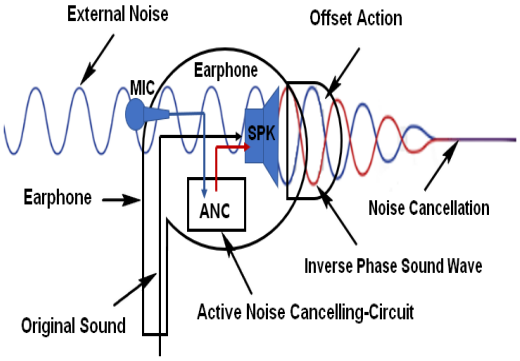

Figure 1. Principle of NCE

The noise cancelling technology has a slightly inferior noise cancelling effect on sudden sounds because the time to create an anti-phase waveform after detecting external noise and the anti-phase signal must be generated by synchronizing with external noise. However, it is effective in reducing the engine sound, motor sound, and calm environmental sound, which are regular and continuous sounds. In order to create an out-of-phase wavelength that attenuates external noise, the noise is detected by the microphone installed outside the earphone, and it is immediately converted into digital data. This sound is generated by the active noise cancelling circuit (ANC_Circuit), which creates an out-of-phase waveform, and sends it out directly through the speaker. It should offset the noise coming from it.

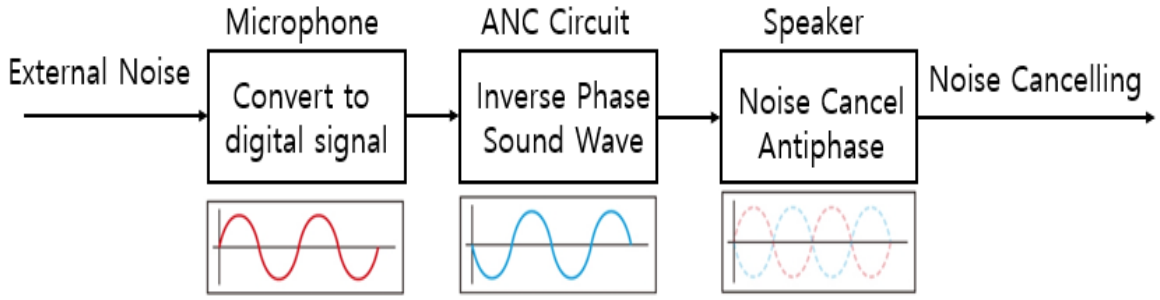

Figure 2. Noise cancelling procedure of the NCE

ANC shows the noise cancelling procedure of NCE as shown in Figure 2. NCE is a technology that reduces external noise by installing a microphone that analyses external noise on the outside of the earphone to receive external noise and to apply a destructive interference phenomenon, one of the acoustic phenomena, by generating an out-of-phase sound wave corresponding to the external noise. Of course, conventional headphones and earphones have made use of sound absorbing agents such as sponges to control external noise, or headphones that adhere to the ear or canal-type earphones that are inserted deep into the ear. This physical type of NCE is called a passive noise control (PNC) type noise cancelling technology. However, since PNC technology has limitations and cannot completely cancel noise, a more active noise reduction method, Active Noise Cancellation (ANC), has been developed. By applying this ANC technology to headphones and earphones, noise is more reliably removed and users can concentrate on the sound. [7][8][9]

NCE(Noise Cancellation Earphone) is a technology that combines the method of cancelling sound with sound to the earphone, and is a method that uses the interference phenomenon among acoustic phenomena. In other words, it is the principle that the original noise disappears if the noise is received by a microphone and artificially generated and synchronized with the incoming noise. Active noise cancelling is more effective for repetitive, regular and calm sounds. Noise cancelling technology is not yet well applied to a little popping or sudden sound.[10][11]

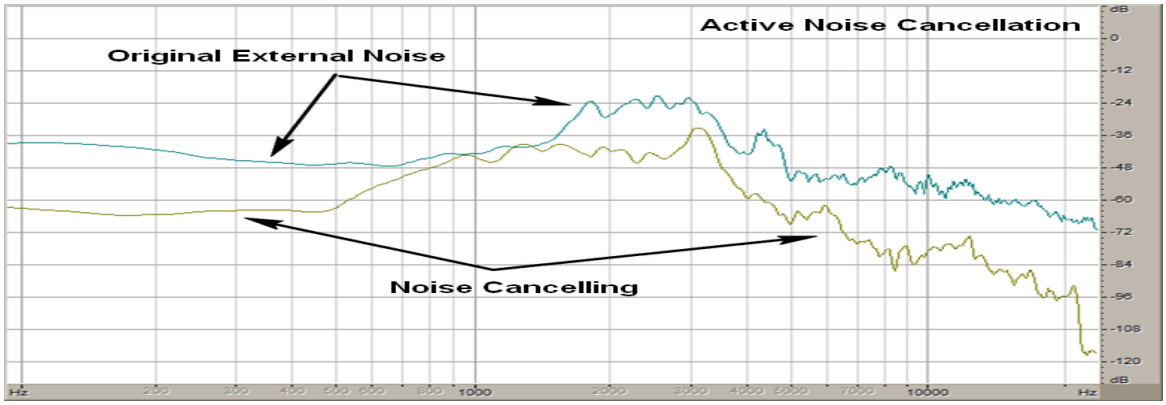

Figure 3. Frequency response characteristics of the ANC

The frequency response characteristic graph of active noise cancelling in Fig. 3 is a graph showing the frequency of music received with external noise through a general earphone and the frequency characteristic of music received through the NCE. As shown in the graph above, the external noise of music received through NCE is attenuated in the low and high frequency regions.

III. RISK TEST OF THE NCE

In order to test the risk of NCE, a hearing test for the possibility of recognizing external situations while using earphones was performed. For the experiment, the hearing test was conducted by dividing the case of 5 people with normal hearing into the case of wearing only one side of the NCE and the case of wearing both of them, and detecting the sound of two situations. One of the hearing tests is listening to the Clackson sound from a distance of 10 meters and judging the degree of hearing. Another hearing test was a test of the degree to which sidewalks perceive the noise of the streets the car travels. The Clackson sound was 80dB, and the distance was 10M from the subject. The five subjects of the test subjects each listened to the claxon sound and distance noise, and set their auditory level from 10 to 0, and judged and scored by themselves. The earphones were played so that the music level was 80dB, and the test was conducted by selecting the song “Burning on Fire” by BTS, which is not a music with a strong beat or a music that is too soft and weak. When wearing NCE, an auditory test was performed. As shown in Table 1, most of the subjects showed similar results. When NCE was worn with only one ear and the horn was heard from a distance of about 10M, the result was very good at levels 7 to 8. Even if the earphones were worn on both ears and the horn was heard from a distance of 10M, it was recognized as level 4-6. This is the result because it is not easy to attenuate the sudden and sudden sound even in NCE. However, if you listen to music with strong beats at a high volume, you cannot hear it at all. When NCE was worn with only one ear and the noise of the streets of a car was heard from the sidewalk, the result was very good at levels 6 to 7. When NCE was worn on both ears and the noise of the street the car travelled was heard from the sidewalk, the result was almost unrecognizable from level 0 to 1. This result is because it is not easy to attenuate the sudden and sudden sound, no matter how much NCE, but the attenuation effect is high for the sound that is uniform or mixed with many sounds.

Table-1 Listening test when wearing NCE

subject Sound /condition	Listener A		Listener B		Listener C		Listener D		Listener E	
	One ear	Both ears	One ear	Both ears	One ear	Both ears	One ear	Both ears	One ear	Both ears
Horn Sound 10M	8	5	7	4	8	6	7	6	8	6
Street sound	6	1	7	1	6	0	6	0	7	1

IV. EXPERIMENT AND SIMULATION

Earphones are used by most people today because they can be easily connected to various devices including smartphones via Bluetooth. Among them, wireless earphones with a noise cancelling function added to them have a greater social risk as they allow people who have been immersed in the vision of a smartphone so far to immerse themselves in both senses by combining their hearing. We want to enjoy the richness of our five senses. At the same time, however, at least the dangers of crosswalks must be coped with. As a result of NCE's auditory test, when using only one side of the NCE, the horn sound was well audible, and the noise from the streets of the car was heard enough to be recognized. However,

even when NCE was worn on both ears and listening to soft music, the horn could be perceived to some extent, but the car street noise was hardly heard. If you are wearing NCE on both ears and listening to strong beat music at a loud volume, you cannot hear the noise of the road or the horn at all. This is because in order for pedestrians using NCE to hear the horn sound and cope with the danger, it is possible only when the volume of the music listening to the NCE is 20dB lower than the horn sound. In this way, when walking on the street with NCE worn on both ears, it is difficult to react immediately to a traffic accident or unexpected danger. To prevent this risk, it is best to sit in a stable indoor seat and use the NCE at an appropriate level. If it is unavoidable to wear NCE and move indoors or streets, it is recommended to lower the volume of the music or sound you are listening to below 60dB or to wear the NCE on only one ear. NCE manufacturers also need to apply technology that can intelligently detect external dangers and provide feedback to earphone users in a timely manner as soon as the danger is detected, so that surrounding dangers can be prevented.[12][13].

V. CONCLUSIONS

Recently, a smartphone called a walking computer is a necessity because it has various functions. However, it has become a serious social problem due to the accident of Smombie (smartphone + zombie), which focuses excessively on the smartphone. In addition, the Earmbie (earphone + zombie) accident, which is vulnerable to accidents due to the high performance of earphones these days, is also a serious social problem. Earlier earphones received a lot of external sound, so the social problem of wearing earphones did not arise much. After that, the technology of earphones gradually developed, and the performance improved with a kernel type earphone that is worn deeply in the ear, and a wireless earphone that can be used freely without wires. In particular, these days, NCE, which almost completely blocks external environmental sounds or noise, has been developed to increase the satisfaction with the listening experience, but in proportion to it, social risks have emerged. Fortunately, the noise cancelling technology still does not completely cancel the warning noise that occurs suddenly, so even if you use earphones, the horn sound is detected to some extent and you can react to the danger. However, if you use NCE on both sides and listen to music with strong beats at a high volume, you may not be able to hear loud horn sounds. In addition, the environmental sound of the street and the sound of a car approaching are almost completely blocked by NCE, so the danger cannot be detected. As a workaround, it is recommended that you use only one side of the NCE instead of using both ears when traveling. Noise cancelling technology is a breakthrough technology and is a very valuable technology in that it has given us a richness of pitch.

REFERENCES

[1] Kyung Hyun Min, "*Evaluation of ANC earphone for reduction of hearing risk and suggestions of design improvement*", Hanyang University Master's Thesis , 2018.

[2] Yi, Eun-Young; Bae, Myung-Jin. "*A Study on Decreasing Earphone Leak Sound by Inverse Wave Generation*," International Information Institute (Tokyo). Information; Koganei Vol. 19, Iss. 5, (May 2016): 1487-1492.

[3] Tae-Young Jung, Jee-Hyung Yoon, Hee-Song Suh, In-Young Suh, In-Young Choi, and Bum-Man Kim, "*Broadband Low-Noise Amplifier with Single-Input Differential Output Structure Using Noise Canceling Technique*", The Institute of Electronics Engineers of Korea, 2010.

[4] Eun-Young Yi, Chan-Joong Jung and Myung-Jin Bae, "*A Study on Relationship between Power of Adapter and Total Harmonic Distortion of Earphone's leaking Sound*", International Journal of Multimedia and Ubiquitous Engineering Vol.9, No.6 (2014), pp.201-208

[5] Ji, Youna ; Lee, Keunsang ; Park, Youngcheol "(*Division of Computer and Telecommunication Engineering, Yonsei University), Secondary Path Estimation Algorithm Based on Residual Music Canceller for Noise Cancelling Headphone, The Journal of the Acoustical Society of Korea*", Volume 34 Issue 5 / Pages.377-384 / 2015 / 1225-4428(pISSN) / 2287-3775(eISSN)

[6] Hyun-Cheol Cho.Kwon-Soon Lee.Hyun-Do Nam, "*A Neural Multiple LMS Based ANC System for Reducing Acoustic Noise of High-Speed Trains",* The Korean Institute of Electrical Engineers, THE TRANSACTION OF THE KOREAN INSTITUTE OF ELECTRICAL ENGINEERS P58(4), 2009.12, 385-390(6 pages) [7] [Naver Encyclopedia], Noise Canceling Headphones and Earphones (Science Dictionary, pmg Knowledge Engine Research Institute)

[7] Lee, Sung Ju, "*Controlling unwanted alarm sound with smartphones*", College of Engineering School of Computing CS-Theses_Master Korea Advanced Institute of Science and Technology, 2017.

[8] Seong-Geon Bae and Myung-Jin Bae, " *A Study on Recovery in Voice Analysis through Vocal Changes before and After Specch Using Speech Signal Processing*," IJAER, Vol. 12(2017), pp.5299-5303, 2017.

[9] S.G. Bae, M.S. Kim, and M.J. Bae, "*On Enhancement Signal Using Non-uniform Sampling in Clipped Signals for LTE Smart Phones*," 2013, IEEE ICCE-berlin, pp.125-126, ICCE-berlin 2013.

[10] Seong-Geon Bae and Myung-Jin Bae, " *A Study on Recovery in Voice Analysis through Vocal Changes before and After Specch Using Speech Signal Processing*," IJAER, Vol. 12(2017), pp.5299-5303, 2017.

[11] S.G. Bae, M.S. Kim, and M.J. Bae, "*On Enhancement Signal Using Non-uniform Sampling in Clipped Signals for LTE Smart Phones*," 2013, IEEE ICCE-berlin, pp.125-126, ICCE-berlin 2013.

[12] Gabriel J. L. Beckers, Brian S. Nelson, and Roderick A. Suthers, "*Vocal-tract filtering by linguistic articulation in a parrot*," Current Biology, vol. 14, pp. 1592-1597, 2004.