Comparison of Emotional Impacts of Interaction with Remote Controlled Plush Media and Those with Video Call Applications

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***Abstract*—We examined if interactions with remote controlled plush media (stuffed animals) have different emotional impacts from those with video call applications. We compared autonomic reactions to interaction between them by the analyses of heart rate and heart rate variability.**

***Keywords*—Remote controlled media; heart rate; heart rate variability**

I. INTRODUCTION

Along with recent popularization of remote controlled media, technical development for smoother interactions between humans and remote controlled media has been desired. Remote controlled media is useful as a technology that contributes to health promotion and medical and nursing care support by consolidating knowledge of networks, hardware, and software such as wireless communication. In this stream, a variety of video call applications and robots have been developed and used as the remote media. However, less attention has been payed to the impact of media characteristics on the quality of interaction.

In the present study, we compared the emotional impacts of interaction through remote controlled plush media and those with video call application. We analyzed the differences in heart rate responses and heart rate variability (HRV) during interactions between a plush of bear and a notebook computer screen displaying its image.

II. METHODS

A. Study Subjects

The protocol of this study was approved by institutional review board of Nagoya City University Graduate School of Medical Sciences and Nagoya City University Hospital (#60160135).

The subjects of this study were healthy men (n = 5, 65 ± 16 [40-77] yr) and women (n = 13, 64 ± 14 [25-81] yr). They displayed a normal sinus rhythm on electrocardiogram (ECG) at rest. All of them gave their informed consent to participate in this study. Participants with older ages were chosen because, in the aged society, the opportunities for elderly people to communicate with families through remote media are thought to increase.

B. Remote Controlled Media

We compared the effects of interactions with two different remote controlled media (Fig. 1). One was a plush of bear (Bear-chan, Takara Tomy, Co., Ltd, Tokyo, Japan), which was chocolate brown stuffed bear with 23-cm sitting height. In this plush bear, an analog 2.4-GHz frequency-modulation wireless system for voice transmission (the maximum communication distance with the receiver, 7 m) is installed in the lower part of the body. In this system, negotiation of transmission and reception and allocation of channels are performed automatically. The head of plush bear has a structure that allows swinging and lip opening and closing according to voice, which make the plush bear feel like it is interacting. We also attached to the plush bear a small microphone of a high sensitivity wireless audio hearing system (Sky Voice II, Ibuki Electronics, Co., Ltd, Kawasaki, Japan) so that smoother

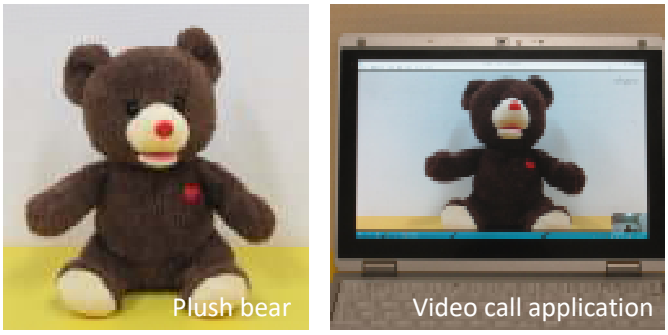

Fig. 1. Remote controlled media used in this study.

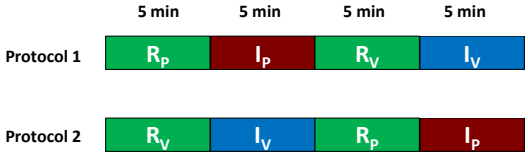

Fig. 2. Study protocol. R_P and R_V, rest before interaction with plush bear and video call system; I_P and I_V, interaction with plush bear and video call

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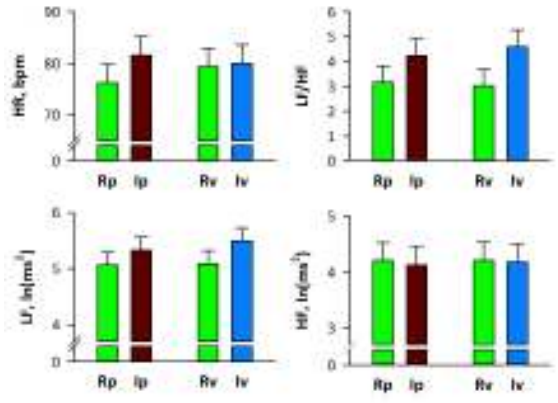

Fig. 3. Heart rate and HRV indices. Data are least-square mean and SEM adjusted for the effects of age and sex.

TABLE I. STATISTICAL ANALYSIS

Variable	Fixed effects			Multiple comparisons		
	Condi-tion	Age	Sex	R_P vs I_P	R_V vs I_V	I_P vs I_V
Hear rate	0.0008	0.4	0.1	0.0002	0.6	1
LF	0.007	0.01	0.5	0.1	0.01	0.6
HF	0.9	0.5	0.8	1	1	1
LF/HF	0.006	0.06	0.5	0.1	0.01	1

Data are P values

TABLE II. RESPONSES TO QUESTIONARE ABOUT INPRESSIONS

	Plush bear	Video call application	P
Familiar	2.5 ± 0.2	1.9 ± 0.2	0.004
Significant	1.4 ± 0.3	1.1 ± 0.3	0.3
Natural	1.7 ± 0.2	1.2 ± 0.2	0.1
Complex	0.3 ± 0.3	0.4 ± 0.3	0.7
Interesting	2.3 ± 0.2	1.8 ± 0.2	0.003
Likable	2.1 ± 0.3	1.7 ± 0.3	0.08
Not bored	1.1 ± 0.3	1.1 ± 0.3	0.8
Humane	1.6 ± 0.3	0.9 ± 0.3	0.01
Good	2.1 ± 0.2	1.7 ± 0.2	0.03
Intelligent	1.5 ± 0.2	1.4 ± 0.2	0.7

simultaneous two-way communication can be made.

The other remote media (for control) was a video call system (Skype). We used a notebook computer (Let's note CF-RZ4, Panasonic Co., Ltd, Osaka, Japan) whose screen displayed the image of the plush bear speaking in a separate room.

C. Study Protocols

Figure 2 illustrates the protocol of this study, which consisted of two sessions of 5-min sitting rest periods (R_P and R_v) followed by 5-min interaction periods through two different media (I_P and I_V). A half of subjects performed interaction with the plush bear first (protocol 2) and the rest of subjects performed interaction with the video call system first (protocol 2), so that the order effects are counterbalanced. During the entire 20-min experiment, electrocardiogram (ECG) was recorded continuously with a Holter ECG recorder (Cardy 303 pico+, Suzuken Co., Ltd, Nagoya, Japan), by which ECG signals were digitized at 125 Hz and stored. Additionally, after finishing interaction session with each media, participants were asked about impression to the media through a questionnaire consisting of 10 items with 7-stage Likert scale.

D. Data Analysis

Digitized ECG data were transferred to a Holter ECG analyzer (Cary Analyzer 05, Suzuken Co. Ltd., Nagoya, Japan), on which all QRS waves were detected and normal-to-normal R-R interval (N-N interval) time series data were obtained. Then, the time series data were segmented into four periods (R_P, I_P, R_V, and I_V) for the analysis of heart rate and HRV. We computed the power of the low-frequency (LF, 0.04-0.15 Hz) and the high-frequency (HF, 0.15-0.40 Hz) components and LF-to-HF power ratio (LF/HF). The power of LF and HF components was transformed into the natural logarithmic value.

E. Statistical Analysis

Statistical Analyses System version 9.4 (SAS institute Inc., Cary, NC, USA) was used for statistical analysis. We used the mixed-model analyses of variance (ANOVA) for repeated measures with condition (R_P, I_P, R_V, and I_V), age, and sex as fixed effects and subject as random effect. For the responses to questionnaire, scale score to each item was compared between I_P and I_V with paired t-test. $P < 0.05$ was considered to be statistically significant.

III. RESULTS

Figure 3 shows the least square means of heart rate and HRV indices and table I shows the results of statistical analyses. Interaction through the plush bear increased heart rate while interaction through the video call system did not change it. Conversely, interaction through the video call system increased LF power and LF/HF, while interaction through plush bear did not change these variables.

Table II shows the responses to questionnaire about impressions to the media. The participants had more familiar, interesting, humane, and good impressions to real plush bear than to video call system displaying its image.

IV. DISCUSSION

To investigate the difference in emotional impacts of interactions with the characteristics of remote controlled media, we compared the autonomic functions during interaction through a plush bear and a video call application. We observed a significant increase in heart rate with interaction through the plush bear, while there was no significant change with interaction through the video call system. These observations support the hypothesis that difference in media characteristics causes difference in the emotional responses during interaction through remote controlled media.

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These are several possibilities for the mechanisms of heart rate increase with communication through plush bear. Emotional responses are often explained by two-dimensional model with the horizontal axis representing the valence or pleasant dimension and the vertical axis representing the arousal or activation dimension [1]. In this model, the changes in emotion along the vertical (arousal) axis may increase heart rate, i.e., such as happiness and angry. The suppression of respiration during verbal communication may also cause an increase in heart rate. Because the participants reported more familiar, interesting, humane, and good impressions to plush bear than video call system, it may have caused higher arousal level and/or greater respiratory suppression by richer conversation.

We observed that LF power and LF/HF increased with interaction through the video call system but not with that through the plush bear and that neither interaction changed HF power significantly. Due to the difference in the mechanism of signal transduction between sympathetic and parasympathetic (vagal) heart rate regulation, sympathetic nervous system cannot cause heart rate fluctuation >0.15 Hz, while parasympathetic system can mediate up to ~1 Hz of heart rate fluctuation [2]. Thus, HF component reflects heart rate fluctuations mediated purely by the vagus, while LF component could reflect the influences of both vagus and sympathetic nervous system [3]. Therefore, HF power is generally interpreted as an index of parasympathetic function and LF/HF as sympathetic and parasympathetic balance. These seem, however, inconsistent with our observations of increased heart rare only during the interaction with plush media. This discrepancy may be attributable to the effects of speaking on HF power that reflects respiratory modulation of heart rate [4] and thus, could be confounded by irregular respirations during speaking [5]. To overcome this problem, autonomic assessment with the other measures seems necessary.

V. CONCLUSIONS

Media property is an important factor affecting emotional responses caused by interaction through remote controlled media.

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