Characterizing Model for *KANSEI* Robot Based on the Tendency of Treatment from User

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Abstract: Recently, many types of robots have been developed for not only industrial manufacturing but also interacting with human. Robots designed for human-robot interaction are expected to have the ability of communicating with human smoothly. In this paper, we propose the character giving model for *KANSEI* robot. This model makes robots individual-beings that are varied with each user. We aim to develop more humanly and empathetic robots by using this model. Robots dynamically get their own characters based on the tendency of user's behaviors which are classified into two dimensions: dominance-submission and acceptance-rejection. Through the interaction experiments between human and the robot with the proposed model, we confirmed that proposed model could give various characters to the robot, and the character, which was given through the communication with a user, suited for each of the users.

Key words: KANSEI ***robot,parent-child relationships,character giving***

1 Introduction

Recently, varied robots are used in not only manufacture fields but also communication with humans, such as PaPeRo [1] and wakamaru [2]. Communication robots are expected to take care elderly people and heal humans' hearts. Therefore, they should have abilities to communicate with human smoothly. Many studies that intend to give the robots these abilities have been reported. Yokoyama [3] analyzed appearance timings of non-verbal information in communications between fellow humans. And they used these timings for controlling non-verbal information of robots. Takada [4] proposed the system controlling robots' facial actions. That system outputs facial actions in compliance with humans' behaviors.

In this paper, we aim to improve humanities of robots and propose the robots that have own individualities. We can see varied kinds of individualities on humans' behaviors such as a gesture, an accent and a character. We focus on "characters." In case of humans, it is thought that the characters are modeled by communications with humans and their own environments. Therefore, we propose the robots that make their own characters from communications with humans and their own environments. It is thought that communication with familiar person is more delightful than communication with unfamiliar person. So we aim to make the robot more empathic by changing the robot's characters based on communications with users.

Fig. 1 shows the overview of our character giving model. Robots store the tendency of user's behaviors and make their own characters based on the stored tendency. Their own characters are expressed by the tendency of robots' emotions. Robots show their emotions by facial expressions. We conduct the interaction experiments between humans and the robot with the proposed model, and make sure that this model has the ability to give robots various characters and improve humanities of robots.

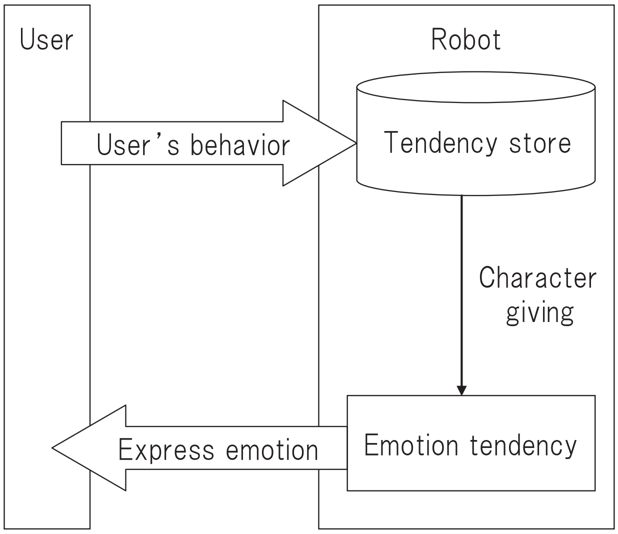

Fig. 1. Overview of character giving model.

2 Character Giving Model

In the field of personality psychology, it has been known that there are many kinds of cause to give children their own characters. In this paper, we give robots their own characters based on parental behaviors.

2.1 Parent-Child Relationships

The character giving model is based on that in a book, “The Psychology of of Parent-Child Relationships [5]”. In this book, Symonds reported about relationships between parental behaviors and children’s characters. He classified parental behaviors into two dimensions: dominance-submission and acceptance-rejection. The tendency of these behaviors makes children’s characters. Fig. 2 shows relationships between parental behaviors and children’s characters. For example, the tendency to dominance and acceptance is defined as “overprotection.” In this tendency, the child is characterized as overdependent and infantile.

In the proposed model, user’s behavior classified into four different types: dominance, submission, acceptance and rejection. The tendencies of user’s behavior dynamically characterize robots.

2.2 Character Expression

Saitoh [6] reported about relationships between interpersonal behaviors and emotions. In this paper, we use these relationships as the relationships between user’s behaviors and robot’s emotions. Saitoh classified interpersonal behaviors and emotions into eight different types. We use four behaviors and four emotions in Saitoh’s classification. We think these behaviors correspond to parental behaviors. These emotions correspond to behaviors that we selected. Table 1 shows the relationships between behaviors and emotions.

We think it is hard that robots give the impression humanly when robots evenly show emotions based on this relationships. So, we propose the method for characterizing robots. In this method, robots show emotions based on expressional tendencies varied by their characters. We aim to improve humanities of robots with this method. In this paper, we treat robots’ characters as expressional tendencies. We aim to express characters defined by Symonds by increasing expressional tendencies corresponding to users’ behaviors.

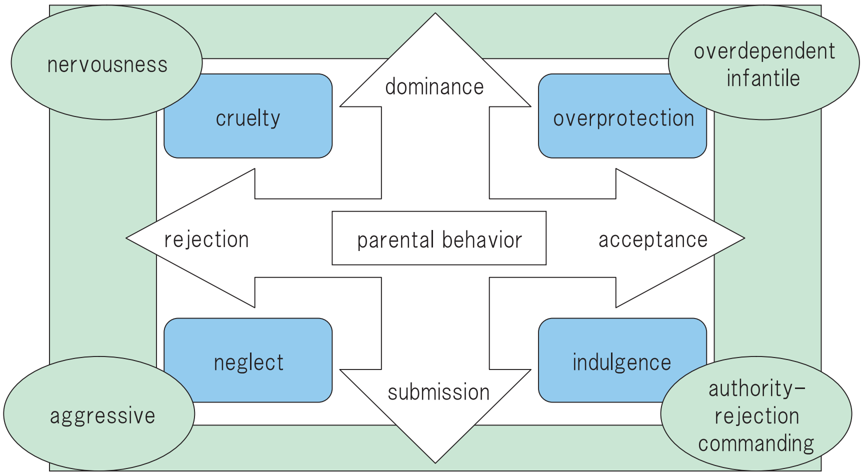

Fig. 2. Relationships between parental behaviors and children's character.

2.3 Communication Model

Fig. 3 shows the proposed model to give robots their own characters. First, a robot shows actions to an user. Second, the reaction of an user was assessed by one of interpersonal behaviors. A robot stores interpersonal behaviors classified into four different types, where are shown by Table 1, and increases expressional tendency of an emotion corresponding to interpersonal behaviors. Finally, a robot shows facial expression to express an emotion chosen by expressional tendencies and interpersonal behaviors. We define this flow as an interchange. Human-robot communication is constructed by repeating this interchange.

We describe the tendency to inferiority as T_1, superiority as T_2, affection as T_3 and antipathy as T_4. These tendencies are defined as:

$$T_1 = \begin{cases} (D-S)*a & \text{if } D > S \\ 0 & \text{if } S \geq D, \end{cases} \tag{1}$$

$$T_2 = \begin{cases} (S-D)*a & \text{if } S > D \\ 0 & \text{if } D \geq S, \end{cases} \tag{2}$$

$$T_3 = \begin{cases} (A-R)*a & \text{if } A > R \\ 0 & \text{if } R \geq A, \end{cases} \tag{3}$$

$$T_4 = \begin{cases} (R-A)*a & \text{if } R > A \\ 0 & \text{if } A \geq R, \end{cases} \tag{4}$$

where D, S, A and R are a number of dominance, submission, acceptance and rejection, respectively. a is a constant defined as strength of expressional tendencies. Here, P_0 represents the probability of expressing an emotion

Table 1. Relationships between Interpersonal Behaviors and Emotions

interpersonal behaviors	emotions
dominance	inferiority
submission	superiority
acceptance	affection
rejection	antipathy

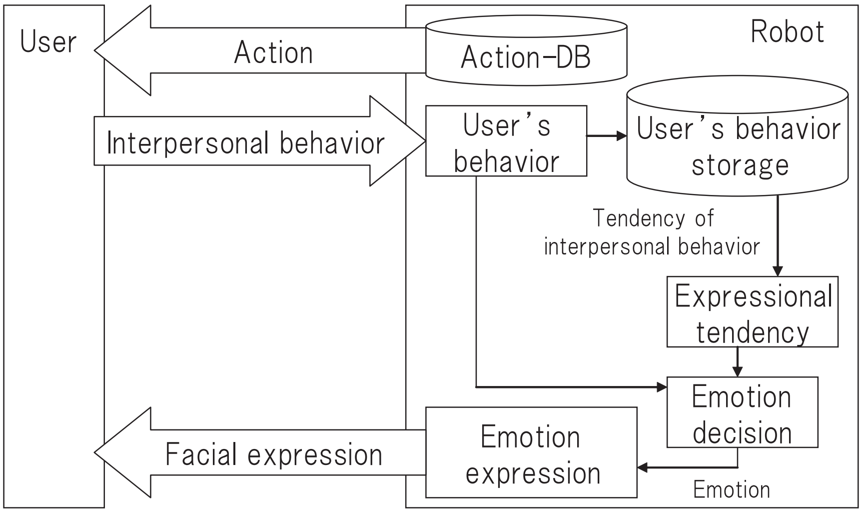

Fig. 3. Structure of character giving model.

based on the relationships shown by Table 1. And we describe the probability of expressing an inferiority as P_1, a superiority as P_2, an affection as P_3 and an antipathy as P_4. Then these probabilities are calculated as:

$$P_0 = \frac{n}{n + T_1 + T_2 + T_3 + T_4}, \tag{5}$$

$$P_i = \frac{T_i}{n + T_1 + T_2 + T_3 + T_4}, \tag{6}$$
$$(i = 1, 2, 3, 4)$$

where n is defined as a constant number of interpersonal behaviors stored in robots. Robots reflect interpersonal behaviors over the past n times in their own characters.

In this paper, we use the GUI to communicate with robots. Fig. 4 shows the snapshot of communication between the user and the robot using the GUI. The robot shows situation text as actions in this GUI. Users read situation text and select users' actions in four buttons on the GUI. Four users' actions correspond to interpersonal behaviors shown by Table 1. In this communication, we didn't show clearly users these correspondences. We set 30 situation texts based on behaviors of five-years-old children. Table 2 shows the examples of situation texts and users' actions. Each situation texts have no relationships and are shown in random order. The communication is ended when the all situation texts were happened.

Table 2. Examples of Situation Texts and Users' Actions

Situations with ifbot	Users' Actions			
	Dominance	Submission	Acceptance	Rejection
wants to play with you.	restrain	play	play later	reject
wants to help cleaning with you.	turn down	rely	clean together	let it go off
begs for toys.	restrain	buy	buy on another time	reject
overslept.	admonish	forgive and prepare	help to prepare	leave it alone
is singing.	prevent	commend	sing together	lay off

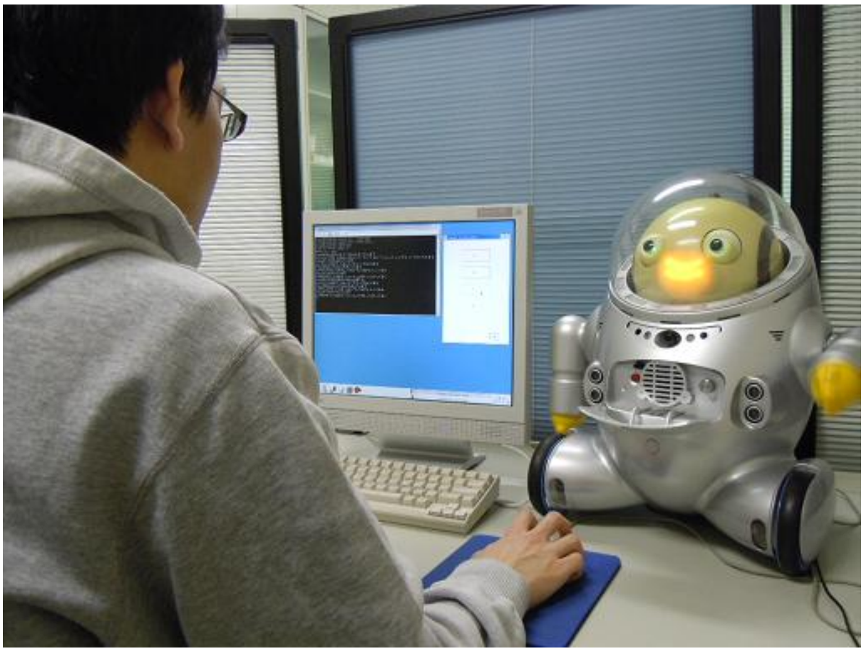

Fig. 4. Snapshot of communication.

3 Experiments and Results

We performed two experiments to confirm the efficacy of the proposed model. We used *KANSEI* robot "ifbot" [7] in experiments. The number of interpersonal behaviors stored in robots was 30(n=30). The strength of expressional tendencies was 2(a=2).

3.1 Evaluation of Character

We performed character evaluation experiment to confirm the proposed model could make robots expressing characters defined by Symonds. For this experiment, we equipped four ifbots characterized by four parental tendencies defined by Symonds. The characters of equipped ifbots were given as follows.

ifbotA :ifbot characterized by "cruelty"
had a strong tendency toward inferiority and antipathy
ifbotB :ifbot characterized by "overprotection"
had a strong tendency toward inferiority and affection
ifbotC :ifbot characterized by "indulgence"
had a strong tendency toward superiority and affection
ifbotD :ifbot characterized by "neglect"
had a strong tendency toward superiority and antipathy

In this experiment, ifbots' characters didn't change. This experiment had 20 participants. Participants communicated with these ifbots and evaluated their impression at five factors on a scale of 1 to 7. These factors are based on "Big Five" factors [8]. In these factors, the more the cobweb chart, which is shaped by each factors' evaluation values, shaped the large equilateral pentagon, the more the character is emotional and ideal. Fig. 5 shows the cobweb chart shaped by each factors' average values of evaluation in this experiment, and Table 3 shows ifbots' combinations which show significant differences about some factors. Conscientiousness and openness are omitted from the table because any robot combinations didn't show significant differences about these factors.

Evaluation by "Big Five" Factors According to Fig. 5, these cobweb charts had different tendencies. So the characters expressed by using the proposed model were confirmed they could give users the impression that these ifbots' characters had differences. In neuroticism factor, ifbotC had the highest score. And ifbotA had the lowest score. These ifbots' combination showed a significant difference about the factor. ifbotC had a strong tendency toward superiority and affection. And it rarely expressed negative emotions such as inferiority and antipathy. On the contrary, ifbotA had a strong tendency toward inferiority and antipathy. From these results, we consider the tendency toward superiority and affection increases the neuroticism factor's score. And the tendency toward inferiority and antipathy decreases that's score. Additionally, there was little difference between the neuroticism factor's score of ifbotB and ifbotD. So we think each emotions' effects on neuroticism factor is about equality. In extraversion and agreeableness factors, ifbotB and ifbotC had high scores. And ifbotA and ifbotD had low scores. Also, in agreeableness factor, ifbotB and ifbotC showed positive significant differences on ifbotA and ifbotD. ifbotB and ifbotC had a strong tendency toward affection. ifbotA and ifbotD had a strong tendency toward antipathy. Therefore, we think a tendency toward affection and antipathy effects on extraversion and agreeableness factors. In conscientiousness and openness factors, ifbotB had a little higher score than others. But, there wasn't a major difference in each ifbots. Overall, the cobweb charts of ifbotB and ifbotC shaped large diagrams and similar to equilateral pentagon. And the cobweb charts of ifbotB and ifbotC shaped small and irregular diagrams. As these results, we consider ifbotB and ifbotC were obtained the characters impressing favorably for users.

Evaluation by Parent-Child Relationships In Parent-Child Relationships, ifbotA is defined as "nervousness" child. In "Big Five" factors, we think the low neuroticism factor's score of ifbotA shows nervous character. So, ifbotA could express the character defined by Symonds. ifbotB is defined as "overdependent" and "infantile" child. But, in "Big Five" factors, each factors of ifbotB had average score. There wasn't dependent and infantile character. ifbotC is defined as "authority-rejection" and "commanding" child. We think ifbotC could express commanding character by the high score about extraversion, agreeableness and neuroticism. ifbotD is defined as "aggressive" child. We think ifbotD could express aggressive character by the low score about extraversion and agreeableness.

Table 3. ifbots' Combinations Which Showed a Significant Difference

factor	positive	negative
extraversion	**ifbotB**	**ifbotA**
	ifbotC	**ifbotA**
	ifbotC	**ifbotD**
agreeableness	**ifbotB**	**ifbotA**
	ifbotC	**ifbotA**
	ifbotB	**ifbotD**
	ifbotC	**ifbotD**
neuroticism	**ifbotC**	**ifbotA**

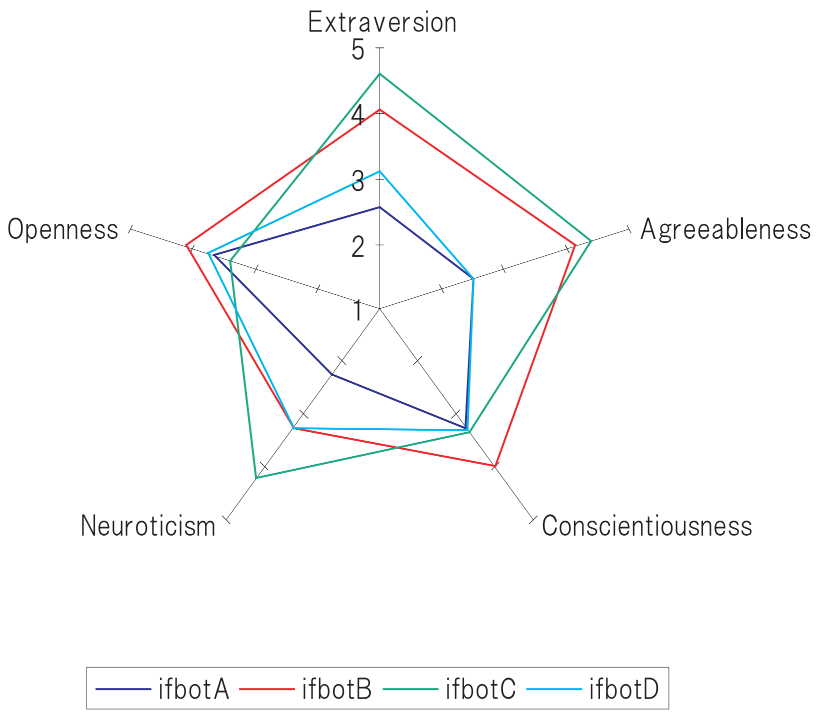

Fig. 5. Character evaluation by “Big Five” factors.

3.2 Evaluation of Impression

We performed impression evaluation experiment to confirm the robot characterized by the proposed model that had high humanity and empathy. This experiment had four groups of participants. Each group had 15 participants and said to treat each ifbot differently. Each treatment was set to give a lot of each action of “dominance”, “submission”, “acceptance” and “rejection”. Table 4 shows the treatments given to each group.

First, in this experiment, participants communicated with the ifbot which we mounted the proposed model on. Then, we equipped three ifbots based on this communication to communicate with the participants. The characters of equipped ifbots are given as follows.

ifbotM :expresses emotions based on the tendencies of participants’ behavior
ifbotR :expresses emotions in a random order
ifbotS :expresses emotions based on the tendencies of others’ behavior

Participants didn’t know the characters of these ifbots. Each participant communicated with these ifbots in a random order. Before this experiment, we performed the pre-communication between 20 participants, which differ from this experiment, and the ifbot which we mounted the proposed model on. Through the pre-communication, we equipped the data of 20 tendencies of users’ behaviors. ifbotS was characterized by the tendency that was nearest to the pre-communication’s data from the origin symmetry of participant’s tendency. After the experiment, participants evaluated their impression by Semantic Differential and answered questionnaires on distinguishing the ifbot characterized by their own tendency from others.

Evaluation by Semantic Differential We used Semantic Differential to evaluate these ifbots' impression. Participants evaluated their impression at ten pairs of adjective on a scale of -3 to 3. Here is the pairs of adjectives we used.

- familiar - unfamiliar
- significant - insignificant
- natural - artificial
- complicate - simple
- interesting - boring
- likable - unlikable
- hard to tire - easy to tire
- human - mechanic
- agreeable - disagreeable
- intelligent - unintelligent

Fig. 6 - Fig. 9 shows the result of each group. The averages of evaluation values are shown by the bar graphs, and these standard deviations are shown by the error bars. The case arcs shows the ifbots' combination which show significant differences. The red case arcs shows 1% significance level and the blue case arcs shows 5% significance level.

By this experiment, in the all groups other than the group focused on rejection, ifbotM shows positive significant differences on ifbotR in pairs "familiar - unfamiliar", "likable - unlikable" and "agreeable - disagreeable". In the group focused on rejection, ifbotM shows positive significant differences on ifbotR in pairs "agreeable - disagreeable". From these results, regardless of the participants' treatments, we consider ifbotM, which we mounted the proposed model on, left a good impression for the participants. In addition, ifbotM shows positive significant differences on ifbotR in pairs "significant - insignificant" and "natural - artificial" in the all groups. So, the robots characterized by the proposed model are more humanly than the robots which show emotions in a random order. In pair "complicate - simple", ifbotR and ifbotS are evaluated more complicated than ifbotM in all groups. Because ifbotM is characterised by the participants and participants also communicated with the ifbot for characterising in the previous, we consider participants felt fresh and complicated impression against ifbotR and ifbotS, these had shown the different reaction from communication with the ifbot for characterising. In the group focused on dominance, ifbotM and ifbotS show positive significant differences on ifbotR in pairs "natural - artificial", "likable - unlikable" and "agreeable - disagreeable". Therefore, the group focused on dominance shows a good impression for not only ifbotM, which was characterised by participants but also ifbotS, which was characterised by others. On the

Table 4. Treatments Given to Each Groups

groups	treatments for ifbots
focus on dominance	control ifbot tightly
focus on submission	prioritize the intention of ifbot
focus on acceptance	worry about ifbot always
focus on rejection	do not interfere much ifbot

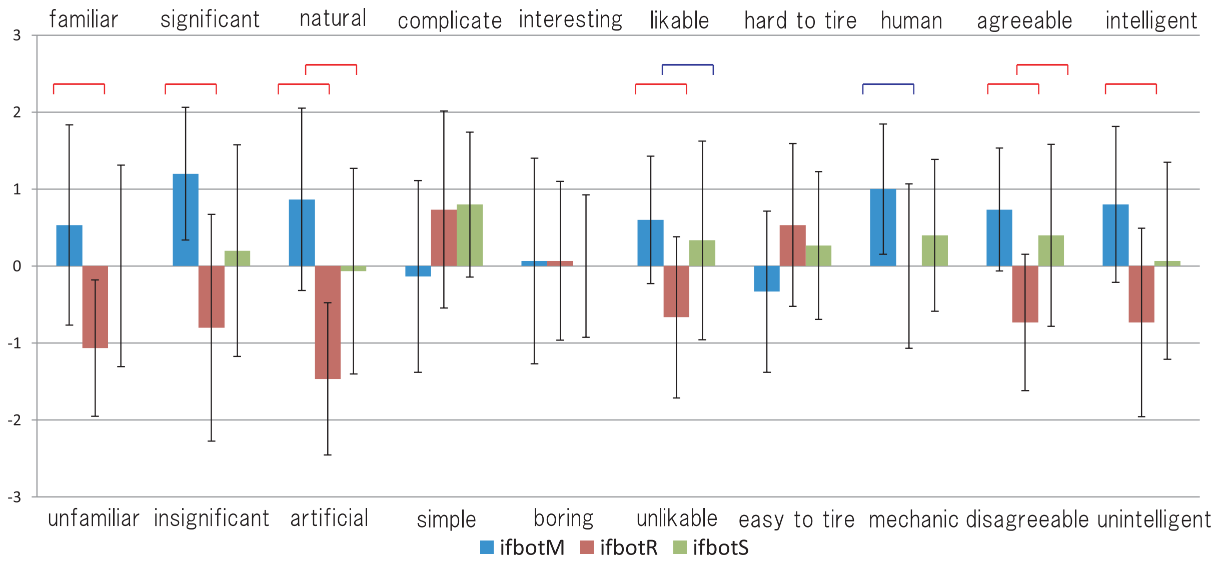

Fig. 6. Impression evaluation of the group focused on dominance.

other hand, in the group focused on submission and the group focused on acceptance, ifbotM shows positive significant differences on ifbotR and ifbotS in multiple pairs. Because these groups tend to coddle ifbot repeatedly, we consider these groups have a higher attachment to the ifbot characterized by participants than the group focused on dominance and the group focused on rejection. So, we think it has a negative effect on the other ifbots' evaluation.

Fig. 10 shows comparison of each groups' evaluation of ifbotM. The averages of evaluation values are shown by the bar graphs, and these standard deviations are shown by the error bars. The case arcs shows the ifbots' combination which show significant differences. As the result, there is little significant difference in each group. Only pairs "familiar - unfamiliar" shows significant differences of the group focused on acceptance and the group focused on rejection. Therefore, we consider the proposed model can give robots a character leaving a good impression to the participants regardless of the participants' treatment.

Questionnaire on Distinguishing the Ifbot We performed the questionnaire for participants. This questionnaire is aimed at distinguishing the ifbot characterized by their own tendency from others. In this questionnaire, participants answered the question "Do you think this ifbot is characterized by you?" by "yes" or "no." This questionnaire wasn't just a multiple-choice question, since, we didn't specify a number of answer "yes". In other words, we allow the case that a participant answer "no" to the question for all ifbots or "yes" to the question for some ifbots. The correct answer is when participants answered "yes" to the question for ifbotM and "no" to the question for ifbotS and ifbotR.

Table 3 shows the result of this experiment. Each group has high probability of participants answered "yes" to the question for ifbotM. Participants answered "yes" to the question for ifbotR or ifbotS were very few. According to the results, users were found to be able to distinguish their ifbot from others ifbot. We think that proposed model could characterize a robot as a unique-being.

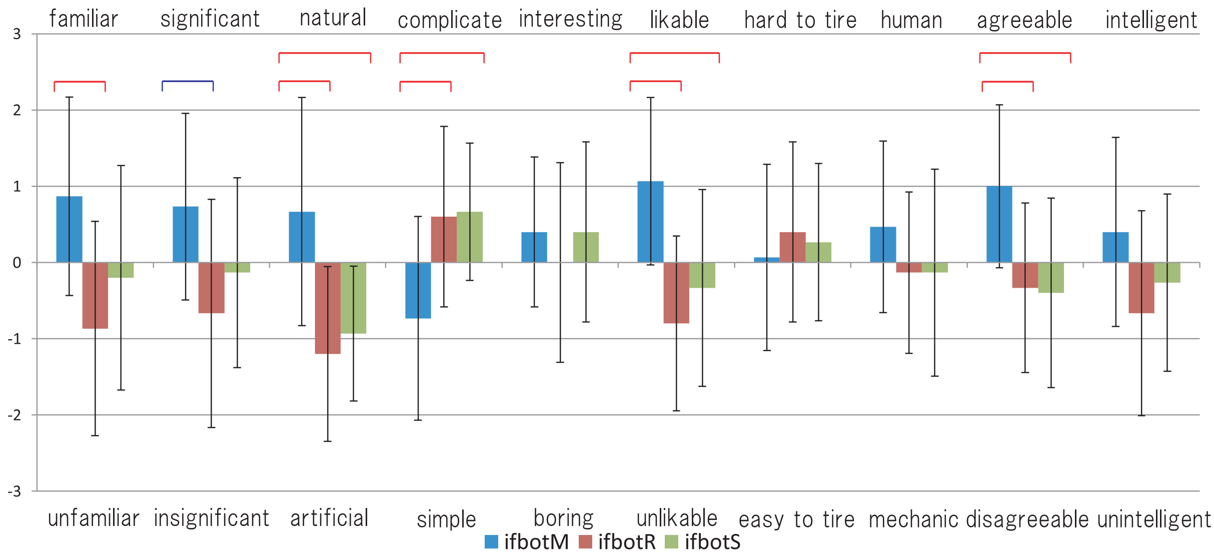

Fig. 7. Impression evaluation of the group focused on submission.

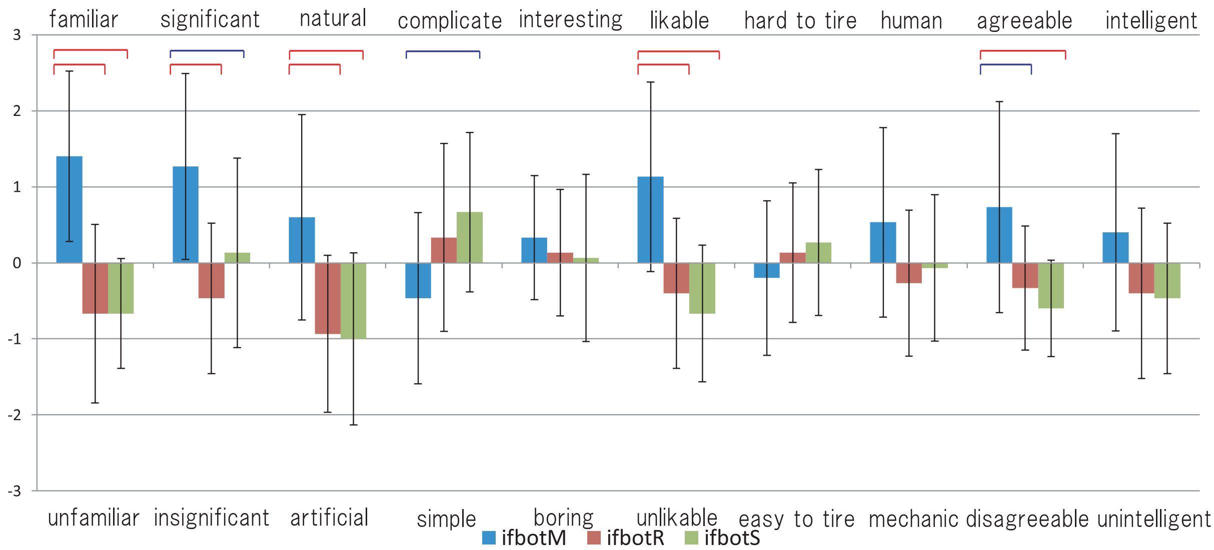

Fig. 8. Impression evaluation of the group focused on acceptance.

Table 5. Result of Distinguishing

	dominance	submission	acceptance	rejection
Answered “yes” to the question for ifbotM	60%	86.7%	93.3%	100%
Answered “yes” to the question for ifbotR	0%	6.67%	6.67%	0%
Answered “yes” to the question for ifbotS	20%	0%	6.67%	6.67%
The answer was correct	60%	80%	80%	93.3%

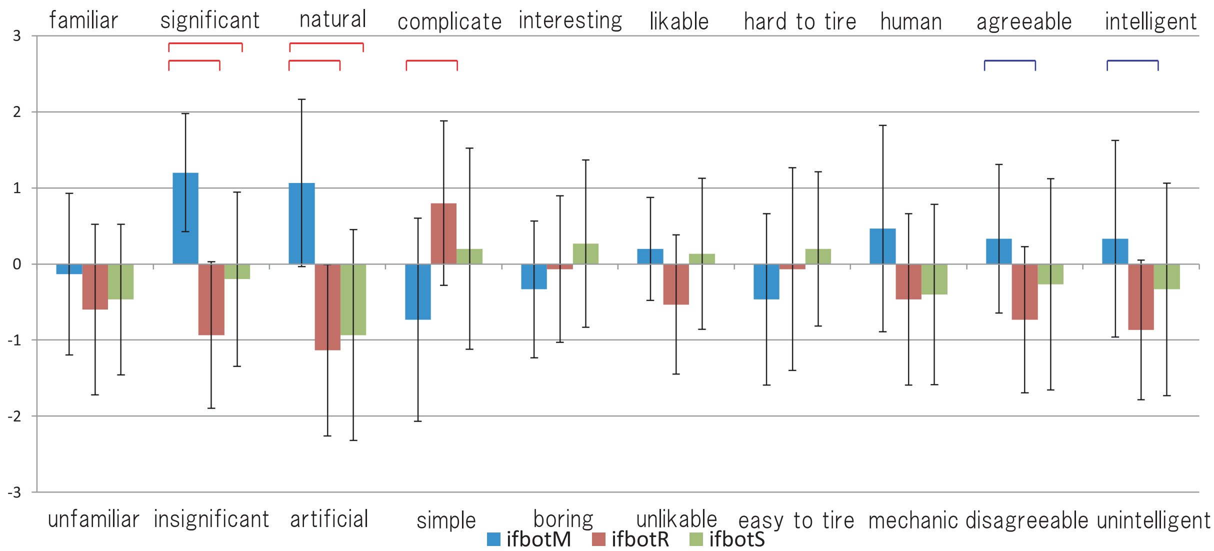

Fig. 9. Impression evaluation of the group focused on rejection.

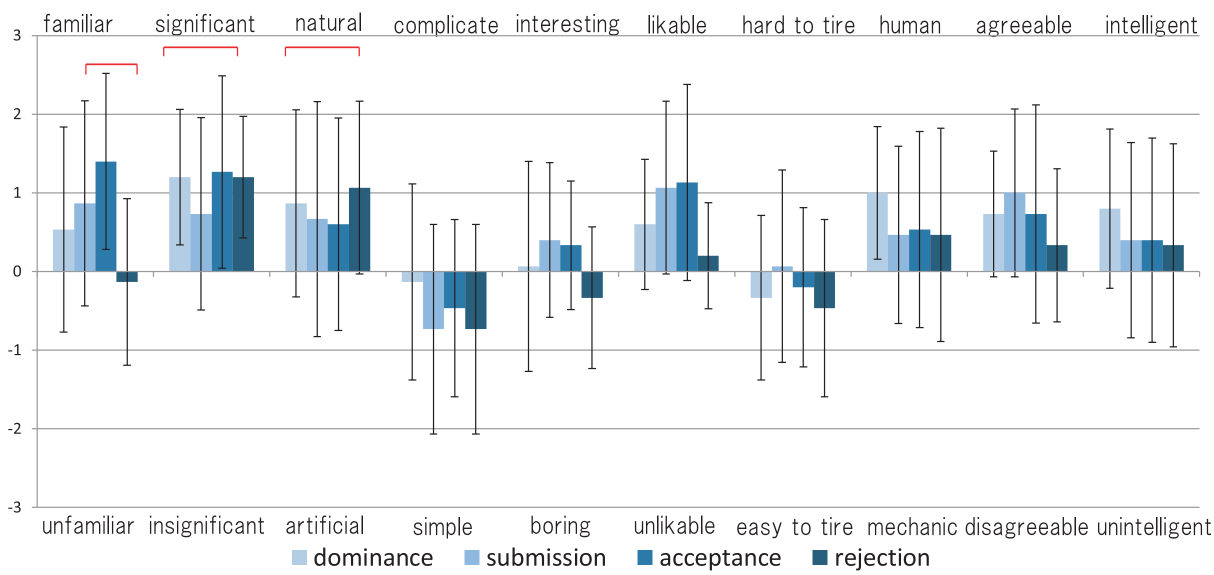

Fig. 10. Comparison of each groups.

4 Conclusion

In order to make robots empathic and humanly, we proposed the method to dynamically characterize robots. We performed the interaction experiments between humans and the robots with the proposed model containing characters defined by Symonds. According to the results, the changes expressional tendencies by the proposed model could characterize robots dynamically and make users to feel robots had characters defined by Symonds. And, we confirmed the proposed model could leave a humanity impression on users and the character based on users' interpersonal tendencies could leave a good impression on users. Therefore, we think the proposed model have efficacy for increasing robots' empathy and humanity.

In future work, we aim to propose the method characterizing robots more flexibly by adding environments or various communications to causes to give robots their own characters.

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