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# Study on relationship between warmness of speech and valence, activation or dominance

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## Abstract

To communicate a robot with a warm voice like humans, it is necessary to understand the characteristics of the warm voice of humans. However, these are not explained clearly yet. In this study, we examined warm voices based on the idea of a multilayer model. We carried out three listening experiments evaluation experiment for warmness for the first layer, evaluation experiment of valence, activation, and dominance for the second layer, and evaluation experiment of semantic primitive for the third layer. Then we examined relationships between the layers of the model. As a result, it was found that the warm voice had a strong positive correlation with Valence. When dominance ratings were low or high, the warmness rating was low. If the dominance rating was close to 0, the warmness rating was high. Moreover, the warm voice had a high positive correlation with Bright and a high negative correlation with Dark, Low and Heavy.

## 1. Introduction

Currently, the proportion of elderly people is increasing in Japan. The use of communication robots in medical care settings is thus desired due to the shortage of human resources. However, communication robots currently only have inorganic voices, causing many people to distrust them. To make the robots trustier, the voice quality of synthesized speech for the robot should be improved.

Interpersonal communication also conveys personality information and non-verbal information. Especially, the voice quality of speech is an important clue for impressive evaluation. However, there are few examples that describe psychologically and physically how medical care workers speak to patients and what voice quality is suitable for them. In order to reassure patients, caregivers and nurses are expected to be able to speak with warm voices to their patients.

The purpose of this study is to explain psychological characteristics of warm voices.

## 2. Multi-layer model of warm voice

We assume that variations in warmness were influenced by the way of expressing the voice. Thus, we examined variations in voices for emotional expression databases, because emotional voices are typically and widely expressed voices

Based on the multi-layer model for emotion perception, a model for perceiving warm voice is constructed to explain warmness. On emotion perception, Huang and Akagi [1] examined the correspondence between emotion categories and semantic primitives (SPs) and found 17 optimal adjectives. Liu et al [2] examined correspondence between valence (V), activation (A) and SPs and determined twenty-eight optimal adjectives. As a result, it was shown that the 17 adjectives introduced by Huang and Akagi [1] are included in the 28 adjectives. Elbarougy and Akagi [3] examined correspondence between the 17 semantic primitives and 16 acoustic features introduced by Huang and Akagi and examined high correlations between them.

Following these studies, this study investigates relationships between warmness and emotion dimensions (V, A and Dominance (D)) and the 17 SPs introduced by Huang and Akagi [1] and defines the warm voice by constructing a multilayer model as shown in Fig. 1. Evaluation experiments are performed to construct a multi-layer model. To construct the first layer, we conduct an experiment to evaluate warmness. Experiments to evaluate V, A and D are performed to investigate relationships between the first and second layers. Evaluation experiments on SPs are performed to investigate relationships between the second and third layers. We describe the methodology of these experiments in the next section.

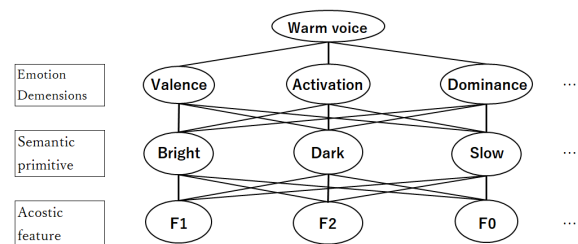


Figure 1: multi-layer model of warm voice

### 3. Methodology

The experimental procedures are shown below. First, an experiment to evaluate the warmness is performed to construct the first layer. To examine relationships between the first and the second layers, we conduct evaluation experiments on V, A and D and examine the correlation between warmness and the emotion dimensions. To examine relationships between the second and third layers, we conduct evaluation experiments on SPs and examine the correlation between emotion dimensions and semantic primitives. Furthermore, referring to these results and the report of Elbarougy and Akagi [3], relationships between the third and fourth layers are considered, and the acoustic features concerning with the SPs are discussed.

#### 3.1 Evaluation experiment for warm

The purpose of this experiment is to evaluate impressions of warm for the first layer in the model. Owing to compare various expression methods, we focused on differences in emotional expression.

##### 3.1.1 Stimuli

Emotional voices recorded in JAIST-ESD emotional speech database were adopted. The speakers were five females who were teachers and students in the same voice actor training school, with different training periods. The word for utterances was /oniichan/(お兄ちゃん). Emotion categories are seven, "joy, anger, sadness, surprise, disgust, and relaxation", and each emotion is expressed in three levels "slight, normal, and very". The experiment is performed using 110 voices with neutral ((7 types x 3 levels + neutral) x 5 speakers).

##### 3.1.2 Experiment procedure

We asked 10 native Japanese (7 males and 3 females) as listeners to evaluate warmness. In the experiment, 110 stimuli were presented randomly. Evaluation was performed on a scale of 0 to 4.0 from "not warm at all" to "extremely warm". The experiment was done in a soundproof room using a PC (Windows 10, MATLAB) and headphones (AKG K272 HD).

##### 3.1.3 Results

The evaluation value of warmness of neutral voice of each speaker was shown in Table1. The average value of the warmness evaluation was shown in Table 2 and the histograms in Figure 2. As the histogram for each speaker, evaluation values on warmness differs depending on the

emotion. Regarding the feelings of "joy" and "relax", warmness was highly evaluated for all speakers. The feelings of "anger" and "disgust" were evaluated for all speakers as low. However, Values of warmness were different among the speakers. In the case of Speaker1, the neutral speech had lower evaluation than that of the other speakers, and the overall evaluation was lower. Even positive emotions are difficult to evaluate as warm. Conversely, the voices of Speaker3 and Speaker5 have higher warmness value on neutral speech compared to that of other speakers, and the overall rating was higher. Also, warm values were higher on voices even with negative emotions. The results suggested that the impression of warmness differs depending on speakers as well as emotion categories.

Table 1: The evaluation value of warmness of neutral voice of each speaker

Speaker1	Speaker2	Speaker3	Speaker4	Speaker5
0.65	0.82	1.67	0.81	1.31

Table 2: The average value of the warmness evaluation of each speaker

Speaker1	Speaker2	Speaker3	Speaker4	Speaker5
1.00	1.19	1.47	1.38	1.71

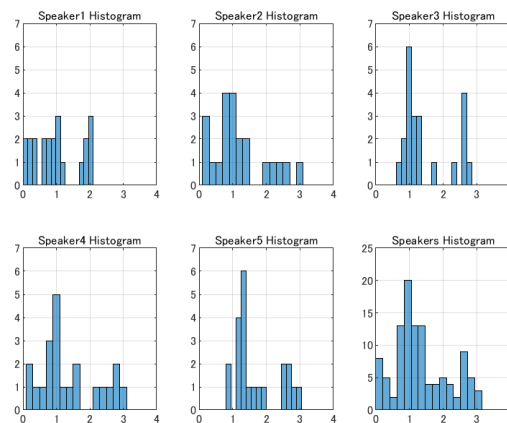


Figure 2: Histogram of average value of warm evaluation

### 3.2 Evaluation experiment of valence, activation and dominance

The purpose of this experiment is to evaluate impressions of V, A and D for the second layer in the model. By examining the relationship between warmness

and V, warmth and A, warmth and D, relations between the upper layers of the multilayer model can be constructed.

### 3.2.1 Stimuli

Experimental stimuli used were the same as those described in 3.1.1.

### 3.2.2 Experiment procedure

The experiments for VAD evaluation were conducted with 10 native Japanese (seven males and three females) as listeners. The experiment was performed separately for each evaluation item. 110 stimuli were randomly presented in each session. Self-Assessment Manikin (SAM) [4] was used as an index of the axis of the VAD emotion space. V was performed on a scale of -2.0 to 2.0 from "very negative" to "very positive". V was performed on a scale of -2.0 to 2.0 from "very negative" to "very positive". A was performed on a scale of -2.0 to 2.0 from "very calm" to "very excited". D was performed on a scale of -2.0 to 2.0 from "very weak" to "very strong". The experiment was carried out in a soundproof room, and a PC (Windows 10, MATLAB) and headphones (AKG K272 HD).

### 3.2.3 Results

Figure 3 shows the relationship between warmth and V evaluations. The higher V ratings are, the higher the warmth ratings are. The correlation coefficient is 0.78, indicating a high positive correlation.

Figure 4 shows the relationship between warmth and D evaluations. The distributions are different when the average warmth score is higher or lower than 1.5. When the warmth value is higher than 1.5, D evaluation value converges to the center. When the evaluation of warmth is lower than 1.5, the evaluation value of D is dispersed. This suggests that, if D is too high or too low, we do not feel warmth.

Figure 5 shows the relationship between the evaluations of warmth and A. The correlation coefficient between values of A and warmth was 0.12. No relationship was obtained.

### 3.3 Evaluation experiment of semantic primitive

The purpose of this experiment is to evaluate semantic primitives (SPs). The middle part of the multilayer model was constructed by showing the relationships between V, A and D and SPs.

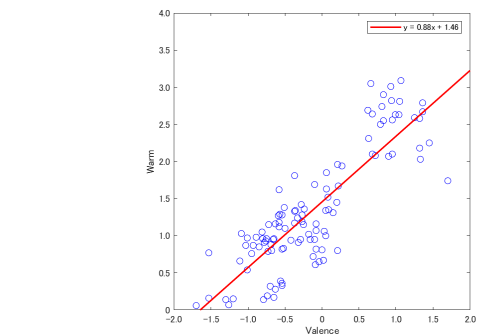


Figure 3: the relationship between the evaluation of warmth and the evaluation of valence

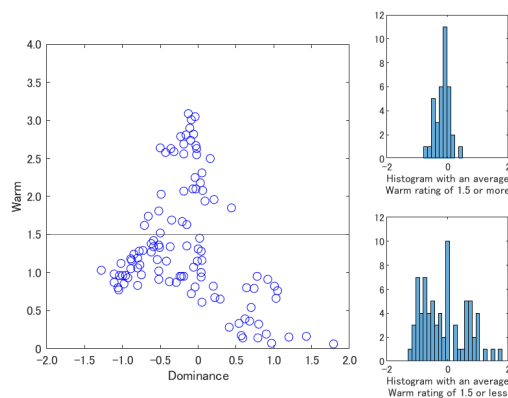


Figure 4: the relationship between the evaluation of warmth and the evaluation of dominance

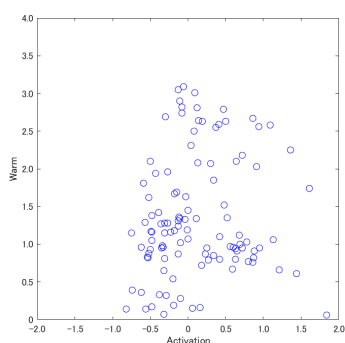


Figure 5: the relationship between the evaluation of warmth and the evaluation of activation.

### 3.3.1 Stimuli

Based on the results of the warmth evaluation experiment, 17 voices with a high warmth rating, 18

voices with a low warmness rating, and 5 neutral voices were selected. A total of 40 stimuli were used.

### 3.3.2 Experiment procedure

Ten native Japanese (seven males and three females) were chosen as listeners. The evaluation items were the 17 adjectives (Bright, Dark, High, Low, Strong, Weak, Heavy, Sharp, Noisy, Quiet, Clam, Unstable, Clear, Well-modulated, Monotonous, Fast and Slow) introduced in the research of Huang and Akagi [1]. The experiment was divided into two sessions. In each session, seven to 10 SPs were evaluated. The stimuli were presented randomly. For each SP, 40 stimuli were evaluated on a five-point scale: 0-Dode not feel at all; 1-Seldom feels; 2-Feels a little; 3-Feels; 4-Feels very much. The experiment was performed in a soundproof room, and a PC (Windows 10, Matlab) and headphones (AKG K272 HD).

### 3.3.3 Results

The correlation coefficients (CC) between VAD and SPs were calculated, as shown in Table2. In the table, orange color indicates the high positive correlation and light blue indicates the high negative correlation. V has high positive correlations with Bright, while high negative correlations with Dark, Strong, and Heavy. A has high positive correlations with Unstable and Well-modulated. D has high positive correlations with Strong, Heavy, and Noisy. Considering the correlation coefficients between SP and warmness, it was found that there was a high positive correlation between warmness and Bright and that Dark, Low, and Heavy has a high negative correlation with warmness.

## 4. Discussion

The results so far have shown the relationship between the upper and middle layers of the multilayer model. Warm voice had a high correlation with V, and V had a high correlation with Bright. This revealed the materials that make up the warm voice multi-layer model. The relationship between the lower layers will be explained with reference to previous results and previous research. Elbarougy and Akagi [3] reports that Bright has a positive correlation with power range, the F0 contour, highest F0 and a negative correlation with the first formant frequency. Dark, Low and Heavy all showed opposite results. This shows that acoustic features such as the power range, the F0 contour, highest F0 and the formant frequency are correlated with warm voices.

## 5. Summary

This study discussed characteristics of warm voices using the concept of a multilayer model. We conducted three listening experiments, evaluation experiment for warm, evaluation experiment of V, A and D, and evaluation experiment of semantic primitive, and examined the relationship between each layer. As a result, it was found that the warm voice had a strong positive correlation with Bight and a strong negative correlation with Dark, Low and Heavy.

Table 3: 17 candidates for semantic primitives and CC

CC	Valence	Activation	Dominance	Warm
Bright	0.84	0.51	-0.61	0.83
Dark	-0.82	-0.54	0.58	-0.82
High	0.52	0.64	-0.40	0.53
Low	-0.68	-0.49	0.60	-0.72
Strong	-0.75	0.46	0.87	-0.65
Weak	0.57	-0.35	-0.70	0.58
Heavy	-0.79	-0.24	0.74	-0.78
Sharp	-0.48	0.67	0.63	-0.42
Noisy	-0.61	0.67	0.78	-0.51
Quiet	0.49	-0.54	-0.65	0.54
Clam	0.47	-0.67	-0.59	0.46
Unstable	-0.47	0.73	0.66	-0.43
Clear	-0.19	0.66	0.36	-0.16
Well-modulated	0.04	0.75	0.22	0.10
Monotonous	-0.16	-0.55	-0.01	-0.30
Fast	0.22	0.29	-0.17	0.20
Slow	-0.18	-0.24	0.20	-0.15

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