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Original Paper

Effects of the Talking Voice on Annoyance and Cardiovascular Reactivity in Young Females

Miho OKURA[*1] **and Kiyoko FUKAI**[*2]

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Key words: talking voices, blood pressure, annoyance, loudness

Abstract

Nurses are aware of and pay attention to their talking voices as background noise in clinical settings. However, there has been little study on the effect of listening to human voices or dialogue. Therefore, this study was undertaken to determine the effect of human conversation on cardiovascular reactivity and noise annoyance. Thirty healthy, female students (20.07 ± 1.14 years) participated in the experiment. The purpose and protocol of the study were explained, and the participants were asked to sign a consent form. Systolic blood pressure increased significantly when listening to loud voices in groups A ($p<0.05$) and B ($p<0.01$), and when listening to a dialogue on love in group C ($p<0.01$), while diastolic blood pressure increased significantly only during the dialogue on love in group C ($p<0.05$). The subjects in groups A and B assessed the loud voices as significantly louder ($p<0.001$) and more annoying. These results suggest that nurses should be careful not to talk in unnecessarily loud voices. Further research in a more clinical setting is intended in the future.

1. Introduction

The medical environment of patients differs physically and socially from the environment in which they used to live when they were healthy. The physical environmental conditions important in nursing settings include daylight, lighting, color, air, and room temperature, in addition to surrounding noise or sounds. The quality of these environmental conditions does not directly influence recovery from illness, but providing patients with a better medical environment is nonetheless an important aim in nursing care. Most research on patients has analyzed the physical characteristics of sounds that occur around patients[1-4] or showed that patients were annoyed with sounds that occurred in the hospital ward[5-8]. In particular, talking voices ranked high among sounds that bothered patients[5]. Even if talking occurs at a low volume, it cannot be completely eliminated as it is an essential means of communication among patients, relatives, visitors and medical staff in order to implement nursing care and medical treatment. However, if nurses are aware of the sounds and voices that accompany their individual actions, they may be able to lower their voices or make noise less frequently. Even if sounds and voices that do not directly relate to patients are emitted, patient comfort is not compromised if these sounds are kept to a volume and frequency that does not annoy

[*1] Department of Nursing, Faculty of Nursing
Kawasaki University of Medical Welfare, 288 Matsushima, Kurashiki, 701-0193, Japan
E-Mail: mohkura@mw.kawasaki-m.ac.jp
[*2] School of Nursing, The Jikei University

patients. However, research has not yet established the physical and mental influence that human voices have on patients when these voices occur within a context such as the medical setting. Topf (2000) clarified a relationship between health and stress and presented the environment stress model[9]. She focused on stressors in patient environments and stated that "sounds" in particular could act as a psychological and physiological stressor for patients. In addition, Fukai et al. also clarified the stress response to sounds generated by nursing actions using sympathetic nervous system indices such as emotional sweating and circulatory dynamics (blood pressure and heart rate/rhythm)[10]. Changes in blood pressure and heart rate when healthy people engage in a conversation have also been investigated[11]. However, the stress response of the human body caused by the different qualities of talking voices (such as sound pressure level, frequency, and content), with a specific focus on those who listen to these talking voices, has not yet been specified. In addition, Topf pointed out that laboratory research is important because each person perceives sounds differently and it is difficult to carry out research on acoustical environment with respect to hospital patients, taking into account the various characteristics of each patient. Based on the above, in this study, we considered talking voices as part of the acoustical environment from a nursing science viewpoint by first selecting healthy participants so that the findings were not influenced by illness, and then carrying out a basic experiment in a laboratory whereby uniform environmental conditions could be set.

One of the purposes of this study was to consider factors that influence people's impressions, particularly those that are psychologically unpleasant, when they listen to talking voices. Another purpose was to record physical response when listening to talking voices.

2. Methods

2.1 Participants

First, written and oral outlines of the experiment were provided to candidates, and those who agreed were selected. A general health assessment was then carried out on the day of the experiment, and 30 healthy female students (average age, 20.07 ± 1.14 years) with no hearing disorders were finally chosen as participants. These participants were randomly divided into three groups of 10 (Group A, Group B, and Group C), and each group took part in one of these three different experiments (Experiments A-C). This research was carried out with the approval of the Department of Nursing Science, Ethics Committee of the Graduate School of Health Science, Okayama University (04-Y004).

2.2 Current methods and the content of talking voices

In research on sounds, intermittent sounds or continuous sounds are presented to subjects depending on the characteristics of the sounds. However, it is widely recognized that length of the presented sounds has a large influence on the subjects' impressions of the sounds as well as their sympathetic nervous system response[10,12]. For example, humans regard continuous sounds as more unpleasant than single sounds, such as the sound of a door slamming[12], and systolic blood pressure increases when they hear continuous sounds such as those caused by dragging a chair along the floor[10]. In this study, talking voices were used, and these are equivalent to continuous sounds in terms of duration. In addition, it has been reported that three minutes is adequate time to sample data on circulatory dynamics during a conversation[11]. Therefore, in this study, the duration of all voices used in Experiments A to C was set at three minutes.

In Experiments A and B, participants listened to voices presented by changing a combination of sound pressure level. In Experiment C, participants listened to voices presented by changing a combination of the content. In this study, we will first conduct basic experiments on healthy subjects in the controlled environment of a laboratory. In a clinical setting, a variety of talking voices can be heard, some loud, some quiet, some of interest to the patient, and some not. Therefore, we thought that the content of talking voices used in the experiment should be suitable for the characteristics of the subjects while keeping the clinical field in mind. For all of these reasons, the content of the voices to be used in the present study was determined as follows: a voice whose message could not be understood; i.e., a murmur; a voice whose message had meaning; i.e., recitation of a fable, and a conversation about love as a subject that female students have an interest in and often talk about in private conversation; and stock market news in which the subjects were expected to have no interest.

In Experiment A, a "crowd murmur" was used. This is a murmuring noise of numerous men and women chatting while gathered in a meeting room prior to the start of a meeting. Although the sounds can be identified as human voices, the content cannot be understood. Such a "crowd murmur" was presented as soft voices (46 dB) in two cases and as loud voices (76 dB) in one instance by changing the sound pressure level.

In Experiment B, the voice of a young female reader reciting a "fable" (Aesop's Fables: The North Wind and The Sun) was used. The narrative was given at relatively slow speed using standard language in a storytelling style. Participants also listened to this fable being read in a soft voice (47 dB) and in a loud voice (70-75 dB).

In Experiment C, "stock market news" and a "conversation on love" were used. The "stock market news" was recorded from a TV program and read by a female announcer. The "conversation on love" was a free conversation on the subject of love between two close female friends in their early thirties. Participants listened to all voices using headphones.

3. Data collection

3.1 Evaluation of the voices

Based on these three attributes of the sounds, Hiramatsu et al. evaluated the annoyance of environmental sounds using the terms "volume," "loudness," and "annoyance," and they discovered that evaluations of volume and loudness were positively correlated with each other[13]. Therefore, regarding volume and loudness as approximate concepts, two kinds of loudness and annoyance were used in the present study as subjective evaluation indices of psychological unpleasantness of the voices, and each was evaluated using the Visual Analogue Scale (VAS)[14,15].

Concerning the VAS used in this study, several pairs of opposing expressions (such as small and big [where small was 0 and big was 100], etc.) were arranged respectively at the end of each 100 mm straight line, on which the impressions of the voices were marked.

3.2 Measurement of physiological indices

Because heart rate increases when people listen to other people's conversations[16] and systolic blood pressure increases due to sounds generated by nursing actions[11], in this study we recorded electrocardiograms (ECGs) and measured blood pressure as physiological indices of the body's response to the voices. The electrocardiogram was obtained via precordial electrodes, while blood pressure was measured with a blood pressure sensor on the left wrist. In addition to constantly monitoring these signal waveforms, the data were also input to a computer installed with an autonomic activation analysis program (Fluclet, Dainippon Pharmaceutical Co., Ltd.). In order to avoid fluctuation of ECG and blood pressure caused by a reason other than the experimental system, participants were not allowed to move their bodies or hands while the data was being recorded, which happened before, during and after presentation of the voices (3 to 5 minutes each).

3.3 Experimental procedures

Before the experiment, participants underwent assessment of vital signs and simple health interviews to determine general health. Furthermore, audiometry was performed to confirm that the subjects did not have a hearing disorder. In addition, in order to determine their personality traits and psychological conditions, all participants were tested using the Yatabe-Guilford Personality Inventory, the State-Trait Anxiety Inventory (STAI) and the Client-Nurse Relationship Scale (CNRS)[17].

The experiment was carried out in an individual room where equipment was installed. Background sound inside the laboratory measured 44.8-46.3 dB. First, the subjects were asked to sit and put on the necessary sensors and headphones, and then they were made to wait until ECG and blood pressure data stabilized. They were instructed to rest with their eyes closed for three minutes (without moving or speaking) (Figure 1).

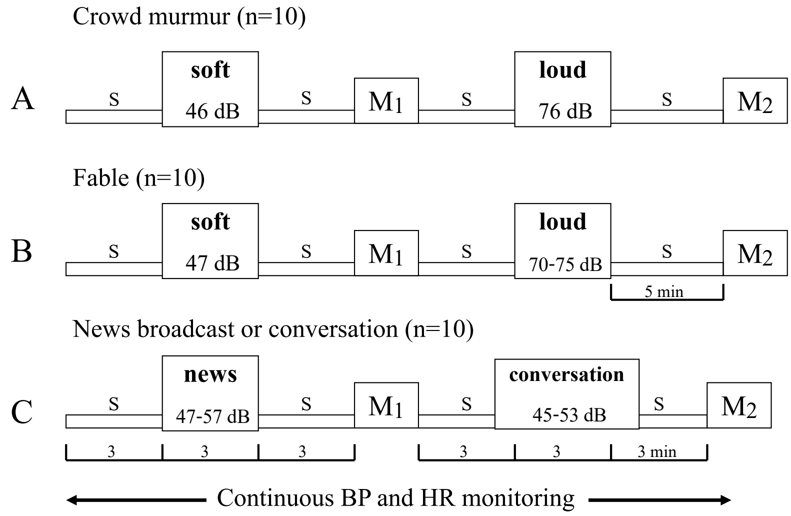

Figure 1 Experimental protocol

S: Silence other than background noise; M: measurement of participants' impressions using questionnaires

During this time, ECG and blood pressure were recorded. Next, under the same conditions, the soft crowd murmur, the soft fable and the stock market news were first presented for three minutes in Experiment A, Experiment B and Experiment C, respectively. Immediately after the end of the voice presentation, three minutes of silence was again provided. Thereafter, participants evaluated the loudness and annoyance of the voices on the VAS. After three minutes of the quiet condition, the loud crowd murmur, loud fable, and the conversation on love were presented for three minutes in Experiment A, Experiment B and Experiment C, respectively. Five minutes of silence was provided after the presentation in Experiments A and B because the presented voices were loud and therefore lingered longer in participants' ears after the presentation, while three minutes of silence was provided for Experiment C because the voice was the same volume as normal speech. After this period, as in the first part of the experiment, participants evaluated the voices.

3.4 Data analysis

ECG and blood pressure signals were input into the computer, converted into an Excel table and analyzed. Statistical software SPSS 20.0J (IBM com.) was used for data analysis. The paired t-test and unpaired t-test were used to verify differences in mean VAS values. In addition, relationships between variables were verified by obtaining the Pearson's product-moment correlation coefficient. Changes in blood pressure and heart rate were evaluated using repeated-measures analysis of variance. The Dunnett (E) post-hoc test was used for posteriori comparison. P-values less than 5% were considered significant.

4. Results

4.1 Subjective evaluation of voices

4.1.1 VAS evaluation of annoyance and loudness

The subjects evaluated the "annoyance" and the "loudness" with respect to each voice in Experiments A to C as shown in Figure 2.

4.1.2 Annoyance

First, when the VAS values for annoyance based on difference in sound pressure level of the voices were compared, participants perceived that loud voices were unpleasant regardless of whether or not there was meaning in the message (Figure 2, A, B, Annoyance). In short, annoyance was significantly greater for the loud murmur (86.9 ± 11.5) than the soft murmur (57.2 ± 14.9) in Experiment A and for the loud fable reading (78.8 ± 17.9) than the soft fable reading (43.3 ± 17.5) in Experiment B ($p<0.001$ for all comparisons).

In contrast, when VAS values for annoyance were compared based on difference in content, the soft murmur was 57.2 ± 14.9 while the soft fable reading was 43.3 ± 17.5; the loud murmur was 86.9 ± 11.5 while

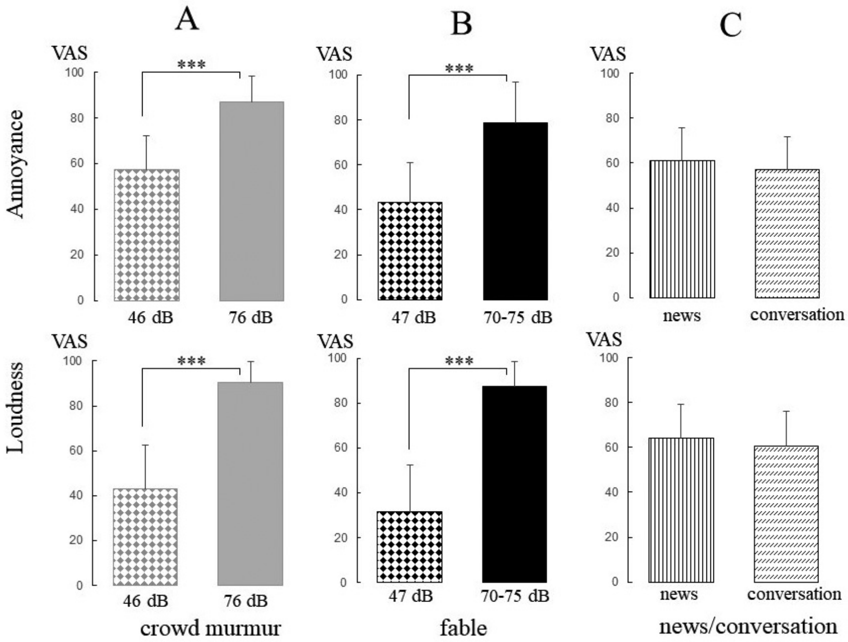

Figure 2 Comparison between annoyance and loudness in relation to various voices

VAS : The Visual Analogue Scale score (0-100). *** p<0.001

the loud fable reading was 78.8±17.9; and the stock market news was 61.0±14.6 while the conversation on love was 57.1±14.7; thus no significant difference was confirmed between either of the two voices in each experiment.

4.1.3 Loudness

Next, VAS values of "loudness" based on difference in the sound pressure level were compared (Figure 2, A, B, Loudness). Participants perceived that loud voices were significantly noisier in the loud murmur (90.6±9.0) than in the soft murmur (43.1±19.6) and in the loud fable reading (87.3±11.1) than soft fable reading (31.5±21.0) (p<0.001).

Furthermore, when VAS values of "loudness" based on difference in content of voices were compared, no significant difference was confirmed between either of the two voices in each experiment: soft murmur, 43.1±19.6 vs. soft fable reading, 31.5±21.0; loud murmur, 90.6±9.0 vs. loud fable reading, 87.3±11.1; and stock market news, 64.1±15.1 vs. conversation on love, 60.8±15.3.

4.1.4 Correlations between annoyance and loudness

In this experiment, VAS values of the six kinds of voices were evaluated based on both annoyance and loudness, and the correlation between these two parameters with respect to each voice was analyzed (Table 1). A strong correlation was observed between annoyance and loudness for each instance of loud murmur, soft fable reading, loud fable reading, and the conversation on love.

Table 1 Correlation between annoyance and loudness of various voices

		Annoyance (VAS)					
		crowd murmur		fable		stock market	conversation
Loudness	(VAS)	46 dB	76 dB	47 dB	70-75 dB	news	on love
crowd murmur	46 dB	0.543					
	76 dB		0.945***				
fable	47 dB			0.634*			
	70-75 dB				0.920***		
stock market news						0.608	
conversation on love							0.961***

* p <0.05 , *** p <0.001

4.2 Physical response to the voices

4.2.1 Blood pressure

Blood pressure when participants listened to the soft murmur in Experiment A was 105.8/56.2 mmHg, 108.6/56.8 mmHg, and 107.9/56.7 mmHg before, during, and after the voice presentation, respectively. Therefore, it did not change remarkably (Figure 3, A). However, for the loud murmur, a significant difference was observed in the systolic blood pressure before the voice (105.4 ± 12.3 mmHg) versus during the voice (111.6 ± 15.5 mmHg) ($p<0.05$), as well as during and after the voice presentation (111.6 ± 15.5 mmHg vs. 106.4 ± 13.8 mmHg) ($p<0.05$) (F (2,7) =4.723, p=0.022) (Figure 3, A).

For the loud fable reading in Experiment B, a significant increase of about 8 mmHg was confirmed in systolic blood pressure between before the voice (103.7 ± 13.5 mmHg) and during the voice (111.8 ± 10.4 mmHg) ($p<0.01$) (F (2,7)=6.469, p=0.008) (Figure 3, B).

In addition, for the stock market news in Experiment C, no significant difference was confirmed between blood pressure during the voice presentation and that before and after the presentation (Figure 3, C). However, systolic blood pressure during the conversation on love was 104.2 ± 14.1 mmHg, 109.3 ± 14.1 mmHg and 108.0 ± 14.7 mmHg before, during, and after the voice, respectively ($F(2,7)=7.243$, p=0.005) (Figure 3, C). Hence, systolic blood pressure increased by about five mmHg ($p<0.01$) during the voice and there was also a significant difference between before and after the voice ($p<0.05$). This means that, for the conversation on love, systolic blood pressure kept increasing for a few minutes after the voice. Moreover, a significant difference in diastolic blood pressure was confirmed between before and after the voice (56.4 ± 12.5 vs. 59.0 ± 12.4) ($p<0.05$) ($F(2,7)=4.871$, p=0.020) (Figure 3, C).

4.2.2 Heart rate

Figure 4 shows changes in the heart rate when the subjects listened to the six kinds of voices. No significant difference was confirmed among the periods before, after, and during each voice. However, when they listened to the loud murmur, which they considered to be the most unpleasant and noisy, heart rate showed a tendency to increase (69.7 ± 7.3/min vs. 71.0 ± 8.9/min). In contrast, when listening to the conversation on love, heart rate tended to decrease slightly (71.1 ± 8.1/min vs. 69.1 ± 7.7/min).

5. Discussion

5.1 Adequacy of the six kinds of voices

In this study, the crowd murmur, the fable, the stock market news and the conversation on love were

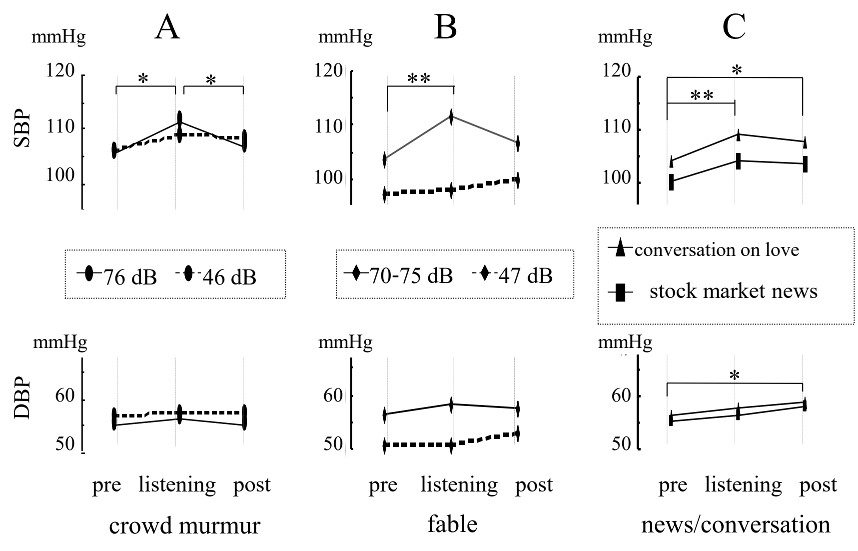

Figure 3 Change in blood pressure while listening to various voices

SBP: systolic blood pressure; DBP: diastolic blood pressure. * $p<0.05$, ** $p<0.01$ (n=10)

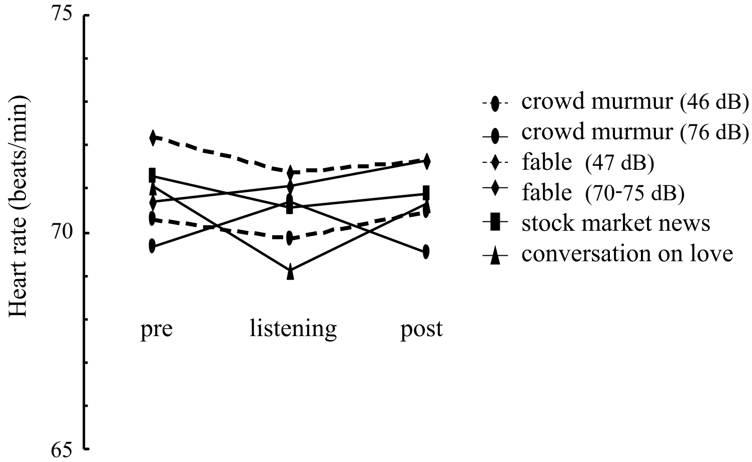

Figure 4 Change in heart rate while listening to various voices

evaluated from the two viewpoints of sound pressure level and content. First, in order to establish the difference in the sound pressure level, a voice with a low sound pressure level was prepared by adjusting volume to around 45 dB, which is normally considered to be the sound pressure level of a whisper. In addition, a voice with a high sound pressure level was adjusted to around 75 dB, which is normally considered to be a loud voice. In fact, sound pressure levels of sounds that occur around patients are about 40 to 90 dB. Taking the medical environment of the patients into consideration, it appears plausible that the six kinds of voices used this time were in the range of background sounds that can be heard daily around patients[1-4]. Baker et al. (1993) divided sounds around patients into four kinds and investigated the influence of these sounds on the circulatory dynamics (the blood pressure and the heart rate) of patients hospitalized in CCU (Coronary Care Unit)[16]. The maximum sound pressure levels of the four kinds of sounds in that study were 67.9 dB with conversation inside a room, 54.9 dB with conversation in a hall, 61.2 dB with environmental sound (bathroom sounds, the sound of a device alarm, etc.), and 49.7 dB with background sound (background noise due to lighting, air conditioning, etc.). The voices and the laboratory background sounds used in the present study had very similar sound pressure levels to the above. In addition, regarding the participants' impressions of the voices that they freely described, one participant commented, "It bothered me very much because I didn't understand what the sounds were", concerning the soft murmur and the soft voice reciting a fable. Regarding the loudness of the sounds, seven people commented that the loud murmur and the loud fable reading were "noisy". Based on the above, and taking into account participants' impressions and changes in blood pressure and in heart rate based on difference in sound pressure level, it seems plausible that the voices used in this experiment were appropriate for this research.

One participant who listened to the murmur noted that, "It was hard to listen to". In addition, concerning the fable reading, there were descriptions such as "I felt at ease because I was able to understand what the reader was talking about" and "I was absorbed in the story", and thus we appeared to have enabled comparison based on whether the talking voices made sense or not.

However, although we tried to consider the difference in influence on participants' impressions and physical responses based on whether they were interested in the story or not, three out of 10 people answered that they were "not interested (they did not think the story was interesting)" in the "conversation on love". Therefore, the content was inappropriate for consideration based on interest. This study revealed that, for groups of participants who have comparatively similar characteristics, preliminary experiments need to repeat a spare experiment to examine the validity of the contents of the story.

5.2 Subjective evaluation of the voices

Hiramatsu et al. evaluated 59 kinds of sounds of environmental sounds and artificial sounds and found a strong correlation between magnitude of sound pressure and the perception of noisiness[13]. That study also found that the perception of annoyance was only weakly correlated to sound pressure level[13]. Furthermore, Shimai et al. investigated the relationship between evaluation of annoyance and sound pressure level of environmental sounds; they noted that people felt more uneasy as the sound pressure level increased[18]. In other words, it is evident that the sound pressure level has a certain influence on impression of sounds. As for psychological unpleasantness caused by voices, this study revealed that VAS scores for the loud voices were significantly higher than those for the soft voices; participants perceived the loud voices as fairly annoying and loud (Figure 2, Table 1). This means that these voices have the same impression on people as environmental sounds and artificial sounds. In addition, when the sound pressure level was high, no significant difference was confirmed between the fable reading and the murmur, for either annoyance or loudness. This indicates that when people listen to a loud voice, whether the voice makes sense does not influence the levels of annoyance and loudness.

Participants' impressions of the voices included some interesting statements that could be used to direct research in the future. For example, one person stated that "I was absorbed in the recitation although it was loud" when the fable was read in a loud voice. This can be also presumed based on the fact that patients' negative impression of sounds decreases after they are provided with an explanation of the sounds[1]. In addition, for the soft murmur, one person perceived that it was "comfortable" and another that it "made me feel I'm not alone." It can therefore be presumed that patients undergoing medical treatment in a private room or on an open ward such as ICU may feel the comfort of someone being with them on hearing a voice, even though they do not understand what the voice is saying. They may feel more comforted in an environment with some sound than in a silent environment. In the present study, since it was presumed that various uncertainties might occur when the experiments were carried out on patients, we tried to perform basic research under conditions in which many variables as possible could be controlled. Hence, it was understood that, even though participants perceived the voice as loud and annoying, once the story had been heard, impressions included positive as well as not negative impressions. This suggests that the impression that people form after listening to a voice could also be influenced by the hearer's characteristics and situation.

5.3 Physical response to voices

Research on physical response to a voice has not yet been reported with respect to normal day-to-day life. This is because voices do not seem to be a big problem in daily life. However, information on the physical and mental influence of such voices on patients who have to live away from their normal place of residence is important for nurses.

In the early days of this kind of research, Lynch et al. (1974) revealed that a patient's heart rate temporarily increased when he listened to his wife's voice on the phone as well as when he was receiving treatments from doctors and nurses[19]. In addition, Baker et al. (1993) considered the influence of Room Conversation, Hall Conversation, environmental sound and Background Sound on circulatory dynamics (blood pressure and heart rate) of patients hospitalized in CCU[16]. Conversations used by Baker et al. were those that patients only listened to and did not contribute to. In the appearance rate of each sound, sound pressure level and heart rate, the maximum value was observed when the subject listened to conversation inside a room, but type of sound did not influence blood pressure.

However, another study evaluated both changes in blood pressure and heart rate while subjects both engaged in talk and just listened to a conversation[11]. That study found a larger change in blood pressure and heart rate when participants talked than when they listened.

Hence, most conventional research has shown that listening to voices talk had little effect on blood pressure but significantly increased heart rate[11,19-21]. Therefore, the same results were expected in the present study; however, the heart rate did not change significantly in response to hearing any of the six kinds of voices that we evaluated. In contrast, systolic blood pressure rose by about 6 mmHg when subjects listened to the loud murmur and by about 8 mmHg when they listened to the loudly recited fable, thus a significant increase was confirmed in each of these scenarios. The increase in the blood pressure caused by listening to loud human voices was experimentally established for the first time in this study. On the other hand, no remarkable change was observed in heart rate and the blood pressure in response to soft voices. This may be because the present study was basic research rather than conventional research. That is to say, it was very possible that the following two facts affected the outcome: 1) The subjects were healthy, and 2) although the content of the conversation was determined on the basis of what we assumed the participants would be interested in, what patients find interesting (such as topics that relate to their disease and therapy, etc.) may differ among listeners. In any case, the present findings indicate that unnecessarily loud voices increase blood pressure regardless of whether the listener is interested in the content of the conversation. This suggests that loud voices can be a stressor for patients hospitalized in ICU or CCU, whose circulatory dynamics are unstable.

6. Conclusion

In this study, a basic experimental research design was used to investigate listeners' impressions of and physical response to voices. When people listened to voices whose sound pressure levels were high, perceptions of unpleasantness and noisiness increased. In fact, participants formed the same impression of these voices as they did of natural or artificial environmental sounds to which they listened daily. In addition, systolic blood pressure increased when participants were highly interested in the content of a conversation, suggesting that such voices could be stressors for patients. However, for the voices used in this study, only content and sound pressure levels were taken into consideration, and acoustic parameters such as frequency and tone were not considered. In addition, since humans were the source of the voices, the relationship between the person speaking and the listener could influence how the listener perceived the voice. In the future, by constructing an experimental system that takes into consideration environmental factors such as the characteristics of the hospital ward and hospital room, the conversation content in which patients are interested, the individual characteristics of each patient, and the relationship with the conversation partner, we aim to consider whether voices can become psychological and physiological stressors for patients.

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