The Influence for Human Boredom in Interaction by Mutual Prediction

M. Shimamoto, T. Shiose, H. Kawakami and O. Katai
Dept. of Systems Science
Graduate School of Informatics, Kyoto Univ.
Kyoto, Japan, 606-8501

Abstract

In the research fields of Human-Robot interaction (HRI) and Human-Agent interaction (HAI), human boredom of robots or agents is a significant problem that needs solving. Clarifying the human characteristic of boredom may be conducive to designing agents and on HRI framework. In this study, we focus on mutual prediction, which is a distinct property of animal-animal interaction, including humans, and we aim to clarify how mutual prediction affects human-agent interaction. In this paper, we explain our experimental setup for investigating influence of mutual prediction on human boredom in human-agent interaction and of subjective congnition of opponents. In these experiments, we set two axes to represent experimental conditions, one is subjective congnition of an opponent, which means subjects believe the opponent is human or a computer, the other is the presence or absence of the opponent's prediction.

1 Introduction

Since the emergence of robots designed to communicate with humans, research in HRI (Human-Robot Interaction) and HAI (Human-Agent Interaction) has gathered momentum [1, 2]. In this research field, human boredom of robots or agents is one of the main problems preventing sustained human-robot or human-agent interaction.

In this study, we aim to clarify one aspect of the human property of boredom with human-agent interaction. We focus especially on mutual prediction, which is a distinct property of interaction between intentional entities such as humans and animals that have the abilities of prediction, adaptation and so on. We aim to clarify how mutual prediction affects human boredom with human-agent (computer) interaction.

2 Research Background

2.1 Psychological Saturation and Boredom in Interaction

In the field of psychology, boredom is called "psychological saturation", and it has been researched from the early twentyth century. Psychological saturation is a psychological state in which someone can't stay with a certain uniform action any more and stops it, even when he/she is told to continue preforming that uniform action. Psychological saturation was manifested experimentally by Karsten [3].

However, when we consider HRI or HAI, there is another aspect of human boredom that can't be treated as psychological saturation. Psychology saturation is a psychological state specific to a certain uniform action, whereas in HRI or HAI, if a robot has a abilities of prediction and adaptation, there is a nested structure of prediction and adaptation between humans and robots (agents) due to interaction between humans and robots (agents). That means humans naturally predict and adapt to objects, but objects also predict and adapt to humans. The phenomenon above is called mutual prediction or mutual adaptation [2, 4].

In this study, we examine how mutual prediction affects human boredom, which can't be treated as psychological saturation.

2.2 Mutual Prediction

We behave based on our prediction of others' behavior in daily life. Naturally others also behave based on their prediction of our behavior. In the case of such interaction that establishes mutual prediction of each other's behavior, there is infinite regress caused by nested structures. Consequently, there is no optimal solution in such interaction.

Luhmann focused on mutual prediction in interaction, and considered how laws and regulations are constituted by mutual prediction [5]. He separated prediction into two types: "congnitive prediction" and "prescriptive prediction". Congnitive prediction is that humans reform and accommodate their predition when actual results are different from the predited one. On the other hands, prescriptive prediction is that humans do not reform their prediction even when actual results are different. Once prediction is formed, prescriptive prediction can be applied to a certain uniform action or physical objects because these do not change drastically. On the contrary, we need to apply congnitive prediction to objects that possess the abilities of prediction and adaption such as humans, animals, or agents because there is a nested structure of prediction and adaptation.

Iizuka and Ikegami proposed a computational model of mutual prediction in interaction [4]. They used a simulated mobile robot with a recurrent neural network, and two agents performed turn-taking behavior. And they reproted that there are two phases of turn-taking behavior: one is a stable phase because each agent can predict the other and there are certain trajectory patterns, the other is unstable phase because prediction of each agent collapses and there are chaotic trajectories. The above phenomenon occur because of mutual prediction, which composes nested structure.

As described above, there is a different aspect in HRI or HAI from interaction between humans and physical objects. We suppose that the ambivalent directional properties described above affect human boredom in HRI or HAI.

2.3 The Differece from Subjective Congnition on Opponetns

The study by Reeves and Nass is pioneering research in the field of human-computer interaction[6]. They reported that people unconsciously treat computers and television as the same as humans.

On the contrary, Gallagher et al. reported that the activated region of the human brain is different when subjects believe an opponent is human from when they believe an opponent is a computer [7]. In their rock-scissors-paper game experiments, subjects were taught that an opponent is either human or a computer, even though the opponent is always a computer whose behavior was programmed randomly in both conditions. Although winning percentages of subjects are the same in both conditons, the activted region of the human brain actually differed according to the conditions. Takahashi et al. also reported that subjects' behavior differs due to subjective congnition of an opponent [8]. When subjects were taught that an opponent was human, their behavior became more explorative than that of the condition in which they were taught that the opponent was a computer. Their experimental results indicate that when people believe an opponent is a computer, people behave more exploitatively which means they use "prescriptive prediction" rather than "congnitive prediction".

As the above reports outline, human behavior differs between when people believe an opponent is human and when it is a computer. This difference may arise from people's belief or perceived notion that a computer must be routine and that it must be ruled by constant rules and designs.

Based on the above perspective, we aim to clarify the following two points in this study.

- First, we aim to clarify the diferences among subjects' boredom from subjective congnition to an opponent.
- Does mutual prediction affect human boredom in a little more complex situations than the rock-scissors-paper game?

In the next section we explain the experimental setup for a method to these two points.

3 Experimental Setting

In this study, we conduct experiments using a simple card game. In this game, a subject and an opponent put down a card from the three each is holding (numbered 1 to 3) at the same moment, and the one who puts down the higher card wins. Players can not put down a card before he/she put down once in one set, and the player who wins two of three games wins a set. For example, if a subject put down cards 3→1→2 in series and an opponent put down cards 2→3→1, the subject wins two games and, therefore, wins that set (Fig:1). Subjects repeat this card game a few dozen times.

This card game is essentially no different from the rock-scissors-paper game, but it may be a little more tactical rather than the rock-scissors-paper game because the card to be put down is restricted by the sequenc in which cards are put down. There are 36 possible patterns by which a player and an opponent can put down cards sequentially in a set. The probabilities of the subject's winning and losing are both 1/6, and the remaining 2/3 are for a draw. If the subject wins a set, he/she gets +100 points, if the result is a draw, 0 points, and if he/she loses, -100 points. Subjects play this card game using a display and a

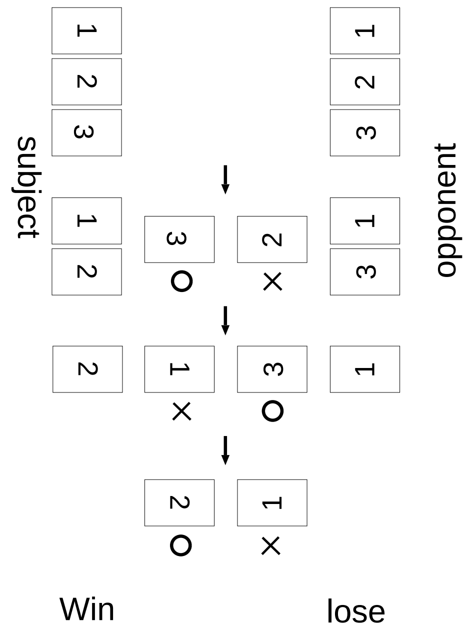

Figure 1: transition of a set

keyboard, and they cannot see the opponent's display and keybord directly.

3.1 Experimetn 1

In this experiment, we examine whether the difference in subjects' boredom arises from subjective congnition of an opponent. We set following two conditions:

- subjects believe the opponent is human;
- subjects believe the opponent is a computer;

To make subjects believe the opponent is human, we allocate an experimental assistant, and have the experimental assistant pretend to play the card game. We set up the assistant's display and keyboard so as to be invisible to the subjects (Fig:2).

The order of putting down the cards in series is decided randomly by a program in both conditons. It is natural that subjects become bored with the game itself, therefore, order of the experimental conditions becomes equal to about two conditions so as to counteract the effect of the sequence. After finishing each condition, we ask the subjects to answer questionnaires about the trial.

To analyze patterns of subjects' behavior and the questionnaire results, we examine whether subjective

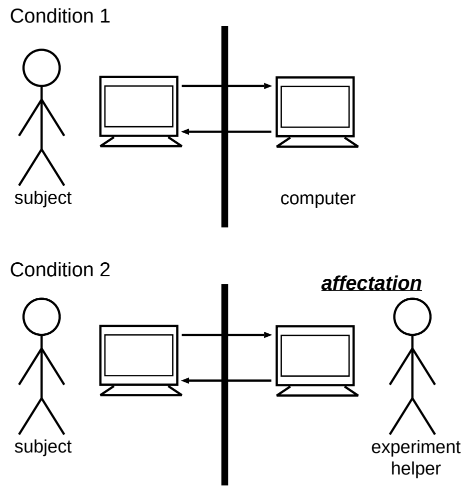

Figure 2: experimental conditions

congnition of an opponent affects subjects' boredom. That is to say, we investigate whether subjects believe the trial is boring because they think the opponent is a computer.

3.2 Experimetn 2

In this study, we focus on mutual prediction in interaction, and aim to clarify how mutual prediction affects human boredom. In experiment 2, we build a mechanism that can predict subjects' behavior from their behavioral history. We then investigate how the mechanism affects subjects' boredom and subjective congnition of an opponent. We set following two conditions.

- How cards are put down decided at random
- How cards are put down is decided by the the mechanism that may predict sabjects' behavior

In both conditions, we do not tell subjects whether the opponent is human or a computer. As in experiment 1, the order of experimental conditions become equal to about two conditions so as to counteract the effect of sequences, and we ask subjects to answer questionnaires about the trial.

We set the predictive mechanism that the probability of how to put down cards changes based on the sequence in which subjects put down their cards. We describe the process of subject putting down cards as a_{s1}, a_{s2}, a_{s3} in a trial, and that of a computer as a_{c1}, a_{c2}, a_{c3}. Furthermore we define a situation as $s = \{a_{s1}, a_{s2}, a_{s3}, a_{c1}, a_{c2}, a_{c3}\}$. The first card to be put down of a computer in a trial is decided as follows.

$$P_1(d|s) = \frac{Count(d|s)}{\sum_a Count(a|s)} \tag{1}$$

After a trial, we add +1 to $Count(a = A|s = S)$, where A is the first instance of subjects putting donw card in that trial, and S is the situation of the previous trial.

The second card to be put down of a computer is simply decided by the first instance of both the subject and the computer. just as with the first instance, we add +1 to the count after a trial, and the probabilities change.

$$P_2(d|a_{s1}, a_{c1}) = \frac{Count(d|a_{s1}, a_{c1})}{\sum_a Count(a|a_{s1}, a_{c1})} \tag{2}$$

In this experiment, subjects must judge whether opponent is either human or a computer, and we investigate how establishing a certain degree of mutual prediction affects subjective congnition of an opponent, and whether if subjective congnition has a relationship with human boredom in interaction.

4 Sammary

In this study, we aimed to clarify one aspect of the human property of boredom. Especially, we focused on mutual prediction, that is a distinct property of humans and animals. We discussed how HRI and HAI are different from interaction between humans and physical objects from the viewpoint of mutual prediction and mutual adaptation, and we explained experimental setttings for investigating a the influence of mutual prediction on human boredom. The experimental results will be reported on the day of our presentation.

We plan to measure not only responses in subjects' questionnaires but also their biological information in the near future, and we would like to deal with human boredom quantitatively to some extent. We intend to use electrocardiograms and skin conductance, which are used to measure stress and excitation, to achieve this.

References

[1] C. Breazeal, "Social Interactions in HRI: The Robot View," *in IEEE SMC Transactions*, Part C., 2004.

[2] S. Yamada and T. Yamaguchi, "Mutual Adaptation to Mind Mapping in Human-Agent Interaction," *IEEE International Workshop on Robot-Human Interaction (ROMAN-2002)*, pp. 105-110, 2002.

[3] A. Karsten, "Psychology Satuartion," *Psychological Research*, Vol. 10, pp. 612-628, 1928.

[4] H. Iizuka and T. Ikegami, "Adaptability and Diversity in Simulated Turn-taking Behaviour", *Journal of Artificial Life*, Vol.10, No.4, pp.361-378, 2004.

[5] N. Luhmann, "Rechtssoziologie", *Rowohlt Taschenbuch Verlag*, 1972. (translated into Japanese)

[6] B. Reeves and C. Nass, "The Media Equation: How People Treat Computers , Television and New Media Like Real People and Places," *University of Chicago Press*, 1996.

[7] H. Gallagher, A. Jack, A.Roepstroff and C. Frith, "Imaging the Intentional Stance in a Competitive Game," *NeuroImage*, Vol. 16, No. 3a, pp. 814-821, 2002.

[8] H. Takahashi and T. Omori, "Intentional Stance Regulates Behavioral Balance of Exploration and Exploitation in a Competitive Game," *"2nd Annual Computational Congnitive Neuroscience Conference*, 2006.