

Building Trust in PRVAs by User Inner State Transition through Agent State Transition

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ABSTRACT

In this research, we aim to suggest a method for designing trustworthy PRVAs (product recommendation virtual agents). We define an agent's trustworthiness as being operated by user emotion and knowledgeableness perceived by humans. Also, we suggest a user inner state transition model for increasing trust. To increase trust, we aim to cause user emotion to transition to positive by using emotional contagion and to cause user knowledgeableness perceived to become higher by increasing an agent's knowledge. We carried out two experiments to inspect this model. In experiment 1, the PRVAs recommended package tours and became highly knowledgeable in the latter half of ten recommendations. In experiment 2, the PRVAs recommended the same package tours and expressed a positive emotion in the latter half. As a result, participants' inner states transitioned as we expected, and it was proved that this model was valuable for PRVA recommendation.

ACM Classification Keywords

H.5.2. User Interfaces

Author Keywords

product recommendation virtual agent, user inner state, emotional contagion, trustworthy, anthropomorphic agent

INTRODUCTION

PRVAs, product recommendation virtual agents, are agents that take the role of clerks and advisers in online stores. In this paper, we experimented to design trustworthy PRVAs to increase users' buying motivation. Terada et al. showed that the appearance of PRVAs affected the recommendation result [?]. Kamei et al. experimented with robot clerks and showed that customers feel more familiarity with robots who navigated them toward the store rather than robots that only recommended lunch [?]. Moon et al. showed that self-disclosure, exchanging information with each other, induced users to give their information to computers [?].

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Moon's study focused on the trust that was constructed within the interchange between users and computers. It takes a long time to construct this trust. In this paper, we aimed for users' trust to be constructed by only perceiving product information that PRVAs gave. This trust needs little time and simple technology. We aimed for user trust to be constructed by PRVAs expressing agent motion and utterance.

USER TRUST STATE TRANSITION MODEL AND USER STATE TRANSITION OPERATORS

User Trust State Transition Model

We describe a user trust state as the user emotion state and knowledgeableness perceived state. Our basic hypothesis is that "positive emotion and high knowledgeableness perceived brings high trust."

Dunn and Schweizer showed that how much people trust their partners depended on familiarity and emotion [?]. They showed that positive people tended to trust partners when partners were unfamiliar with the truster. Myers and Tingley studied negative emotion [?] . They showed negative people trust their partners less than positive people. From these studies, the emotion state seemed to affect the trust state.

We aimed to cause a user's emotion state to transition by using *emotional contagion*. Emotional contagion is a phenomenon in which a speaker's emotion is spread to a partner [?]. Tsai et al. showed that emotional contagion can be caused between users and virtual anthropomorphic agents [?].

"Knowledgeable" is one aspect of intelligence. Geven et al. showed that users perceived more intelligence and trustworthiness with real agents rather than cartoon-like agents [?]. Also, Mimoun et al. indicated that a lack of intelligence was one of the most crucial problems with anthropomorphic agents [?]. In our experiment, we focused on knowledgeableness, one aspect of intelligence. From these prior pieces of research, it is clear that positive emotion and high knowledgeableness perceived brings high trust.

In our model, we described a user's emotion state and knowledgeableness perceived state as { + } and { - }. State { + } means a positive or high state, and state { - } contains a negative, low, and neutral state. We defined a user's basic state to be { - - }. The left value means the emotion state, and the right value means the knowledgeableness perceived state. Thus, state { - - } means a negative or neutral emotion

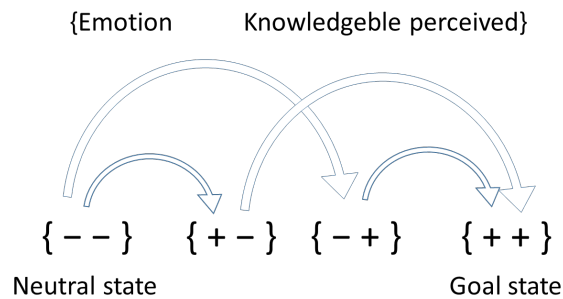


Figure 1. User inner state transition model

and low or neutral knowledgeable perceived. If a user's emotion transitions to positive, the user state transitions to $\{ + - \}$. If a user's knowledgeable perceived transitions to high, the user state transitions to $\{ - + \}$.

Our goal state was $\{ + + \}$, that is, positive emotion and high knowledgeable perceived. Users having this state seem to trust PRVAs more than when having the other three states. We show this model in Figure ??.

Positive emotion and high knowledgeable are instinctively effective for PRVAs or any agent; however, it is not clear whether positive emotion and high knowledgeable work together. In this paper, we inspected this point.

User State Transition Operators

The aim of this research was to increase users' trust by causing only the agent state to transition. Thus, positive emotion and high knowledgeable perceived were executed with only the agent state. Positive emotion was executed by "agent's smile" and "cute gesture" in order to cause positive emotional contagion [?]. High knowledgeable perceived was executed by "much product knowledge."

We carried out two experiments to prove that these transition operators were effective in user inner state transition and that our transition model was valuable for designing PRVAs.

EXPERIMENT 1: EXECUTING HIGH KNOWLEDGEABLE-NESS PERCEIVED

Experiment 1: Materials and Method

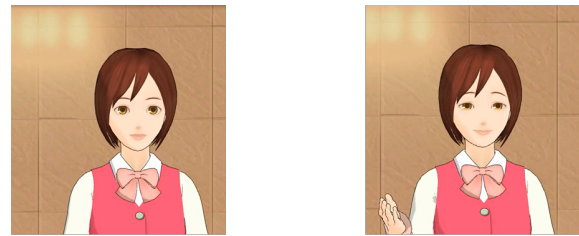
Participants

Fifteen Japanese participants were recruited for experiment 1. They were aged between 20 and 39, for an average of 29.0 and *SD* was 5.7. There were seven males and eight females; however, one female's data was removed from analysis because of machine trouble. Each participant spent about 20 to 30 minutes for the whole experiment.

Task

The PRVAs and recommendation systems were constructed with MMDAgent¹, the free dialogue agent "Mei," and a platform that is distributed by the Nagoya Institute of Technology.

¹<http://www.mmdagent.jp/>



No Emotion

Positive Emotion

Figure 2. Agent with positive emotion transition operators and agent without operators (neutral emotion)

Also, we executed smooth utterance with text to speech software, VOCELOID+ Yuzuki Yukari EX². Figure ?? shows the agent with and without emotion transition operators.

The PRVAs recommended package tours to Japanese Middle Ages castles. They recommended ten tours by taking turns, and the destination changed for each recommendation. The order of destinations was random for each participant. We defined each recommendation as R_n , and n means the recommendation number (1 to 10). Each recommendation took no longer than one minute.

From R1 to R5, the PRVAs executed only positive emotion operators. The PRVAs made recommendations with smiles and cute gestures; however, their utterances contained only location and expense information. Also, from R6 to R7, the PRVAs executed positive emotion transition operators and high knowledgeable perceived transition operators. They made recommendations with smiles, cute gestures, and knowledge on location, expense, history, and architecture. Thus, from our hypothesis, from R1 to R5, the participants' state was $\{ + - \}$, positive emotion and low knowledgeable perceived. Also, from R6 to R7, the participants' state was $\{ + + \}$. Thus, knowledgeable perceived transitioned to high.

After watching each recommendation, participants were asked to answer some questions. In this paper, we focus on the result for two of the questions as follows.

- Q1: Did you feel happy when you watched the movie?
- Q2: Did you feel that the agent has correct knowledge?
- Q3: Did you feel that the agent have considerable persuasive power?

Question Q1 was the indicator of the user's emotion, and Q2 was the indicator of the user's knowledgeable perceived. Q3 was the indicator of the agent's trustworthy perceived by user. All participants were asked to answer "Yes" or "No" for these questions. Also, all participants were asked to answer the same questions before recommendations after watching PRVAs standing without any motion and utterance.

²<http://www.ah-soft.com/voiceroid/yukari/>

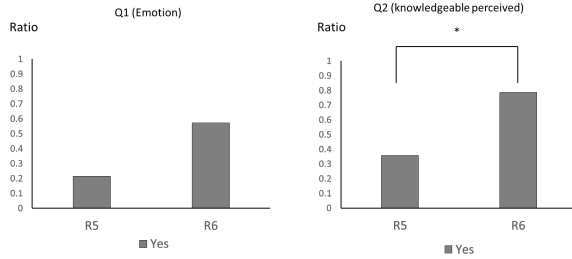


Figure 3. Ratio of participants' answers for Q1 and Q2 in experiment 1

Experiment 1: Result

We conducted a statistical analysis based on the ratio of the number of participants who answered "Yes" for each question. The x-axis indicates each questions. We conducted a chi-square test for every successive recommendations. If there were significant differences, the number of users whose inner state transitioned increased significantly between those two recommendations. For the result of Q1, there were no significant differences. For the result of Q2, there was a significant difference between R5 and R6 ($p < 0.05$).

The left graph of Figure ?? means the ratio of the number of participants who answered "Yes" for Q1 after R5 and R6. The right graph of Figure ?? means the ratio of the number of participants who answered "Yes" for Q2 after R5 and R6.

Regarding Q3, we conducted a chi-square test between the average of the ratio of the participants who answered "Yes" in the first five recommendations and the ratio of the participants who answered "Yes" in the latter five recommendations. As a result, there was a significant difference between R5 and R6 ($p < 0.01$).

EXPERIMENT 2: EXECUTING POSITIVE EMOTION

Experiment 2: Materials and Method

Participants

Fifteen Japanese participants were recruited for experiment 2. They were aged between 20 and 39, for an average of 29.3 and *SD* is 6.9. There were eight males and seven females. Each participant spent about 30 minutes for the whole experiment.

Task

The PRVAs, recommendation products, recommendation format, and questions for experiment 2 were the same as in experiment 1. All participants watched the recommendations for package tours to Japanese castles. The difference was what transition operators were executed for each recommendation.

From R1 to R5, the PRVAs executed only high knowledgeable perceived operators. The PRVAs' recommendations contained historical and architectural knowledge; however, they stayed expressionless without making any gestures. Also, from R6 to R7, the PRVAs executed high knowledgeable perceived transition operators and positive emotion transition operators. They made recommendations with historical and architectural knowledge, smiles, and cute gestures. Thus, from our hypothesis, from R1 to R5, the participants' state was { - + }, negative or neutral emotion and high knowledgeable

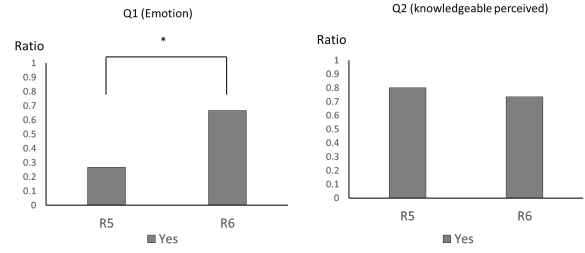


Figure 4. Ratio of participants' answers for Q1 and Q2 in experiment 2

perceived. Also, from R6 to R7, the participants' state was { + + }. Thus, emotion transitioned to positive.

Experiment 2: Result

We conducted the same analysis as in experiment 1. For the result of Q1, there was a significant difference between R5 and R6 ($p < 0.05$). For the result of Q2, there were no significant differences.

The left graph of Figure ?? means the ratio of the number of participants who answered "Yes" for Q1 after R5 and R6. The right graph of Figure ?? means the ratio of the number of participants who answered "Yes" for Q2 after R5 and R6.

Regarding Q3, we conducted a chi-square test between the average of the ratio of the participants who answered "Yes" in the first five recommendations and the ratio of the participants who answered "Yes" in the latter five recommendations. As a result, there was a significant difference between R5 and R6 ($p < 0.05$).

DISCUSSION

The result shows that our hypothesis and model is proper. The right graph of Figure ?? shows that our knowledgeable perceived transition operators worked according to our assumption. This graph shows that many participants felt that the agents imparted historical and architectural knowledge was more knowledgeable than agents who imparted only location and expense information. This result seems to be axiomatic; however, historical and architectural knowledge seemed to not be more important information than location and expense information for many users. It was possible that participants judged the knowledgeable PRVAs as being redundant. This result contradicted this expectation. Also, this result seems to suggest that an "informative" agent is perceived knowledgeable/intelligent. However, knowledgeable PRVAs may not only impart many pieces of knowledge but also proper information to users.

The left graph of Figure ?? shows that our emotion transition operators worked according to our assumption. This graph shows that smiles and cute gestures were effective for emotional contagion between agents and users. This effect was already reported for 3D game characters and users [?] and robots and users [?]. However, there are scarcely any studies about emotional contagion between PRVAs and users. This result suggests that emotional contagion is valid for PRVAs to increase their own trustworthiness.

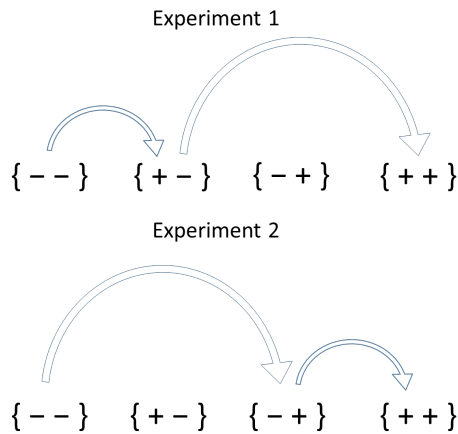


Figure 5. Observed transition paths in two experiments

The left graph of Figure ?? and the right graph of Figure ?? show no significant differences. However, in both figures, the ratio of R5 showed high values. The participants' emotion state kept at { + } between R5 and R6 in experiment 1, and their knowledgeableness perceived state kept at { + } between R5 and R6 in experiment 2.

The result of Q3 shows the emotion state and knowledgeableness perceived state transitions effected to trustworthy state. When emotion state and knowledgeableness perceived state transited to { + }, trustworthy state also transited to positive.

From these result, we constructed two different participants' transition paths as shown in Figure ??. From this, we suggested that the transition operators worked immediately for user inner state transition. In general, long and complex interaction (for example, self-disclosure [?]) was regarded as the essential phase constructing trust or other social relationships between an agent and user. Our result suggested that trust could be constructed by only expressing the agent state. This method takes little time and can be executed on finite media, for example, small screens or simple structure machines.

Also, these results suggested that emotion and knowledgeableness perceived can be operated independently. In both experiments 1 and 2, participants' emotion and knowledgeableness perceived transitioned independently. This is valuable for constructing agents for varying aims.

This research contained some limitations. First, we did not use biological signals (for example, brain waves, perspiration, and heartbeat) to measure the user inner state. This is our future works. Second, although PRVAs can work passing across borders, the notion of trust depends on cultures. Ozono et al. showed that both Japanese and American people judged partners as being trustworthy by observing their smiles; however, they focused on the other part of smiling faces [?]. This study suggests that we need to customize an agent's smiling depending on the culture.

CONCLUSION

In this research, we suggested a model of user inner state transition regarding trustworthiness and experimented to inspect this model. This model supposes that the user inner state can be operated by only changing the agent state. The result of experiments showed that this hypothesis was proper and that we can cause user the inner state to transition in an arbitrary phase. The emotion transition operators and the knowledgeableness perceived transition operators immediately worked after executing operators. Also, trustworthiness can be increased by only an agent's positive emotion and knowledge without complex interactions.

This result suggests a valuable new design method for PRVAs. This method does not need any particular equipment and pre-recommendation phase. Also, this result suggests that complex social relationships can be constructed without bidirectional communications.

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