inter.noise
21-24 AUGUST
SCOTTISH EVENT CAMPUS
GLASGOW 2022

Masking effect of sounds during treatment on dental drill sound

Tomomi Yamada[1]
Mikako Hayashi[2]
Osaka University Graduate School of Dentistry
1-8, Yamadaoka, Suita, Osaka 565-0871, Japan

Kazunori Nozaki[3]
Osaka University Dental Hospital
1-8, Yamadaoka, Suita, Osaka 565-0871, Japan

Sonoko Kuwano[4]
Professor Emeritus: Osaka University
1-1, Yamadaoka, Suita, Osaka 565-0871, Japan

ABSTRACT

Sound environment of dental clinics has changed with the COVID-19 pandemic. Because the use of dental suction devices for infection control measures during dental treatment has increased compared to their use before the COVID-19 pandemic. Many dental patients experienced unpleasant feeling with the sound of a dental drills in dental clinics. In this study, the sounds emitted by dental drills and sound related to dental suction devices were prepared and psychoacoustic evaluation of the stimuli combined the both noises was conducted. The results showed that masking of some prominent frequency components of dental drill noise changed subjective impression and it may help to improve the discomfort feeling in the dental sound environment.

1. INTRODUCTION

The sound emitted by a dental drill has a significant influence on the sound environment in a dental clinic. In a questionnaire survey associated with the dental clinic environment for patients, approximately half of the respondents reported experiencing unpleasant feelings on hearing the sound emitted by a dental drill [1]. In our previous study, we found that the spectra of the sound of dental drills had several prominent frequency components in the wide-frequency region over 20 kHz [2]. In Japan, the sound environment of dental clinics has changed with the COVID-19 pandemic because the use of dental aerosol suction devices during dental treatment has increased for infection control compared with their use before the COVID-19 pandemic [3]. We need to determine the effects of the

[1] yamada@dent.osaka-u.ac.jp

[2] mikarin@dent.osaka-u.ac.jp

[3] knozaki@dent.osaka-u.ac.jp

[4] kuwano@see.eng.osaka-u.ac.jp

noise emitted by a dental suction device on dental drill noise to identify cues to improve the sound environment in dental clinics for patients,

In this study, psychoacoustic evaluation was conducted using ten sound stimuli to find the psychological effect of the noise emitted by dental suction devices on dental drill noise.

2. METHODS

We conducted psychological measurements. The experiment was approved by the Ethics Committee of the Osaka University Graduate School of Dentistry. All participants provided written informed consent before taking part in the experiment.

2.1. Participants

Eleven female and four male participants aged between 24 and 29 years participated. All the participants were Japanese and dentists.

2.2. Sound stimuli

In a quiet environment in a dental clinic, we recorded sounds emitted by a dental drill and a dental suction device separately using a sound level meter (LA-5560; Ono Sokki, Japan). The sound of a dental drill was not stable because it was recorded during drilling an artificial tooth. We edited the duration of the both noise recording to approximately 5 s using sound software. The both average spectra of a dental drill noise and a dental suction noise are shown in Figure 1.

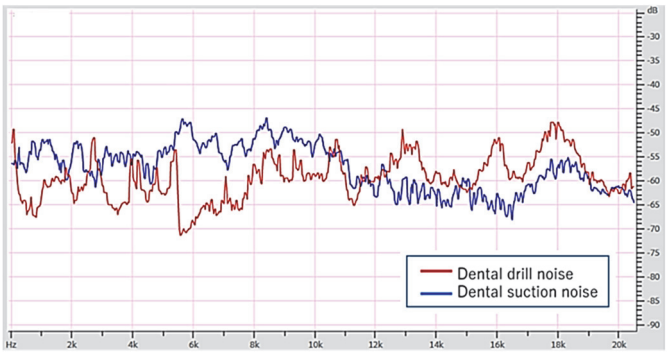

Figure 1: The average spectra of a dental drill noise and a dental suction noise used in the experiment.

Ten sound stimuli for psychological experiment were prepared. Three stimuli of dental drill noise with different sound level were prepared (Stimuli A). Three stimuli were made by mix-pasting a dental suction noise and a dental drill noise at the same ratio with different sound levels (Stimuli B). Three stimuli were made by mix-pasting a dental suction noise including only the frequency components below 6 kHz and a dental drill noise, and they were different sound levels (Stimuli C). One stimulus was also made by mix-pasting pink noise and a dental drill noise (Stimulus D). We adjusted the sound level of the stimuli using the sound software.

2.3. Procedure

We conducted psychological measurements using a semantic differential scale with 15 adjective pairs (see Figure 3) selected on the basis of the previous study [3]. Participants were seated alone in a room and instructed to judge the impression of the sound stimuli delivered through headphones (SRM-313; STAX). Before exposure to the test stimuli, participants were informed that the test stimuli consisted of the recordings of dental drill sounds. Participants were then asked to judge their impressions of the sound stimuli twice in two separate sessions.

2.4. Analysis

The analyses, processing and calculating sharpness were conducted using sound quality software (7698, 5265; Brüel and Kjær). Spectrum analysis was conducted using sound software (Audition, Adobe).

3. RESULTS and DISCUSSION

We found a significant correlation between the results from the two psychological evaluation sessions in all participants (Spearman's rank correlation, correlation coefficient r = 0.73). This result indicates that the judgments of all participants were reliable. Therefore, we combined the results of the two psychological evaluation trials in the subsequent analyses.

The spectra of four stimuli A-D are shown in Figure 2. Sound levels of the four stimuli were adjusted to 65 dB. The specific frequency components were observed and temporary varying in spectrum of stimuli A. Some of these prominent frequency components seemed to be covered by the additional noise in stimuli B-D.

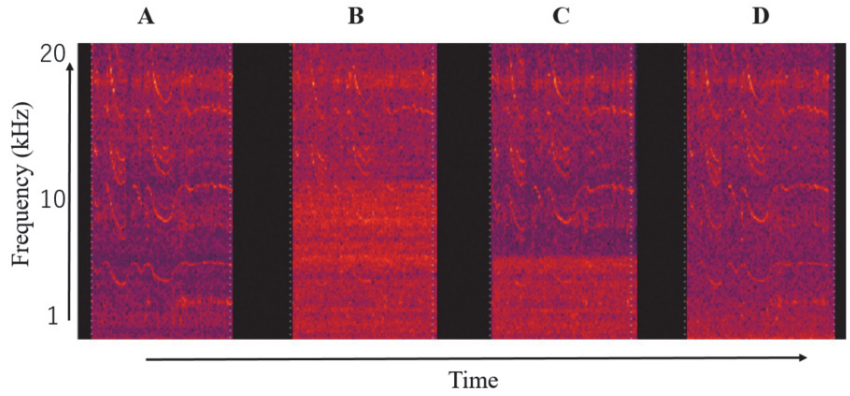

Figure 2: Spectra of stimuli A-D used in the experiment.

The profiles of these stimuli A-D are shown in Figure 3(a) .The scores of the adjectives "loud" and "quiet" of Stimuli A and B were evaluated similar, however they got different subjective evaluations on the other several adjectives. Figure 3(b) shows the profiles of three stimuli B with different sound level. The L_{Aeq} values were 65, 60 and 55 dB, respectively. There are statistically significant differences among the scale values of "loud" or "clamorous" for the three stimuli. However, the "unpleasant- pleasant" impressions hardly improved.

Seven categories from "very soft" to "very loud" were used, which have proven successful for noise evaluation in machinery noise [4]. We have assessed the sound quality of dental drills [5]. High correlation was found between sound level attenuation and the results of "soft-loud" and "quiet - clamorous". In this study, the correlation coefficients between the "soft-loud" adjective scales and L_{Aeq} were 0.94. Attenuation of the sound level seemed to improve the impression of "loud" in this experiment. On the other hand, there was low correlations between the reduction of the sound level and the other scores of the adjectives compared with the adjectives such as "loud".

Sounds of dental drills have several prominent frequency components in a wide frequency range [2]. The specific frequency components in dental drill noise were observed, and they were temporarily varying, as shown in Figure 2. The results that stimuli B was judged to have better impression compared with stimuli A may be because that several frequency components of drill sounds were masked.

Several limitations of the present study warrant mention. First, the length of each stimulus in the present experiment was 5 s, which was considerably shorter than the typical duration of exposure during clinical treatment. Second, sound pressure levels of some stimuli prepared for psychological experiment were lower than the typical sound level of exposure in dental clinic.

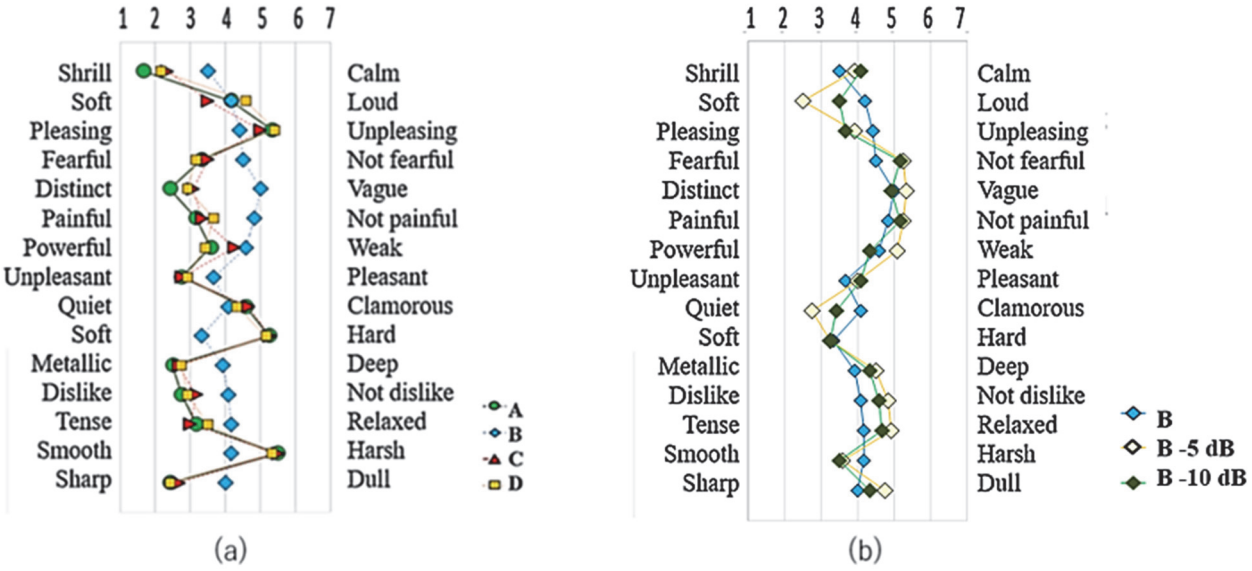

Figure 3: Profiles of stimuli used in the experiment.

4. CONCLUSIONS

We conducted a psychological experiment using semantic differential to facilitate potential modifications of the sounds of dental drills using masker sound. The results showed that overall attenuation of the sound level statistically improved the scale of "soft-loud". Mixture of the frequency components were slightly effective of the scale of "pleasing- unpleasing". The present findings suggest that reducing the sound pressure level and refining the frequency characteristics of sounds emitted by dental drill considering acoustical characteristics is important for creating a comfortable sound environment in dental clinics. The results may help to improve the discomfort feeling in the dental sound environment.

5. ACKNOWLEDGEMENTS

This work was supported by a Grant-in-Aid for Scientific Research (grant number 19K10148 and 22K09999) from the Japan Society for the Promotion of Science.

6. REFERENCES

1. Yamada T, Kuwano S, Ebisu S. A questionnaire survey on the effect of the sound of dental drills on the feeling of patients in dental clinics. *Acoust Sci Tech*, **27**, 305–8 (2006).
2. Yamada T, Kuwano S, Ebisu S, Hayashi M. Statistical analysis for subjective and objective evaluations of dental drill sounds. *PLoS One*, **11**, e0159926, (2016).
3. Yamada T, Nozaki K, Kuwano S, Hayashi M, Impact of COVID-19 on the sound environment in a dental office - a case study. *Proceedings of INTER-NOISE 21*, Washington, USA, August2021.
4. Kuwano S, Namba S, Takehira O, Fastl H., Subjective impression of copy machine noises: An examination of physical metrics for the evaluation of sound quality. *Proceedings of INTER-NOISE 09*, Ottawa, Canada, August 2009.
5. Yamada T, Kuwano S, Ebisu S, and Hayashi M, Effect of processing of dental drill noise on subjective impression, *Appl. Acoust.* **177**, 107895 (2021).