The effect of "Maverick": A study of Group Dynamics on Breakthrough in Collaborative Problem solving

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Abstract

The presented study is concerned with one aspect of the effect of a "whistleblower" or a person arousing or informing a different perspective on a collaborative problem-solving task. Its purpose is to find out, through an experiment, how a whistle-blower (which we called "Maverick") affects the facilitation of a breakthrough in a rule-discovery task. In the experiment two hypotheses were tested: 1) Collaborative problem-solving task is facilitated by contribution of member with different perspective. 2) Problem-solving task is facilitated more as the number of participant with a different perspective increases. In the experiment, several sets of figures were presented in three different settings (without a different perspective, with Maverick, three members with a different perspective), where a group of six members (one human and five conversational agents) collaboratively engaged in a rule-discovery task via a text-based chat system. The experiment revealed an interesting result to the effect that while a different perspective, overall, contributed to the facilitation of problem-solving such contribution was not statistically significant when it was presented by half of the members. The implications of the result were discussed by referring to the related literature in psychology.

Keywords: Collaborative Problem Solving; Different Perspectives; Conversational Agent.

Introduction

In Cognitive Science, many studies have been conducted to investigate what contributes most to collaborative problem solving. Several of them found that different perspectives promote an interaction between a pair and lead to collaborative problem solving (Miyake, 1986; Shirouzu, Miyake, & Masukawa, 2002; Hayashi, Miwa, & Morita, 2006). Others reported that asking reflective questions to conversational partners is a useful interaction strategy for gaining a deeper understanding about the problem (Okada & Simon, 1997; Miwa, 2004). They argued that the use of verbal probes such as providing clarification questions and suggestions prompted the problem solvers' reflective thinking and metacognition. A study by Shirouzu, Miyake, & Masukawa (2002) also suggested that taking different roles is an effective way to reconstruct the external representation of problem solvers and stimulate creative thinking.

Unfortunately, most of the findings on collaborative problem solving in the past have been based on the experimental data using a few participants such as a pair. Only few studies investigated the interactional aspects of collaborative process in a group of people and it remains unknown what kind of group dynamics actually operates in the perception and interpretation of different perspectives during the task of collaborative problem solving among several people. In the present study, the author will look into the nature of such operation through an experimental set-up where a different perspective is presented to illusionary members of a conversational group.

Integrating different perspectives of others during collaborative problem solving

Cognitive operations such as combing and integrating different perspectives during problem solving are effective strategies for generating new ideas (Finke, Ward, & Smith, 1992). They are also considered to play important roles in several cognitive domains. In the model of Hegelian dialectic thinking, different perspective is regarded as a key concept for creativity. Also important in this model is a process called the 'aufheben' whereby contradicting different opinions are integrated and interpreted into a higher level of concept (Hegel, 1874). In group problem solving, it is assumed that this process of integrating different perspectives can play an important role during collaborative problem solving.

Hayashi & Miwa (2009) is one of the few experimental studies that examined the effect of cognitive operations such as combining and integrating different perspectives upon collaborative problem solving. In that study, they investigated the nature of such operations in a rule-discovery task where each of a pair had a different perspective. Results of the experiment showed that establishing a common ground between the two through such operations is a key to success in problem solving.

It can be expected that such operations would become more difficult when more than two people with different perspectives engage in problem solving. The present study will focus on the nature of group dynamics of collaborative problem solving in a group, which very few studies have investigated and still remains an unsolved issue in cognitive science (see Figure 1 for an experimental set-up of this study).

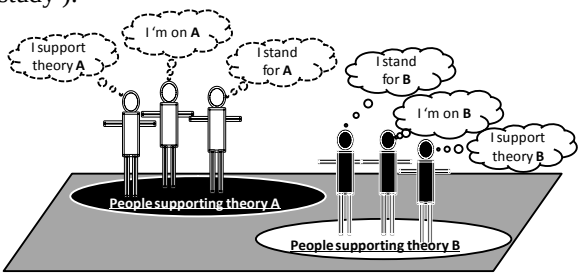

Figure 1. An experimental setting.

Changing perspectives in group problem solving: Participation of 'whistle blower'

One of the common phenomena observed in problem-solving task is that people are often fixated on or biased in favor of a particular perspective. In such a situation, it is vital that they take a different perspective, but an important question is how we can make that happen.

In the field of organizational study, it has been found that participation by so-called a 'whistle blower' often arouses a different perspective among group members (Elliston, Keenan, Lockhart, & Van Schaick, 1985; Near & Miceli, 1987). In general, a whistle blower is defined as the person who dissents from the laws and systems of the organizations to which she/he belongs. It is said that such person may be perceived as a troublemaker that brings a confusing idea to a group, or, sometimes as a reformer who brings an innovative idea to a group. In either case, whistle blower is known to become a potential provider of an 'anomaly cue' that stimulates reflective thinking. We may predict that participation of whistle blower with a different perspective promote reflective process of collaborative problem solving.

Aim of this study

Studies discussed above suggest that different perspective provided by whistle blower may provide breakthrough and facilitate their task in collaborative problem solving. The group dynamics of incorporating different perspective may also be affected by several factors such as the number of whistle blower in a group. It may be natural to expect that collaborative problem solving will be facilitated more when a different perspective is suggested by more than one person. The purpose of the present study is to examine these assumptions, by testing the following hypotheses:

1) Collaborative problem-solving task is facilitated by contribution of member with different perspective.

2) Problem-solving task is facilitated more as the number of participant with a different perspective increases.

Experiment of design

In this study, we used a modified version of the experimental design in Hayashi et al. (2006), where pairs of participants with different perspectives engaged in a rule-discovery task. The design of the experiment was developed based on the Gestalt theory.

Controlling the participants' perspective

In the experiment, several sets of random patterns of several figures on a 6 x 6 grid base, each colored black or white, were generated, (see Figure 2). In each set, a pattern consisting of combined square blocks was shown against the background of either black or white background colors. The background color was controlled to derive, through Gestalt effect, the change in problem-solver's perspective (Koffka, 1935).

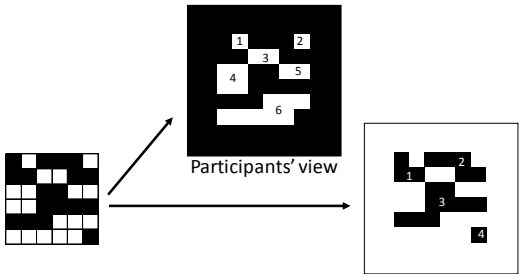

Figure 2. Example of stimuli with ten components (six in white and four in black).

Each set consists of several "objects" (or patterns) in black or white color, each of which consists of a single block or combined multiple blocks. In one example shown in Figure 2, one of the paired objects has a total of ten "components" comprising four black components and six white components. They were shown on a computer display against either black or white background. When a participant is focusing on white components inside a black background, they becomes the figure and the six components pop out; on the other hand, when a participant is focusing on a black object, it becomes the ground. The default setting was such that the participants easily see figure component in white color (See Figure 2). The alternative perspective is a perspective that suggests figure component in black.

While only two members engaged in the task in Hayashi et al. (2006), in the present study a group of six problem solvers collaboratively worked on the problem solving task through computer terminals connected via a local network. The six members of the problem solvers consisted of one human participant and five chat partners of computer gents. In this study we call member with a different perspective 'maverick'. It is agent that plays the role of group member and focuses on a background color which is different from that the human participant does. Shown in Figure 3 is an illustration of the setting where all six members except one (or Maverick) see four white components against black background.

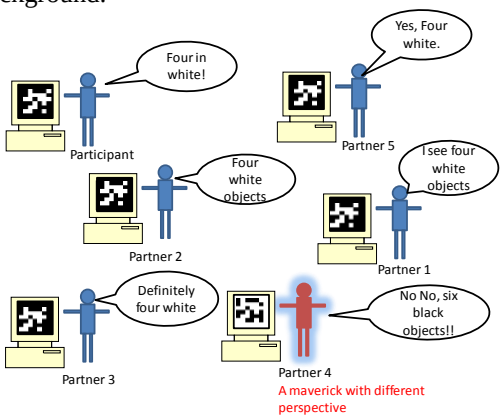

Figure 3. Example of experimental situation.

In the experiment, several types of objects were presented in sequence on a computer display (see Figure 4). For each

object, a square outer-box was shown on the display for one second, which was followed by stimulus picture presented inside the box frame. The number of white components and black components was controlled and the total number of the components presented to the participants was between six and twelve. Sequential pattern of the sums of black components and white components was repeatedly presented (i.e. 6, 8, 10 / 6, 8, 10) (see Table 1).

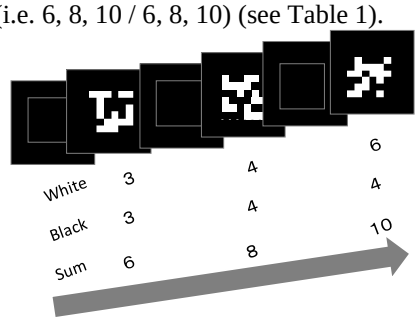

Figure. 4. Series of presented stimuli.

Table 1. Example of sequences of the presented objects.

White	4	6	4	7	2	4	6	5	3
Black (maverick)	2	2	6	5	4	4	4	7	3
Sum of Black and white	6	8	10	12	6	8	10	12	6

In this experiment, the task of a participant is to discover a rule concerning the regularity of the series of sums of the components. If participants are preoccupied to focus on only one of the two background colors, they cannot find a target rule. To make a breakthrough in the task, problem solvers have to take into consideration the number of components that pop out as figure and that of components hidden in the background. In order for a participant to find a rule, he/she needs to focus on the components hidden in the background. In a setting shown in Figure 3, for example, the maverick (partner 4) keeps suggesting an alternative perspective to call their attention to the presence of the black components.

The task required of the participants in the experiment was to type in the chat exchange when engaging in the task. The participants were assigned to always talk first during the chat exchange. Shown in Figure 5 is an illustration of interface record of a text-based exchange among a participant and five other agents that are discussing the problem. During the task, they were able to use buttons at the bottom of the screen to change objects, send messages, and to terminate the experiment. The participants were allowed to write only one sentence of less than 30 characters for each pair of components and were asked to finish the task within 30 minutes.

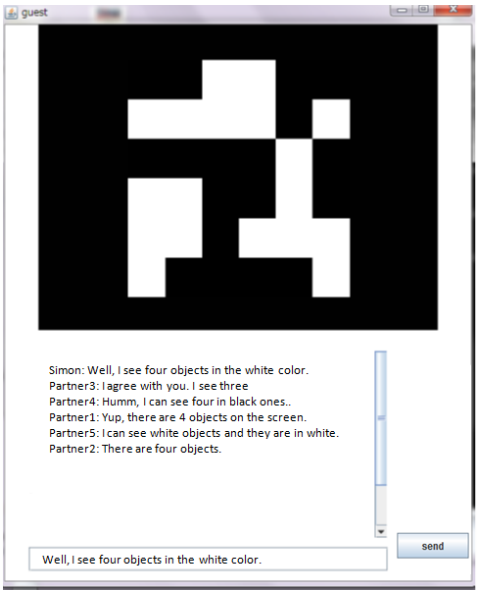

Figure 5. Example of the interface.

Conversational agents and the experimental system

The system used in the experiment was designed by Java (see Figure 6) and consists of four program modules: (1) Server, (2) Client, (3) Agent, and (4) Problem Generator. Multi-threads, which process all the messages simultaneously, were used for the Server. When messages are sent to the Server, they were re-distributed to all Clients (Agents). The Problem Generator generates the objects that were presented in sequence (see Table 1). This module provided important information about the sequence of the stimuli and the objects presented by GUI, which was used by the agents to generate messages. A simple conversational computer agent used in this study is a typical rule-based system. Based on some pre-defined rules, it can respond meaningfully to sentences that were input by the participants (See Figure 7).

The Semantic Analyzer extracts keywords from input messages and detects keywords relevant to the task. Keywords collected from a previous study were used to build the Dictionary which contained important keywords for the task (Hayashi et al., 2009). Working Memory is created by the Generator, and it consists of two associated database: (a) presented objects (Picture Database), and (b) detected key words (the Semantic Analyzer). Various types of argument statements are stored in Rule Base in the form of 'if-then' format. Definitions from Working Memory are sent to Rule Base to search for matching statements. When there are several overlapping statements, a simple conflict-resolution strategy is utilized. When a matching process ends, selected sentences are sent to the Generator. Then, definitions in Working Memory are updated, and finally, output messages are displayed.

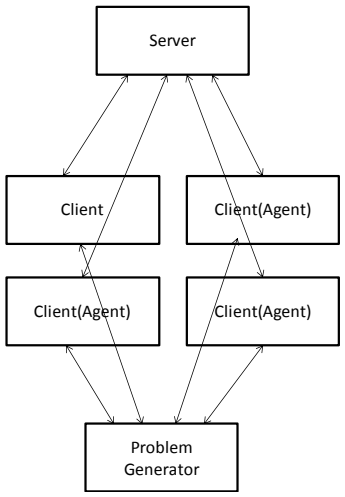

Figure 6. The structure of the system.

The conversational agent described above played the role of partner and produced a virtual experimental environment. The participants of the experiment were instructed that they are interacting with real people, though they were actually interacting with computer agents to solve the task.

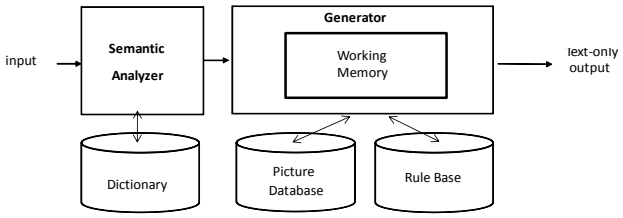

Figure 7. Structure of the agent.

Experimental Setting

To test the hypotheses, the following three conditions were set up: (1) 6:0 condition, (2) 5:1 condition, and (3) 3:3 condition. The third condition was included to test the second hypothesis. In the first 6:0 condition, all of the members had the same perspective; there were no members with different perspectives in this condition. In the second 5:1 condition, one of the collaborating agents had a different perspective. In the third 3:3 condition, half of the six members had a different perspective. In all conditions, a group of six members consisted of one human participant and five computer agents and a different (or an alternative) perspective based on black background color was provided by computer agent to a human participant (See Figure 8).The participants engaged in the task, without being told that they were interacting with computer agents.

101 undergraduate students participated in the experiment (38 males and 63 females; the average age was 20.3). The experiment took place in a computer room where maximum capacity was 60 people. All participants were randomly assigned to each condition and they were instructed that they will start the task with someone inside the room. Those participants who did not follow the instructions to answer the final questions or who felt suspicious about their partners were excluded from data. Participants who did not begin the experiment by focusing on the objects by figure color were also excluded. After this screening, the total number of participants that provided to the data was 92 (31 participants each for the 6:0 and the 5:1 condition and 30 participants for the 3:3 condition.)

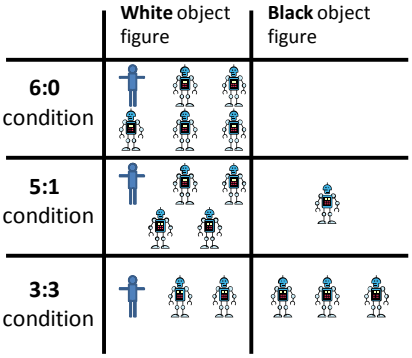

Figure 8. Experimental conditions.

Dependant variables

After the task, each participant was asked to describe the target rule on an answer sheet. If their answers were in some ways related to the number of black or white components of the objects, they were judged as 'integrated' (e.g. The sums of the black and white components are 6,8,10 and the sequence is repeated in the same order. The difference of the number of the black and white components is between zero to two.) If their answers did not include such information, they were evaluated as 'not integrated'.

All of the answer sheets were also analyzed to evaluate their cognitive process of perspective change. If the conversation data included a description that referred to the background color, it was counted as a token of 'a change of perspective'. (e.g. "I was counting only the white objects, but maybe the black objects have something to do with the target rule…". If their data did not include such information, it was counted as a token of 'no perspective change'. The data was then statistically analyzed for (1) the number of integrated answer, and (2) the process of change in perspective.

Results

Problem Solving Performance

The results were analyzed using a 1 x 3 between-subjects factorial design. Figure 9 shows the results of the performance of problem solving. The vertical axis represents the ratio of the problem solving performance, and the horizontal axis represents the experimental condition. The numerals shown on the cylindrical bars indicate the number of participants in each condition.

A Chi square analysis was conducted to verify if the difference of the number of problem solvers who used perspectives of others was statistically significant. An over-all analysis suggests that, a group which had a member with a different perspective integrated its perspective into their own perspective more frequently than a group which did not. There were a significant difference among the three conditions (x^2 (2) = 7.189, p < .05). Next, a multiple comparison was conducted on each two conditions using the Fisher's exact test. There was a significant difference between the 6:0 and the 5:1 condition (p < .05). On the other hand, the differences between the 6:0 condition and the 3:3 condition were marginal (p < .10). There was no significant difference between the conditions of 5:1 and 3:3 (p = .41).

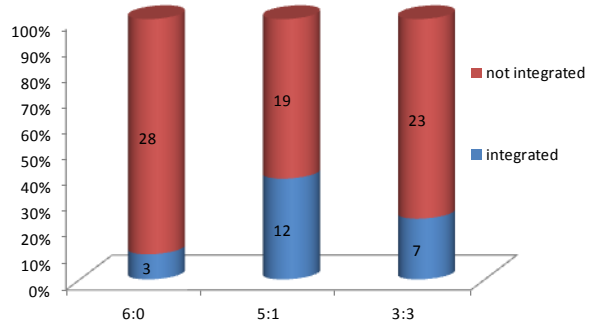

Figure 9. Results of the problem solving performance

Perspective change process

Figure 10 shows the results of the performance of a change of perspective. The vertical axis represents the ratio of the change of perspective, and the horizontal axis represents the experimental condition. The numerals shown on the cylindrical bars indicate the number of participants in each condition.

A Chi square analysis was conducted to check the difference of the number of problem solvers who integrated their perspectives during the task. Results indicate that there were differences among the conditions ($x^2(2) = 15.230$, $p < .01$) Next, a multiple comparison was conducted on each two conditions using the Fisher's exact test. There were differences between the 6:0 and 5:1 condition (p < .01). On the other hand, the differences between 6:0 and 3:3 conditions were marginal (p < .10). At last, differences were found between the conditions of 5:1 and 3:3(p < .01).

Like the problem solving performance, an over-all analysis suggests that a group which had members with different perspectives were taking into consideration the perspectives of others more frequently than a group which did not. More importantly, the results showed that the problem solvers were incorporating others' perspectives most when a different perspective was proposed by a single partner; the difference was greater than when different perspectives were proposed by more than one person.

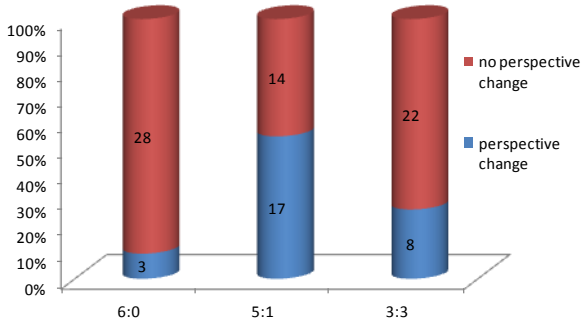

Figure 10. Results of the problem solving process

The effect of 'Marverick 'and experimental condition

The statistical analyses above indicated that in both problem solving performance and perspective change process, a group which had member with a different perspective were incorporating their alternative perspective more frequently than a group which did not have such member. In other words, the over-all analysis revealed the results that support the first hypothesis.

Further analysis showed, however, that the participants were not incorporating an alternative perspective when it was proposed by three members; that is, different to the expectation, the effect of an alternative perspective by a single partner was greater than that by three partners (i.e. half of group members). In other words the results of the experiment did not support the second hypothesis; Marverick outperformed the impact of its alternative perspective than multiple members with an alternative perspectives. In other words, it suggests that people are less inclined to integrate a different perspective when it is suggested from several people. Implications of this finding will be presented below.

Discussion

It has been pointed out that a different perspective in a group may be favored especially when people face a situation which is comprehensible only vaguely or partially. Though people tend to be influenced by a perspective that is dominant in a group, a breakthrough can take place when a member of a group presents a dissenting view. In psychology this type of social influence is called the "minority influence". In one of the classical studies on 'minority effects', Moscovici & Nemeth (1974) argued that a minority of one is more influential than a minority of more than one. They argued that if one person is consistent with the minority view, over time, it may capture more attention from the majority. In the 5:1 condition of the experiment, suggestions of a different perspective from a single member (i.e., Marverik) was not only consistent but persistent in that it gave suggestions more frequently and over longer time compared to those in the 3:3 condition. That may have aroused the participants to think that the suggestion of

alternative perspective from that person must be very helpful if he/she is so sure of it. One of the possible reasons why the facilitation effect from Marverik was higher in the experiment may have to do with the effect of attention and its consistency. Other studies have shown that the influence of a minority perspective is a desirable condition for increasing the diversity of views, prompting reconsideration, processing information and making a decision (Moscovici, Lage & Naffrechoux, 1969; Nemeth, Brown, & Rogers, 2001). While the situations investigated in these studies are somewhat different from the present study, the result of the experiment showed that minority overall can exert a similar desirable effect to the facilitation of the task of collaborative problem solving where a breakthrough is needed.

The experiment also suggested that a different perspective from a single member may be more easily incorporated to facilitate cooperative problem-solving task than that from multiple members. One of the factors that are involved in the rejection of the second hypothesis may be related to the notion called "groupthink". It is a psychological phenomenon that often occurs when the desire for harmony overrides critical evaluation of own perspective and serious appraisal of alternatives. In a more realistic setting, social influence may force people to adapt a perspective a majority of others take. People may ignore the view of a minority, favoring a certain perspective, whether that perspective is ideal or not. This may take place in the process of decision making in a group where its members want to minimize conflict and reach a consensus decision without critical evaluation. This is similar to a negative effect associated with a whistle blower mentioned above. It may be that this negative effect of groupthink was working for the participants in 3:3 condition.

Also, a different perspective with people with the same opposing perspective may have lead to confusion. This type of confusion is pointed out in the literature of organizational psychology (Pondy, 1967). To confirm why the point investigated by the second hypothesis was rejected, these and other factors may need to be taken into account in a further experiment.

CONCLUSION

This study investigated the influence of different perspective during collaborative problem solving. The results showed that, while a different perspective is more likely to contribute to problem solving, it was more effective when it was presented by only one person than by several people. The discussion suggested that further study is needed to confirm the latter point.

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