1. INTRODUCTION

In recent years, techniques for Human-Agent Interaction (HAI) have been increasingly studied and developed. In particular, agent systems that assist our daily activities by providing us with useful information are becoming widespread (e.g., Siri by Apple Inc. [1]).

For such systems to be used continuously, it is important that the agents gain sufficient trust from users. Although one of the best ways to gain user trust is to provide the most useful information, the agents cannot always achieve this due to the limits of technology. Therefore, it is necessary to minimize the users’ loss of trust in the agents even when they fail to provide correct information, and there have been several related studies. For example, Saito [2] conducted a study that focused on an agent’s self-disclosure regarding its own ability. The experimental results show that the users’ trust is better maintained when the agent tells the users that its ability is poor when it provides incorrect information, than one reporting that its ability is good. Furthermore, Naito et al. [3] have reported that it is harder for an agent existing in the real world to lose user trust, when it provides correct information than one existing only in a virtual space.

In these studies, it was assumed that all the information provided by the agents was classified into just two categories: “correct” and “incorrect.” Correct information generates a profit for the users, while incorrect information generates a loss. Although, in real situations, there can be a range of sizes of profits (or losses) that correct (or incorrect) information generates for users, such moderate profits (or losses) were ignored in these studies. Sakumoto et al. [4] focused on this point and carried out several experiments to investigate the effects of such moderate profits on the trustworthiness of the agents. Their experimental results show that an agent that reliably provides “Neither-Good-Nor-Bad” (NGNB) information, which is not the best but good enough to generate some profits for users, tends to gain greater user trust than an agent that unreliably generates either the maximum profit or nothing with equal probability, in a scenario where the users act to obtain profits or when the users have high expectations of the agent in advance.

However, considering the application of their approach to practical problems, there are several points in their study that appear to be over-simplified. Here we point out two of them. First, the size of a small profit generated by the NGNB information was fixed at 50% of the maximum profit, even though this ratio can vary in practical situations. Furthermore, in this experiment, all the consequences were disclosed to the users, including those that they had not chosen. In practical situations, we are often unaware of consequences that we have not chosen. In this study, we focus on these two factors and investigate the effects of them on the trustworthiness of the agents. Experimental results reveal that the agent that reliably provides the NGNB information tends to gain a greater degree of users’ trust in a situation where it is harder to obtain large profits, and when consequences that they had not chosen were not disclosed to them.

Therefore, in this paper, we investigate the effects of the following two factors on the trustworthiness of agents:

- The variation in the size of the profits generated by the NGNB information
- The disclosure and non-disclosure of the consequences that the users did not choose

Abstract: The effect of the provision of “Neither-Good-Nor-Bad” (NGNB) information on the trustworthiness of agents has been reported. However, in this previous study, the size of the profits generated by the NGNB information was fixed at 50% of the maximum profit, even though this ratio can vary in practical situations. Furthermore, in this experiment, all the consequences were disclosed to the users, including those that they had not chosen. In practical situations, we are often unaware of consequences that we have not chosen. In this study, we focus on these two factors and investigate the effects of them on the trustworthiness of the agents. Experimental results reveal that the agent that reliably provides the NGNB information tends to gain a greater degree of users’ trust in a situation where it is harder to obtain large profits, and when consequences that they had not chosen were not disclosed to them.

Keywords: Human-agent interaction, “Neither-Good-Nor-Bad” information, Trustworthiness of agents
The findings in this paper are expected to lead to a useful principle when designing agent systems that are trusted by users for long-term use and that assist their activities more effectively in the real world.

2. REVIEW OF PREVIOUS STUDY

In this section, we briefly review a previous study [4] on which our study is based and which we develop.

Sakumoto et al. [4] defined three types of information provided by agents. The “best” information is defined as that generating the maximum profit, the “worst” information is defined as that generating no profit, and “Neither-Good-Nor-Bad” (NGNB) information is defined as that which is not the best, but good enough to generate some profit for the users. Next, they also defined two types of agents, which assist users by giving advice during a task. A “solid” agent is defined as one that reliably provides NGNB information. An “extreme” agent is defined as one that unreliably provides either the “best” or the “worst” information. In this study, we basically follow these definitions of information and agents. Then, they compared these agents in terms of user trust by performing the following two experiments.

First, they carried out an experiment inspired by the prospect theory [5]. In this experiment, they focused on the effect of various scenarios, namely participants’ behavioral motivation. They set three scenarios where the participants should, as far as possible, act “to gain profits,” “to avoid losses” and “to avoid the loss of already obtained profits.” The experimental results revealed that, in a scenario where users act to obtain profits, the solid agent that reliably provides the NGNB information gains greater trust from the participants.

Second, they carried out an experiment inspired by the assimilation-contrast theory [6]. In this experiment, they focused on the effect of participants’ expectations of the agents in advance. They set two conditions regarding the participants’ expectations of the agents. Under one condition, the participants were controlled so that they had a higher expectation of the agents in advance. Under the other condition, they were controlled so that their advance expectation was lower. Their experimental results revealed that, under the condition where the users have a lower expectation of the agent, the solid agent that reliably provides the NGNB information was less trusted by the participants.

As mentioned in the Introduction, there are several points that appear over-simplified in the previous study. In this paper, we focus on two of these points.

First, the size of a small profit generated by the NGNB information was fixed at 50% of the maximum, regardless of the scenes and the expectations in advance. Furthermore, the probability that the unstable agent would generate the maximum profit was set at the same level. In real situations, of course, this level can vary. It is not clear whether the findings obtained from their previous study still hold under wider conditions, that is, when the size of the profits generated by the NGNB information differs from 50%.

Second, all the consequences were disclosed to the users, including those that they had not chosen, regardless of the experimental conditions. Therefore, they could compare the profits that they actually gained with those that they would have gained from the options they did not choose. In other words, they could know how good the profits generated by the agent were. This information constitutes an important clue with which to estimate the agent’s ability. In practical situations, we are often unaware of consequences that we did not choose and what we should have done.

These two factors may affect the users’ trust in the agents. Therefore, in this paper, we focus on these two factors, instead of the scenarios and the expectations dealt with in the previous study. We investigate the effects of them on the trustworthiness of the agents using the two experiments described below.

3. EXPERIMENT 1: EFFECTS OF SIZE OF PROFITS

In this section, we carry out the first experiment to investigate the effects of the size of profits generated by the NGNB information on the trustworthiness of the agents.

3.1 Hypothesis

The results of the previous study show that, in a scenario where users act to gain profits, they prefer a solid agent that is guaranteed to generate some profit to an extreme agent that occasionally generates the maximum profits. We can infer from this that, particularly in a situation where it is harder to obtain large profits, the user will attach more importance to a solid agent that generates small but stable profits. Conversely, in a situation where it is easier to obtain larger profits, it is considered that the value of both the solid agent and the NGNB information will decrease. Therefore, we formulate the following hypothesis and perform an experiment to verify it.
Hypothesis 1: A solid agent that provides NGNB information reliably will be highly trusted in a situation where it is harder to obtain larger profits, and consequently the size of profits generated by the NGNB information must decrease.

3.2 Method

3.2.1 Experimental Task

In this experiment, as a task, participants with agents perform a “treasure hunt game,” which was also used in the previous study. In this task, the participant is asked to choose one of three options (treasure chests) and obtains gold coins as a profit according to the choice. This task corresponds to the scenario where the participants act “to gain profits” [4]. One of the three chests contains 10 coins, one contains $n$ coins and the third contains nothing. $0 < n < 10$ and the value differs according to the condition of size of the profits described in Section 3.2.2. The agent tells the participant which chest he or she should choose (“You should choose the treasure chest on the left/center/right”), but the participant does not have to follow this instruction. After the participant’s choice, the agent reports that “you got 10/n coins” or “you did not get any coins” depending on the result. All the consequences are disclosed to the participants, including those that they did not choose. Figure 1 shows an example screenshot of the task. (Actually, the version written in Japanese was used for the experiment.) If the agent recommends the chest containing 10 coins (or no coins), it will have provided the best (or worst) information. If it recommends the chest containing neither 10 nor zero coins, it will have provided the NGNB information. The task consists of twenty trials, namely the participants will make choices twenty times, and the agent will also give advice twenty times during the task.

3.2.2 Experimental Conditions

In this experiment, we set the following two conditions regarding agents as a within-participants factor.

Solid Agent: This agent provides mainly the NGNB information, and occasionally the best and worst information during the task.

Extreme Agent: This agent provides only either the best or worst information during the task. It never provides the NGNB information. The ratio of the best information to the worst depends on the size of profits conditions described below.

We also set three conditions regarding size of profits generated by the NGNB information, 20%, 50% and 80%, as a between-participants factor. Under the 20%, 50% and 80% conditions, in the task, $n = 2, 5$ and 8, respectively. These ratios also represent the percentages of the number of provisions of the best information by the extreme agent during the task. The 50% condition corresponds to the setting in the previous study [4].

Table 1 (a), (b) and (c) show the number of provisions of information by the agents during the task in each combination of agent and size of profits. These values are set to make the expected profits that users would realize by following all the advice the same for the solid and extreme agents. Therefore, we can compare the trustworthiness of the agents regardless of differences in their performance.

3.2.3 Questionnaires

In the experiment, the participants were asked to complete three different questionnaires.

Table 1: Number of Provisions of Information by Agents

| Conditions | Number of Provisions |
|------------|----------------------|
|            | Best  | NGNB | Worst | Total |
| Solid      | 2     | 15   | 3     | 20    |
| Extreme    | 5     | 0    | 15    | 20    |

| Conditions | Number of Provisions |
|------------|----------------------|
|            | Best  | NGNB | Worst | Total |
| Solid      | 2     | 16   | 2     | 20    |
| Extreme    | 10    | 0    | 10    | 20    |

| Conditions | Number of Provisions |
|------------|----------------------|
|            | Best  | NGNB | Worst | Total |
| Solid      | 3     | 15   | 2     | 20    |
| Extreme    | 15    | 0    | 5     | 20    |

Figure 1: Screenshot of Experimental Task (Ex. 1)
Table 2: Questionnaire on Agent Trustworthiness

| Items (*: Reverse Scoring) |
|---------------------------|
| Q1 | This agent is excellent. |
| Q2 | This agent’s advice led to a good result. |
| Q3 | This agent is useless.* |
| Q4 | I am satisfied with this agent. |
| Q5 | I will follow this agent’s advice. |
| Q6 | This agent’s mistake is unacceptable.* |
| Q7 | I can trust this agent. |
| Q8 | I want to play other games with this agent. |
| Q9 | I feel tired when with this agent.* |
| Q10 | I want to ask this agent to give me advice if I play the same game again. |

Table 3: Questionnaire on Relative Trustworthiness between Agents

| Items |
|-------|
| Q1 | Which agent provides a better result? |
| Q2 | Which agent provides greater satisfaction? |
| Q3 | Which agent do you want to ask to give advice if you play the same game again? |

Table 4: Questionnaire on Maximization Scale [7]

| Items |
|-------|
| Q1 | I will pursue things while the possibility of obtaining them remains. |
| Q2 | When I make a decision, I will consider all the options. |
| Q3 | I think I spend more time shopping and choosing products than others. |
| Q4 | I always collect information on new products, trendy health methods, etc. |
| Q5 | I thoroughly pursue my favorite things, TV stars, singers, etc. |
| Q6 | Even when I buy only one, I often compare products at many stores. |
| Q7 | I tend to become extremely enthusiastic and immersed in any hobby. |
| Q8 | Whenever I choose a product, I try to choose the best one. |

3.3 Procedure

30 college students (28 males and 2 females) participated in this experiment. Their ages ranged from 20 to 26 years. They were randomly assigned to one of three conditions as regards the size of profits, namely 20%, 50% and 80%. Therefore, ten participants were assigned to each condition.

First, the participants were asked to perform the task with one of the agents under the assigned condition. Then, they were asked to complete the agent trustworthiness questionnaire shown in Table 2. Next, they were asked to perform the task again with the other agent and complete the questionnaire again. Finally, they were asked to complete the questionnaires on the relative trustworthiness of the two types of agents shown in Table 3 and on the Maximization Scale shown in Table 4.

3.4 Results

The graphs on the left side in Figure 2 (a), (b) and (c) show evaluation scores (mean values for all participants) of agent trustworthiness for each condition of the size of profits. The error bars denote the standard error. The statistical difference was determined by a two-sided paired t-test. For the 20% condition, the trustworthiness score of the solid agent was statistically higher than that of the extreme agent (\(t(9) = 4.81, p<.001\)). On the other hand, there was no significant difference under either the 50% (\(t(9) = 1.07, n.s.\)) or 80% (\(t(9) = -1.24, n.s.\)) conditions.

The graphs on the right side in Figure 2 (a), (b) and (c) show evaluation scores (mean values for all participants) of relative trustworthiness for the solid and extreme agents under each condition of the size of profits.
The error bars denote the standard error. The statistical difference from zero was determined with a two-sided \( t \)-test. There was no significant difference under all the 20\% \((t(9) = 1.25, \text{n.s.})\), 50\% \((t(9) = 0.86, \text{n.s.})\) and 80\% \((t(9) = -0.31, \text{n.s.})\) conditions.

Table 5 (a), (b) and (c) show the rates of participants who followed the agent’s advice at intervals of five trials under the 20\%, 50\% and 80\% conditions, respectively. The statistical difference was determined with Pearson’s chi-squared test. Then, there were significant differences for 11-15 trials \(\chi^2(1, N = 100) = 18.90, p < .001\) and 16-20 trials \(\chi^2(1, N = 100) = 23.50, p < .001\) under the 20\% condition, and 11-15 trials \(\chi^2(1, N = 100) = 9.16, p < .01\) under the 80\% condition.

Finally, Table 6 shows the correlation coefficients between the maximization score and the evaluation scores of the trustworthiness of the solid agent, those of the extreme agent, and those of relative trustworthiness under each condition.

### 3.5 Discussion

#### 3.5.1 Verification of Hypothesis

We can see from Figure 2 that, under the 20\% condition, the trustworthiness of the solid agent is significantly higher than that of the extreme agent, and the relative trustworthiness has a positive value, namely the solid agent is evaluated higher than the extreme agent even though this difference is not significant. Furthermore, we can also see from Table 5 (a) that the rate of participants who followed the extreme agent’s advice decreases considerably as the task progresses, while that for the solid agent maintains a relatively high level. Therefore, it is considered that, under the 20\% condition, the solid agent is more trustworthy than the extreme agent. On the other hand, under the 50\% condition, the significant difference disappears although the tendency is similar to that under the 20\% condition. Furthermore, this tendency reverses for the 80\% condition. These results support Hypothesis 1 described in Section 3.1, namely that “the solid agent that provides the NGNB information reliably will gain users’ higher trust in a situation where it is harder to obtain larger profits and consequently the size of profits generated by the NGNB information must decrease.”
To investigate in detail the reason for the hypothesis holding, we rearranged the data in the graphs on the left side in Figure 2 (a), (b) and (c) from a different viewpoint, namely the differences in the trustworthiness scores among the conditions as regards the sizes of profits for each agent. Figure 3 (a) and (b) show the results. The statistical difference was determined by an analysis of variance and Tukey’s test. We can see from Figure 3 that, for the solid agent, no significant difference was observed for any of the size of profit conditions. It is considered from this result that the size of profits generated by the NGNB information in itself has little effect on the perceived trustworthiness of the agents. On the other hand, for the extreme agent, significant differences were observed between 20% and 80%, and between 50% and 80%. Therefore, the extreme agents gain significantly lower trust for the lower size of profits, that is, in a situation where it is harder to obtain large profits. These results suggest that the number of times that users realize profits thanks to the agent’s information has a great influence on trust in the agent in a scenario where the users act to achieve profits.

Therefore, the provision of NGNB information that generates smaller but stable profits works effectively to prevent losing the users’ trust in the agents especially in a situation where it is harder to obtain large profits.

3.5.2 Influence of Participants’ Personalities

Finally, we consider the influence of the participants’ personalities on the degree to which they trust agents. We can see from Table 6 that the correlations between the participants’ personalities and the perceived trustworthiness of the agents are very weak. The correlations under the 80% condition are somewhat stronger than the others, but they are still weak. Therefore, from this experiment, we can conclude that the participants’ personalities have almost no influence on the perceived trustworthiness of the agents.

4. EXPERIMENT 2: EFFECTS OF DISCLOSURE AND NON-DISCLOSURE OF CONSEQUENCES

In this section, we carry out the second experiment to investigate the effects of the disclosure and non-disclosure of the consequences that the users did not choose in relation to agent trustworthiness.

In this experiment, we assume the following:

- The users know the maximum and minimum profit that they can gain theoretically.
- The users believe that they cannot realize the maximum (or minimum) profit every time and the best (or worst) profits at that time can be lower (or higher).

4.1 Agent’s Transparency

It is said that there are various factors that affect users’ trust of agents. Agent’s “transparency” is one such factor. Transparency is defined as the ability of the agents to convey information to human operators in a clear and efficient manner [9]. Yang et al. [10] have reported that as the transparency of automation increases, the trustworthiness of that automation system increases. Even in this experiment, whether or not it is clear how the agent provides users with information may affect the perceived trustworthiness of the agents.

4.2 Hypothesis

Given that the agents’ transparency affects their trustworthiness, it is considered that the trustworthiness of the solid agent (and the NGNB information) will decrease when the consequences that the users did not choose are not disclosed to them, because the solid agent will look like an “untransparent” agent that for some reason rarely provides the best information. Therefore, we formulated the following hypothesis and undertook an experiment to verify it.

**Hypothesis 2:** A solid agent that provides NGNB information reliably will lead to a lower trust level in users in a situation where the consequences that they did not choose are not disclosed to them.

4.3 Method

The experiment used basically the same method as Experiment 1.
4.3.1 Experimental Task

In this experiment, participants perform a modified version of the “treasure hunt game,” which is used in Experiment 1, with agents as a task. (The differences will be described later.) The numbers of coins in chests are the same as for the 50% condition in Experiment 1.

4.3.2 Experimental Conditions

In this experiment, we employed the same two conditions regarding agents as those in Experiment 1 (i.e. the solid and extreme agents) as a within-participants factor. The number of provision of information by each agent was the same as for the 50% condition in Experiment 1.

We also set two conditions regarding the disclosure and non-disclosure of the consequences as a between-participants factor. Figure 4 shows example screenshots of the task under the two conditions. (Actually, the version written in Japanese was used for the experiment.)

Under the disclosure condition, all the consequences are disclosed to the participants, including those that they did not choose as shown in Figure 4 (a). This condition is exactly the same as the 50% condition in Experiment 1.

Contrastively, under the non-disclosure condition, the consequences that the participants did not choose are not disclosed to them as shown in Figure 4 (b). Furthermore, to allow the assumptions described above, the participants under this condition receive the following explanation: “The chests contain 10 or 5 coins, or nothing. However, it is not always the case that one chest contains 10 coins, another contains 5 coins and the other contains nothing. There may be two treasure chests with the same number of coins.” In fact, the three chests always contain 10 coins, 5 coins and nothing, respectively. However, the participants are unaware of this fact.

4.3.3 Questionnaires

In the experiment, the participants are asked to complete three different questionnaires. These are the same as those in Experiment 1 as shown in Tables 2, 3 and 4, except for one point. The questionnaire includes the following item regarding the agent trustworthiness shown in Table 2, only for the non-disclosure condition.

“I think that this agent’s advice is correct.”

With respect to the non-disclosure condition, after the task, the participants are asked to state how strongly they agree to this sentence on a 7-point scale. A higher value indicates a stronger agreement with the sentence.

The answers to this question are not used to calculate the evaluation scores of trustworthiness of the agents, but to estimate the participants’ impressions of the agent in a situation where they cannot know how good the profits generated by that agent are.

4.4 Procedure

Since the disclosure condition is exactly the same as the 50% condition in Experiment 1, we regard the experimental results under the 50% condition of Experiment 1 as those under the disclosure condition in this experiment. Therefore, we carry out the experiment only under the non-disclosure condition.

The basic procedure is the same as that used for Experiment 1. 10 college students (all males) participated in the experiments in the non-disclosure condition. Their ages ranged between 21 and 22 years.

4.5 Results

The graphs on the left side in Figure 5 (a) and (b) show evaluation scores (mean values for all participants) for agent trustworthiness under the disclosure and non-disclosure conditions. The error bars denote the standard error. The statistical difference was determined by a two-sided paired t-test. Under the non-disclosure condition, the trustworthiness score of the solid agent was statistically higher than that of the extreme agent ($t(9) = 3.15, p < .05$). On the other hand, there was no significant difference under the disclosure condition ($t(9) = 1.07, n.s.$).

The graphs on the right side in Figure 5 (a) and (b) show evaluation scores (mean values for all participants) of relative trustworthiness between the solid and extreme
agents under the disclosure and non-disclosure conditions. The error bars denote the standard error. The statistical difference from zero was determined with a two-sided $t$-test. There was no significant difference even under the non-disclosure condition ($t(9) = 1.59, n.s.$).

Table 7 shows the rates of participants who followed the agent’s advice at intervals of five trials under the non-disclosure condition. The statistical difference was determined by Pearson’s chi-squared test. There was no significant difference even for 16-20 trials, which was the interval with the widest difference between the two agents ($\chi^2(1,N = 100) = 2.57, n.s.$).

Figure 6 shows evaluation scores (mean values for all participants) of the additive question under the non-disclosure condition. The error bars denote the standard error. The statistical difference was determined by a two-sided paired $t$-test. The score of the solid agent was statistically higher than that of the extreme agent ($t(9) = 3.75, p < .01$).

Finally, Table 8 shows the correlation coefficients between the maximization score and the evaluation scores of the trustworthiness of the solid agent, those of the extreme agent, and those of relative trustworthiness under each condition.

### 4.6 Discussion

#### 4.6.1 Verification of Hypothesis

We can see from Figure 5 that, under the non-disclosure condition, the trustworthiness of the solid agent is significantly higher than that of the extreme agent, and the relative trustworthiness has a positive value, namely the solid agent is evaluated higher than the extreme agent again even though this difference is not significant. Furthermore, we can also see from Table 7 that the rate for the participants who followed the solid agent’s advice was always higher than for the extreme agent even though the difference at each interval is not significant. These results do not support Hypothesis 2 described in Section 4.2. That is, it is considered that a solid agent that provides the NGBN information reliably will gain users’ higher trust in a situation where the consequences that they did not choose are not disclosed to them.

The reason for the hypothesis not holding can be inferred from Figure 6. The evaluation score of the extreme agent is significantly lower than that of the solid agent. Furthermore, its value is much less than 4, which is a moderate evaluation. These results indicate that, under the non-disclosure condition, the participants thought that the information provided by the extreme agent was incorrect. Therefore, contrary to the hypothesis, the participants appear to gain a stronger impression from a lot of incorrect information than from a lot of correct information provided by the extreme agent in a situation where they cannot know how good the profits that the agent has achieved are. On the other hand, the evaluation score for the solid agent, which is slightly higher than 4, indicates that the participants did not gain a bad impression regarding the NGBN information provided by the solid agent because “it is not incorrect.” The relative trustworthiness is considered to have a positive value for the same reason.

### Table 7: Rates of Participants Who Followed Agent’s Advice under Non-Disclosure Condition (Ex. 2)

| Conditions | Trials | 1–5 | 6–10 | 11–15 | 16–20 |
|------------|--------|-----|------|-------|-------|
| Solid      |       | 0.86| 0.68 | 0.58  | 0.56  |
| Extreme    |       | 0.82| 0.58 | 0.48  | 0.38  |

### Table 8: Correlation Coefficients between Maximization Scale and Trustworthiness (Ex. 2)

|          | Solid | Extreme | Relative |
|----------|-------|---------|----------|
| Disclosure | -0.19 | -0.04   | -0.02    |
| Non-disclosure | -0.03 | -0.71   | 0.41     |
In terms of the agent’s transparency, we expected that the trustworthiness of the solid agent will become lower under the non-disclosure condition because the solid agent will appear as an untransparent agent that rarely provides the best information for some reason. However, the experimental results show that it is possible that the participants evaluate the transparency of the solid agent as high because it looks rather transparent to them because it reliably provides information that is not incorrect.

4.6.2 Influence of Participants’ Personalities
We can see from Table 8 that there was a strong negative correlation ($r = -0.71$) between the participant’s maximization score and the trustworthiness of the extreme agent under the non-disclosure condition. On the other hand, the correlations under the disclosure condition were very weak. From these results, we can say that the influence of the participants’ personalities is strengthened by the non-disclosure of the consequences that they did not choose.

The reason is likely the same as that described in Section 4.6.1. As mentioned above, it is considered that the worst information provided by the extreme agent tends to give the participants a strong impression. Participants who have a high maximization score may be more distrustful of the extreme agent whose information resulted in few profits. On the other hand, participants with a low maximization score may evaluate the best information more favorably.

5. CONCLUSION
In this paper, we investigated the effects of the following two factors on the trustworthiness of agents:
- The variation in the size of profits generated by NGNB information
- The disclosure and non-disclosure of consequences that the users did not choose

First, we formulated a hypothesis stating that an agent providing NGNB information reliably gains higher trust in a situation where it is harder to obtain larger profits and consequently the size of profits generated by the NGNB information must decrease, and carried out a verification experiment. The experimental results supported this hypothesis and revealed that the provision of the NGNB information that generates smaller but stable profits works effectively in preventing the users from losing trust in the agents especially in a situation where it is harder to obtain large profits.

Second, we formulated a hypothesis stating that a solid agent that provides NGNB information reliably will garner less trust from users in a situation where the consequences that they did not choose are not disclosed to them, and carried out a verification experiment. The experimental results revealed that, contrary to the hypothesis, the solid agent that provides the NGNB information reliably will gain higher trust from users in a situation where the consequences that they did not choose are not disclosed to them.

The results obtained in this study expand the application range of the provision of NGNB information. We can expect these results to constitute a useful principle when designing agent systems that gain users’ higher trust over a long term.

As future work, we should conduct further studies to expand the findings obtained in this paper and reveal in detail the conditions under which the provision of the NGNB information by the agent works more effectively to gain users’ trust.

In particular, we should investigate interactions between the experimental conditions. In this paper, the size of profits and the disclosure/non-disclosure of the consequences were investigated as independent problems. However, for example, we did not investigate the interaction between the 80% condition in Experiment 1 and the non-disclosure condition in Experiment 2.

Furthermore, it is also necessary to eliminate the bias of the experimental participants’ characteristics. Most of the participants in the experiments in this paper were college students who had knowledge of computers. The results of Experiment 2 show that individual characteristics may affect the trustworthiness of the agents. In the future, we should conduct experiments with a wider range of participants of various ages and occupations.

NOTE
This paper is an extended version of our conference paper [11] that was presented at the 2020 International Conference on Kansei Engineering and Emotion Research (KEER 2020).

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