How to Design Adaptable Agents to Obtain a Consensus with Omoiyari

Yoshimiki Maekawa(✉), Fumito Uwano, Eiki Kitajima, and Keiki Takadama

The University of Electro-Communications,
Chofugaoka 1-5-1, Chofu, Tokyo 182-8585, Japan
m1510141@edu.cc.uec.ac.jp

Abstract. This paper focuses on *Omoiyari* in Japanese as consideration/thoughtfulness for others in order to promote people to obtain a consensus among them especially in Internet society where is difficult to reach a consensus due to the limited communication/interaction, and aims at exploring the preliminary agent design that can promote people to obtain a consensus by Omoiyari. For this purpose, this paper starts by designing Omoiyari as the behaviors of filling the *numerical* and *psychological* gaps (*e.g.*, a different income as the numerical gap while a different way of thinking among people as the psychological gap), and conducts the human subjective experiment to understand what kinds of aspects should be implemented in the Omaiyari agent. In detail, we employ Barnga as a cross-cultural game which cannot determine the winner without a consensus, and analyze the behaviors of the human players in Barnga with the emotional panels expressing happy, angry, sad, and surprise, which help the players to indirectly express their feeling to the other players. The analysis of human subject experiment has derived that the emotional panels are used to express their feeling for filling the numerical and psychological gaps and derive the change of the opponent's behaviors. In detail, we found the following implications: (1) omoiyari-based behaviors are achieved by a sequence of showing the surprise/sad panels; showing the angry panel after recognizing the feeling of others; and changing the decision of the winner to the same one selected by others; (2) the surprise panel is increasingly used as the psychological gap increases; the sad panel is increasingly used as the numerical gap increases; the angry panel is used after recognizing the surprise/sad panels and contributes to changing the opponent's behaviors; and the happy panel is used when the numerical and psychological gaps are filled.

Keywords: Omoiyari · Consensus · Numerical and psychological gap · Emotional panel · Collective adaptation

Supported by Evolinguistics: Integrative Studied of Language Evolution for Co-creative Communication.

S. Yamamoto and H. Mori (Eds.): HCII 2019, LNCS 11569, pp. 462–475, 2019.
https://doi.org/10.1007/978-3-030-22660-2_34

1 Introduction

It is important to obtain a consensus among people in their community, but it is difficult to reach it because we cannot perfectly understand how the other persons think. This problem becomes serious in Internet society due to the limited communication/interaction. To tackle this problem, Ushida et al. focused on Human-Agent Interaction (HAI), and proposed the agents with three kinds of roles (*i.e.,* claiming; supporting; quiet agents), which needs to obtain a consensus in a human-agent group through an interaction among human and agents [1]. This research mentioned that the balance of three kinds of roles that persons/agents have is important to reach a consensus in their community. This implication is very important, but this approach limits to work well because it is difficult to change the role of human for a consensus among them due to the fact that we cannot control the mind of human. This means that one directional approach from the agents to human limits to derive the appropriate balance of three kinds of roles in a human-agent group.

From this fact, this paper focuses on *Omoiyari* in Japanese as consideration/thoughtfulness for others because human show their Omoiyari in some cases to obtain a consensus among them. This is very important because a consensus is not reached by *one* directional approach from the agents to human but by the bi-directional approach from human and agent. To promote such Omoiyari not only by human but also by agents, this paper explores the preliminary agent design based on Omoiyari from an analysis of the human subject experiment (*i.e.,* we try to understand what kinds of aspects should be implemented in the Omaiyari agent through the human subject experiment). For this purpose, we start by designing Omoiyari as the behavior of filling the *numerical* and *psychological* gaps (*e.g.*, a different income as the numerical gap while a different way of thinking among people as the psychological gap).

To investigate the effectiveness of Omoiyari and analyze it for the preliminary agent design, we employ Barnga [2] as a cross-cultural game, which is studied in the context of Gaming Simulation designed for an educational purpose. In Barnga, players cannot determine their winner without a consensus, which requires Omoiyari-based behaviors. Since the numerical and/or psychological gaps are needed to be recognized to derive Omoiyari, this paper introduces the emotional panels expressing happy, angry, sad, and surprise into Barnga to show how the other players feel. In particular, the numerical gap occurs when increasing the difference between the number of win of the winner and that of the looser, while the psychological gaps occurs when finding that other players have the different criteria of the winner selection.

This paper is organized as follows. Section 2 starts by designing Omoiyari, Sect. 3 explains Barnga, and Sect. 4 introduces the emotional panels in Barnga. The result of the human subject experiment is shown in Sect. 5 and its analysis is conducted in Sect. 6. Finally, our conclusion is given in Sect. 7.

2 Omoiyari as Filling Gaps

According to Uchida and Kitayama [3], Omoiyari consists of the following three components: intuitive understanding; sympathy; and prosocial behavior. The process to arise Omoiyari is as follows: (1) noticing about gaps; (2) sympathizing with these gaps; (3) acting appropriate behaviors for the gaps. In this research, we modeled the flow of Omoiyari as the expanded control theory [4] in the domain of social psychology. Control theory proposed that people take actions to fill gaps when minus gaps happen between ideal and reality of themselves. It means that ideal is higher than reality. However, we think that Omoiyari cannot be expressed by filling the gaps between ideal and reality of only self because people cannot live thinking about only self, and keep on getting information from environments around them. Therefore, we expand the compared object from the self to the environments around us. To fill the gaps, the following factors are needed: (1) noticing about the gaps; (2) standing the side of an opponent; (3) understanding what the opponent wants. Those requirements are included in the components of Omoiyari, so filling the gaps can be expressed as Omoiyari.

To represent Omoiyari as filling the gaps, we should define the gaps. Table 1 shows the kinds of gaps considered in this paper. This table has two clusters. The first cluster indicates the characters of the gaps: "numerical" or "psychological". The numerical gaps can be counted: weight, height, income and so on and they are visible. On the other hand, the psychological gaps are not visible. It means that the gaps of the notion, the emotions, and so on. For example, misunderstandings and differences of thought between some people are the psychological gaps. Such gaps happened between the minds is not easy to be indicated. The second cluster indicates the targets of the gaps: "between you and other people"; "between other people". In this paper, we consider the combinations of the gaps made by the two clusters.

Table 1. The clusters of the gap

Targets\Characters	Numerical	Psychological
You and other people	Gap 1	Gap 2
Between other people	Gap 3	Gap 4

3 Barnga Game

3.1 Overview

Barnga, developed by Thiagarajan [2], is a cross-cultural game, which is studied in the context of *Gaming Simulation* (GS) [5], which provides human players with a cross-cultural experience in a virtual environment. Barnga is the card

game without communication (*e.g.*, speaking, writing, and utterance) among players, which requires the players to interact with other players using the non-verbal communication (*e.g.*, gesture) instead of the verbal communication. This situation simulates the situation where we have to interact with foreign peoples without knowing their language. As the other important point of Barnga, the rules of players are slightly different among the players, which reflects the cultural difference among them. From these characteristics of Barnga, the players have to understand the rules of others without communication and have a chance to discover how to cope with such a complex situation without the verbal communication. Since Barnga is designed for the educational purpose, Barnga is conducted as the following three steps:

(1) **Briefing**
The players learn the assigned rules individually. Note that each rule represents the culture of the player.
(2) **Playing**
The players play Barnga according to their own rules. They feel something difference with the other players but cannot tell it because of no communication among them. Such a situation causes a culture shock.
(3) **Debriefing**
After the players are informed that they have different rules among them, they understand the difficulty of communicating with the others who have a different cultural background and discuss how to cope with the cultural difference.

3.2 Details of Playing Sequence

The detailed sequence of (2) playing in Barnga described above is summarized as follows and its diagram is shown in Fig. 1.

1. Barnga starts.
2. The players sit down in each table. More than two tables and more than three players in each table are preferable for reflecting cultural difference.
3. The first player is determined and discards any card which s/he wants. Any number with any suite is acceptable for the first player. In this game, 28 cards (from A to 7 of each suit) are used.
4. The players discard their cards from their hands in turn. Note that the players should discard the cards with the same suit as the first card discarded by the first player.
5. The players select a winner from the cards on the table. The winner is the player who discards the strongest card in the players.
6. If all players select the same player as a winner, the winner is determined; otherwise they re-select a winner until they select the same winner.
7. The number of *game* is counted by 1.
8. The players play Barnga again (*i.e.*, return to the step 4) if the game count does not exceed the pre-determined number of the games (MAX_GAME_COUNT); otherwise proceed to the step 9.

9. The number of *round* is counted by 1.
10. Proceed to the step 11 with setting the game count as 1 if the round count does not exceed the pre-determined number of the round (MAX_ROUND_COUNT); otherwise proceed to the step 12.
11. The players move to other tables. In detail, the player who is the best winner in each table moves to a clockwise table, the player who is the worst loser in each table moves to an anti-clockwise table, and the other players remain the same table. Return to the step 2.
12. Barnga ends.

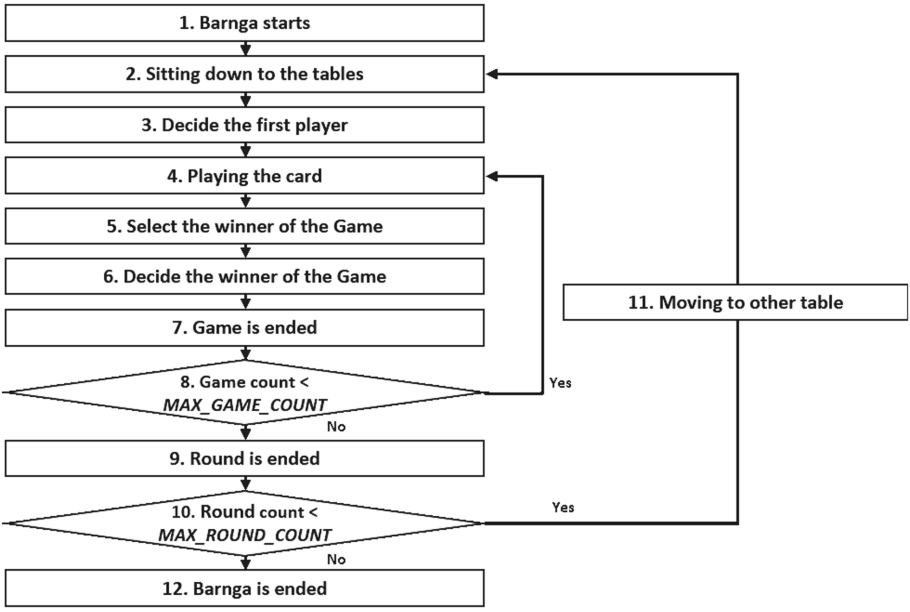

Fig. 1. Playing sequence of Barnga

3.3 Description of Rules

As a basic rule of Barnga, the bigger number the card is, the stronger the card is. However, the strength of the card changes by the two additional rules: Ace's strength and trump suit, both of which depend on the rule that the player has. First, the Ace's strength changes the strongest or the weakest. If Ace is the strongest, the strength order of the card number is $2 < 3 < 4 < 5 < 6 < 7 <$ Ace. If Ace is the weakest, on the other hand, the order becomes Ace $< 2 < 3 < 4 < 5 < 6 < 7$. Second, the trump suit decides the strongest suit. When the trump suit is HEART and you are the only player who discards the HEART

card, you can win the game even if HEART is not the same as the suit of the first discarded card. However, if other players discard their HEART cards, the winner is decided by the strength of the card with the HEART suit according to the Ace's strength. To understand the winner selection, let's focus on the situation where the Ace's strength is strong and the trump suit is HEART. When the first player discards the Ace of SPADE, the second player discards 3 of DIAMOND, the third player discards 6 of SPADE, and the fourth player discards the 7 of HEART as shown in the left side of Fig. 2, the winner of the game is the fourth player. But, when the second player discards the Ace of HEART in the above case, the winner changes to be the second player as shown in right side of Fig. 2.

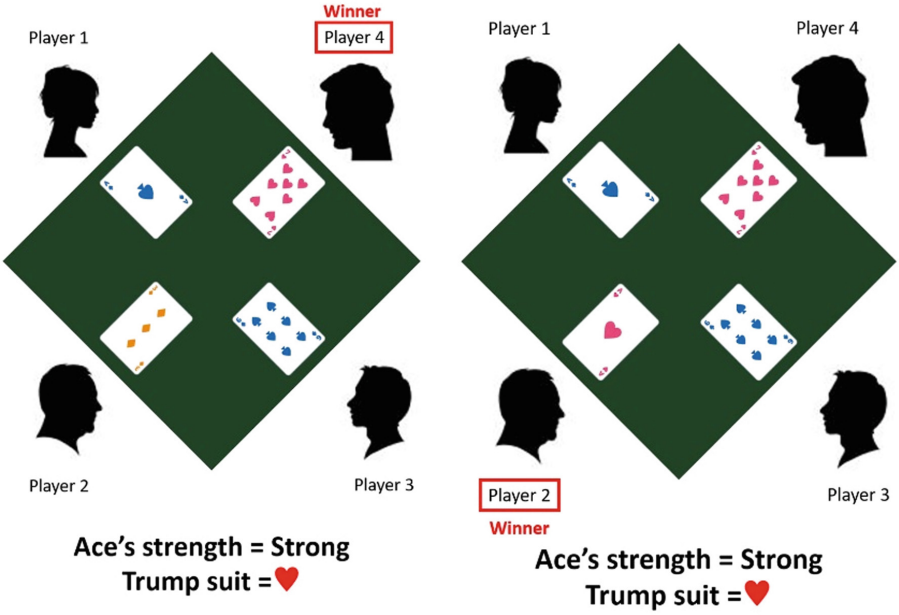

Fig. 2. The winner selection in Barnga

3.4 Moving to Other Table

In the 1st round, the players share the same rule by learning how to determine the winner from the rule instruction provided to the table. Note that one rule instruction is provided to one table but the rule instructions are slightly different among the tables, which promotes the players to learn their own rules (corresponding to their culture). From this characteristic of Barnga, the players who learn the different rules have to play Barnga at the same table from the 2nd round after the best winner and the worst loser change their table to a clockwise/anti-clockwise direction as shown in Fig. 3. Due to the different rules in the table, it is difficult for the players to determine the winner just one time after the 2nd round.

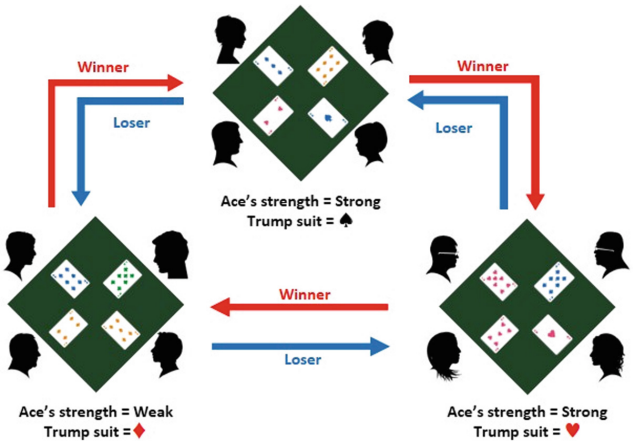

Fig. 3. Situation after the 1st round in Barnga

4 Emotional Panels

Since the verbal communication among the players is not allowed in Barnga, it is difficult for them to express their feeling precisely when they determine the different winners. To tackle this problem, this paper introduces the *emotional panels* which can express four kinds of emotion (*i.e.*, happy, angry, sad and surprise), and the players can use these panels anytime in Barnga to show their feeling indirectly. Figure 4 shows the emotional panels employed in the human subject experiment. Concretely, the most left, middle left, middle right, and most right panels in Fig. 4 express the feeling of happy, angry, sad, and surprise, respectively. These four kinds of emotion are selected from the fundamental emotion composed of the six kinds of emotion proposed by Ekman [6].

By using such panels, the players can recognize some kinds of feeling of the other players, which promote the players to change their behaviors (*e.g.*, the they may change the winner to the other winner). This contributes to selecting the same winner with a consensus among the players when the players encounter the situation where they select the different winners. From the viewpoint of the *numerical* and *psychological* gaps proposed in Sect. 2, the psychological gap in Barnga can be represented by the rule difference among the players while the numerical gap in Barnga can be represented by the difference of the number of wins among the players.

Fig. 4. Emotional panels (happy (most left), angry (middle left), sad (middle right), and surprise (most right))

5 Human Subject Experiment of Barnga

5.1 Experimental Setting

To investigate the effect of the emotional panels, we conduct the human subject experiment and explore the preliminary agent design based on Omoiyari from an analysis of the human subject experiment (*i.e.,* we try to understand what kinds of aspects should be implemented in the Omaiyari agent through the human subject experiment). Note that the players wear a mask and sun grasses in order not to show their emotions to other players, which helps to directly investigate the effect of the emotional panels. As mentioned in Sect. 4, the players can use the emotional panels when they want to use it.

In the experiment, the number of the player is four, and the rules that the players learn is shown in Table 2. For example, the player1 learns that Ace is the weakest among the cards and the trump suit is SPADE. Although many players (which is generally four players or more) separately sit down in each table in usual Barnga as shown in Fig. 3, each player in this experiment learns its own rule from the facilitator before the experiment and then four players who have the different rules play Barnga. This regards as the situation where the players start to play Barnga from the 2nd round. In this experiment, the players play Barnga in the four rounds (*i.e.,* 28 games (7 (games/round) $\times$ 4 (rounds)).

5.2 Experimental Results

Usage of Four Kinds of Emotional Panels: The human subject experiments found that the four kinds of emotional panels are used as follows:

- The *surprise* panel is increasingly used as the *psychological* gap increases (*i.e.,* as the players recognize the rule difference among them by noticing that the other players select the different winner).

Table 2. The rule of the players in the experiment

Player	Ace's strength	Trump suit
Player 1	Weak	SPADE
Player 2	Strong	SPADE
Player 3	*Strong*	*DIAMOND*
Player 4	Weak	HEART

- Although the *sad* panel is used when the player loses the game or when the different winner whom the player does not think to win is determined, but it is increasingly used as the *numerical* gap increases (*i.e.,* as the difference of wins among the players increases).
- The *angry* panel is used after recognizing the *surprise/sad* panels to express her/his claim to the other players, which provide a notice of an increase of the *psychological* and *numerical* gaps to other players. Such a panel contributes to changing the opponent's behaviors.
- The *happy* panel is used when the *numerical* and *psychological* gaps are filled (*i.e.,* when the player who often loses the games becomes the winner of the game by changing other players to select the loser as the winner after recognizing their rule difference).

Rate of Using Emotional Panels in Four Rounds: Fig. 5 shows the rate of using the emotional panels in the four rounds, where the vertical axis indicates the rate of using the emotional panels while the horizontal axis indicates the number of the rounds. Figures from Figs. 6, 7, 8 and 9 respectively show the rate of using the emotional panels in the 1st, 2nd, 3rd, and 4th round, where the vertical axis indicates the rate of using the emotional panels while the horizontal axis indicates the number of the game. In these figures, the blue, red, gray, and yellow lines indicates the happy, angry, sad, and surprise panels, respectively.

From Fig. 5, the ratio of using the happy panel increase as the number of the rounds increases while the ratio of using the surprise panel decreases until the 3rd round as the rounds increases. The rate of using the sad panel slightly increases and decreases while the rate of using the angry panel is small in the experiment. The detailed usage of the emotional panels is summarized as follows:

Round 1

From Fig. 6, the players used the surprise panel around the first several games because they noticed that the other players select the different winner. Although the rate of using the surprise panel decreases as the number of games increases, its averaged rate shown in Fig. 5 is the largest among the four emotional panels, which indicates that the players were confused by the different winner selected by the other players. From the viewpoint of the numerical and the psychological gaps, the players felt the *psychological* gap because the players recognized the rule difference among them.

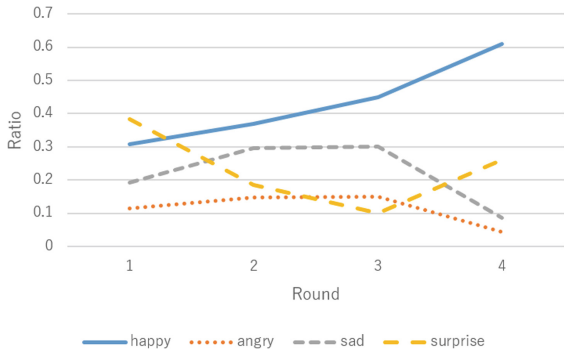

Fig. 5. The rate of using each emotional panels in four rounds (Color figure online)

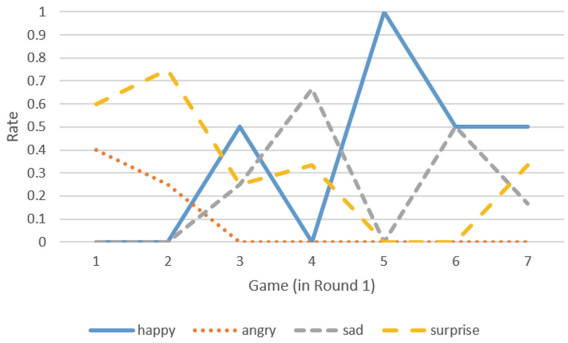

Fig. 6. The rate of using the emotional panels in 1st round (Color figure online)

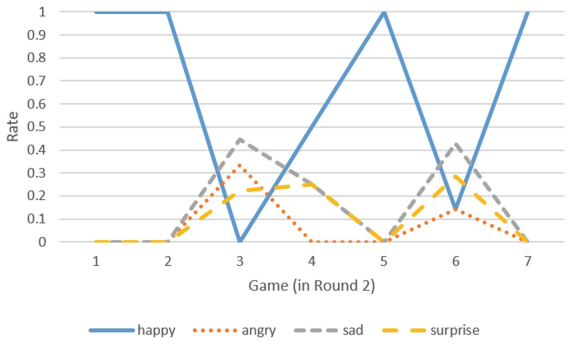

Fig. 7. The rate of using the emotional panels in 2nd round (Color figure online)

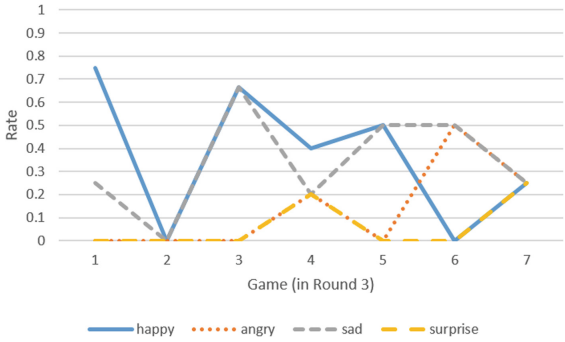

Fig. 8. The rate of using the emotional panels in 3rd round (Color figure online)

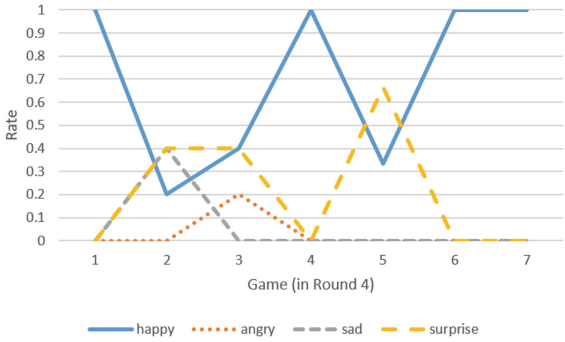

Fig. 9. The rate of using the emotional panels in 4th round (Color figure online)

Round 2

From Fig. 7, the rate of using the sad panel increases when the rate of using the happy panel decreases and vice versa, which indicates that the players were happy when the winner whom they thought to win is determined while they were sad when the winner whom they did not think to win is determined. Interestingly, the players started to use the sad panel not only when the not-expected winner were selected but also when the same players always won. This indicates that the players felt the *numerical* gap because the players recognized the difference of wins among the players caused by the win of the same players.

Round 3

From Fig. 8, the players used the angry panel around the last several games. This is because the winner was fixed (*i.e.*, the same winner was determined) around the first several games and the other players noticed that most of the players were not satisfied with this situation (caused by the psychological and numerical gaps) and some of them wanted to change this situation. In this time, the numerical and the psychological gaps become largest during the game.

Round 4

From Fig. 9, the players often used the happy panel because some players change to select the different winner after the angry panel was shown in the round 3. This derives the situation where the player who often loses the games becomes the winner of the game. As a results, the numerical and the psychological gaps are filled. In detail, the psychological gap was filled because some players sometimes accepted the different rule after recognizing the rule difference while the numerical gap was filled because the difference of wins decreases by increasing the chance of the loser to win the game.

6 Discussion

6.1 Omoiyari-Based Behaviors by Emotional Panels

According to the analysis, the emotional panels with the four kinds of the emotions express the numerical gap (*i.e.,* the difference of wins among the players) and the psychological gap (*i.e.,* the rule difference among the players) gaps. More importantly, the panels do not only express the numerical and psychological gap but also promote players to fill these gaps by changing their behaviors.

To understand this issue, let's focus on the round 3 again. In this round, the angry panel was shown to the winner players, which promotes some players to change to select the different winner. Note that the behavior of showing the angry panel was caused not only for the player's self but also for other players who may felt the same numerical and psychological gaps. In order words, this behavior has both the selfish and altruistic aspects, *i.e.,* the behavior for the player's self is selfish while the that for other players is altruistic. In particular, the latter altruistic behavior is regarded as Omoiyari.

What should be noted here is that the altruistic behavior as Omoiyari is not derived accidentally, *i.e.,* Omoiyari-based behavior requires a trigger to be derived. In this viewpoint, a recognition of both the numerical and psychological gaps of *others* becomes the trigger. As the recognition order of these gaps, firstly the player felt own psychological gap, secondly the player recognized the psychological gap of others (by looking at the surprise panel of others), and thirdly the player recognized the numerical gap of others (by looking at the sad panel of others). All of these sequence of recognition is needed to derive Omoiyari-based behaviors. In Barnga, Omoiyari-based behaviors can be achieved by a sequence of showing surprise/sad panels; showing the angry panel after recognizing the feeling of others; and changing to select the different winner, which increases to show the happy panel.

6.2 The Agents with Omoiyari

In order to implement the agent which can derive the Omoiyari-based behaviors, the agent has to know the appropriate timing and the situations when the emotional panels should be shown to fill the numerical and psychological gap of

Table 3. The usage and the effect of the emotional panels for the gaps

No.	Gap	Emotional panel	Target	Result
1	Gap 2	Happy	Other players	The situation become stable
2	Gap 3 & 4	Angry	Winning players	The situation changes
3	Gap 2	Angry	Losing players	The table lead by the user
4	Gap 2	Sad	Winning player	User's selection is adopted
5	Gap 1 & 2	Surprise	Other players	The gap is expressed

other players. Table 3 summaries the usage and effect of the emotional panels found in the human subject experiment. In this table, "Gap" column indicates the type of gaps categorized in Table 1, "Emotional panel" column indicates the type of the used panel, "Target" column indicates the target of the players for showing the emotional panels, and "Result" column indicates what is happened by using the emotional panels. For example, No. 2 in Table 3 shows the case that the angry panel shown to the winner players in Gap 3 & 4 (*i.e.,* the numerical and psychological gaps of others) results in changing the situation by promoting some players to change to select the different winner.

Even though the emotional panels are the simple tools to show the numerical and psychological gaps indirectly, the emotional panels has a potential of changing the situation of the table to fill the numerical and psychological gaps. This suggests that the agent can derive the above suitable situation if the agent shows the emotional panels at the appropriate timing and situations. Since such appropriate timing and situations are summarized in Table 2, it is easy to implement the agent by introducing them as the if-then rules. The design of such an agent and an investigation of its effectiveness will be done in the future work.

7 Conclusion

This paper focused on *Omoiyari* in Japanese as consideration/thoughtfulness for others to promote people to obtain a consensus among them, and verified the effectiveness of Omoiyari by analyzing behaviors of players in the cross-cultural game Barnga. Concretely, we designed Omoiyari as the behaviors of filling the *numerical* and *psychological* gaps and proposed the emotional panels into the Barnga in order to derive Omoiyari-based behaviors of players. In detail, the proposed emotional panels have four kinds of emotional panels expressing happy, angry, sad, and surprise, which help the players to indirectly express their feeling to the other players. The analysis of human subject experiment has derived that the emotional panels are used to express their feeling for filling the numerical and psychological gaps and derive the change of the opponent's behaviors. In detail, we found the following implications: (1) Omoiyari-based behaviors are achieved by a sequence of showing surprise/sad panels; showing the angry panel after recognizing the feeling of others; and changing the decision of the winner to

the same one selected by others; (2) the surprise panel is increasingly used as the psychological gap increases; the sad panel is increasingly used as the numerical gap increases; the angry panel is used after recognizing the surprise/sad panels and contributes to changing the opponent's behaviors; and the happy panel is used when the numerical and psychological gaps are filled.

Since this paper analyzed Omoiyari-based behaviors through the human-subjective experiment but have not yet developed Omoiyari agents, we should investigate an effectiveness of Omoiyari agents through the game composed of human and agents. For this purpose, we are planning to develop Omoiyari agent by employing Q-learning as one of the machine learning algorithms, which try to reduce its own numerical and psychological gaps by estimating the rules of the other players in Barnga.

References

1. Ushida, Y., Takadama, K.: Validation of agent model in highly-dynamic environment via Barnga Game. In: The Multi-Agent-Based Simulation Workshop (MABS2012) (2012)
2. Thiagarajan, S., Steinwachs, B.: Barnga: A Simulation Game on Cultural Clashes. Intercultural Press, Yarmouth (1990)
3. Uchida, Y., Kitayama, S.: Development and validation of a sympathy scale. Jpn. J. Psychol. **72**(4), 275–282 (2001)
4. Carver, C.S., Scheier, M.F.: Control theory: a useful conceptual framework for personality-social, clinical, and health psychology. Psychol. Bull. **92**(1), 111–135 (1982)
5. Wolfe, J., Crookall, D.: Developing a scientific knowledge of simulation/gaming. Simul. Gaming **29**(1), 7–19 (1998)
6. Ekman, P., Friesen, W.V.: Constants across cultures in the face and emotion. J. Pers. Soc. Psychol. **17**(2), 124 (1971)