

Survey on the recognition of emergency vehicles by hearing-impaired drivers

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Abstract

An automobile is a convenient means of transportation for hearing-impaired persons to participate in society because it is less burdensome than public transportation. When driving a vehicle, a hearing-unimpaired person can obtain information from both hearing and vision, however, it is difficult for a hearing-impaired person to obtain auditory information without using a hearing aid. There are many demands, especially to be able to know the approach of an emergency vehicle, while auditory information is not sufficiently obtained. Therefore, the purpose of this study is to investigate the actual situation of the siren of an emergency vehicle when driving a vehicle for hearing-impaired persons, and to understand the current situation and problems from the viewpoint of consciousness. As a result of a questionnaire survey, more than half of the people have not noticed the siren of an emergency vehicle. However, about 70 % of the hearing-impaired persons do not think of it as a hearing problem. Also, about half of them feel that it is more difficult to recognize visual information during nighttime driving than during daytime. Hearing-impaired persons may have difficulty in obtaining visual information in the dark, and if the amount of auditory information decreases, it may be more difficult for them to collect information around them, and driving may be difficult.

Keywords

hearing-impaired persons, emergency vehicles, auditory information, visual information, driving

1. Introduction

Motorization has advanced in Japan, and the number of people using automobiles as a means of transportation has increased. According to a survey by the National Police Agency [2020], the total number of license holders in 2019 was 82,158,428, of which 40,425 were licensed to people using hearing aids. Automobiles are a very convenient means of transportation because they are less burdensome and have a wider range of travel than public transportation. This is not limited to people with normal hearing, but also for people with hearing impairment. Vehicles are an important means of transportation for hearing-impaired persons to participate in society.

People with disabilities are encouraged to participate in society, including hearing-impaired persons, the ADA law (Americans with Disabilities Act of 1990) was enacted in the United States as a law to successfully promote social participation of people with disabilities. In Japan, the Transport Barrier Free Act and the Heart Building Act have been enacted, and barriers in public transportation and buildings are being changed [Ikeda, 2013]. In this way, society as a whole has shown the direction that people with disabilities can participate in the society based on the idea of normalization, however, the awareness and understanding of people with physical disabilities regarding vehicle driving is still weak. It is important to consider how people with disabilities participate in society, and not to exclude people with disabilities in the use of automobiles.

A hearing-impaired person can be said to be an information-impaired person who has difficulty in hearing sounds and identifying sound sources. This is true not only for everyday life but also for driving a vehicle. When driving a vehicle, a hear-

ing-unimpaired person can obtain information from both hearing and vision, but it is difficult for a hearing-impaired person to obtain information without using a hearing aid. However, with the use of hearing aids when driving, there is a problem that excessive noise is generated due to the engine, etc., and a survey conducted by the Japanese Federation of the Deaf [2006] showed that hearing-impaired persons who always use hearing aids while driving a car experienced excessive noise, and there is also a report that this is about one-third of the whole. In Tsuge and Ohnishi's [1999] research on the identification of warning sounds, some sounds have a poor identification rate when the noise is mixed. In addition, not only for hearing-impaired persons, the research by Lee [1998] on the role of driver's hearing while driving a vehicle reported that the higher the noise level, the higher the accident rate.

For this reason, there is a large demand for hearing-impaired persons to be able to know the approach of an emergency vehicle, especially when the auditory information is not sufficiently obtained while driving a vehicle. Since vehicles are more convenient as a means of transportation for the hearing-impaired than public transportation, it is important to investigate the actual usage of automobiles in order to maintain a safe driving environment. Therefore, the purpose of this study is to investigate the actual situation of the sirens of emergency vehicles when driving a vehicle for hearing-impaired persons, and to understand the current situation and problems from the viewpoint of consciousness.

2. Method

A survey was conducted by using a questionnaire to collect information on the driving conditions of the hearing-impaired when driving a vehicle. Specifically, in addition to individual attributes, the contents regarding the approach of an emergency vehicle while driving for hearing-impaired persons were imple-

mented in a questionnaire format.

Based on the survey results [Nihon Hochouki Kougyoukai, 2018] that 80 % of hearing aid users have hearing impairment in both ears, the questionnaire subjects were persons who have a driving license and hearing impairment in both ears. The total number of valid responses of the hearing-impaired group obtained from the survey was 91. The average age of respondents was 49.5 years, with 67.0 % males and 33.0 % females. The average number of years since the driver's license was obtained was 23.1 years. Regarding the content of disability, 53.8 % had congenital hearing loss and 46.2 % had acquired hearing loss. The level of disability was 25.3 % for Grade 1, 54.9% for Grade 2, and 19.8 % for Grade 3. For some of the questions, similar questions were also asked to a hearing-unimpaired group as a comparison. The total number of valid responses was 115, and the average age was 45.5 years. Table 1 shows the list of respondents.

The questionnaire for the hearing-impaired group was distributed to the subjects with the cooperation of two groups related to hearing impairment. The question items were created after a prior meeting to understand the driving environment of the hearing-impaired. It should be noted that the answers to the questions were a selection method, and if there was no intention to answer, it was not necessary. In order to protect the privacy of the respondent, the envelope containing the questionnaire was sealed by themselves and then mailed to a designated address.

3. Results

3.1 Hearing information when driving

Hearing-impaired persons and hearing-unimpaired persons were asked about their experience of not being aware of the siren of an emergency vehicle. Answers were selected from "yes" and "no". As shown in Figure 1, 56.0 % of the hearing-impaired group and 10.4 % of the hearing-unimpaired group responded that they "did not notice the siren of the emergency vehicle." Compared to the hearing-unimpaired group, the hearing-impaired group had a higher rate of not being aware of the siren of the emergency vehicle, and more than half of the

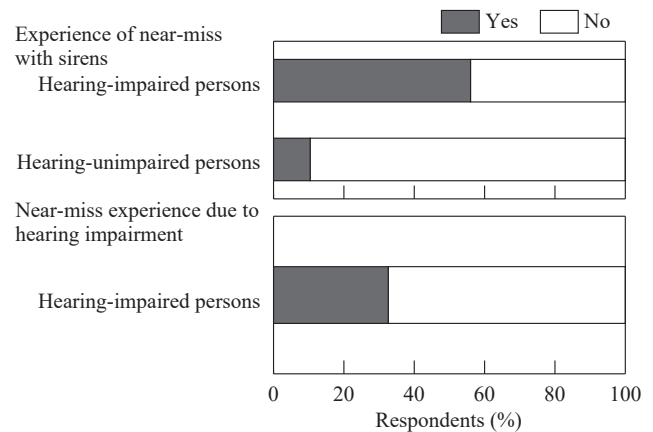


Figure 1: Near-miss experience due to not hearing the siren of an emergency vehicle

respondents had a near-miss experience ($\chi^2 = 49.78$, $df = 1$, $p < 0.01$). In addition, when asked about the near-miss experience while driving due to hearing impairment, 32.6 % of the hearing-impaired respondents answered "yes" and 67.4 % answered "no". However, regarding the experience of not hearing the emergency vehicle siren, there was no statistically significant difference in both the level of disability and the time of disability.

Next, the respondents were asked about the frequency of wearing hearing aids while driving. The answers were chosen from three: "frequently", "sometimes" and "not at all". As a result, 41.6 % of the respondents answered that they "frequently" drive without wearing hearing aids, 23.6 % of respondents answered "sometimes", and 34.8 % answered "not at all". However, no statistically significant difference was found when comparing both the time of disability and the level of disability, so it can be said that it is not related to the frequency of wearing hearing aids.

With a revision of the law in 2008, it is now possible to drive a vehicle without wearing a hearing aid by attaching the deaf person's mark and using a special rear-view mirror. However, only 6 % of the hearing-unimpaired respondents know about

Table 1: List of respondents

	Group of hearing-impaired persons	Group of hearing-unimpaired persons
Number of respondents	91 persons	115 persons
Average age	49.5 years old ($SD = 12.5$)	45.5 years old ($SD = 14.5$)
Sex	Male: 61 persons, female: 30 persons	Male: 110 persons, female: 5 persons
Years after license acquisition	23.1 years ($SD = 9.2$)	23.5 years ($SD = 13.2$)
Time of disability	Congenital hearing loss: 49 persons, acquired hearing loss: 42 persons	—
Disability level	Grade 1: 23 persons, Grade 2: 50 persons, Grade 3: 18 persons	—

Notes: Hearing level of Grade 2 is for each ear 100 dB or more. Grade 3 refers to those with a hearing level of 90 dB or higher in both ears. In addition, if a language disorder is added, it will be certified as Grade 1.

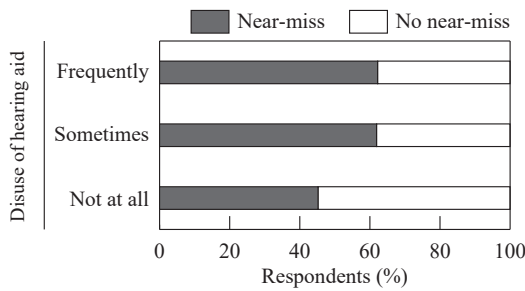


Figure 2: Relationship between wearing hearing aids and emergency sirens

the deaf person's mark.

The respondents were asked about the frequency of hearing aid disuse while driving and the experience of a near-miss due to not being aware of the siren of an emergency vehicle. As a result, as shown in Figure 2, the highest percentage, 62.2 %, of respondents who "frequently" disuse their hearing aid while driving answered that they had not noticed the emergency vehicle. 61.9 % of the respondents who "sometimes" did not use the hearing aid while they were driving, and 45.2 % who did not disuse a hearing aid at all answered that they had a near-miss experience. However, there was no statistically significant difference, and it was suggested that the experience of not being aware of the siren of an emergency vehicle and having a near-miss was unrelated to the use or disuse of a hearing aid.

3.2 Visual information when driving

The respondents were asked if driving at night would be more difficult than driving during the day. Answers were selected from three types: "feel difficult", "neither" and "not feel difficult". 53.4 % of the hearing-impaired group answered that they felt that driving at night was more difficult than driving during the day. 21.6 % of the respondents answered "neither", and 25.0 % answered "not feel difficult". In the hearing-unimpaired group, more than half of the people felt that when driving at night it became difficult to recognize visual information, and that it was more difficult than during the day.

It is considered that the use of hearing aids is effective for obtaining auditory information that changes when the amount of visual information decreases during night-driving. However, there is a significant difference between questions about hearing aid wear frequency and difficulty in driving at night. In fact, it was suggested that hearing aids were not worn even if the driver had difficulty driving at night.

Figure 3 compares the time of disability and the difficulty of driving at night. Although there was no statistically significant difference, both congenital and acquired hearing-impaired persons tended to have difficulty driving at night. 61.9 % of people with acquired hearing loss found it difficult to drive at night, which is larger than those with congenital hearing loss.

Next, the respondents were asked if they had misunderstood that an emergency vehicle came due to the movement of another

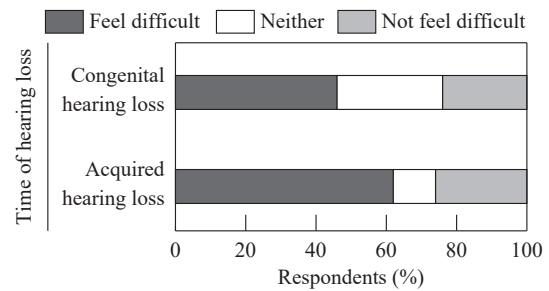


Figure 3: Time of disability and difficulty of driving at night

er vehicle. Answers were selected from "yes" and "no". 40.4 % of the hearing-impaired group answered "yes", and 59.6 % answered "no". Therefore, about 40 % of hearing-impaired people answered that they had such an experience. Hearing-impaired drivers have to constantly use their nerves about the movement of other vehicles, and it can be said that the information for grasping the surrounding driving environment may sometimes be misunderstood information.

In a comparison of the frequency of wearing a hearing aid while driving and the experience of misunderstanding that an emergency vehicle came due to the movement of another vehicle, as shown in Figure 4, hearing aids were "frequently" not used. 52.8 % responded "frequently" disuse, 42.9 % "sometimes" and 23.3 % "not at all", showing a statistically significant difference ($\chi^2 = 5.98, df = 2, p < 0.05$). It suggests that if a hearing aid was not worn frequently, it would be easy to misunderstand that an emergency vehicle came due to the movement of another vehicle.

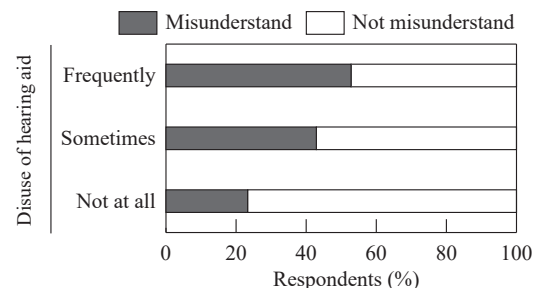


Figure 4: Relationship between misunderstanding due to movement of other vehicle and wearing hearing aid

Figure 5 shows the results of questions about the experience of being confused because it was difficult to judge the surrounding situation at an intersection with a lot of traffic. 4.5 % of the hearing-impaired people answered "frequently", 37.1 % "sometimes", and 58.4 % "not at all". On the other hand, none of the hearing-unimpaired group answered "frequently", with 25.2 % "sometimes", and 74.8 % "not at all". There was a statistically significant difference between the two groups ($\chi^2 = 4.89, df = 1, p < 0.05$). There is a lot of information at intersections, and it is necessary to judge information appropriately. An intersection with a lot of traffic is a unique place for hearing-

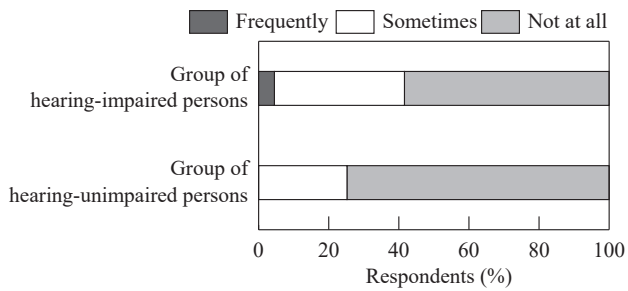


Figure 5: Confusing experience at a busy intersection

impaired persons where visual information is difficult to grasp. If there is a lot of traffic, it is difficult to check the movements of other vehicles and direction indicators when making a right or left turn or changing lanes. It can be said that the difficulty in grasping visual information leads to delay in driving operation.

4. Discussion

From the questionnaire survey, the actual conditions for hearing-impaired drivers were examined. With regard to auditory information, more than half of all the people who were unaware of the siren of an emergency vehicle experienced a scary incident. If the hearing-impaired person does not hear the siren of the emergency vehicle and does not notice the approach of the emergency vehicle, he or she will visually confirm it. Delay in finding an emergency vehicle can lead to difficulties in both driving and avoiding a collision. However, about 70 % of the hearing-impaired group were not aware of a near-miss due to hearing difficulty. And, although no significant difference was observed, it should be noted that those who drove without hearing aids felt a near-miss due to the siren of an emergency vehicle compared to those who drove with hearing aids on.

On the other hand, about half of the respondents feel that it is more difficult to recognize visual information during night-driving than during daytime. This can be said for normal hearing persons, but it is more difficult for hearing-impaired persons to obtain visual information in the dark, and it becomes more difficult for the hearing-impaired persons to collect information around them than normal hearing persons. So, it is presumed that driving will be difficult.

Regarding the experience of misunderstanding that an emergency vehicle came due to the movement of another vehicle, when comparing people who often drive without hearing aids with people who use hearing aids each time, the former had more experiences of misunderstanding the situation. Further, the hearing-impaired group may have difficulty in recognizing information at an intersection having a large traffic volume in comparison with the hearing-unimpaired group. There was also an opinion that when an emergency vehicle is approaching and another vehicle moves to the side of the road, it is possible to predict its existence, but if the vehicles are slow-moving, it is difficult to know what is happening. Especially when there is a lot of traffic, it is difficult to check the movements of other ve-

hicles and direction indicators when making a right or left turn or changing lanes.

5. Conclusion

Hearing-impaired persons may not notice the siren of an emergency vehicle. If the auditory information is reduced, it may lead to a mistake in driving judgment. However, in reality, the noise from the hearing aid causes headaches due to the loud noises of buses and trucks, and the excessive noise is generated further in the rain and on roads with many lanes. On the other hand, in passenger cars, the engine noise is low, and it is difficult to notice even with hearing aids. For those who do not use hearing aids while driving, they may be able to drive with only visual information because they can live with visual information in their daily lives without relying on auditory information. However, there is no doubt that it is possible to drive more safely with auditory information, and even from the current situation, the mental burden to understand the surrounding environment while driving is large. It is important to enhance measures in order to maintain a safe driving environment.

In the near future, all vehicles will be connected through the internet, and it will be possible to communicate information between vehicles, called a connected car. At that time, the system will be user-friendly for both hearing and visually-impaired persons, and it will become possible to provide information, such as emergency situations, by monitor, audio, and also vibration. Currently, there are several kinds of technology being developed in many countries. This paper is about the actual situation of subjective information collection from the viewpoint of consciousness, however, it is necessary to clarify the objective physical and mental burdens of hearing information collection for further development of such technologies. In addition, the subjects in this research were those with severe hearing loss, however, in the future it will be necessary to include subjects with a wider range of hearing difficulties.

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