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THE INFLUENCES OF SEX ON THE HUMAN EMOTIONS TOWARD ROBOTS

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Abstracts This paper evaluates the influences of sex on the human emotions while coexisting with robots. When we consider human vision, robot's motion is the most important parameter which influences human emotions and must be well controlled for males and females emotions. On the other hand, when we consider human touch of sense, which is effective for cooperation transmitting mutual forces, the softness of robot is an important parameter for human emotions and must be also well controlled for males and females emotions. From these points of view, at first, we evaluate robot's motion under four different shapes of velocity pattern while handing over a cup to humans. Second, we evaluate robot's softness realized by impedance control. From the first experiment, we concluded that the conditions of choosing an adequate maximum velocity value and locating the velocity peak at the center or the first half of the duration are necessary for male's emotions. In addition, the smooth velocity decrease in the last part of the velocity pattern's duration is desired for female's emotions. From the second experiment, we concluded that females prefer lighter values of virtual impedance characteristics than males and any small increase on the heaviness of virtual impedance values is followed by the negative exponential change on human emotions.

Keywords Human emotions, Sex, Maximum velocity, Virtual impedance, Rating scale method

1. INTRODUCTION

Robots are expected to play important roles in the fields of social welfare, nursing, and so on. In such cases, robots must coexist and cooperate with humans to accomplish several complicated tasks. It is desired that robots are human friendly and reassuring for human minds.

In view of the sex, let us consider the way to control robots. Females by nature feel strange and frighten to insects or reptiles sensitively more than males. They also fear the sudden changes on the velocity of moving objects. We can expect that females receive stronger impressions from robot's motions. On the other hand, when coexisting with robots in the same space, humans may touch or hit the robot unexpectedly. In this case, the robot should be as soft as humans to reassure their minds and should not hurt their emotions. Therefore, we have to consider the softness of robots.

In order that robot possess the intelligent abilities to satisfy all these requirements, the control strategy of robots must consider human emotions and must be changed according to the sex.

In this research, two different approaches are considered based on psychological evaluations on robot's motion and softness from the view point of males and females emotions.

1) One is the evaluation of robot's motion when robot hands an object over to humans as an example of cooperation in experiment 1. In the experiment 1, the influence of velocity profile of robot's motion on male and female emotions are examined. Eleven males and eleven females perform the experiments of receiving task on four different shapes of velocity pattern.

2) The other is the evaluation of the softness of the robot. Shibata et al.[1] realized the softness of robots for coexistence with humans by giving virtual impedance characteristics to the robot. They examined the relations between human emotions and the virtual impedance values of the robot, but they did not consider these relations for female subjects. In our work (in experiment 2), the influence of virtual impedance characteristics of a robot on both males and females emotions is examined. The experiment is conducted on the combinations of various impedance parameters (virtual mass, viscous coefficient and stiffness) by subject's pushing the impedance controlled robot under the assumption that he/she coexists with the robot in the same work space.

Here, the rating scale method is used for evaluating human emotions subjectively in all the experiments, which is based on Semantic Differential method.

2. EXPERIMENT 1

2.1 The selection of adjective measures for rating scale method

Recently, subjective evaluation method has been used for psychological evaluation of humans on various stimulus like color, smell, etc..., and also widely used in the field of ergonomics.

Semantic Differential method is famous as an evaluating method based on several step-wise measures in which opposite adjective measures are located at the both poles, and the main factors defined by the results are obtained by factor analysis. However, since the stimulus is momentary phenomenon, it is not effective for subjects to evaluate a lot of adjective pairs in this research. Moreover, our purpose is not to obtain main factors but to find favorite robots for coexisting with humans. So indispensable five adjective pairs for this purpose are selected as follows.

It is reported that humans hold several emotions based on the factors of "pleasure" and "speed"[2] when they see the movement of machines. In this experiment, we also try to evaluate the same "motion". For that reason, we choose two adjective pairs based on them;

1." Pleasant---Unpleasant"

This is from the factor of pleasure.

2." Careful---Careless"

This is from the factor of speed.

On the other hand, Shibata et al.[3] examined human arm positioning motion. The results show that the learning effects are observed when severe positioning accuracy is required. This implies the possibility that we can feel the skillfulness by observing the movement of the robot. So, the following adjective measure is determined;

3." Skilled---Unskilled"

In the society that human coexists with robot, robot should be friendly for humans so that they can be accustomed to it immediately;

4." Human-like---Mechanical"

Moreover, the most important thing of handing motion from robot to human is that handing and receiving is conducted smoothly as human do. We choose the following adjective pair to confirm whether robot and human can cooperate effectively or not;

5." Easy to receive---Difficult to receive"

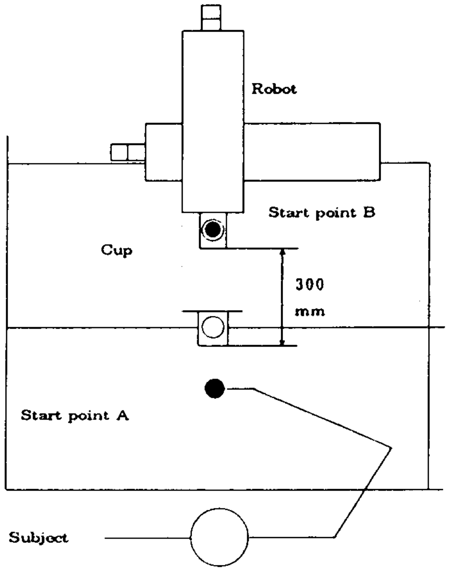

Figure 1. The apparatus in the experiment 1

2.2 The method of emotional evaluation test

2.2.1 Subjects. Healthful 11 males and 11 females students, aged from 21 to 25 conducted the experiment.

2.2.2 Materials and apparatus. Figure 1 shows the experimental arrangement. Subject receives the glass holded out to him/her by the one dimensional robot by THK Co.Ltd. The subject sits on a chair facing the robot.

2.2.3 Procedure. The emotional evaluation test is conducted as follows: a testing paper is handed out to the subject and the method of filling it is explained to him/her before the experiment. The subject sits in a chair face to a desk in front of the end effector. Where, the robot moves an aluminum glass 300 mm from start point to the appropriate handing point in front of the subject, which is based on the result between humans, and waits for being received at that point. Then the robot starts the returning motion a few seconds after being received by the subject. After finishing the receiving motion, the subject evaluates it by filling out the testing paper.

The motions to be evaluated are demonstrated twice in order. No information about robot's motion are given to the subject. The experiment are conducted any numbers of time on the request of the subject. The subject has to choose one of seven steps of stimulations of five adjective pairs in the test sheet according to his/her impression toward the robot's movement. Here, the subject is instructed to evaluate the motion as much intuitively as he/she can.

2.3 The influence of the difference of velocity pattern on human emotions

In previous works, the characteristics of human handing-over motion were investigated[4], and it was confirmed that the velocity profile of hand path of a hander shows smooth bell shaped velocity distribution whose peak is located in the first half of the duration.

On the other hand, trapezoid velocity pattern is generally used for the movement of the end effector of industry robot. It is important to know what velocity pattern should be realized on robot for human emotions.

From these ideas, Shibata et al.[5] examined the influence of the difference of velocity patterns on human emotions experimentally. In our work, we fellow this approach and try to examine the robot motions when conducting cooperation with humans from the view point of the difference of the sex.

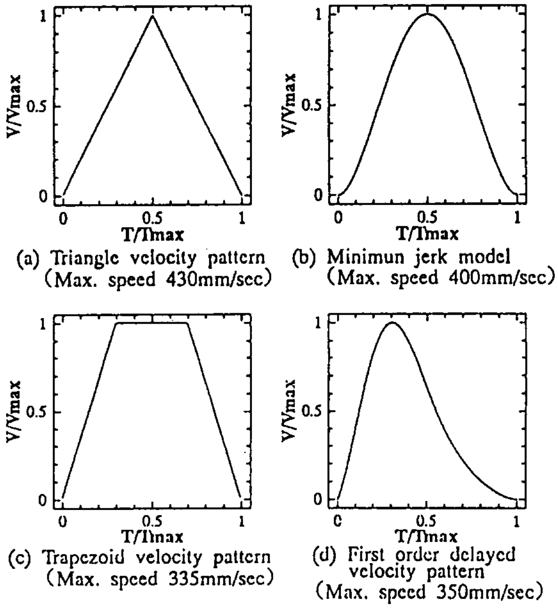

Figure 2. Velocity patterns to be evaluated

The velocity patterns of the hand movement to be evaluated (Figure 2) are as follows;

(a) triangle velocity pattern (the velocity peak is located in the middle of the duration);

(b) symmetrical bell shaped velocity pattern (the velocity peak is located in the middle of the duration);

(c) trapezoid velocity pattern;

(d) first order delayed velocity pattern (the velocity

peak is located at the 30% of the duration).
All the maximum velocity values are chosen from the view point that human subject regards maximum velocity value of all the motions as the same, which are based on the pre-experiment conducted by more than 20 subjects.

2.4 Results

The results of male subjects are shown in Figure 3 and the results of female subjects are shown in Figure 4. Here, the mean value and variance are shown in the Figure by giving from one to seven point to each steps of stimulations.

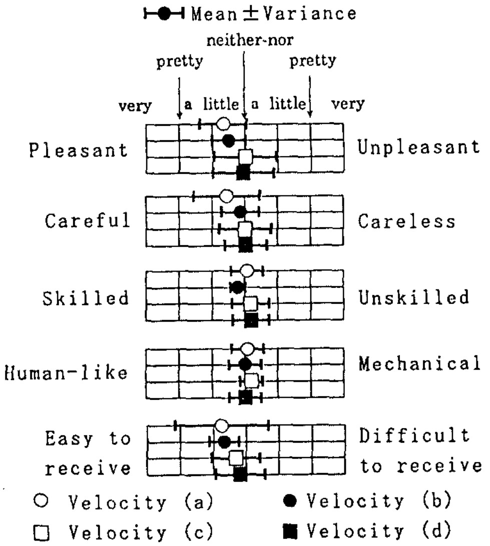

Figure 3. The results of males for the velocity patterns

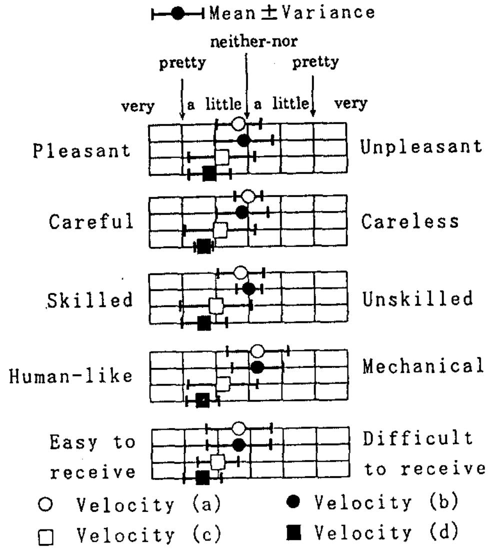

Figure 4. The results of females for velocity patterns

From Figure 3, the following results are observed:
A lot of male subjects answered "neither or not" on all the adjective pairs, which means that having an appropriate maximum velocity and locating its peak at the center or at the first half of the duration are the important factors for male emotions.

From Figure 4, the following results are observed: Female subjects are impressed very sensitively compare with the male subjects. Moreover, in all the adjective pairs female subjects show the most positive evaluation on motion (d), and they find it the most favorite movement. This may be due to smooth velocity decrease in the last part of the motion. The smooth velocity decrease in the last part of the duration is desired for female's emotions. Being smooth in the last part of the motion gives female reassuring emotions, which is confirmed by the questionnaire conducted in the experiment.

3. EXPERIMENT 2

3.1 The selected groups of the emotion being reassuring

We try to investigate the influence of the robot's impedance values on male and female emotions experimentally.

Shibata et al.[1] examined the softness of the impedance controlled robot for male subjects and divided the evaluations into four groups A, B, C and D. In our work, we use the same approach as Shibata et al. That is, we also adopt these four groups of evaluations.

1. Group A: light group, the contact force is very small and male subject can not rely on this contact force;
2. Group B: intermediate group, both the contact force and the response speed are proper for male emotions. This group's combination of impedance parameters is reasonable for robots coexisting with males;
3. Group C: pretty heavy group, the response is small but the contact force is pretty large. The emotions being light and pleasant show negative and the emotion being human-like shows a little negative, but the emotion being reassuring shows neither-nor;
4. Group D: very heavy group, the response is very small and the contact force is very large. All the adjective pairs show negative. Male subjects feel dangerous to high stiffness of the robot.

We choose one representative combination of the virtual mass, the virtual viscous coefficient, and the virtual stiffness for every group (see Table 1).

Table 1

	Mv(kg)	Cv(N.sec/m)	Kv(N/m)
A	3	20	80
B	8	50	80
C	13	120	130
D	20	200	30

3.2 Methods

3.2.1 Subjects. 18 male and 17 female subjects aged from 21 to 24 conducted the experiments.

3.2.2 Materials and apparatus. Our apparatus consists of the same one dimensional robot (THK Co.Ltd) used in experiment 1. Here, the subject adds force by his/her palm to the end effector. The added force is measured by the force-moment sensor (NITTA Co. Ltd.) and taken in the computer through A/D converter. We use the computer PC-9801 AP2 for virtual impedance control.

The virtual impedance control system is realized by controlling the robot motions to satisfy the following dynamic equation (1) in response to the obtained force F.

$$F = Mv\ddot{Z} + Cv\dot{Z} + KvZ \qquad (1)$$

Here, Mv(kg) is the virtual mass, Cv(N.sec/m) is the virtual coefficient, and Kv(N/m) is the virtual stiffness.

3.2.3 Procedure. The subject is requested to fill out a testing paper. The method of filling and the objectives of the research are given to the subject before the experiment.

3.3 The selected adjective measures of rating scale method

The subject adds force to the end effector with his/her palm and evaluate its feel and response subjectively. The subject has to choose one of seven steps of the stimulations of four adjective pairs in the testing paper corresponding to his/her impression toward the robot. Four adjective pairs are considered as follows:

1."Light---Heavy"

This adjective pairs come from the idea that robot should be soft when contact with humans unexpectedly.

2."Pleasant---Unpleasant"

3."Reassuring---Anxious"

This is from the idea that robot should not only be safe physically but also be reassuring for human mind.

4."Human-like---Mechanical"

The adjectives 2 and 4 are the same as in section *2.1.*

3.4 Results

The results of male and female subjects are shown in Figure 5 and Figure 6 respectively. The results observed in Figure 5 are similar to those found by Shibata et al.[1]. In Figure 6, we observe that females prefer group A the most and they like group B too. It is so clear that females distinguish between group A,B and group C,D, which means that females are very sensitive to the change of softness of the robot. That is not the case of males.

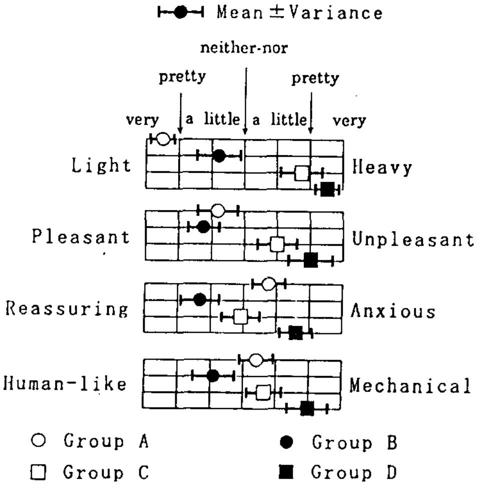

Figure 5. The results of males for the impedance values

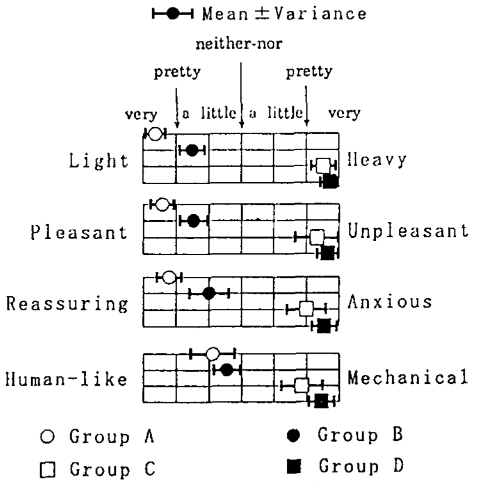

Figure 6. The results of females for the impedance values

4. CONCLUSIONS

Our results can be summarized as follows:

The robot should change its characteristics according to the sex with whom he coexists. To control robot's motion, for males, the velocity pattern must have an adequate maximum velocity and its peak should be located at the center or the first half of the duration. For females, the velocity pattern should be better a first order delayed one.

To control robot's softness, the virtual impedance characteristics should be lighter for females than for males. We also conclude that a small increase on the heaviness of virtual impedance values is followed by the negative exponential change on human emotions.

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