Improvement of Member's Concentration during Discussion

Junko Ichino[1], Kazuhiro Takeuchi[2], and Hitoshi Isahara[3]

[1] University of Electro-Communications
1-5-1 Chofugaoka, Chofu-shi, Tokyo 182-8585, Japan
[2] Osaka Electro-Communication University
18-8 Hatsu-cho, Neyagawa, Osaka 572-8530, Japan
[3] National Institute of Information and Communications Technology
3-5 Hikaridai, Seika-cho, Soraku-gun, Kyoto 619-0289, Japan
ichino@is.uec.ac.jp, takeuchi@isc.osakac.ac.jp,
isahara@nict.go.jp

Abstract. We developed face-to-face single display groupware (SDG) that has a novel circular frame and enhanced multiple pointers. The aim of the study is to encourage groups to concentrate on their discussions and thereby improve their cooperative decision-making. We analyzed the information input methods and information that should be shared in a face-to-face SDG by surveying related work. The interface was designed based on this analysis. Three experiments were carried out, with a general parallel input system tested for comparison. The results proved that group task accuracy, participants' memory, and their subjective evaluation improved when our SDG was used.

Keywords: face-to-face meeting support, concentration on discussion, single display groupware (SDG), pen-based, awareness.

1 Introduction

Various groups make critical decisions by coming together for sharing of information and to make choices on a set of options. We are interested in building interfaces that assist groups in improving their cooperative decision-making [3]. We treat the case of face-to-face and synchronous meetings in which a few people (about 4-5 participants) gather in front of a single display. Our goal is to encourage groups to concentrate on their discussions, in order to promote higher quality group decision-making.

For this goal, we examined multiple input methods and information-sharing methods as an interface to support a visual interaction. It can be difficult for many people to verbally communicate because only one person may talk at a time, and coordination among speakers is necessary. However, it is possible for many people to communicate visually. The visual interface has a lot of flexibility. It may be able to expand and narrow the range of behavior of each member of the group. We discuss the impact of changes in the visual interaction. We study how changes in the visual interaction affect the groups' whole communication including the verbal interaction.

M.J. Smith and G. Salvendy (Eds.): Human Interface, Part I, HCII 2009, LNCS 5617, pp. 59–68, 2009.

2 Related Work

This section surveys of some of the research on information input methods and information-sharing in groupware.

2.1 Information Input Methods for Single Display Groupware

Single display groupware is for users who share one display between them and write or edit on it. Input methods in studies on SDG are roughly categorized as parallel input and serial input. Parallel input methods allow multiple users to input at the same time, whereas serial input methods allow only one user who acquires the operational authority to input. Colab [10] pioneered research on the parallel input method. In their system, opinions were written on the single display and all users were able to focus on the input action. The display's context was reportedly difficult to understand as the users found it difficult to understand what all the others were writing at the same time. Inkpen revealed that children playing on a computer with multiple input devices tended to be more active [4]. CaptureLab [8] is a meeting support using the serial input method. The authors of the report on CaptureLab claimed that serial input makes participants focus on the content written on the display, and gives time to throw in verbal explanations during the input. Some studies (e.g., [9, 12]) have compared both input methods. Prante et al. [9] pointed out that although the serial input results in fewer opinions, these are still difficult to structure. The developers of Roomware [12] analyzed participant's glances. They reported that participants using the parallel input method kept gazing at the individual input terminals. On the other hand, participants using the serial input method mostly kept their gazes on the shared display rather than their own terminals. We compared the parallel and serial input methods of using shared displays (Table 1).

Table 1. Features of general input method in SDG

	General parallel input method	General serial input method
Direction of user's attention	Individual input terminal	Shared display
User's input frequency	High	Low
Consistency of display's context	Difficult to maintain	Easy to maintain
Focusing on the most important points	Difficult	Easy

2.2 Information Sharing in Groupware

There is obviously presence in a face-to-face environment. Such presence is missing from groupware operating in a distributed environment. There have been many studies [7, 11] on how to supplement for the lack of presence in a distributed environment. Dourish et al. [2] defined them by using the word "awareness".

On the other hand, participants train their eyes on input or output devices rather than on the participants when groupware is used in a face-to-face environment. In fact, users tend to busy themselves with the operation of the input device and do not look at others' faces [5]. Users fix their eyes on another's input or operations for passing operational authority on the shared display [12]. The above observations suggest the possibility that in a face-to-face environment, the use of a shared display may

actually decreases awareness about surrounding persons and may disturb rather than enhance communications. There are only a few studies that consider support in a face-to-face environment from such an angle. DiMicco et al. [1] and Iqbal et al. [6] support face-to-face meetings by visualizing information about participant's activities on the screen. However, the user's burden is still large because s/he should take special care about the information presented during the discussion.

We consider information that should be shared in a meeting group in order to support concentration during discussion in a face-to-face environment, because new groupware media will become part of that and other meeting environments.

3 Face-to-Face Single Display Groupware Encouraging Member's Concentration during Discussion

Here, we gain insight into the user interface requirements for an input method and information sharing to support concentration during discussion in face-to-face meetings using SDG based on the previous section.

3.1 SDG User Interface Requirements

Input method to encourage independent interaction. To establish a consensus based on a mutual understanding between participants, a discussion should include various perspectives. Therefore, various opinions need to be presented on a shared display. New ideas synergistically develop from viewing the others' ideas presented on the display. To write positively on an SDG, the user must easily be able to adjust the position, range, and timing of her or his writing. During a meeting, a user has to plan not only "What do I say?" but also "When do I start writing?", "Where do I write?", and so on. In a word, input operations in SDG require ease of coordination of when or where each user writes on a shared display. The requirements for the input method to support positive participation in a face-to-face SDG are therefore that a user should be able to interact with others through an easy operation for transferring the right to write.

Information sharing to help user's concentrate on discussion. Firstly, to make continuous involvement that leads to consensus building, participants should always be able to understand a presented idea; there be shared attention among participants. Secondly, a user should be able to promptly perceive the represented information, to check its meaning, and to give responses to make the conversation go smoothly. Therefore, it is necessary to present information that encourages spontaneous participation, starting with noticing changes in others' behavior. Thirdly, enabling participants to reflect upon their behavior is important for activating a discussion. If a user becomes aware of someone with a negative attitude, s/he can encourage that person to write or speak. Moreover, a participant who over participates may find it easier to refrain from speaking. With such behavioral control, we believe that a group will have an animated discussion expressing various viewpoints. The requirements for information sharing to support positive participation in a face-to-face SDG are therefore that a user should be able to grasp the focus of an argument easily, that a user should be able

to easily perceive change in another's behavior, and that a user should be able to easily assess how s/he and others have been participating.

Summary of user interface requirements. Table 2 summarizes the user interface requirements for a face-to-face SDG to support positive participation.

Table 2. Interface requirements

Requirement 1	**Positive attitude:** a user should be able to interact with others positively.
Requirement 2	**Concentration:** a user should be able to grasp of the point of discussion easily.
Requirement 3	**Awareness of others:** a user should be able to be easily aware of the change in the behavior of others.
Requirement 4	**Historical awareness:** a user should be able to easily assess how s/he and others have been participating.

3.2 User Interface Design

We designed a user interface of the meeting support tool that addresses the four requirements summarized in Table 2. The features are a novel circular frame and enhanced multiple pointers.

Interface that meets requirements 1 and 2. With requirement 2 in mind, we designed a circular frame whose center is the center of balance of all users' pen pointer locations on the shared display (Figure 1). Its appearance calls the user's attention. The frame interlocks with the movements of each pointer so that all participants always maintain a common recognition of the discussion on the shared display. The frame size is fixed according to the result of the preliminary test. To satisfy requirement 1, we designed a parallel input interface that limits the input range within the frame. A user's pointer might be located outside of the frame because the frame is located at the center of balance of all users' pointer locations. Users whose pointers are inside the frame can write in the frame of the display at the same time. That makes it unnecessary for users to take turns writing, and it helps to activate writing interactions.

Interface that meets requirement 3. Our research deals with the activities of writing and speaking as observable user behaviors in SDG. In this case, a change in the behavior indicates events such as beginning writing, stopping writing, beginning speaking, and stopping speaking. With requirement 3 in mind, we visually represented the user's writing behavior by making multiple pointers transparent on the display (Figure 2). Multiple pointers are spontaneously attracts users' gazes. User pointers while writing are displayed with a translucent color, while other pointers are displayed with an opaque color. Translucent colors are used because everyone should be able to see the writing under the pointer as the user writes it. Pointing pointers are displayed with a shadow.

Interface that meets requirement 4. With requirement 4 in mind, we made it so that the size of the user's pointer represents the relative proportion of characters a user has written from the beginning of the meeting to the present moment. The size of each pointer shows the relative proportion of each user's writing participation (Figure 3). The size of the pointer changes in real time to show everyone how much a user has been writing during the meeting.

With requirement 4 in mind, we visually represented the proportion of time a user has spent speaking from the beginning of the meeting to the present moment, by using

the angle of the user's arc in the circular frame. The frame consists of different colored arcs for each user. The arcs show the relative proportion of each user's speaking participation as in a pie chart (Figure 4).

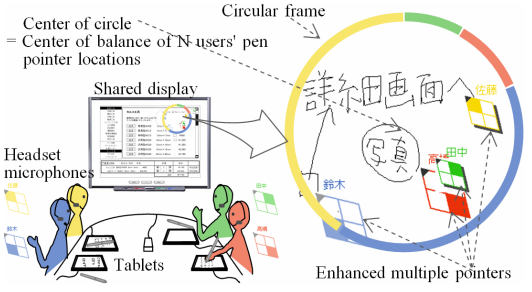


Fig. 1. Circular frame and enhanced multiple pointers

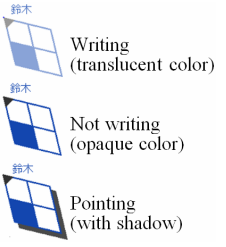


Fig. 2. Representation of writing states using multiple pointers

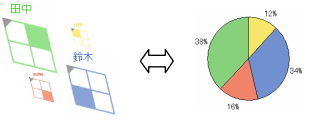


Fig. 3. Representation of proportion of characters written using multiple pointers

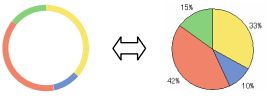


Fig. 4. Representation of proportion of time spent speaking using frame arcs

4 Basic Experiments

We developed a prototype and carried out two experiments. The experiments compared the prototypes with a general parallel input system. The reason we chose parallel input method as the object of comparison is that it is more similar to our system than the serial method. The experiments assessed the basic functions to meet requirements 1, 2, and 3 in Table 2. The interfaces corresponding to requirements 1, 2, and 3 are closely related to the user's interactions. On the other hand, the scale of the interaction involved in requirement 4 is larger.

4.1 Viewpoints

Group task accuracy. As for the first aspect, we measured the accuracy of the task that the group completed.

Participants' memory accuracy. As for the second aspect, we measured the accuracy of each participant's memory about the results of the completed task. Each participant was given a questionnaire after a fixed period of time had elapsed from the task's completion.

4.2 Methods

Design. Our system (called "frame mode") was compared with a general parallel input system (called "parallel mode"). For the frame mode, the systems were prepared

without the function to satisfy requirement 4 (Figure 3 and Figure 4). Therefore, a colorless frame was prepared because the function to indicate user's speaking percentages was not included. The two experimental systems are shown in Figure 5.

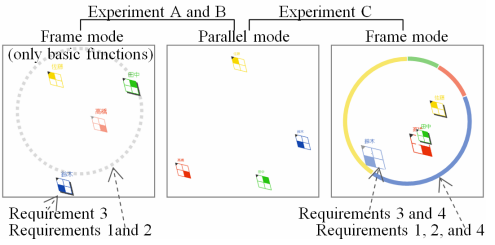


Fig. 5. Experimental conditions in the experiments

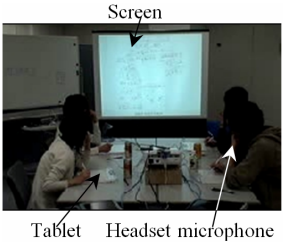


Fig. 6. A scene during the experiment

Participants. Twenty-four men and women in their 20s and 30s participated in experiment A. They were randomly assigned to six four-person groups. Three groups performed the tasks in frame mode, and the other three groups performed the tasks in parallel mode. Thirty-two people participated in experiment B. They were assigned to eight four-person groups. Four groups performed the tasks in frame mode and the other four groups performed the tasks in parallel mode.

Environment. Four users of a group sat face to face at a rectangular table. Each user had a tablet device (WACOM FAVO CTE-640) and wore a microphone (Logicool Internet Chat Headset A450). The screen was placed in front of them as a shared display. The input data of the four people were displayed in this screen.

4.3 Task for Experiment A: Artificial Task

We prepared a simple task to test the interface's usability. In this experiment, there were no differences in knowledge and memory among the participants. The group put down the locations, names, and symbols of twelve stores on a blank map on information sheets given to each subject. A total of twenty-four different information cards composed of twelve cards with the locations and names of stores and twelve cards with symbols of the stores were prepared. The cards were equally divided among the participants in a group. All participants were able to check these cards during the task. Figure 7 shows information cards distributed to participants and an example of a completed store map. They were told to answer as quickly as possible.

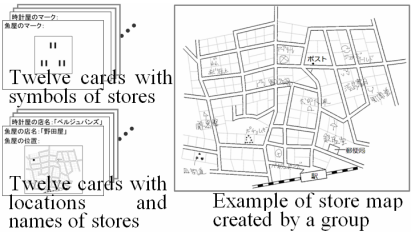


Fig. 7. Task for experiment A

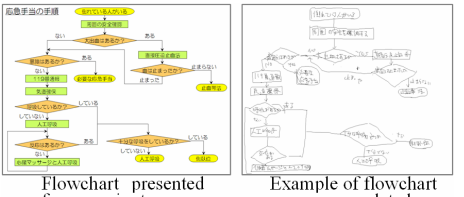


Fig. 8. Task for experiment B

4.4 Task for Experiment B: General Task

Generally, there are differences in participants' knowledge and memory. We assumed that this task would simulate a realistic situation wherein participants would each have vague and non-symmetric knowledge and would need to solve a problem cooperatively. First, a group was shown a flowchart that showed a procedure of emergency operations, for one minute. The flowchart was hidden afterwards. They then reproduced the flowchart on a shared display while discussing what they remembered. The word "reproduce" means not a copy of the chart's appearances but a copy of the substance of the flowchart. The time allowed for a group to reproduce the flowchart was 20 minutes. Figure 8 shows the flowchart that was presented for one minute and a flowchart reproduced by a group.

4.5 Results and Considerations

Group task accuracy. We evaluated how consistent the figure that each group wrote was with the original one. In experiment A, we determined whether the store's map that the participant group completed corresponded to the information on the cards distributed to the participants. In experiment B, we determined how well the flowchart completed by the group completed corresponded to the flowchart presented at the beginning. Table 3 lists the group task accuracies on a 100-point scale and the times taken to complete the task. In experiment A, the groups for both modes completed the map perfectly. We asked the participants to answer as quickly as possible. There was no significant difference in time taken between modes, although the parallel mode allowed participants to fill in the map faster than the frame mode did. In experiment B, the frame mode groups reproduced flowcharts with a significantly higher degree of accuracy than the parallel mode groups did.

Participants' memory accuracy. The participants answered the questions on the results of the task that their group had completed. In experiment A, they were asked if they recognized the locations, names, and symbols of the twelve stores written by the group. In experiment B, they were asked to recall the parts of the flowchart written by the group. Table 3 lists the participants' memory accuracy on a 100-point scale. In both experiments, the frame mode enabled participants to memorize the results of the task the group completed with a significantly higher degree of accuracy than the parallel mode. Frame mode's accuracy was especially superior in experiment A, although the time to complete the task was also a little longer.

Table 3. Results of experiments

		Frame		Parallel		One-tailed t-test	
		Mean	Std	Mean	Std		
Group's task accuracy	Exp. A	100.00	0.00	100.00	0.00	–	–
	Exp. B	93.33	8.16	78.00	17.89	t=1.891	**p<0.05**
Group's task time (minutes)	Exp. A	7.75	1.56	6.29	0.78	t=1.444	p=0.111
	Exp. B	fixed time (twenty minutes)					
Participants' memory accuracy	Exp. A	26.62	17.98	12.04	7.97	t=2.568	**p<0.01**
	Exp. B	67.15	29.64	44.17	22.34	t=2.246	**p<0.05**
	Exp. C	100.00	0.00	62.50	45.21	t=2.346	**p<0.05**

5 Application Experiment

Next, we devised a realistic task in which a group discusses graphical user interface for a new web site and determines functions to be included. This experiment determined whether the functions could meet requirement 4.

5.2 Methods

Design. For the frame mode, the function to meet requirement 4 was added to the system used in experiments A and B. For the parallel mode, the same system as in experiments A and B was used. The two experimental systems are shown in Figure 5.

Participants. Sixteen men and women in their 20s and 30s participated. They were randomly assigned to four four-person groups. Two groups performed the task in frame mode, and the other two groups performed the task in parallel mode.

5.3 Task for Experiment C: Realistic Task

We devised a realistic task for discussing online stores that a machine tool company had just established. The group discussed how it was necessary to improve the draft web site so that customers could order items without error. They refined the draft version (Figure 9) on the shared display. We divided the group discussion into a first half and latter half. The each member of the group presented their opinions for 20 minutes in the first half. Afterwards all their opinions had been stated or written down, they corrected or added to the draft version on the shared display. They discussed their opinions and selected the best three.

5.4 Results and Considerations

Participants' memory accuracy. Participants were asked to recall the three opinions that the group finally chose, and described them in the order that the group chose. Moreover, they were asked to recall the details of each opinion, the reasons about why the site should be improved, and the reason for their choice. Table 3 lists the results on a 100-point scale. This result show that the frame mode participants could memorize the results of the task with a higher degree of accuracy than the parallel mode participants could memorize.

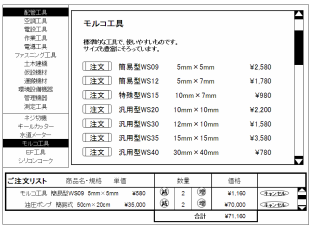
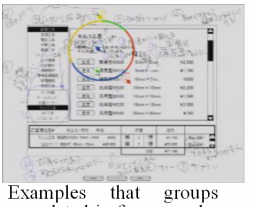
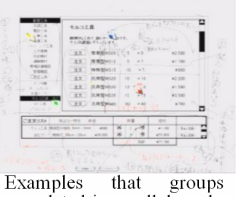


Fig. 9. Task for experiment C



Examples that groups completed in frame mode



Examples that groups completed in parallel mode

Fig. 10. Screenshots of shared displays in experiment C

Variation in amount of written and spoken opinions. The proportions that each participant wrote and spoke in experiments A an B were compared with those in experiment C. The presentation functions of these proportions were embedded in experiment A and B, but not in experiment C. Figure 11 plots the proportion of distances that each participant drew with their pen. Figure 12 plots of proportion of words that each participant spoke.

The task of experiment A is artificial task that would not cause a difference in knowledge or memory among the participants. In fact, the comparison of these variations in the frame mode and these variations in parallel mode in experiment A is the simplest without presentation functions showing the proportion of expressed opinions written and spoken by the participants. The variation in the amount of written opinions was small in both modes. It seems that this is because the cards containing the same amounts of information were written on the shared display, since we asked the participants to answer as quickly as possible. The variation in the amount of spoken opinions was wider than the variation in amount of written opinions in both modes.

The task of experiment B supposed that there were the differences in knowledge and memory among the participants. The frame mode resulted in wider variations in the amount of expressed opinions, both written and spoken. Moreover, the variation in experiment B was wider than in experiment A. We think that this difference reflected the difference between experiment A (which controlled knowledge and memory) and experiment B (which did not control them).

The task of experiment C was a realistic one supposing that there were differences in the knowledge and memory among the participants. The frame mode resulted in wider variations in amount of expressed opinions, both written and spoken, for the participants of experiment B, but resulted in narrower variations in experiment C. This difference suggests the possibility that the presentation functions for showing the proportion of written and spoken expressed opinions had some effect on the participants. Instead of exploring this possibility directly, we attempted to analyze the following qualitative changes. For instance, which kind of written or spoken opinions influenced the change? Or, did the content of the written or spoken opinions change?

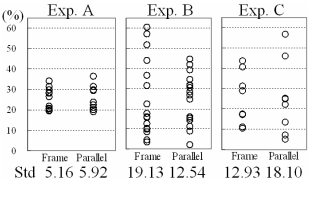


Fig. 11. Plot of individual writing rates

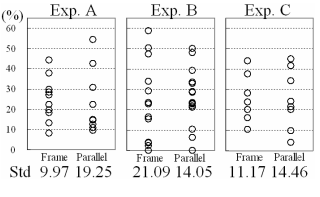


Fig. 12. Plot of individual of speaking rates

6 Conclusion

We described face-to-face single display groupware that has a novel circular frame and enhanced multiple pointers. We carried out three experiments (two basic, one application). The groupware's effectiveness was confirmed by comparing it with a general parallel input system. The experimental results indicated that the group task accuracy and the participants' memory improved when our system was used.

References

1. DiMicco, J.M., Pandolfo, A., Bender, W.: Influencing group participation with a shared display. In: Proc. CSCW 2004, pp. 614–623. ACM Press, New York (2004)
2. Dourish, P., Bellotti, V.: Awareness and coordination in shared workspaces. In: Proc. CSCW 1992, pp. 107–114. ACM Press, New York (1992)
3. Ichino, J., Takeuchi, K., Isahara, H.: Face-to-face Single Display Groupware Encouraging Positive Participation. In: Proc. UIST 2006, Poster and two-page paper (2006)
4. Inkpen, K.M., Ho-Ching, W., Kuederle, O., Scott, S.D., Shoemaker, G.B.D.: This is fun! We're all best friends and we're all playing: Supporting children's synchronous collaboration. In: Proc. CSCL 1999, pp. 252–259 (1999)
5. Ishii, H.: Design of Realtime Groupware. Journal of IPSJ 34(8), 1017–1027 (1993)
6. Iqbal, R., Sturm, J., Kulyk, O., Wang, J., Terken, J.: User-centred design and evaluation of ubiquitous services. In: Proc. SIGDOC 2005, pp. 138–145 (2005)
7. Kam, M., Wang, J., Iles, A., Tse, E., Chiu, J., Glaser, D., Tarshish, O., Canny, J.: Livenotes: a system for cooperative and augmented note-taking in lectures. In: Proc. CHI 2005, pp. 531–540 (2005)
8. Mantei, M.: Capturing the Capture Lab Concepts: A Case Study in the Design of Computer Supported Meeting Environments. In: Proc. CSCW 1988, pp. 257–270 (1988)
9. Prante, T., Magerkurth, C., Streitz, N.: Developing CSCW tools for idea finding - empirical results and implications for design. In: Proc. CSCW 2002, pp. 106–115 (2002)
10. Stefik, M., Foster, G., Bobrow, D.G., Kahn, K., Lanning, S., Suchman, L.: Beyond the chalkboard, Computer support for collaboration and problem solving in meetings. Comm. of the ACM 30(1), 32–47 (1987)
11. Tang, A., Boyle, M., Greenberg, S.: Display and presence disparity in Mixed Presence Groupware. In: Proc. AUIC 2004, pp. 73–82 (2004)
12. Watanabe, S., Obata, A., Matsukura, R., Sasaki, K.: A Comparative Study of Information Input Method to an Electronic White Board in face-to-face Meetings. IPSJ SIG Notes 97(046), 31–36 (1997)