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Emotional Contagion between User and Product Recommendation Virtual Agent

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***Abstract*— The notion of *Emotional contagion* is a phenomenon in which a human emotion infects others. Various studies have been done to cause emotional contagion between a human and a robot or an anthropomorphic agent in HRI research fields. However, few studies have been done to compare different kinds of agents in order to find important properties in emotional contagion in human-agent interaction (HAI). In this research, we conducted an experiment to determine which properties cause this phenomenon between anthropomorphic agents and users. We prepared two kinds of agents. One is a cartoon-like agent, and the other is a concrete agent. The cartoon-like agent smiled exaggeratedly, and the concrete agent smiled modestly. As a result, we found that the concrete agent was more effective than the cartoon-like agent at emotional contagion. This result suggests a model for designing more trustworthy and familiar agents and robots.**

I. INTRODUCTION

Emotional contagion is a phenomenon in which a speaker's emotion infects his or her partner during conversation [1]. Hatfield et al. showed that this phenomenon is caused not only by a partner's utterances but also by their non-verbal cues [1]. Kim et al. showed that positive emotions have the tendency to infect partners even in character-based conversations on Twitter [2]. This effect must be caused by conversational text. However, in face-to-face communication, non-verbal cues are more important [1]. Many cues were investigated after the report by Hatfield et al., for example, facial expression mimicry [3], vocal expression of voice [4], and whole body movement [5]. Through these studies, it was revealed that these factors are important for emotional contagion.

In the research areas of HAI and HRI, emotional contagion between a user and an agent or a robot was studied through experiments with participants. Tsai at al. showed that 3D visual game characters can infect users with their emotion through facial expression [6]. In the area of HRI, Xu et al. showed the humanoid robot NAO can express and infect users with his mood [7]. From these studies, agents, including anthropomorphic agents and physical robots, can infect users with their positive emotions, which is useful for constructing a positive interaction between users and agents. Dunn and Schweizer showed that people trust unfamiliar persons when they expressed a positive emotion [8], and Druckman and McDermott showed that people judged risky choices by their positive and negative valences [9]. Barsade showed a positive emotional contagion among group members was useful for group work [10]. Pugh showed that a positive emotion contagion between customers and employees causes customers to evaluate service quality highly [11]. In this paper, we investigate emotional contagion between a user and product recommendation virtual agent (PRVA).

Our final goal is to make users evaluate the PRVA's service as having high quality. Terada et al. showed that a young woman agent is one of the most effective agents for increasing a user's buying motivation [12]. Thus, we used two young women agents and compared a concrete agent and a cartoon agent. Geven at al. showed that interaction with a concrete anthropomorphic agent is perceived to be more concrete than that with a cartoon-like agent [13].

It has not been clarified which properties affect emotional contagion from PRVAs to users in on-line shopping. Thus, we aimed to experiment to show that concreteness is an important property for the emotional contagion of PRVAs.

II. EXPERIMENT: MATERIALS AND METHOD

We recruited 30 Japanese participants for this experiment. The participants were 15 males and 15 females, and they were between the ages of 20 and 39, for an average of 30.0 (S.D. = 6.3). They were recruited for this experiment. We arranged participants into two groups. Each group contained 15 participants. Group 1 contained seven males and eight females, and they were between the ages of 21 and 39, for an average of 30.7 (S.D. = 5.6). Group 2 contained eight males and seven females, and they were between the ages of 20 and 39, for an average of 29.3 (S.D. = 6.9).

We designed two series of recommendation movies for each groups. Both series were contained 10 successive recommendations. All recommendations were presented by virtual agents executed by MMDAgent[1], distributed by the Nagoya Institute of Technology.

In the movie series shown for group 1, the PRVA had long black hair and wore a black suit. This model[2] and suit[3] is distributed by one of the general users. The model is called "Mobuko-san" by users. The model is shown on the left of Fig. 1 and is a cartoon-like agent. She has big eyes and cute smile but looks to be constructed with only a few polygons. She does not appear very concrete and has a high level of abstraction.

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[1]http://www.mmdagent.jp/
[2]https://bowlroll.net/file/3706
[3]http://bowlroll.net/up/dl43967

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Fig. 1. "Mobuko-san" and "Mei"

For group 2, the PRVA was "Mei," distributed by the Nagoya Institute of Technology. She has short hair and wears a warm colored suit. She looks like a 3D game character. She looks to be constructed elaborately and moves smoothly. This model is shown on the right of Fig. 1. She appears more concrete and has a low level of abstraction. Also, we use VOCELOID+ Yuduki Yulari EX[4], which is text to speech software, for both agents in order to execute smooth utterances.

The PRVAs recommended the same ten package tours to Japanese castles at random. All castles are tourist destinations in Japan. For the recommendations, they did not show any facial expressions and gestures from the first recommendation to the fifth. We defined these PRVA states as the neutral states. From the sixth recommendation to the tenth, the agents smiled and made cute gestures. We defined these PRVA states as happy states. Fig. 1 shows the neutral states of the two models. In Fig. 2 and Fig. 3, both models are in happy states. The left-most pictures of Fig. 2 and Fig. 3 show the agents smiling. The middle pictures show the agents introducing the tours. The right-most pictures show the agents are making cute gestures. We executed different gestures for the two agents because more overstated gestures seemed to have more of an effect on users than did small gestures. In Fig 2, the model moves her shoulder. In Fig 3, the model strikes a victory pose with both arms. Although the recommendation utterances are slightly different between the two PRVAs, the utterances of both contained historical episodes of each castles. This means both agents expressed the same intelligence and familiarity in the utterances. None of the movies were more than one minute. Fig. 4 shows one screenshot of a recommendation made by Mei. Table I shows the recommendation text spoken by Mei.

The participants were required to watch the movie series and answer two questions after watching each movie:

Q1: Do you feel happy?
Q2: Do you feel at home?

The participants were required to answer these questions with "YES" or "NO." In addition to this, before all the recommendations, the participants were required to watch a short movie showing the agent only standing without making any smiles, gestures, and utterances and answer the same two questions. We called these "pre-recommendation questions."

[4]http://www.ah-soft.com/voiceroid/yukari/

TABLE I
RECOMMENDATION TEXT

Text	Well, I recommend that you take a trip to Gihu castle. Gihu castle stands in Gihu city, Gihu Prefecture. This castle stands on a mountain, so you can get a nice view from the castle tower. In the Warring State Period, the Saito family lived in the castle and reigned over the prefecture. In particular, Saito Dozan is well-known for being Oda Nobunaga's father-in-law We are currently selling a package tour to this castle for only 21,060 yen, which covers the admission fee to the castle. The package tour also contains travel expenses and lunch. If you miss this chance, you will surely regret it.

Fig. 2. PRVR, "Mobuko-san," shown to group 1

Fig. 3. PRVR, "Mei," shown to group 1

Fig. 4. Screenshot of "Mei" recommending package tour

III. RESULTS

We indicated the calculation of the t-test between the first five recommendations and the latter five recommendations. We compared number of participants that answered "Yes" after each recommendations. Fig. 5, Fig. 6, Fig. 7 and Fig. 8 shows these results. The error bars in these graphs means standard deviation. In Fig. 6, Fig. 7 and Fig. 8 shows significant differences ($p<0.01$).

In the upper graphs of Fig. 9, Fig. 10, Fig. 11, and Fig. 12, the x-axis indicates pre-recommendation and R-n (the nth

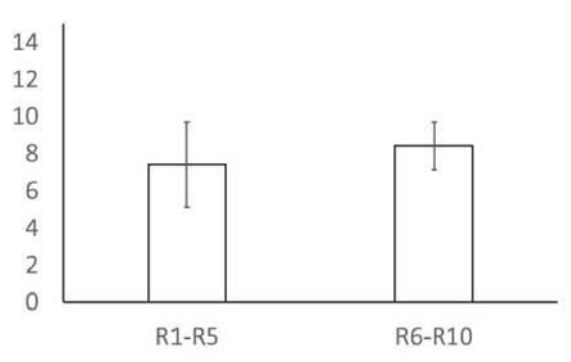

Fig. 5. Average of number of participants in group 1 answering "YES" to Q1 for each recommendations

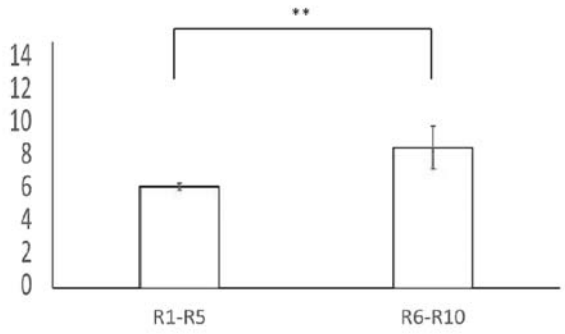

Fig. 6. Average of number of participants in group 1 answering "YES" to Q2 for each recommendations

recommendation), and the y-axis indicates the frequency ratio of the participants who answered "Yes." We analyzed these results by applying a chi-squared test to two ratios of "'Yes" answers for every two consecutive questions.

The lower graphs of these figures show the participant's inner state transitions. We defined that an inner state as transitioning if there is a significant difference between the two consecutive questions obtained by applying the chi-square test.

Fig. 9 and Fig. 10 show the result of Q1. Fig. 11 and Fig. 12 show the result of Q2.

In Fig. 10, there is a significant difference between R5

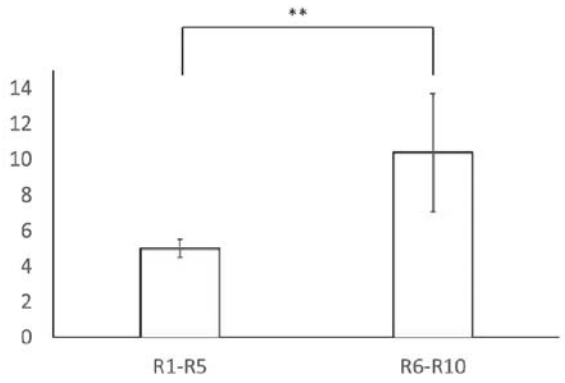

Fig. 7. Average of number of participants in group 2 answering "YES" to Q1 for each recommendations

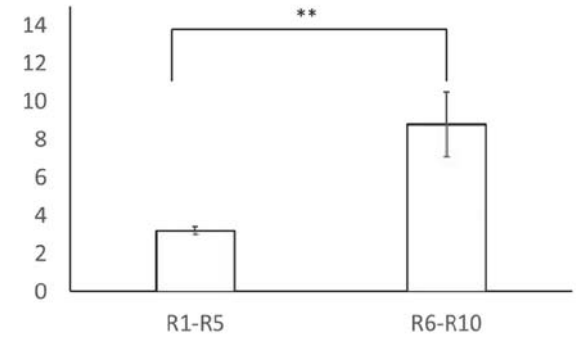

Fig. 8. Average of number of participants in group 2 answering "YES" to Q2 for each recommendations

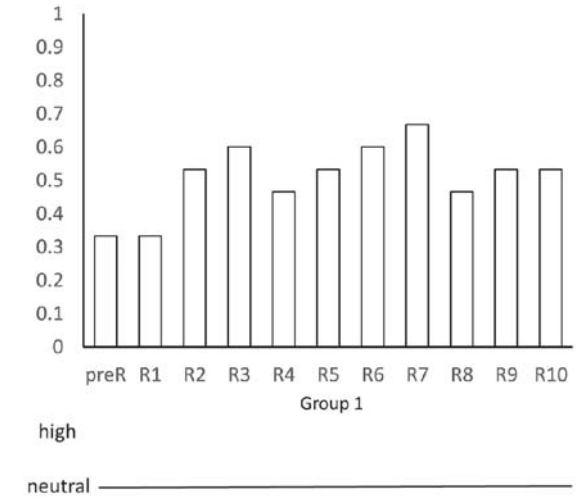

Fig. 9. Frequency ratio of participants in group 1 answering "YES" to Q1

and R6 for group 1 ($p<0.05$). Thus, we determined that the participants inner states transitioned between R5 and R6. In Fig. 9 Fig. 11, and Fig. 12, there was no significant difference.

IV. Discussion

The result of t-test shows whether user inner state transition happened or not. From Fig. 6, Fig. 7 and Fig. 8, user inner state transitions happened through 10 recommendations. These result may be caused by emotional contagion, however, we can't know when state transitions happened. Thus, we judged whether transitions caused by transition operators or not by the result of chi-squared test.

From Fig. 10, we can see that the agent's positive emotion infected only participants in group 2. This effect must be caused from the agent's smile and cute gestures because the contagion occurred between R5 and R6 when the agent started to smile and make gestures. However this effect did not occur in Fig. 9 although the same actions occurred for this group. This difference is considered to be caused by the difference in the level of abstraction between these two agents.

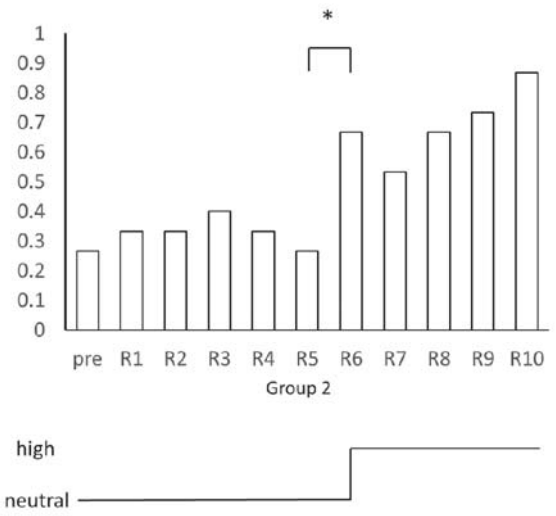

Fig. 10. Frequency ratio of participants in group 2 answering "YES" to Q1

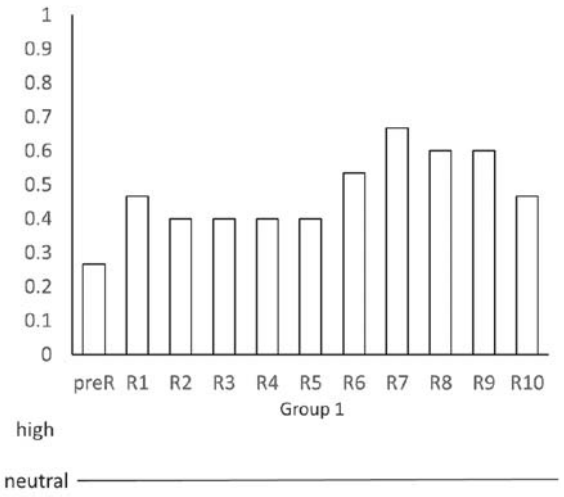

Fig. 11. Frequency ratio of participants in group 1 answering "YES" to Q2

Fig. 11 and Fig. 12 show that both agents had no effect that made participants feel at home. This result shows that the significant difference that occurred in Fig. 10 was not caused from feeling at home. This effect must be caused by emotional contagion. The significant differences in Fig. 6 and Fig. 8 may be caused by only listening recommendations, not emotional contagion. From these results, Mobuko-san failed to infect positive emotion to users. We proved that the level of abstraction affect emotional contagion.

However, other interpretations may be happened. That is, "the appearances of Mobuko-san caused positive emotion in pre-recommendation phase, thus the effect of emotional contagion was buried". This hypothesis is rejected by the ratios of pre-recommendation in Fig. 9 and Fig. 10. There are almost no differences between the ratios of pre-recommendation in Fig. 9 and Fig. 10. Thus, the inner state

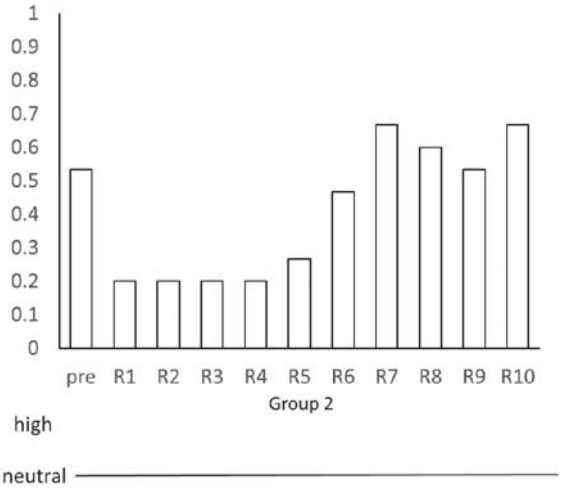

Fig. 12. Frequency ratio of participants in group 2 answering "YES" to Q2

of participants in each groups had no differenced in pre-recommendation phase.

A. Uncanny Valley

In the research field of HAI, the uncanny valley hypothesis has been researched for a long time. This hypothesis states that robots have familiarity as they come to resemble humans, but those that appear too similar to humans cause people to feel an uncanny emotion [14]. This hypothesis has been verified for a long time. MacDorman shows that participants feel more eerie toward images of a robot morphing into a human than a robot or a human; however, video clips of anthropomorphic androids do not have this effect [15]. MacDorman insisted that human likeness is not the only factor for familiarity or eeriness. In our research, Mei has more of a human likeness than Mobuko-san. The result that she was more effective at positive emotion contagion shows that having a human likeness makes users feel more familiarity than eeriness.

For the first reason explaining this effect, Mei's smiling and gesturing was appropriate for the recommendations. She made an introduction gesture by only moving her right hand and an emphatic gesture by striking a victory pose. If we execute many more and overdone facial expressions and gestures, we cause participants to feel uncomfortable and eerie feelings. For the second reason, Mei's design seem to be the halfway point between cartoon characters and concrete humans or androids. Mei is more of a concrete agent than a cartoon character. However, she has less concreteness than the CGI characters in games and movies.

Both of the two agents we used in this experiment smiled during the recommendations. However, these smiles were different as shown in Fig. 2 and Fig. 3. Mobuko-san smiled with scrunched eyes. Mei only smiled softly. Mei's smile has less distinction from her neutral face than Mobuko-san's, but Mei's smile was more effective than Mobuko-san's.

This result may be based on the difficulty of mimicry. Hatfield et al. suggested that emotional contagion primarily

stems from facial expression mimicry [1]. We assume that the smile of the cartoon-like agent was difficult to mimic because we cannot scrunch up our eyes like Mobuko-san did in Fig. 2 . Mei's smile can be mimicked. Thus, Mei's smile was more effective than Mobuko-san's.

Also, these results may be caused by the difference of the color of suits, the color of hair, and the length of hair. One female participant wrote in a free description column, "This agent seemed to be untidy because she has long hair." We guess she means long and unbraided hair appears untidy on clerks. We do not know if this impression is something felt by the general public or not and whether the color of suits or other dresses have the same effect. This is our future research.

B. Implementing robots that can infect humans with emotion

From this experiment, the concreteness, smiling, and the cute gestures were determined to be useful factors for emotional contagion. We suggest implementing these factors in robots in order to spread positive emotions between robots and users. We discovered that a more human-like simple smile is more effective than an exaggerated smile. This is practical for robots. Also, the gestures are needed only a little. Only occasionally expressing two kinds of gestures can infect users with a positive emotion. If we aim to construct rapport between a robot and user, we may need to execute many kinds of facial expression and gestures frequently and satisfy many other conditions. For example, Tichle-Degnen et al. suggested that mutual attentiveness, positivity, and coordination are the three essential factors for constructing rapport [16], and Huang et al. applied these three factors to their Rapport Agent [17]. However, infecting only a positive emotion is very easy. This can occur with only a few patterns of facial expressions and gestures.

V. CONCLUSION

In this experiment, we investigated the important factors for emotional contagion between an agent and a user. We experimented with two kinds of agents that have a difference in concreteness and level of abstraction. As a result of the experiment, the concrete agent was found to be able to infect participants with a positive emotion better than the cartoon-like agent.

The result shows that the effect of emotional contagion from an anthropomorphic agent depends on the design of the agent. A concrete agent can infect a positive emotion better than a cartoon-like agent. Also, our future work is to discover the factors that are perceived by users when they judge how concrete an agent is. In this experiment, the two agents had differences in the roughness of their surfaces, gestures, hairstyles, and color of hair and suits. One of them may be a critical factor. However, these factors express the level of concreteness when combined together. Investigating the relationships between each factor and effect can help suggest a methodology for designing agents.

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