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Psychological Effects on Interpersonal Communication by Bystander Android using Motions Based on Human-like Needs

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Abstract— **Recently, many humanoid robots have been developed and actively investigated all over the world in order to realize partner robots which can coexist in an environment shared with humans. having good communication skils is essential in order to interact naturally with humans. However, even with state-of-the-art interaction technology, it is still difficult for humans to interact with humanoid robots without conscious effort.**

In this paper, we use the android robot, which has an appearance which is quite similar to that of a human, as a bystander in human-human communication.The android is not explicitly involved in the conversation, however it makes small reactions to the behavior of the humans, and the psychological effects of its behavior on the human subjects are investigated. Through the experiments, it is shown that if the android mimics the behavior of the subject this can be quite effective in harmonizing the human-human communication.

I. INTRODUCTION

In recent years, research and development has been conducted on humanoid robots [1], [2] that are capable of interacting with humans in daily life. Because many robot tasks that need a human-like presence including medical care of patients, selling tasks and hospitality, namely communication with humans in daily life. Many robot tasks need a human-like presence, including medical care , work in sales and in the hospitality industry, all of which require communication with humans in normal daily life scenarios. However, the degree to which a human-like nature is needed and how much perception is needed in order to realize natural human-robot communication are not yet understood to a sufficient degree. We have been conducting research on these issues to explore the necessary principles for realizing natural human-robot communication using a robot with a very human-like appearance, which is called an "android" [3], [4]. According to Mori, humans are very sensitive to whether objects with a very human-like appearance are natural or uncanny , and the motion of the object influences a human's impression [5]. Noma et al. showed that 70% of subjects believed the android to be a real human when observing the android for a period of 2 seconds, when the android made primitive motions including blinking and breathing [6]. However, almost all subjects realise the android is an artificial object when they observe it for periods of greater than 2 seconds. There are a lot of complex reasons for this issue. Particularly, the motions are not very similar to those of a real human and the android is unable to give responses that are natural and similar to those of a real human. However, Shimada et al. have shown that the android can illicit normal human social reactions in situations where it asks humans simple questions [4]. Therefore, we can expect that the android can perform interactive tasks using that are of a human-like nature, in situations which do not involve careful observation (e.g., human-android communication). In interpersonal communication, humans communicate with each other through various channels [7]. Chikaraishi et al. show the android's humanlike nature increases when it uses motions which are based on a human-like mental model where the information about the interpersonal position was obtained using sensors [8]. This shows the android can change the impression of humans through the use of proper motions and timing. In addition, the "chameleon effect," the tendency of humans to mimic the motions of a conversation partner in bilateral communication is known to make human-human communication smoother [9]. From these results, it is possible that the android can psychologically influence human-human communications as a bystander with the proper motion and timing.

While motions of existing communication robots are mainly generated in order to accomplish a task such as the expression of joint attention [10], [11], expression of emotion [12], [13], studies which focus on human-like nature are very rare. Studies about animacy have also been conducted [14]. Yamaoka et al. realized a robot has a lifelike impression [15] by using a condition of animacy perception [16]. Obviously humans are a kind of life form, and motion of human is characterized by psychological factors from other living things, from this we propose a hypothesis about human-like motion. Humans have a wide variety of action purposeswhich are generated from needs. That is, human-like motion is generated from human-like needs. Maslow's hierarchy of needs [17] is a well known theory dealing with this topic. Human needs consist of five levels; physiological needs, safety needs, social needs, esteem needs, and self-actualization needs. These four lower needs are essentially imperatives for human minds. In order to realize human-like motion of the android, we focus on this hierarchy (Fig. 1).

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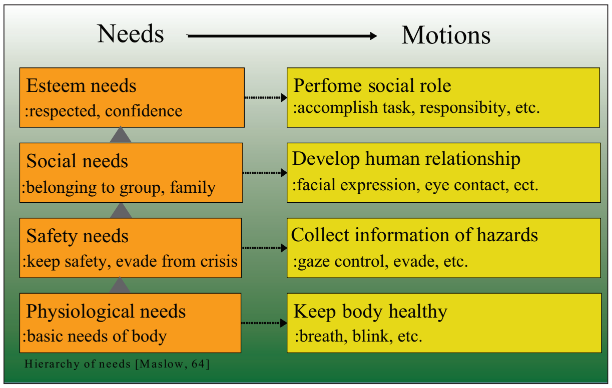

Fig. 1. Motion based on hierarchy of needs.

Fig. 2. Android Robot ReplieeQ2.

To achieve our goal of realizing a human-like nature for the android, we need to generate the android's motions based on all levels of the hierarchy. The first lower level of needs is associated with physiological needs. This level of needs is for human survival and to simply allow the human body to continueto function. From this point of view, the basic motions mentioned above (e.g. blinking, breathing motion) can be seen to correspond to this level. It is known that these primitive motions contribute to the human-likeness for a short time, without aggresive interaction [6]. The next level of needs is associated with safety needs. With these needs, people need to keep safe and to protecte their body and life. From this perspective, motions are used to gather information about the environment around the body and to be alert (e.g. gaze motion). However, it is not known how the motion based on these needs contribute to the human-like nature. Therefore, we conducted preliminary experiments to show this motion is needed for natural communication. The third level of needs is associated with the social needs. The social needs are needs for friendship and intimacy. In other words, motions based on these are the first step towards social interaction. We make the android influence human-human communication with the motions based on these needs. Lastly the top level of needs is associated to the esteem needs, the needs to be respected by others and to have self-esteem. These needs are satisfied by performing jobs or duties in the society to increase a human's status. At the present time, the robots do not have sufficient abilities to perform such tasks. In the future, the robots will be able to participate in society in completely the same was as humans do. From these results, we hypothesize that the android can psychologically influence human-human communications as a bystander with the proper motion and timing. In this paper, first we report two preliminary experiments, the former is to investigate the effect of motions based on safety needs, and the latter to confirm the extension of the chameleon effect to trilateral situations. Next we report about a trilateral experiment in a clinical situation. The android plays the role of a bystander in doctor-patient consultation.

II. Android in Trilateral Communication

A. *Android Robot*

Fig.2 shows the android robot ReplieeQ2 utilized in this research. The main features of the android are its appearance which highly resembles with those of human. The face of the android is made of soft silicon rubber made by taking a copy of a real face of a human. The height of the android is approximately 150[cm], and there are 42 degrees of freedoms in the upper body. The lower body (i.e. the legs) are not movable. All of the degrees of freedom are driven by pneumatic cylinders with air powered servo motors. An air compressor is necessary for controlling the android, because it uses pneumatic air actuators. The face has 17 degrees of freedoms which enables various facial expressions. All of the joints are position controlled from an external PC. The use of air actuators enables the robot to have the physical compliance in order to realize smooth motion and to allow safe interaction with human.

B. *Android as a bystander*

There have been many robotic systems which interact with humans. For example, the humanoid robot ROBITA can communicate with two persons [18] by recognizing speech and visual information. However the conversation partners have to take the ability of the robot into account and make conscious efforts in order to politely interact with the robot, which limits the type of communication which is possible. Even for the state-of-the-art robots, it is still hard to endure long direct interaction with human since the communication abilities such as speech recognition, speech synthesis, dialog processing, and gesture generation are not as developed as those of humans. In order to compensate for such disabilities, we take an approach to utilize the android as a bystander in trilateral communication, in which the android is not explicitly involved in the conversation. There have been several researches which dealt trilateral communication in robotics, and the role and the relationship of three participants, each of which is a human or a robot, can be variously determined (e.g., [19]).

III. THE CHAMELEON EFFECT

In psychology, it is shown that nodding and facial expression are two major channels in non-verbal communication which humansuse to judge the degree of intimacy [20]. In addition, the "chameleon effect," which refers to non-conscious mimicry of the conversation partner in bilateral communication is known to make human-human communication smoother [9]. It includes mimicry of the postures, mannerisms, facial expressions. It was experimentally shown that a conversation partner who mimicked participants was more highly regarded than a partner who did not, despite the fact that participants did not explicitly notice the mimicry.

We use the situation of a real clinical examination in a hospital, where a doctor and a patient communicate seriously with each other in an examination room. The reason we chose this situation is that the participants (patients) are highly stressed and are nervous in such a situation, and harmonizing such communication is socially valuable, and could lead to robotic therapy. The android acts as a bystander like a nurse or a medical student, and does not explicitly participate in the conversation. That is, it does not directly interact with either the doctor or the patient. Therefore, if the motions based on social needs are generated properly, the android can have a positive influence on human-human communication.

IV. PRELIMINARY EXPERIMENT FOR MOTIONS BASED ON SAFETY NEEDS.

In this section, we investigate how the motion based on safety needs influence the impressions of observers. In addition, we investigate whether the motions of the lower layer are executed when motions of the upper layer are executed. We researched the animacy of the android with motion based on safety needs. Because the android does not have sufficient abilities for all levels, the human-like nature is not perfect yet. A questionnaire proposed by Bartneck [21] is used to evaluate the animacy.

A. Experimental conditions

The participants could see the android within their field of view, even when the participants are looking at the experimenter. This is the same setup as the doctor-patient situation (Fig.6).

- **Condition 1: motions based on physiological needs** (i.e., blinking, breathing and slight movements) are used for the android. The particiant and the experimenter talked for 1 minutein front of the android.
- **Condition 2: motions based on safety needs** (i.e., gaze and turning towards the speaker) are used for the android. The participant and the experimenter talked for 1 minute in front of the android.
- **Condition 3: motions based on both physiological and safety needs** (i.e., blink, breath slight movements, gaze and turning towards the speaker) are used for the android. The participant and the experimenter talked for 1 minute in front of the android.

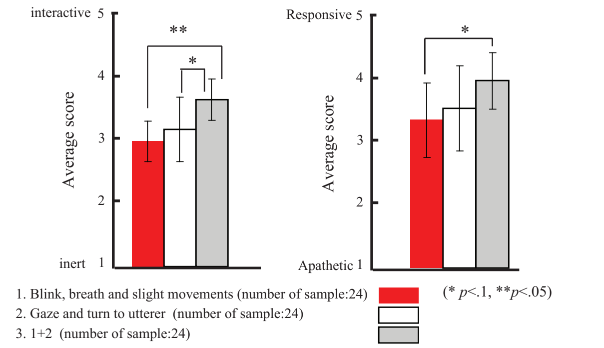

Fig. 3. Impression of motions based on physiological and/or safty needs.

24 patients (age range 19-29, average 23.0, variance 5.3) participated in the experiment. The number of samples for each condition was 24. The participants were divided into 6 groups and presented the stimuli using different combination patterns to cancel any order effect.

B. Result

The ANOVA test showed siginificant differences in 'Interactive-Inert' between condition 1 and condition 3, and a significant tendency between condition 2 and condition 3. In addition, we obtained significant tendency on 'Responsive-Apathetic' between the condition 1 and the condition 3 (Fig.3). These results showed us that motions based on only physiological needs or only safety needs do not increase impressions of interactiveness and responsiveness, but motions basedon both needs increase these impressons. Therefore, both motions are needed to give us effective impression in the situation of a real human communication.

V. PRELIMINARY EXPERIMENT WITH HUMAN BYSTANDER

A. Experimental conditions

We conducted a preliminary experiment with a human bystander in order to confirm how the behavior of a bystander psychologically influences the patient. This can be regarded as the extension of the chameleon effect to trilateral situation. This experiment was performed in an examination room of orthopedics at outpatient department of Osaka University Medical Hospital. 44 patients (age range 30-69; 70's is 40%, 60's is 40%, 50's is 16% and 40's is 3%) participated in the experiment. In this experiment, a female graduate student the role of a bystander (i.e., experimenter) with wearing a white coat, which makes her look like a nurse or a medical student observing the examination. She behaved in one of two conditions as follows which was unknown to both the doctor and participants:

- **Condition 1: Synchronized with participants**: When the bystander recognizes that the participants are smiling or nodding, she smiles or nods.
- **Condition 2: Without expressions**: The bystander does not either nod or smile.

TABLE I

PREFERENCE FOR HUMAN-BYSTANDER.

	Synchronized with participants	No expression
Prefer presence	33.3%	4.3%
Indifferent	61.9%	91.3%
Prefer absence	4.8%	4.3%

The motion of the condition 1 was determined based on the chameleon effect found in bilateral conversation. The participants answered the following questionnare by choosing one option from three.

- **Prefer presence:** I preferred the presence of the bystander,
- **Indifferent:** I was indifferent about the existence of the bystander,
- **Prefer absence:** I did not like the presence of the bystander.

The experimental result on this questionnaire is shown in Fig.I.The impression of the bystander seems to be rather better in the condition 1 (smile and nod synchronized to participants), however the dominant opinion was they were indifferent about the existence. Most of the participants also reported that the bystander did not do anything concerning the medical care. This is understandable because they all came to the hospital with severe diseases or injuries, and their interests must be the result of the clinical diagnosis. The participants had a following questionnaire about the consultation:

- **Q1.** Did the doctor kindly listen your opinion?
- **Q2.** Did the doctor empathize with you?
- **Q3.** Was the doctor's attitude good?
- **Q4.** Did you understand the doctor's explanation?
- **Q5.** Was the doctor's explanation satisfactory?
- **Q6.** Was your anxiety decreased by the clinical examination?

B. Result

The ANOVA shows that the motion of condition 1 is statistically significant difference or tendency from condition 2 (Fig.4). This result shows that the smiling and nodding motion synchronized with the pariticipants had a positive effects on the participants However, it is possible that this questionnaire is not related with the bystander's motion but with the contents of clinical consultations. It should also be noted that the conscious impression of the bystander was different between both conditions as shown in table.I, and the existence of the bystander clearly unconscioulsy influenced the impression.

VI. CLINICAL EXPERIMENT WITH ANDROID

In order to confirm the hypothesis that proper behavior of the android bystander can have positive effects on human communication, we conducted a clinical experiment in Osaka University Hospital under the permission of Ethical Review Board. This experiment was also performed in an examination room of orthopedics at outpatient department for approximately a month.

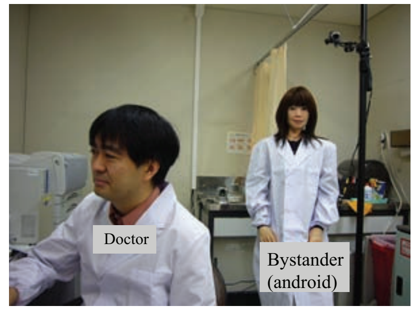

Fig. 6. View for the doctor and the android from participants' poisition.

A. Experimental Setup

The android was placed behind the doctor as shown in Fig.5, and a terminal PC together with an air compressor was put in the neighboring room. The participants could observe the bystander within their field of view, while it was out of the doctor's field of view as shown in Fig.6. The doctor and participants were asked to have an examination as usual, and most of them did not consciously pay any attention to the bystander. The behavior of the bystander android during the clinical examination was generated under the following four conditions, which was unknown to both the doctor and subjects:

- **Condition 1: Synchronized with participants**: The bystander nods and smiles synchronized with the participants,
- **Condition 2: Without expressions**: The bystander blinks, breathes and slightly moves,
- **Condition 3: Random timing**: The bystander randomly choose timing of nods and smiles.

One of these conditions was assigned to each subject, and the bystander acted based on the condition during the clinical examination. The condition 1 corresponds to the chameleon effect, which we expected to have good psychological effect on the participants. In the condition 1, an operator in the neighboring room was observing the examination room through a monitor, and determined the timing of the nodding and smiling. In these conditions, the android was blinking, breathing and slightly fluctuating, because these motions can regarded as motions based on physiological needs. In addition to this, the android executed gaze motion as motions based on safety needs. 64 patients (24 males and 40 females, age range 10-79; 70's is 58% 60's is 11%, 50's is 17% and 40's is 2%) participated in the experiment. The same doctor was present throughout the experiment, and was unaware of the conditions of the experiment. In addition, some participants answered same questionnaire after the normal examinations (i.e., without android). The motions of smiling and nodding behaviors are depicted in Fig.7,Fig.8. These motions are quite small, and no large gestures are taken with other parts of the entire body.

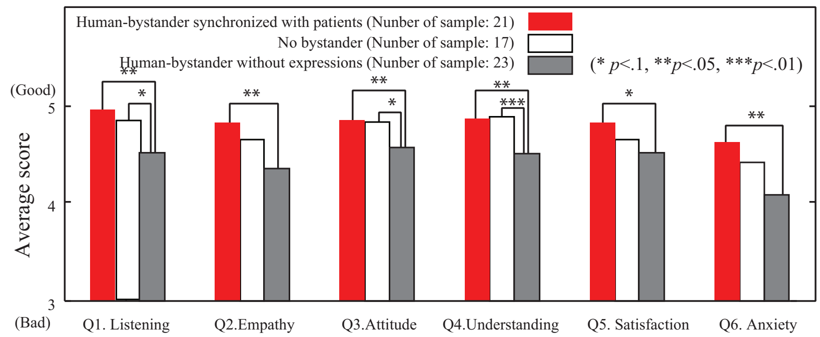

Fig. 4. Patients' satisfaction for doctor's care with human bystander.

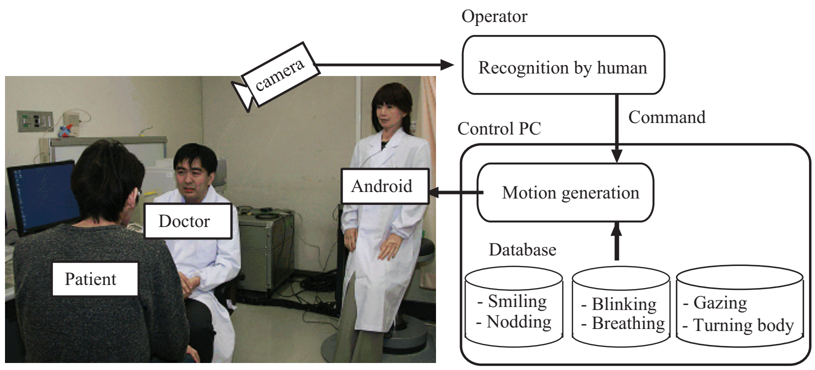

Fig. 5. System setup for clinical experiment.

Fig. 7. Android in smiling motion.

Fig. 8. Android in nodding motion.

B. Experimental Results

The most frequent opinion about the presence of the bystander in all conditions was that they were indifferent to the presence of the bystander, which was the same result as the preliminary experiment. This was the same result as the preliminary experiment. The most frequent opinion on the presence of the bystander in all conditions was that they were indifferent about the presence of the bystander, which was the same result as the preliminary experiment. However the presence tended to be preferred when the bystander behaved in a manner that synchronized with participants, as in the condition 1. Actually many subjects also commented that the presence was comfortable, or relaxing in this condition. Another frequent comment was that they were interested in the android, therefore subjects seemed to regard it as an object of interest rather than an object of communication. Fig.9 shows the response of the participants to the questions on the clinical examination. The questionnaire was the same as the

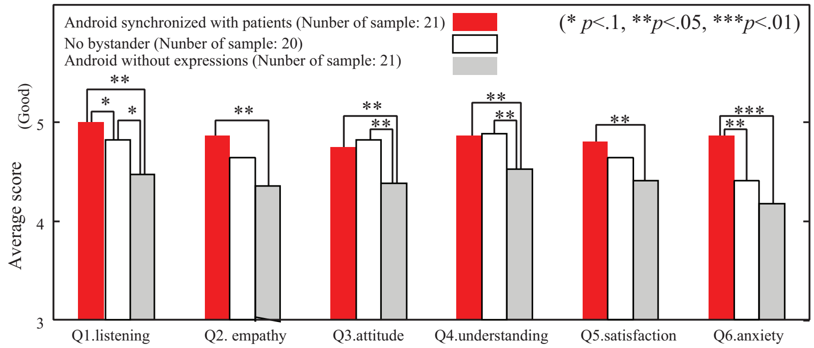

Fig. 9. Impression on clinical examination with/without android and motions based on social needs.

one utilized for preliminary experiment. In Fig.9, impressions of subjects in th condition 1 (android synchronized with subjects) and the condition 2 (android without expressions) are compared with the case of no android in the examination room. When the android didn't express smiling and nodding behaviors, the impression was worse than that for the android which smiled and nodded synchronizing with the subjects for all questions. This is the same result as that in the preliminary experiment. In addition to this, it became clear that it is even worse than the case when there is no android in the examination room.

VII. Conclusion

In this paper, we investigated the psychological effects of the presence and the motions of the android on trilateral communication in the clinical examination in a hospital. The experimental result indicated that the android android succeeded in having a positive influence on the human-human communication with the motions based on human needs are sufficiently effective. It should be noted that this experiment was conductedin a "real" communication situation in the hospital, where the patients were much stressed and nervous, and thus concentrated on the conversation with the doctor. This fact convince us that even current android without agressive interactional ability can improve the human-human communication in the practical clinical situation.

Our next work includes further investigation of the effect of the appearance of the robot in order to conform whether other humanoids with mechanical appearance have similar psychological effect. We are also planning to automate the recognition process of the behavior generation system of the android by utilizing vision technology.

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