Can Human Jobs be Taken by Robots? :The Appropriate Match Between Robot Types and Task Types

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Abstract

Background Autonomous robot can be controlled with its full autonomy without a robot operator and telepresence robot enables a live two-way video or audio communication to deliver the presence of communicators. In this study, we compared autonomous robot vs. telepresence robot vs. human when an objective or subjective task was given in an art appraising situation.In order to investigate the appropriate match between robot types and task types, we explored the impact of robot types and task types on perceived social presence of the robot and willingness to follow the robot's advice.

Methods In a 2 (robot types: autonomous robot vs. telepresence robot vs. human) x 2 (task types: objective task vs. subjective task) mixed-participants experiment (N=30), participants experienced two task type scenarios with either the autonomous robot, the telepresence robot or the human art appraiser.

Result Participants perceived more social presence of the human and the telepresence robot than of the autonomous robot. In addition, when the robot performed the objective task, participants tended to follow the robot's advice more than when it performed the subjective task regardless of its autonomy level. In the case of the objective task, people were more willing to follow the autonomous robot's advice than that of the telepresence robot or human. On the other hand, in the case of the subjective task, people were more willing to follow the human's advice than the advice of the telepresence robot and the autonomous robot.

Conclusions The results indicate that people's perceptions of robots are different depending on the robot types and the attributes of given tasks. This study suggests that robot developers or designers should consider the appropriate match between robot types and task types. Implications for the design of human-robot interactions are discussed.

Keywords Autonomous Robot, Human-Robot Interaction, Objective Task, Social Presence, Subjective Task, Telepresence Robot

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1. Introduction

In 1965, Herbert Simon (1993) said, “Machines will be capable in 20 years of doing any work a man can do.” Similarly, Rifkin (1995) has warned people that as technology advances, robotic employment would eliminate millions of jobs – called “worker-less world.” Advanced technology such as computers, robotics, telecommunications, and other types of leading edge technology has been fast replacing humans in almost every sector of industry. At home, for instance, Roomba, an autonomous robotic vacuum cleaner, has done household duty instead of humans (Sung et al., 2008). And Minerva, a tour guide robot, has replaced humans in public spaces such as in museums (Thrun et al., 1999). Instead of human doctor, Robodoc system performs medical tasks which need sophisticated techniques and high level of concentration (Pransky et al., 1997). Although it seems that most of the human’s jobs can be technically replaced by robotic system, there are still some jobs that mostly belongs to humans. And this raises the following question: can human jobs be taken by robots? The objective of this study is to investigate the impact of robot types and task types on people's perception towards robots.

2. Related Works

2. 1. Robot Types

In Yanco et al. (2002)’s study, robots can be classified into an autonomous robot and a tele-operated robot according to the robot’s autonomy level. Degree of robot’s autonomy can be also measured by the amount of the human intervention. An autonomous robot has higher level of autonomy and less amount of human intervention compared to a tele-operated robot. Several researchers have studied on the effect of robot types comparing autonomous and tele-operated robots. In Lee et al. (2014)’s study, in a collaboration situation, people were better motivated when interacting with a tele-operated robot than with an autonomous robot. Similarly, when collaborating with a robot, the focused group interview results showed that participants tended to feel intuitively more secure when there is a remote human operator controlling the robot at a distance, even though participants expected that the autonomous robot would produce less failures than humans (Weiss et al., 2009). According to Dole et al. (2013)'s study, in a rescue situation, participants who were interacting with the tele-operated robot felt safer than participants who were interacting with the autonomous robot. Like above, robots are perceived differently when they are connected to a human operator compared to when they are autonomous.

Robot-mediated communication could be done either with a tele-operated robot or a telepresence robot for its manner and objective of the interaction. According to Sheridan (1994)’s study, a tele-operated robot enables a human operator to move about, sense, and mechanically manipulate objects at a distance. That is, a tele-operated robot is physically manipulated by a human operator connected to the robot in order to perform a task instead of the human operator. On the other hand, a telepresence robot can be described as mobile

embodied video conferencing systems with live two-way video or audio communication in order to deliver communicators' presence (Tsui et al., 2011a; Tsui et al., 2011b). Choi et al. (2014a) demonstrated participants felt more embarrassment with telepresence robots than with autonomous robots in a situation of having an interview with robot interviewers. They also felt more social presence of the telepresence robot. On the other hand, autonomous robot was perceived as having more intelligence than the telepresence robot was (Choi et al., 2014b). Kwak et al. (2013) compared a simulated robot which expresses its own emotional state autonomously, and a mediated robot which delivers the emotional states of the remote user. In the study, people empathized more with the telepresence robot than with the autonomous robot.

Considering all the evidences mentioned above, the robots which has a remote human user were evaluated more positively than the autonomous robots. However, people evaluated autonomous robots more intelligent and less erroneous than telepresence robots. According to the analyses above, we proposed the following hypothesis:

H1. There would be a main effect of robot types on people's perception of the robot.

2. 2. Task Types

Even if the recent robotic technology may be able to handle a large part of work that human used to manage, some types of work would still remain as a duty of a human being. An NBC news editorial entitled "Nine jobs that humans may lost to robots" stated that there would be human jobs that are going to be fully replaced with robots: pharmacists, drivers, astronauts, store clerks and etc (Aquino, 2012). On the other hand, Frey et al. (2013) supposed that several jobs would have still low probability of being automated, such as elementary school teacher, police officer or hairdresser. Thus, it needs to be investigated the types of tasks that robots could approapriately take in charge.

Previous research suggested that there are two categories of essential human capacity: agency, the capacity for thinking and intention, and experience, the capacity for feeling and emotion (Gray 2012). In terms of task types, Waytz et al. (2014) categorized tasks given to the robots into two types: cognition-oriented task and emotion-oriented task. Cognition-oriented task is related to thinking that associates cognition whereas emotion-oriented task is related to feeling that associates emotion. They demonstrated that when people were faced with their own jobs being replaced by a robot, they felt more threat and discomfort when the jobs were related to emotion-oriented tasks than to cognition-oriented tasks.

Agency and cognition are related to objectivity which refers to information or decision based on facts while experience and emotion are related to subjectivity which refers to a statement or an attitude influenced by personal opinion. People tend to expect that objectivity matches with machine-ness and subjectivity matches with human-ness (Heidegger, 1977). Due to the objectivity in technology (Heidegger, 1977), robot was perceived as more effective than human in a task with objectivity, repeatability or precision (Kreb et al., 1998). On the other hand, Nonaka et al. (2006)'s study showed that subjective emotions and abstract values are the key elements of human-ness.

According to these studies, we suppose that attributes of robot's task would affect how people perceive or respond to robots. These analyses led to the following hypothesis:

H2. There would be a main effect of task types on people's perception of the robot.

Neisser(1963) asserted that machines are capable of replicating 'cold cognition (objective)' behaviors such as reasoning, planning, perceiving, and deciding, whereas they would not be able to replicate 'hot cognition (subjective)' behaviors such as pain, pleasure, desire, and other emotions. Moreover, Choi et al. (2014b) demonstrated that the autonomous robot was perceived more intelligent than the telepresence robot whereas the telepresence robot was more effective on perceived social presence than the autonomous robot. Therefore, we supposed that the autonomous robot would be evaluated more positively with a objective task, while telepresence robot would be more effective with a subjective task. These analyses led to the following hypothesis:

H3. There would be an interaction effect of robot types and task types on people's perception of the robot.

3. Study Design

In order to explore the effect of robot types and task types on people's perception of a robot, we executed a 3 (robot types: autonomous robot vs. telepresence robot vs. human) x 2 (task types: objective task vs. subjective task) mixed-participants experiment. Human condition in the robot types was the control variable in this experiment.

Figure 1 The appraiser robot

3. 1. Participants

Thirty Koreans (12 male and 18 female) aged from 19 to 35 participated in the experiment.

3. 2. Materials

We used an art appraising robot Ra-i for this study (see Fig.1). It recognizes images with a camera and generates speech feedbacks. We developed two robots by different human

intervention levels. The autonomous robot appraises art pieces autonomously while the telepresence robot transfers the appraisal of the remote operator (a human appraiser). The autonomous robot generated a female voice in TTS (Text-to-Speech) system while telepresence robot delivered the female operator's live human voice. The other elements such as the robot appearance or the expertise of the appraisers were the same across the conditions. The robots were controlled via Wizard-of-Oz technique.

Pictures presented for the appraisal introduced in the experiment are the computer-modified versions of an artwork of Damien Hirst (2001) (see Fig. 2). Each picture was shown for 7 seconds to the appraiser and the participant on a screen in the room. They contain the same elements but the tilt angles are slightly different.

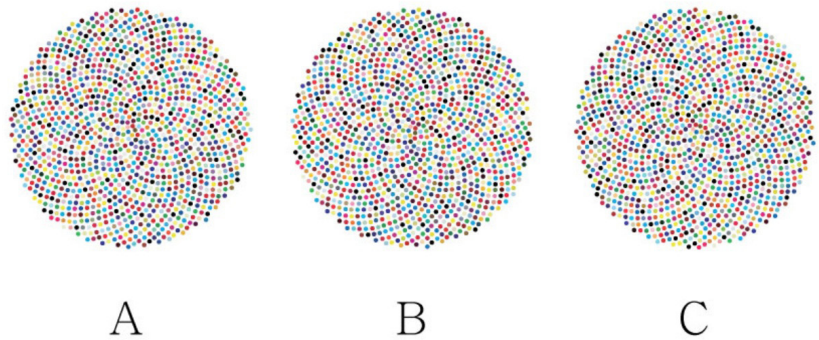

Figure 2 Pictures presented in the experiment

The independent variable, the task type, was manipulated by asking objective and subjective questions to both the participant and the appraiser. In this experiment, in an objective task condition, an objective question ("Which one does consist of more than 1136 dots?") was asked, and in a subjective task condition, a subjective question ("Which one would be the most effective in psychotherapy session?") was asked. Participant had to evaluate perceived level of objectivity and subjectivity for each question. Task types were properly manipulated (See Fig.3).

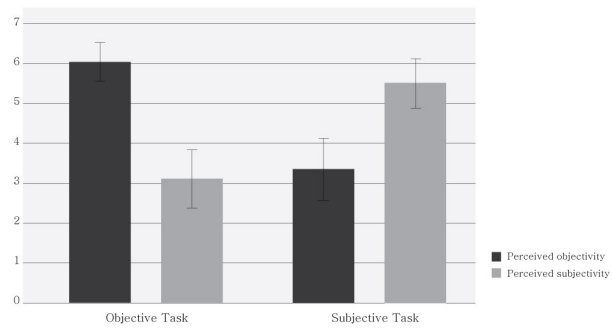

Figure 3 Manipulation results of the task types

3. 3. Procedure

Participants were welcomed to the lab and an explanation about the experiment was introduced. Since the concept of robot types could be unfamiliar to the participants, explanation and examples of autonomous and telepresence robots were presented based on Yanco et al. (2002) and Tsui et al. (2011a)'s study. It was informed to the participants that the autonomous robot is autonomous while the telepresence robot is connected to the remote appraiser. Participants who misunderstood the main setting of the experiment were excluded later in the statistical analyses. Participants experienced two task type scenarios with one of the art appraisers, either the autonomous robot, the telepresence robot or the human art appraiser.

Three pictures A, B and C were shown to the appraiser and the participant through the screen. Then the moderator asked an objective question ("Which one does consist of more than 1136 dots?") and a subjective question ("Which one would be the most effective in psychotherapy session?") to both the appraiser and the participant in random order. The appraiser chose one of the pictures for each question as a right answer. After the participants experienced each condition, a questionnaire regarding performance of the appraiser was administered, and a post-experimental interview was proceeded (See Fig.4).

Picture A, B and C　　Objective question　　Subjective question

Figure 4 Procedure of the experiment

3. 4. Measures

The post experimental survey consists of 5 Likert-type items, which were combined into two scales: social presence and willingness to follow the robot's advice. Social presence (α = .85) was drawn from Heerink et al. (2008)'s study which consists of five items: "When interacting with a robot, I felt like interacting to a real person," "It sometimes felt as if a robot was really looking at me," "I can imagine a robot to be a living creature," "I often realized the robot is not a real person" and "Sometimes a robot seems to have real feelings." Since there was not a direct face-to-face interaction during the session, the item "It sometimes felt as if a robot was really looking at me" was deleted. Willingness to follow the robot's advice were measured by a single item, "I am willing to follow the robot's advice."

4. Results

We investigated the impact of robot types and task types on social presence and willingness to follow the robot's advice. Statistical analyses were conducted using repeated measures analysis of variance (ANOVA) test.

4. 1. Social Presence

As predicted by H1, a significant effect of the robot types on perceived social presence of a robot was found, $F(2,27) = 7.08$, $p < .05$ (See Fig. 5). Participants perceived more social presence of the human ($M = 5.59$) and the telepresence robot ($M = 4.01$) than of the autonomous robot ($M = 3.46$).

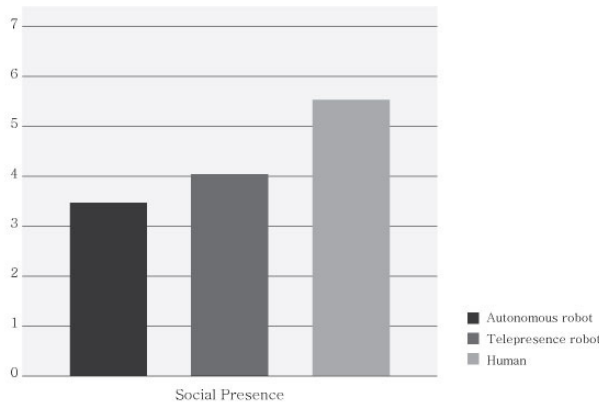

Figure 5 Main effect of the robot types on social presence

4. 2. Willingness to follow the robot's advice

As predicted by H2, task types had a significant impact on participant's willingness to follow the robot's advice, $F(1,27) = 5.17$, $p < .05$. (See Fig. 6). They would take the advice when the robot performed the objective task ($M = 4.33$, $SD = 1.27$) more than the subjective task ($M = 4.33$, $SD = 1.27$). When the robots, regardless of their autonomy level, performed the objective task, participants tend to follow the robots' advice more than when they performed subjective task.

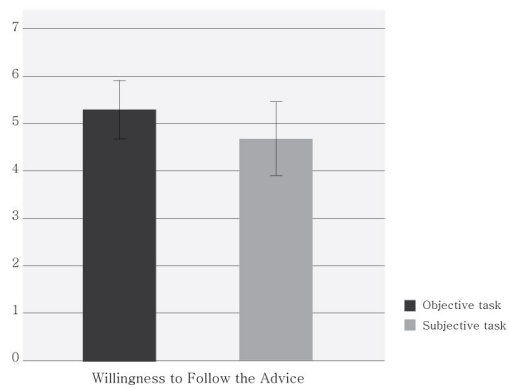

Figure 6 Main effect of the robot types on willingness to follow the robot's advice

In addition, the interaction effect of robot types and task types was significant, supporting H3, $F(2,27) = 3.88$, $p < .05$ (See Fig. 7). When the human ($M = 4.80$, $SD = 0.99$) and the telepresence robot ($M = 5.20$, $SD = 1.03$) had the objective task, participants were less willing to follow the advice than when the autonomous robot did ($M = 5.90$, $SD = 0.99$). On the other hand, when the human had the subjective task ($M = 5.10$, $SD = 1.66$), people were more willing to follow the advice the over the telepresence robot ($M = 4.60$, $SD = 1.35$) and the autonomous robot ($M = 4.30$, $SD = 1.95$).

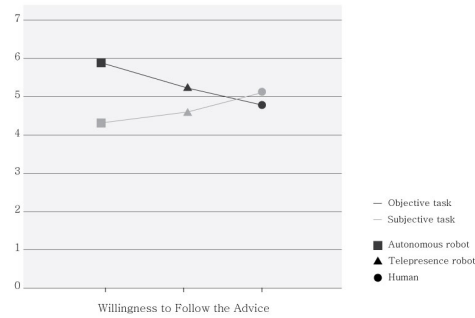

Figure 7 Interaction effect of the robot types and the task types on willingness to follow the robot's advice

5. Discussions

5. 1. Summary and Interpretations of Results

H1 was supported by the data. Participants felt more social presence to the human and the telepresence robot than to the autonomous robot. This is consistent with several previous researches that telepresence robots are more effective to increase social presence than autonomous robots. This indicates that the degrees of human intervention contributed to the perceived social presence of the robots.

Consistent with H2, participants were more willing to follow the robot's advice when they had the objective task than the subjective task. This implies that regardless of the autonomy level of the robot, we could imagine that people have a general tendency to rely on robot's advice when they confront with objective decision making.

Finally, H3 was also supposed by the data. There was a significant interaction effect of robot types and task types on willingness to follow the advice. In the objective task condition, people were willing to follow the autonomous robot's advice the most, and the human's the least. In the subjective task, however, people were willing to follow the human's advice the most, and the autonomous robot's the least. This means that there is a desirable correspondence between robot types and task types.

The statistic results above are consistent with the participant statements from the interview. Participants reported that they would expect more objectivity to the robot than to the human. They were more likely to follow the advice of the autonomous robot than of the telepresence robot with the objective task. On the other hand, participants in the subjective task condition doubted if the robots were able to think and judge by themselves.

5. 2. Implications

Back to answer our basic question if human jobs can be taken by the robots, we suggested to categorize robots by their autonomy level, and categorize tasks by objective and subjective attributes. Even though this study was limited in a situation that robot appraised art pieces instead of humans, it demonstrated that the aspects of robots and tasks affect how people perceive robots when robots replace the human jobs. When robots take the human jobs related to subjective decision such as counselor, actor, artist and etc., researchers and designers should consider applying higher level of human intervention. Moreover, it is needed to investigate the design elements that enables people to perceive more presence of human especially when the robots are to make subjective decisions.

On the other hand, with objective tasks, as people might depend more on robots than on humans, autonomous robots could possibly take human jobs that is related to objective tasks, such as cashier or ticket inspector. Robots will be developed and designed to replace larger part of human jobs in the future. Human intervention level as well as appearance, material or sound interface of robots should be considered in robot design to increase human's acceptance of the robots.

5. 3. Limitations

There are several limitations in this study. First, our participant pool was limited to people living in Korea. Replicating this study with people of different cultures would be needed. Second, the robot used in this study has a human-like appearance which has a face and body shape with facial features. Future studies has to be examined by using various types of robots. Third, the study presented in this paper was limited to an art appraising situation. It is needed to be reexamined the results also in different other situations.

6. Conclusions

The objective of this study was to investigate the effect of the robot types and task types on social presence and willingness to follow the robot's advice in art appraising situation.
People felt more social presence of the human and the telepresence robot than of the autonomous robot. Accordingly, people were more willing to follow the advice of the appraiser which had more degree of human intervention in the subjective task condition and reverse tendency was shown in the objective task condition. The results suggest that there is an appropriate match between robot types and task types. We suggest that robot developers or designers should consider the appropriate match between robot types and the task types.

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