Effect of Robot's Active Touch on People's Motivation

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ABSTRACT

This paper presents the effect of a robot's active touch for improving people's motivation. For services in the education and healthcare fields, a robot might be useful for improving the motivation of performing such repetitive and monotonous tasks as exercising or taking medicine. Previous research demonstrated with a robot the effect of user touch on improving its impressions, but they did not clarify whether a robot's touch, especially an active touch, has enough influence on people's motive. We implemented an active touch behavior and experimentally investigated its effect on motivation. In the experiment, a robot requested participants to perform a monotonous task with a robot's active touch, a passive touch, or no touch. The result of experiment showed that an active touch by a robot increased the number of working actions and the amount of working time for the task. This suggests that a robot's active touch can support people to improve their motivation. We believe that a robot's active touch behavior is useful for such robot's services as education and healthcare.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces-Interaction styles

General Terms

Design, Experimentation

Keywords

Haptic interaction, Active touching, Motivation improvement

1. INTRODUCTION

Figure 1: Does active touch from a robot improve motivation?

As the human-robot interaction (HRI) field advances, social robots have started to work in daily environments. For example, robots have been developed that provide guide information at museums [34][38] and shopping malls [22][13]. Moreover, recent social robots are working at schools for education purposes [15][4][20] and providing health support through conversations [26][29]. For such daily supports, social robots must increase the motivation of people who have to perform such repetitive, monotonous but important tasks as exercising or taking medicine.

Can a robot improve the motivation for such tasks by interaction? Some past works have reported the possibility for such increases by a robot's physical body, e.g., physical presence or haptic interaction. For example, a robot with physical presence affects human decision making more than a screen agent in the real world[32]. Wada et al. reported that haptic interactions had benefits for therapy purpose [40]. Moreover, in human-human interaction (HHI), actively touching others in haptic interaction (e.g. lightly touching others' arm) increases both feelings of friendliness and persuasive effect [9][14]. These reports indicate the possibility of positive effect for improving the motivations of people

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by robot's haptic interaction, such as an active touch, even though such effects have not been explored yet.

However, from another point of view, robot's haptic interaction might discourage people's motivation because robots are perceived as different from humans. For example, Takayama et al. revealed that people want humans rather than robots for relation-based jobs that require interaction both inside and outside an organization with such people as producers and directors [36]. Some researchers concluded that a robot was perceived as "social others" that is a different being from human beings [19][25]. They reported that people did not grant intrinsic moral rights to humanoid robots, even though they interacted with them socially. Such different perceptions might change the effect of a robot's active touching. Cramer et al. reported that touching by a robot negatively affects its dependability [6][5]. Thus, it remains unknown whether people prefer active touching from a robot that is perceived as different beings.

In this paper, we investigate whether a robot's active touching behavior improves people's motivation. For this purpose, we implement an active touch behavior that a robot puts its hand on participants hand and stroke it. To test the effect of active touching from a robot in the context of improving people's motivation, we conduct an experiment and report how haptic interaction changes people's motivations and impressions.

2. RALATED WORKS

2.1 Physical Interaction in HRI

Recent research topics using physical interaction in social HRI can be generally divided into commands to a robot and those for healthcare purposes including therapy.

The former was well studied and surveyed by [3]; developed a robot with a direct physical interface (e.g., leading people by hand) to control its movements. Other researchers used a physical interface to demonstrate a task to the robot [2], handing objects to people [8] and adjusting a person's posture with a robot for such tasks as dance instruction [37]. Goller et al. developed a cart robot that can be controlled by haptic interactions [12].

The use of the latter is especially growing to meet the demand for assisting the increase of senior citizens. For example, nursing-care assistant robots have been developed in Japan that can move a person from a bed to a chair [28][31]. Physical interactions are used not only for physical assistance but also for therapy purposes. Paro, a robot that resembles a seal, is one famous successful case for robotics therapy including physical interaction in the real world [40]. The research of Paro presented that the attitudes of elderly people were improved by interaction with robots, and urinary tests showed that their ability to overcome stress was also improved.

Thus, even though the former research successfully developed robust physical interfaces to give commands to robots from people, it failed to focus on the psychological effect of active touches from robots. The latter research also showed the usefulness of physical interactions for physical assistance in therapy, but the psychological effect of active touching by a robot has not been explored yet.

2.2 Persuasion in HRI

Captology [10][39] (Computer as Persuasive Technology) is one well-known area of research in the field of persuasion in human-computer interaction(HCI). This field's research focus is expanding from HCI to HRI.

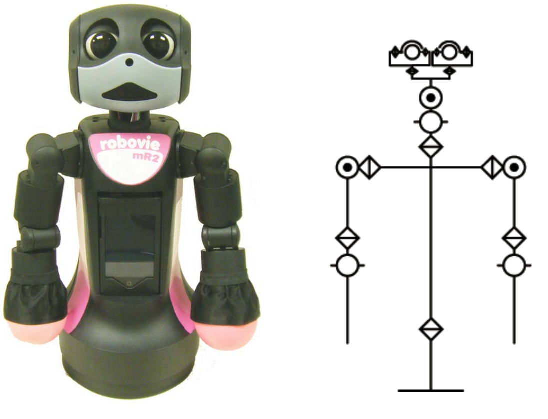

(a) Overview (b) Link mechanisms

Figure 2: Desktop-sized robot: robovie-mR2

Researchers originally focused on whether a robot's physical presence improves persuasive effects [32][30][24][1]. For instance, Shinozawa et al. reported that a real robot could affect people's decision making more effectively than computer agents in real world environment[32]. Bainbridge et al. investigated how people respond to a request to throw a book by comparing humans, agents, and robots [1].

Based on the research field's progress, not only the robot's physical presence but also such social physical behaviors as whispering and touching are being explored [33][6][5]. For example, Shiomi et al. concluded that a whispering gesture of a robot increases people's motivation during annoying tasks [33]. On the other hand, some research reported a negative effect of haptic interaction with a robot. Cramer et al. investigated the effectiveness of touching by a robot and found that it decreases machine-likeness but negatively affects dependability [6] [5].

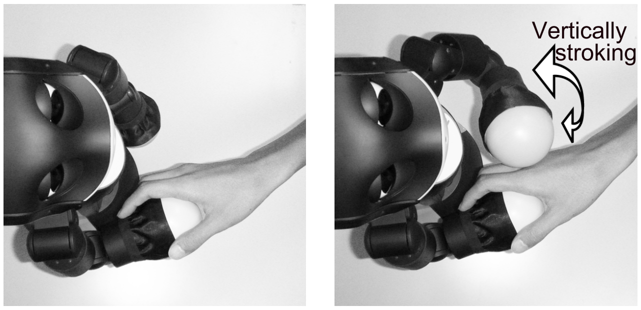
In the context of improving motivation for performing such repetitive, monotonous, but important tasks as exercising or taking medicine, social robots have been deployed in such real environments as schools [15][4][20] and nursing homes [26][29] for daily support. Thus, as cited in Section 2.1, a robot's physical presence is used not only for improving the persuasive effects but also its physical assistance in the real world.

These previous works mainly reported the effectiveness of a robot's physical presence without focusing on the effect of active touching from a robot for improving motivation. Some reported the negative effects of touching by a robot. In this study, we unveil how haptic interaction changes people's motivations and impressions.

3. IMPLEMENTATION OF ACTIVE TOUCHING

3.1 Robot

To investigate the effectiveness of a robot's active touch, we used "robovie-mR2," an interactive humanoid robot characterized by its humanlike physical expressions (Fig.2). It



(a) Passive touch (b) Active touch

Figure 3: Touch behavior

has four DOFs in its arms, three in its head, and four in its eyes. It stands 42cm tall. Such a robot is often used as a table-style, conversational partner in natural-HRI studies [33][17][27]. We used a corpus-based speech synthesis to generate speech [23].

To ensure safety when the robot touches a person, soft sponge balls were used for its hands. To control the movement of its arms during touching, we installed an atmospheric sensor on its hand to detect pressure; it enables the robot to prevent touching a person too strongly.

3.2 Active touching from robot

We prepared two touching behaviors for the experiment: a passive touch behavior that the robot asks participants to touch it, and an active touch behavior that the robot touches participants itself.

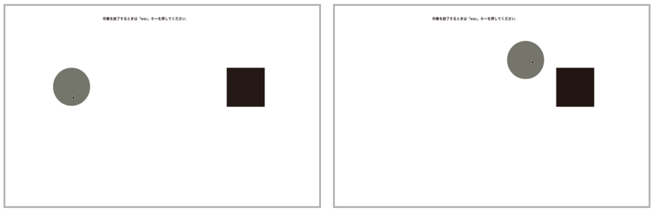
To safely realize active touching by the robot, we designed the robot that asks a person to touch its hand first, and then it actively touches the person's hand that is touching the robot. For this purpose, we designed the following two behaviors to request a passive touch from the person and to actively touch him/her:

[Behavior requesting a passive touch]: The robot extends its right hand and says, "Please hold my hand while I talk to you (Fig.3(a))."

[Behavior for touching the person]: When the person touches the robot's right hand, it moves its own left hand until it touches the person's hand. Then the robot strokes the person's hand with its own left hand (Fig.3(b)). Because people have different touching styles, might hold the robot hand differently, and so on, the robot must control a stroking gesture that realizes identical touch behavior. So we installed an atmospheric sensor in its left hand as written in Section 3.1.

The following is the active touch behavior:

1. Robot asks a participant to hold its right hand.
2. Robot extends its left hand to the right hand until it touches the participant's hand.
3. Its left hand moves out to horizontally widen the space between both of its hands until the sensor value drops below the threshold.
4. The left hand repeatedly moves vertically to the right hand. (stroking)



(a) Initial screen (b) Dragging

Figure 4: Screenshots of the experimental task

We conducted pre-trials to investigate the adequate threshold values of sensors that enable consistent touching of participant hands. Based on the result, we determined that the threshold value was 32 millibar higher than the value without touch.

4. EXPERIMENT

To evaluate the effectiveness for improving a motivation for a monotonous task, we conducted a laboratory experiment. In this section, we describe its details.

4.1 Participants

The participants were thirty university students (14 men and 16 women whose age averaged 21.0, S.D. is 2.3) were recruited on the web regardless of faculty or specialty, so their backgrounds were various and most of them were not familiar with robots. They were paid 1,000 yen (roughly $10 U.S.) for one hour of participation.

4.2 Task

To investigate the effect of a robot's touch to improve motivation, we adopted a monotonous task whose degree of effort was objectively measured. For this purpose, we prepared an on-screen task by referring to a study of behavioral economics [16]. Fig.4(a) shows the initial screen of the task. The participants dragged the circle on the left side to the square on the right side on the screen (Fig.4(b)). When the light gray circle is dragged into the dark gray square, the circle disappears, and a new circle appears on the left side (Fig.4(a)). Participants can repeatedly drag as many circles as possible. Since the termination method is displayed on the screen during the task, participants can terminate whenever they want. The task ends after the participants press the ESC key or the maximum time (10 minutes) has expired; participants are not informed of the maximum time.

The following is the procedure of the task: 1. Participants read the task instructions on the screen. 2. They practice dragging for 10 seconds. 3. If they have no problem performing the task, they start.

4.3 Conditions

To evaluate and compare the effectiveness of with/without robot touch, we used a between-participant experiment design with three conditions:

- *No touch* : robot asks participants to perform the task.

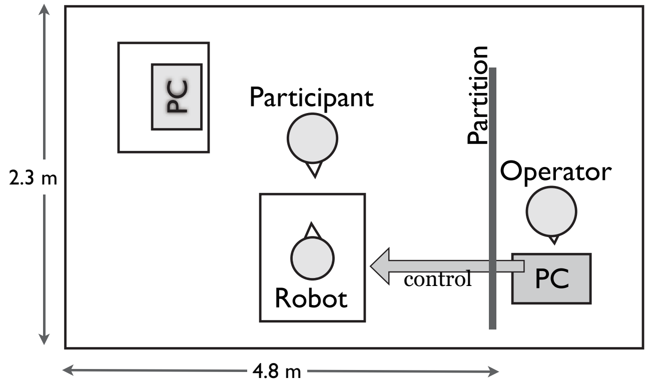


Figure 5: Experimental settings

- *Passive touch* : robot requests a passive touch from participants and then asks them to perform the task (Fig.3(a)).
- *Active touch* : robot first requests a passive touch from the participants and then touches thier hand while it asks them to perform the task (Fig.3(b)).

4.4 Experiment procedure

The experiment was conducted in a laboratory room (Fig.5). Robovie-mR2 was placed on a table, and a laptop computer for the task was placed on the other table. Before the session, participants were given a brief description of the experiment's purpose and procedure. They were randomly assigned to the experiment conditions; thus ten participants were assigned to each condition. The gender ratio in each condition was counter-balanced.

First, participants sat in front of the robot. In the interaction, the robot requests participants to perform the task. After the request from the robot, they start it. As described in Section 4.2, the participants can terminate the task whenever they want. Table 1 shows the flow of the robot speeches and behaviors. The trigger of each behavior was sent by the operator in the Wizard of Oz method [7].

4.5 Measurements

4.5.1 Objective measurement

To investigate whether an touching behavior improve a motivation for the monotonous, we measured both *the number of actions* (dragged circles) and *the working time* (time spent on task).

4.5.2 Subjective measurements

To measure the subjective impressions of the participants, we prepared a questionnaire that addressed *feelings of friendliness*, *authority*, and *trust*. After the session, participants answered a browser-based questionnaire on a 1-to-7 point scale where "7" is the most positive and "1" is the most negative.

4.6 Hypothesis

The effect of robot's active touch on people's motivation remains unrevealed in HRI, though haptic interaction increases friendliness and persuasive effect [14][9]. So, we propose a hypothesis that *active touch* increases the participant motivation to do the monotonous task. Moreover, *active touch* is preferred by the participants more than *passive touch* and *no touch*. Thus, we made the following hypothesis:

Hypothesis 1: *active touch* will increase *the number of actions* and the amount of *working time* more than *passive touch* and *no touch*.

Hypothesis 2: *active touch* will be rated higher than *passive touch* and *no touch* for *feelings of friendliness*.

Table 1: The flow of the experiment

Speaker	Speech and behavior	
Robot	Hello! I'm robovie-mR2. Thank you for coming.	
Participant	You're welcome.	
Robot	Well, I'd like to ask you a favor. Please hold my hand while I talk to you. (Robot extends its right arm)	[*1, *2]
Participant	OK. (Participant holds robot's hand)	
Robot	(Robot starts stroking the participant's hand. The pressure for the hand is automatically controlled.)	[*2]
Robot	I'd like you to do the following task as well as you can. The task procedure is displayed on the computer screen on your right.	
Robot	(Robot stops stroking the participant's hand)	[*2]
Robot	Do you understand?	
Participant	Yes.	
Robot	Thank you. OK, let's get started!	

*1: *passive touch* condition
*2: *active touch* condition

5. RESULTS

We note that all the participants in the active/passive touch condition kept holding robot's hand while the robot asked them to perform the task. To test our hypotheses, we conducted the analyses below.

5.1 Verification of hypothesis 1

We analyzed *the number of actions* (Fig.6) and the amount of *working time* (Fig.7).

To test the hypothesis, we conducted a one-factor between subjects ANOVA for *the number of actions*. There was a significant difference between conditions (F (2,27)=6.044, p=0.007). Multiple comparisons with the Scheffe method revealed significant differences: *active touch* > *passive touch* (p=.022), *active touch* > *no touch* (p=.018); but there was no significant difference between *no touch* and *passive touch* (p=0.996). This means that *active touch* significantly increased *the number of actions*.

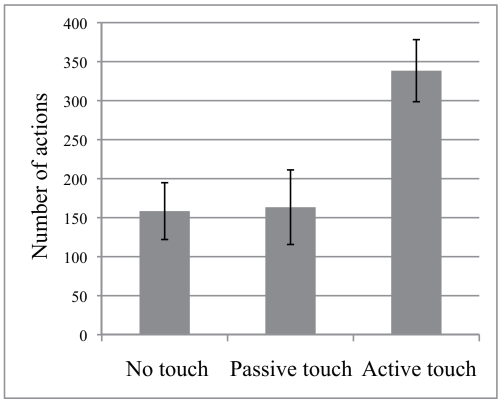


Figure 6: Number of actions

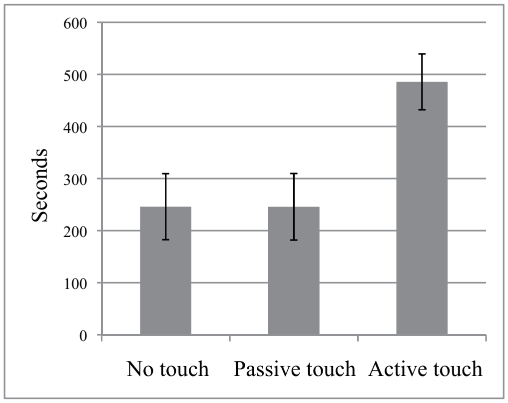


Figure 7: Working time

Moreover, we conducted a one-factor between subjects ANOVA for the amount of *working time*. There was a significant difference between conditions (F (2,27)=5.238, p=0.012). Multiple comparisons with the Scheffe method revealed significant differences: *active touch* > *passive touch* (p=.032), *active touch* > *no touch* (p=.032), but there was no significant difference between *no touch* and *passive touch* (p=1.000). This means that *active touch* significantly increased the *working time*. Thus, these results support hypothesis 1.

5.2 Verification of hypothesis 2

We further analyzed *feeling of friendliness* (Fig.8) to investigate how the participants perceived the robot.

We conducted a one-factor between subjects ANOVA for *feeling of friendliness*. There was a significant difference between conditions (F (2,27)=3.669, p=0.039). Multiple comparisons with the Scheffe method revealed a significant difference: *active touch* > *no touch* (p=.050); but there was no difference between *active touch* and *passive touch* (p=.158), and between *passive touch* and *no touch* (p=.838). These results mean that *active touch* significantly increased the *feeling of friendliness* more than *no touch*, but it was not rated higher than *passive touch*. Thus, hypothesis 2 was partially supported.

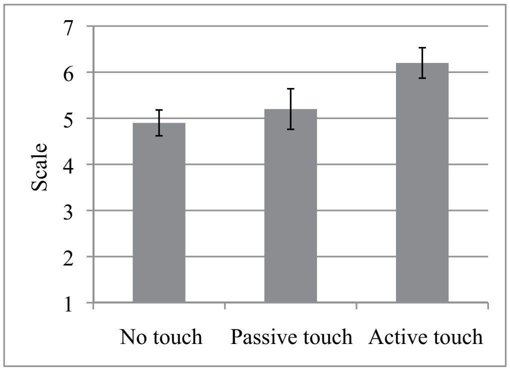


Figure 8: Feeling of friendliness

5.3 Did the impressions of the robot affect the motivations for the task?

The impressions of the robot for participants might caused the positive effects on *the number of actions* and *working time*. Thus, we analyze relationships between the number of actions/working time and three kinds of participants' evaluations: friendliness, authority and trust. Spearman's correlation analysis showed that there was no significant correlation between the impressions and both of these variables ([friendliness] *the number of actions*: $r = .27, p = .16$, *working time*: $r = 0.28, p = .14$, [authority] *the number of actions*: $r = -.02, p = .93$, *working time*: $r = .02, p = .93$, [trust] *the number of actions*: $r = -.02, p = .92$, *working time*: $r = -.01, p = .96$). The results showed that there was no significant relationship between the impressions of the robot and the motivations for the task.

5.4 Are responses to the robot's touch different between males and females?

Gender is an considerable factor that influences persuasive effect and motivation improvement. In order to investigate gender's effects in our experiments, we conducted two-factor between subjects ANOVA. Two factors were touch condition and gender. The results showed that there was no significant difference between male and female for both the number of actions ($F(1, 24) = 1.9, p = .18$) and working time ($F(1.24) = 2.1, p = .16$). Therefore, at least in the experiment, the robot's active touch increased the motivation irrespective of gender.

6. DISCUSSION

6.1 Design implication

Our result revealed that a robot's active touching behavior improves people motivation and showed a positive effect. In the past, some research argued that active touching from a robot had a negative effect[6]. On the other hand, our result agrees with the work of many researchers who are investigating the positive effects for haptic interaction in HRI [40][21]. This study supports the research and development of a social robot that interacts with people by such haptic interactions as actively touching others.

As an example of an application for active touch, we have already developed a counseling robot for lifestyle diseases in the healthcare field that provides health information and advice for users[35]. The problem is that the motivations of the users dynamically change when they are seeking to their lifestyles, so it is important how they overcome periods when their motivation becomes low. Therefore, we believe that a counseling robot can support user's lifestyle improvement by encouraging him/her using touch behaviors at such a time. Moreover, there would be many situations that touch interactions between humans and physical robots are natural and acceptable. So, we believe that this study provides important findings for many applications toward long-term human-robot interaction that changes people's lifestyle.

6.2 Why did an active touch result in positive effects?

Our experimental results indicated that *active touch* increased a motivation for a monotonous task and friendliness. Such positive effects of touch behaviors show similar trends in the researches of haptic interaction in HHI or a part of researches in HRI [40][21]; however, other part of researches in HRI show a contradictive result (i.e. a negative effect for dependability) of touch behaviors from a robot [6][5].

It is not easy to make clear why *active touch* from our robot showed positive effects by comparing our study with those researches [6][5], because there are many differences between them: appearance, the feel of hands' material, character, task, cross culture effect, touching behavior and so on. Mixing of these differences might considerably change perceived impressions for a robot. One of the future works that comes from these considerations is to investigate what kinds of features will change the effects of *active touch* from the robot.

The results in 5.3 indicate that the psychological indices that were measured in the experiment could not explain the reason why the robot's active touch improved participants' motivation. We think that these results are quite interesting, that will make worthy discussions. Basically, past research works claim that some psychological indices, such as friendliness or trust, would relate to persuasive effects; however, our experimental results cannot be explained in the points of view of psychological indices' effects. Thus, it is still unknown as to what kind of psychological factors increased motivations of the participant. Some physiological measures might be helpful for that analysis. In fact, a previous work investigated the effect of shaking hands with a robot for decreasing a person's perception of stress with physiological indices [18]. As a future work, we will investigate whether a robot's active touch physiologically affects humans and their behaviors by conducting experiments with physiological measurements.

On the other hand, robot's appearance is one of key design issues for HRI. The robot's appearance might contribute to its foundation, and then *active touch* might cause positive effects on user's motivation. Our robot was designed to give positive impression with cute appearance; such design policy would be common policy for almost all communication service robots (e.g., AIBO[25], Paro[40], Robovie-II[21]). The experiment results with our robot cannot be extended to different types of robots, however, they show that our design of active touching behavior have possibility to increase for such various communication service robots.

6.3 Influence of *foot-in-the-door* effect

The foot-in-the-door effect [11] is a famous manipulative technique for persuasion, achieves agreement to a large request by first getting agreement to an easy request. Perhaps our experimental design was affected by this tactic; the robot makes an easy request, "Please hold my hand while I talk to you," and is touched by the participants before it requests the monotonous task.

However, the experimental results did not show significant differences between *passive touch* and *no touch* for both *the number of actions* and the amount of *working time*. Therefore, at least in the experimental settings, we consider that only easy request from the robot did not make a significant difference in the context of improving motivation.

6.4 Ethical issues of persuasion

Ethical issues will play an important role based on the advancement of social robots, particularly when such robots persuade or change human behavior. Past examples of persuasive research in HCI [10] focused on promoting the widely held conceptions of "good," but they also pointed out that persuasive research in HCI can be used for "bad" purposes. Such problems will continue to appear in the future, and they must be considered.

On the other hand, for daily support, we must increase the motivation of people who face repetitive, monotonous but important tasks such as taking medicine. In our society, many simple services to improve motivation have already been replaced by machines, including mobile phone schedulers and reminder systems on web mail. Especially for senior citizens living alone who rarely have a chance to get support for such tasks, the current computer/internet-based helper devices are difficult to use. One possibility is using robots for such daily support instead of machines or web services.

6.5 Limitation

One of the goals of this study was to reveal that people's motivation in repetitive and monotonous tasks could be improved using active touching robots. This study showed positive results for a short term interaction, however, this result cannot be easily extended to long term interactions. The ongoing study in the healthcare field referred in 6.1 would help us for investigating the effects of active touch behavior on improving motivation in case of long term interactions.

Since the experiment was conducted with an existing robot, robovie-mR2, robot generality is also limited. We cannot ensure that our findings can be applied to all interactive robots, particularly unhuman-like robots. However, we believe that the setting is adequate to offer critical knowledge for researchers interested in improving motivation with interactive robots.

7. CONCLUSION

We focused on the effect of a robot's active touch for improving people's motivation. Even though previous research reported the positive effects of haptic interaction in HRI, the effect of a robot's touch for improving motivation remains unrevealed. To investigate the effect of a robot's active touch, we conducted a between-subjects experiment in which a robot requested a participant to perform a repetitive task with an *active touch*, a *passive touch*, or *no touch*. The experimental results indicate that the robot's active touch increased *the number of actions* and the amount of *working time* with the task, showing its effectiveness for improving motivation in human-robot interaction. We believe that a robot's active touch behavior is useful for such robot services as education and healthcare that require motivating people to do monotonous but important tasks.

8. ACKNOWLEDGMENTS

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