The effect of "mood": Group-based collaborative problem solving by taking different perspectives

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Abstract

Collaborative problem solving based on different perspectives is an effective strategy for constructing new knowledge and discoveries. It remains unclear what kind of interaction process underlies development of an abstract or integrated perspective upon experiencing conflict with different perspectives in a group. The present study investigates two factors in an experimental setting: (1) groups with a single opposing perspective (maverick) would hold an advantage over groups and (2) groups with positive moods would hold an advantage over groups with negativity. We investigate the factors influencing perspective taking in problem-solving groups using conversational agents. Results showed that (1) a single different perspective in the group can be accepted for perspective taking compared to several members with an opposing perspective, and (2) positive mood generated by group members facilitating perspective taking compared to negative mood.

Keywords: Collaborative problem solving; minority influence; emotion and cognition; perspective taking; conversational agents.

Introduction

Studies in collaborative problem solving have found that the use of meta-cognition can be promoted by externalizing the problem from different perspectives (Chi, Leeuw, Chiu, & Lavancher, 1994; Lombrozo, 2006; Miyake, 1986) and asking reflective questions (Okada & Simon, 1997). Dunbar (1995) investigated the use of inductive reasoning in a scientific research group and developed the concept of distributed reasoning, in which group members achieve their goals by taking charge of different types of inferences. New perspectives and knowledge can be discovered or generated by integrating different views and abstraction (Schwartz, 1995). The present study focuses on collaborative problem solving based on different perspectives in groups where individuals can discover a new solution by combining others' knowledge and perspectives. Past studies have shown that in such situations, conflicts occur upon emergence of a different perspective in the group, making problem solving difficult (Hayashi, Miwa, & Morita, 2006). It is important to understand how individuals adopt the different perspective and generate a higher abstract understanding to solve the problem. However, it remains unclear the cognitive process underlying development of and motivation towards this abstraction of different perspectives in collaborative problem solving. Accordingly, this study focuses on the cognitive and affective factors, such as the presence of a single different perspective in the group and the affective mood, that are critical in perspective taking and integration of perspectives.

A single member with a different perspective vs. multiple members

Studies in group problem solving have shown that conflict may occur at several levels, such as task conflict, interpersonal conflict, and process conflicts (de Wit, Greer, & Jehn, 2011). In collaborative problem-solving settings where a member encounters members with a different perspective, it is likely s/he will experience conflict (Hayashi et al., 2006). Studies from social psychology have shown that negative moods brought on by conflicts can emerge when encountering members with different perspectives (De Dreu & Weingart, 2003). Group members become dissatisfied when they interpret challenges to their viewpoints by other group members as a negative assessment of their own abilities and competencies (Swann, Polzer, Seyle, & Ko, 2004). Research in social psychology has also discovered that a "maverick" can encourage other group members to contemplate different perspectives (Elliston, Keenan, Lockhart, & Van Schaick, 1985; Near & Miceli, 1987). A maverick provides dissent and opposing views about the organization and the social system. S/he can be seen as a person who may cause trouble and confusion, or can be interpreted as a person that can bring innovative ideas as a reformer in the group. Research on group dynamics shows that such mavericks can influence other group members to reconsider different views. Members with little power and anti-normative positions can influence the majority of group members, a phenomenon called "minority influence" (Moscovici, Lage, & Naffrechoux, 1969; Nemeth, Brown, & Rogers, 2001). This study shows that a different perspective can be effective when it is presented in a small quantity. Such a minor opposing perspective can provide important information but with less conflict, thereby producing a better outcome. Hayashi (2012) has shown that the use of a maverick can play an important role in perspective taking in a group problem-solving task. The study investigated these cognitive processes through long-term verbal protocol analyses by controlling the number of partners and their utterances in laboratory-based experiments. This previous study found that a mere single other perspective will provide less conflict and better accessibility to the different source of information. However, the cognitive mechanisms involved when individuals pay attention to these mavericks and use their perspectives remains unclear. Further, in the previous study, a significant difference was not found at several levels of perspective-taking performance between members with the same number of different perspectives. By conducting a follow-up experiment, we may be able to clarify our hypothesis that maver-

icks, who produce less conflict and are accessible, bring constructive thoughts toward development of abstract perspectives(integration). Here, we conduct a new experiment by focusing on the effect of the maverick along with new aspects that relate with cooperative thinking, such as group mood.

The effect of mood in the group

In collaborative problem solving, others with different perspectives are liable to bring conflict, thereby producing negative impressions among others. Small group research has shown that negative mood in the group suppresses productive interaction. On the other hand, despite conflict during interaction, if members retain a positive mood within the group, it may function to facilitate active behaviors, such as directing more attention towards different perspectives and motivating consideration of others' perspectives. Therefore, even if one experiences conflict with others with different perspectives, a positive mood may aid in considering an alternative perspective. Previous studies investigating positive effects on task performance have found that partners' positive utterances facilitate more task engagement (Martenes, Bradley, & Eckert, 1997) and flexible thinking (Bless, 2000). Pleasant feelings towards others may also facilitate perspective taking (Weinstein, Hodgins, & Ryan, 2010). It can be predicted that even though members encounter others with opposing views, if members are motivated to interact in a way that promotes greater cooperative behavior, they may try to integrate different perspectives and abstraction. Such motivational effects that are generated during interaction may play an important role and could be a strong factor, over and above the effects of interacting with a member with a mere different perspective.

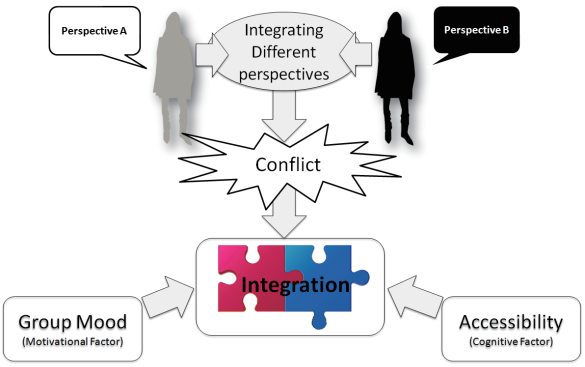

Figure 1: Research framework

Given the above, this study investigates two factors: (1) groups with a single opposing perspective (maverick) and (2) groups with a positive mood. We investigated factors influencing perspective taking in problem-solving groups.

Study goals

The first goal of the present study is to discover the power of groups with a single different perspective (maverick) and examine the strength of this influence on groups with several members. Second, based on the implication above, we examine whether groups with positive feelings provide an opportunity for the whole group to think more flexibly and motivate others to more frequently consider differing perspectives. Our goal is to investigate the next two points:

1. Investigate the effect of a maverick(5:1) in comparison with members with same number(3:3) of perspectives.
2. Investigate how emotional states shared by the members affect the perspective-taking process and impressions among others.

We predict that a mere member with a different perspective will produce conflict compared to groups with several members, and that it will be easier to access the dissenting information. We also focus on the motivational factors based on previous studies showing that affective mood may play a role in facilitating cooperative behavior. Our hypotheses are as follows.

H1: A mere different perspective in the group will facilitate perspective taking compared to several members with an opposing perspective.

H2: Positive mood generated by group members will motivate higher cooperative states, thereby facilitating perspective taking compared to negative mood.

Method

The rule discovery task

The current study uses an experimental paradigm designed by Hayashi et al. (2006). In this paradigm, two participants engage in a rule discovery task, and each of them engages in the task with a different perspective. While solving the task, each of the participants confronts conflict about a different perspective proposed by the other member and has to develop an abstract perspective of the self and other to discover the rule. In this task, the participants' goals were to count a series of objects presented on a computer display and discover its sequential rule. However, as will be explained in the following section, these other "members" were manipulated by the conversational agent to control their behavior. Materials for the objects were several sets of stimuli with white and black unit squares randomly arranged on a 6×6 grid (colored black or white; see Figure 2). In each set, a pattern consisting of combined square blocks was shown against either a black or white background. Using the Gestalt effect from perception psychology, the background color was controlled to change in the problem-solver's perspective (Koffka, 1935).

Each set consisted of several "objects"(or patterns) in black or white, each of which consisted of a single block or multiple blocks. As shown in Figure 2, one of the paired objects has a total of 10 "components" (4 black and 6 white). When a participant focuses on the white components inside a black

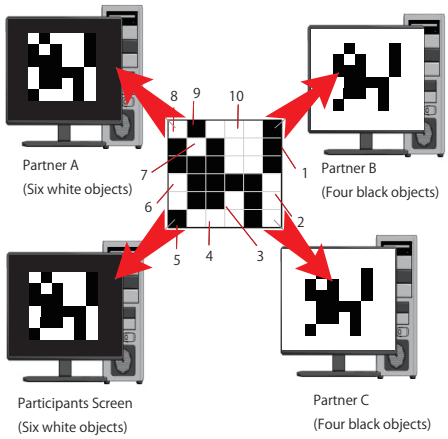

Figure 2: Experimental stimuli used in the study(from Hayashi (2013)).

background, the white components become the figure, and the six components pop out. Conversely, when a participant is focusing on black components inside a white background, it becomes the figure. Participants, collaborating through computer terminals, were separated so that neither could see the partner's display. They collaboratively worked on the task through computer terminals connected via a local network. All members exchanged their opinions about the number of objects and the sequence of the target rule by text-based chat messages. Participants were informed that they would conduct the task with real humans inside the room and were told not to chat about anything else related to the task. As shown in Figure 2, six members(including the conversational agents) saw the objects with either a black background (white perspective) or a white background (black perspective). Three members saw a black and the other three saw a white background, and each member counted the number objects that appeared as a figure. For each trial/object, a square outer box was shown on the display for 1 second, which was followed by a stimulus picture presented inside the box frame. Participants were required to send one message per trial to the other members. Participants were told that they had to count the number of objects inside this box frame. Based on the experimental settings of Hayashi (2012, 2013), the number of white and black components was controlled so the total number of components presented to the participants varied between 6 and 12. The sequential pattern (target rule) of the sums of black components and white components was repeatedly presented during each trial (i.e. 6, 8, 10, 12 or 6, 8, 10, 12; see Figure 3). In the initial stage of the task, the local black/white numbers were controlled to be the same. Experiments from a previous study showed that participants are fixated to the figure perspective, and participants try to search for the target rule based on their perspective (Hayashi et al., 2006; Hayashi & Miwa, 2009; Hayashi, 2012, 2013). On trial 9, we controlled the trials for differentiation in responses so that participants would report different numbers. Through this manipulation, participants experience conflict. To discover the rule for this task, the participant has to look at the different colored objects and integrate the other two members' perspectives.

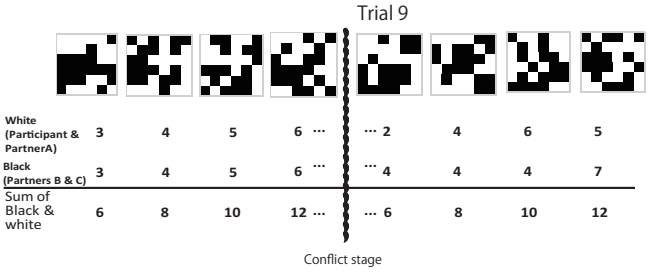

Figure 3: Sequence of objects used in Hayashi (2013).

Experiment design

Controlled factors

The experiment has a 2 × 2 between-subjects factorial design. The two factors were number of different perspective (single(5:1) vs. multiple(3:3)) and the mood(positive vs. negative). The first factor was controlled by arranging the number of partners(agents) looking at the different perspective. The second factor was controlled by manipulating partners' (agents') conversations. In the positive mood condition, the partner was manipulated to include messages that provides positive phrases such as, "I like this group" and "It is interesting to see others with different perspectives." On the other hand, in the negative mood condition, the conversational agents were manipulated so that they would include negative phrases such as "I don't like this group" and "It is quite frustrating to work with others with different perspectives."

Participants

Undergraduates in a psychology class participated in the experiment. All participants were randomly assigned to each condition and participants who recognized their partner's (agent's) purpose and those who did not complete the task or refused to continue the task were excluded from analysis. After this exclusion, the following number of participants were arranged to each condition: 5:1/positive: 40, 5:1/negative: 50, 3:3/positive:50, and 3:3/negative:37.

Procedure

Conversational agents

A text-based chat communication platform using one server and clients, including one chat engine and five conversational agents(Figure 4), was utilized. The system developed by Hayashi (2012, 2013) was programmed in Java. On the server side, a broadcast mechanism was used to distribute all the messages simultaneously. When messages were sent to the server, they were re-distributed to all clients and/or agents.

The conversational computer agents were designed by a typical rule-based system. Based on pre-defined rules, the system can respond to sentences that were inputted by the participants (Figure 4).

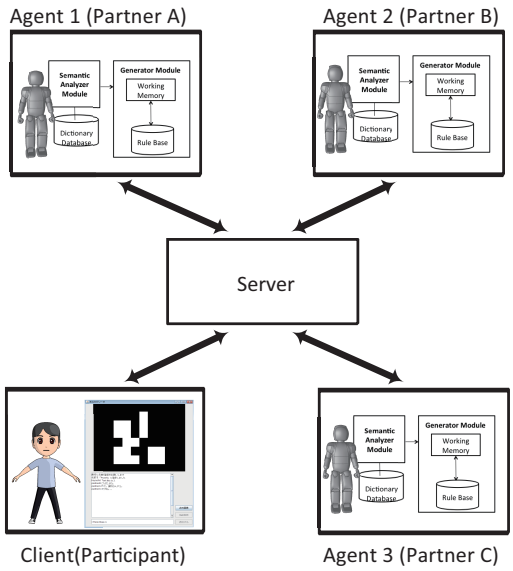

Figure 4: Communication platform(from Hayashi (2013)).

All three agents were implemented by the rule shown below. All agents autonomously responded to each other's text messages as independent interlocutors, and had different expressions. The conversation agent extracts keywords from the sentences that were distributed by the participant. The most frequent keywords used during this task are related to the (1) number of objects, (2) colors of objects, and (3) rules about the sequence. The agent contains a temporary working memory storage to represent the current status of the input messages from the (1) keywords of the participant, (2) keywords from the agents, and (3) objects presented on the screen. A rule base, in an "if-then" format, defined all responses from the agents. When the agent detects keywords of (a) numbers, (b) colors, and (c) the hypothesis, working memory is updated. Then, a pattern-matching strategy is used for binding the rules. In the present study, the agents were programmed to respond based on the numbers or colors of the objects that were set for its perspective (Agents 1 and 2 responded based on the black objects, which was the same as the participant. Agents 3, 4, and 5responded based on white objects, which was different from the participant). The following shows a simple example of some of the basic rules utilized in the study:

$< Rules >$
$Trials < 8$
$(agent\ 1,2)$
$-> numbers(white\ objects)$
$(agent\ 3,4,5)$
$-> numbers(black\ objects)$
$Trail > 8$
$(agent\ 1,2)$
$IF : "numbers(any)" -> numbers(white)$
$ELSE\ IF : "colors" -> colors(white)$
$ELSE\ IF : "rules" -> rules$
$ELSE -> numbers(white)$
$(agent\ 3,4,5)$
$IF : "numbers(any)" -> numbers(black)$
$ELSE\ IF : "colors" -> colors(black)$
$ELSE\ IF : "rules" -> rules$
$ELSE -> numbers(black)$

For example, if a sentence by the participant inputs "I think this is four objects," indicating four as black objects, agent 1 will respond based on the number of objects such as "Well, I think this is four, too." If the inputs such as "Is it the black objects you are counting ?", agent 1 will respond "I count white objects." As noted in the previous section, the agents in the positive mood conditions responded with additional positive phrases, and negative phrases were used in the negative mood condition.

Dependent variables

Two variables were used to investigate the effects of the two factors. The first index is the evaluation towards their partners(agents) to evaluate the effectiveness of the manipulation of the agents producing positive/negative mood. It assessed the degree of pleasantness and the importance of developing a solution. They were asked to rate the following statement on a 5-point scale, ranging from 1 (extremely unpleasant/inefficient) to 5 (extremely pleasant/efficient): "The degree of pleasantness felt while working with this member." The second index asked for the description of the target rule on an answer sheet. If their answers were in some way related to integrating the number of black or white components of the objects, they were judged as 'integrated' (e.g., The sum of black and white repeat by 6, 8, 10, and 12). The difference in the number of the black and white components is between zero and two.) The ratio of participants in each condition was collected.

Results

Evaluation of others

Figure 5 indicates the results of the evaluation. A $2 \times 2 \times 5$ mixed-effects ANOVA was conducted on the average scores of evaluation of the partner, with perspective (5:1 vs. 3:3) and emotion (positive vs. negative) as between-subject factors and evaluation (partner 1 vs. 2 vs. 3 vs. 4 vs. 5) as a

within-subject factor. The second-order interaction was not significant ($F(4, 680) = 2.06$, $p = .036$). There was significant interaction between perspective and evaluation ($F(4, 680) = 2.92$, $p < .05$). Consequently, an analysis of the simple main effect was conducted on each evaluation. Focusing on the affective state, the rating score towards partners 1, 2, 3, 4, and 5 in the positive condition was significantly higher than it was in the negative conditions($F(1, 850) = 42.65$, $p < .001$; $F(1, 850) = 18.40$, $p < .001$; $F(1, 850) = 14.86$, $p < .001$; $F(1, 850) = 24.90$, $p < .001$; and $F(1, 850) = 18.73$, $p < .001$, respectively).

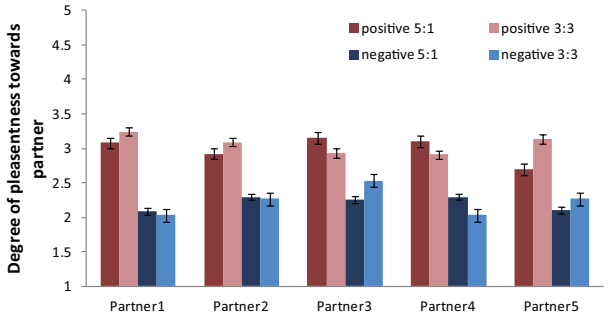

Figure 5: Results of the evaluation of others.

These results show that only the emotional mood factor influenced evaluation of group members. This indicates that the manipulation of collaborative members' positive mood produced a strong effect on making the participants feel pleasant towards their partners. Next, we examine how the two factors affected problem-solving performance and determine whether the two hypotheses are confirmed.

Performance

Figure 6 describes the problem-solving performance. The vertical axis represents the ratio of participants who succeeded in integrating the perspective on their final answers, and the horizontal axis represents each experimental condition. Our interest is to investigate how the two factors influence performance. Therefore, we conducted an ANOVA using the χ^2 distribution based on the arcsine transformation method. This method enables detecting both the main effects and interaction of the two experimental factors. The analysis was performed by a 2×2 ANOVA with the perspective (5:1 condition vs. 3:3 condition) and emotion (positive condition vs. negative condition) factors as between-subjects variables. There was a main effect of both perspective and emotion ($\chi^2(1) = 7.65$, $p < .001$; $\chi^2(1) = 6.77$, $p < .001$). The performance in the experience condition was better than was that in the no experience condition, and the performance in the conversation condition was also better than was that in the chat condition. In addition, there was no interaction between the two factors ($\chi^2(1) = 0.04$, $p = .85$).

The main effects of the two factors indicate that the single perspective and positive mood contribute to successful problem solving. This result indicates that both **H1** and **H2** were supported.

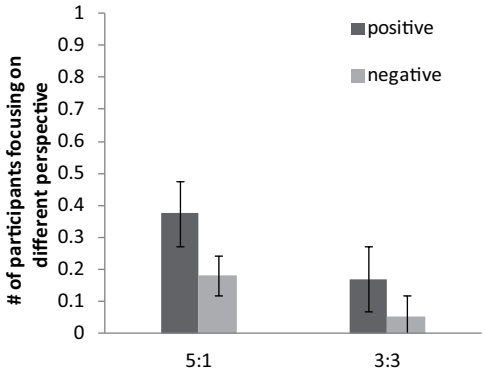

Figure 6: Results on perspective-taking performance.

Discussion and Conclusion

The present study investigated the two factors that influence perspective integration in a group-based collaborative problem-solving task. The results from the questionnaire show that participants were influenced by the emotional state that was constructed in the group. That is, participants engaging in a group with positive members felt more pleasant to partners compared to those with negative members. This was consistent even if the number of members with different perspectives increased in the group. Interestingly, even when participants received the same amount of information with the same rule base, with the only difference being positive/negative phrases, the impressions towards others changed drastically. From the point of system development for using conversational agents as experimental tools, it shows new implications that mood can be controlled when using multiple agents. This provides advanced implications from the work by Hayashi (2012, 2013). For the main results of the study, performance results show that both factors were effective. Participants performed better when they (1) encountered members with different perspectives less in the group(5:1) compared to those with several members, and (2) engaging in a group with positive members tended to integrate different perspectives as compared to those with negative mood. For (1), this provides stronger evidence compared to Hayashi (2012), where there was no clear difference between the two conditions(5:1 vs. 3:3) in terms of problem-solving performance. This is interesting in the sense that participants have more opportunity to interact with members with the different perspective in the 3:3 condition as compared to those with a single member in the 5:1 condition, but integration is better in the latter. A phenomenon found by attending to a fraction of the available information is the discovery of "anomalies," which are crucial for developing and generating new theories under stalemated conditions (Chinn & Brewer, 1993). The present findings could be interpreted in that individuals could

have considered the potential of a maverick functioning as an anomaly in problem solving. Either way, it can be pointed out that the mere single individual with a different perspective provides less conflict and motivates others to consider it as a potential, and that this can be related with emotional states. For the results of (2), this indicates that under situations where members meet with conflicting perspectives, the positive mood created by group members facilitates active behaviors and motivates consideration of their perspectives. Such results are consistent with previous work in group studies showing the effects of group emotion (Martenes et al., 1997; Bless, 2000; Weinstein et al., 2010). The current results add new insight in terms of the effect of affect over conflictive situations demonstrated in this study. This result shows how the power of social influence plays an important role in cognitive activities and thus could influence performance. Further, taken together with the results of the mere single member's effect, it is possible that two factors can produce a synergetic effect. That is, if problem-solvers perceive the mere individual, it may produce positive mood, which could then facilitate better performance. Focusing on this point, further analysis could be conducted on verbal inputs and processes. Such attempts could provide implications on how the emotion in groups moderates the problem-solving process and its role in social cognition.

Acknowledgments

This work was supported (in part) by The Ministry of Education, Culture, Sports, Science, and Technology, Japan (MEXTGrant), Grant No. 16K00219.

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