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Qualitative, Quantitative Evaluation of Ideas in Brain Writing Groupware

Ujjwal NEUPANE[†a)], ***Nonmember***, **Motoki MIURA**[†], **Tessai HAYAMA**[†], ***and*** **Susumu KUNIFUJI**[†], ***Members***

SUMMARY The problem with traditional Brain Writing (BW) is that the users are restricted from viewing all sets of ideas at one time; and they are also restricted from writing down more than three ideas at a time. In this research we describe distributed experimental environment for BW which was designed to obtain better results and can thus eliminate the problems of traditional BW technique. The actual experimental system is an integration of three BW modes with mutually different features and characters. We conducted three different tests implementing this environment, and confirmed quality and quantity of ideas generated by three different groups. It was confirmed that unrestricted inputs are effective in generating a large quantity of ideas, whereas limiting the number of sharable/viewable ideas shows better tendency in some aspects. However, qualitative evaluation results were not confirmed as different functions show variant results. The evaluation of the functions that support viewing and sharing of ideas show that synergy is not always an advantage in generating ideas. The results of number of ideas in correlation with time show that 20 minutes time was appropriate to conduct BW in distributed environment.

key words: *divergent thinking, BW, distributed-idea generation support system*

1. Introduction

Whenever there is a genuinely important decision to be made in an organization a group is assigned to make it. The group communicates, shares information, generates ideas, and organizes those generated ideas. Hence, the idea generation process is essential to the process of group decision-making or creative problem solving. Therefore, the influence of divergent thinking processes is considered to be one of the most important elements in idea generation or GSS [1]. To date, a number of programs have been developed to automate the idea-generation process. Provided that the group size is sufficiently large, if an idea needs to be shared among a number of participants, then automated idea generation meetings like BW can be more productive and satisfying than traditional or verbal meetings [2]. The BW process can be split into two categories: traditional and automated. Due to human intervention, the traditional process is not independent, whereas, in an online distributed process an overbearing respondent does not have the same power to influence. Compared to the traditional process of BW, the automated process is usually considered to be more versatile, as it is capable of accommodating many users and serving many functions. The practical benefits of online distributed BW are wide ranging. Some of the most important gains are its abilities to cross the time and space barriers. In face-to-face meetings some participants might be reluctant to express his/her ideas within a group, but the online distributed environment has the potential to defuse such tension, and allows groups to speak about sensitive issues in an open and candid way without the fear of judgment or shyness that characterize face-to-face groups [3]. Another, potential advantage of automated meetings is that the participants gain benefits from simultaneous input/output. Moreover, the fundamental procedures of BW, in which participants input their ideas on pieces of paper and exchange ideas with others, do not need oral communication, and hence it is easy to implement in a distributed environment.

Considering all these merits, in this research, we inherit the traditional concepts of BW and apply them to develop the distributed environment of a BW support system. However, traditional BW based on paper, has restrictions on input of ideas, and restrictions on viewing and sharing others' ideas. To eliminate the restrictions imposed by traditional BW procedures, and also provide a better system for idea generation, we concentrated on three different modes namely, [1s-3+i], [6s-3+i], and [1s-3i]. Although all three modes are intended to support the BW process, the contrast between them will highlight their productivity and efficiency.

"Hassotobi" and "Hasso-no-mori" were developed in the past [4] and were used as BW support tools. Both "Hassotobi" and "Hasso-no-mori" had functions like simultaneous input by participants from geographically remote locations, and in both systems all inputs are visible and sharable. "Hassotobi" is a combination of brainstorming and BW, in which participants can input as many ideas as they can without any restrictions. Though "Hasso-no-mori" is more like a bulletin board system, neither of these two systems is based on the concept of traditional BW, nor do they conduct any analysis regarding the number of inputs and number of ideas that can be shared, and its influence upon quality of ideas. Almost all previous studies in this realm determined performances on the basis of the number of ideas generated. Very few have attempted to examine the nature of generated ideas. For instance, a few have tried to measure quality, but most researchers have abandoned this path and followed "Bouchard's" recommendation that quality correlates very highly with quantity [5]. Therefore, in this research, we also endeavor to find the tradeoff between quality and quantity generated by different groups using dif-

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[†]The authors are with the School of Knowledge Science, Japan Advanced Institute of Science and Technology, Nomi-shi, 923–1292 Japan.

a) E-mail: neupane@jaist.ac.jp

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ferent modes of our prototype system.

As all participants get equal opportunity to generate new ideas and share one another's ideas, synergy is likely to increase. As participants are exposed to more ideas, they have more sources from which they can draw inspiration in triggering a new idea [6]. This approach also fulfills the demand of participants to be able to view all comments input by group members at any given time. However, when participants were exposed to a large number of ideas, they spent more time reading other ideas and not writing their own ideas. In this paper, we also evaluate the effect of synergy in participants by judging the results of the ideas they generated using different modes.

Different idea generation studies got different results regarding the total time frame to generate ideas in groups. Previous results have concluded that electronic brainstorming groups should be given at least 30 minutes to work [7]. However, still no work has been done to evaluate the time constraints and mental pressure to generate a single idea. Hence in this present work we endeavor to trace the time taken by different participants to generate ideas.

2. Procedures and Problems of BW

BW, a creative technique aimed to address the potential deficiencies of "Brainstorming," was a term coined in Germany, and it is said that "Holiger" invented the procedure of BW in 1968 [8]. In BW, ideas generated by individuals are written down on paper, and then exchanged and combined with those of other individuals in the group. Written ideas are circulated and read by every other participant in the group, who in turn add newer ideas. In general six participants in a group generate and write three ideas in five minutes. After five minutes, in the second round, each participant passes the paper to the person on their right, who adds three more ideas [8]. This process continues until a fixed time has passed, or until each participant gets their original paper back. The process of BW and a BW sheet are presented in Fig. 1. BW can be considered as an excellent technique to generate ideas from groups, but BW also has a few restrictions: as participants are limited to write three ideas at a time, the process prevents group members from unhindered contributions of their ideas. The participants, who could contribute more but had already written three ideas before the allocated five minutes passed, have to wait for the next "turn," which may prevent them from contributing an idea when they first think of it. Participants cannot see all ideas generated by other participants. The ideas they can refer to are the ideas written on the sheet in front of them.

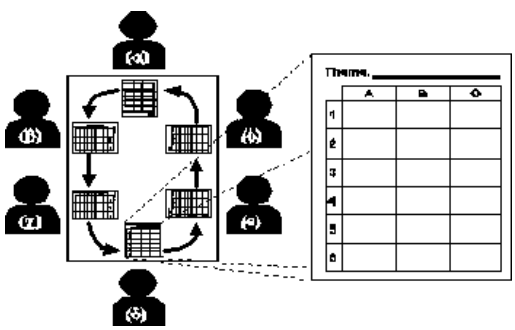

Fig. 1 BW process and BW sheet.

3. Approaches and Detail of the System

The paper-based traditional BW process has restrictions on input of ideas, and participants were also restricted from viewing other ideas. To overcome the drawbacks and restrictions of the traditional BW process, in this section we explain our objective and approaches we have adopted to combat those traditional problems. The restrictions on input of ideas and the restrictions on viewing other ideas can be suppressed technically by designing the system more specifically. Moreover, the characteristics of traditional BW make it easier to tame it in a distributed environment.

Hence, in an effort to overcome the drawbacks of traditional BW, and to improve the efficiency and effectiveness of the BW process, we have proposed and developed a prototype system, which consists of three different modes ([1s-3+i], [6s-3+i], and [1s-3i]) each with different functions and characteristics as shown in Table 1.

As a whole, the prototype is based on a server-client model using the Java-applet. The client functions to take the ideas of the participants and display them to other participants. When the applet sends the input ideas, the server, first takes the log of the user, his/her idea, and the time it was sent. Second, it transmits the ideas to the monitors of the participants based on the characteristics of the modes. The main window of the prototype is presented in Fig. 2.

Participants can login to the system by using IE or any other web browser. After all participants have logged in, the clock at the bottom right starts to run, and shows the progress of time. Participants' list will appear at the bottom left of the monitor, and the list is made easy to read with different colors. The system is not very complex and is easy to use. The monitor scrolls automatically to fit the different ideas generated, and the latest input idea glitters in yellow color, hence participants do not have to bother with scrolling to see the newly input ideas, and they can also trace the newer ideas with ease. However, in every mode each participant has to input at least three ideas to move on to

Table 1 Specification of modes in prototype system.

		Numbers that can be input of ideas	
		Classical way (3 ideas)	Prototype system (3 + ideas)
Number of sharable and viewable ideas	Classical way (1idea sheet)	[1Sheet - 3ideas] (1s-3i)	[1Sheet - 3 + ideas ([1s-3+i])
	Prototype system (Multiple sheets)	-	[6Sheets- 3 + ideas ([6s-3+i])

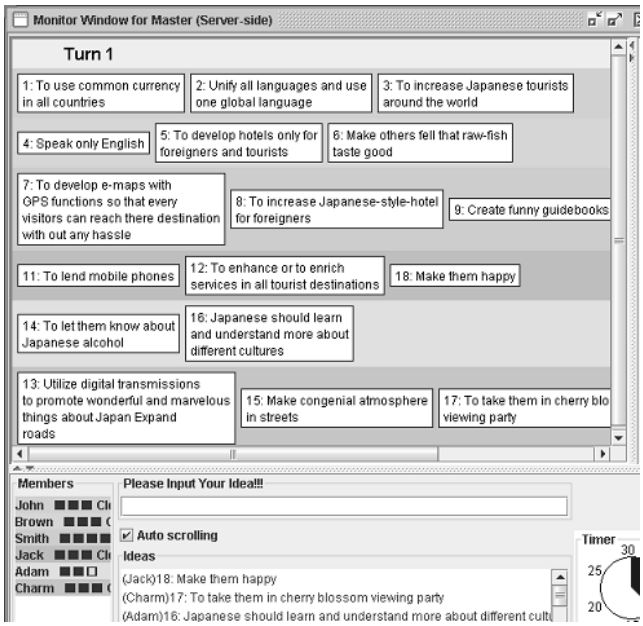

Fig. 2 Ongoing process of BW in prototype system.

the next "Turn." The details of the three different modes are described below.

[1Sheet - 3+ideas] (1s-3+i)

In (1s-3+i) mode, in their "first turn" participants were restricted from viewing other ideas. After all the participants input at list three ideas (minimum), they can then proceed to the "second turn," where they can view one sheet of ideas. Hereafter, in every new "turn," according to login order, the system automatically passes one new idea sheet to individuals in a round robin process. In the case of inputting ideas, in every "turn" each participant is able to input as many ideas as they can.

[6Sheet - 3+ideas] (6s-3+i)

In this mode, from the very beginning participants can view all input ideas without any restrictions. The idea which one participant inputs in at his/her keyboard is immediately transmitted to the group as a whole. Participants can also input ideas without any restrictions.

[1Sheet - 3ideas] (1s-3i)

This mode is completely based on the traditional concept of BW, where participants were restricted from viewing others' ideas at the beginning. Moreover, each participant is restricted from inputting more than three ideas in each "turn." If any participant finished inputting three ideas in a "turn," system automatically sent a message to his/her monitor to wait until all participants had input the minimum number of ideas. They have to wait for other participants to input their three ideas, and when all participants have input three ideas, then they can proceed to the next "turn."

4. Method and Comparison Experiment

Almost all previous studies in the realm of idea generation have used the quantity of ideas generated as the principle means of comparison between treatments. But in this research we study the quality of such ideas as well. Next, we trace the time taken by different participants to generate the minimum number of ideas, and evaluate the tradeoff between time and ideas. We also try to evaluate the effects on participants when they are exposed and when they are not exposed to a large number of ideas, and the effects on the quality and quantity of ideas when they are allowed to input a large number of ideas, and when they are restricted from inputting many ideas.

Interpreting the quality of ideas is a tedious process. Evaluation criteria and beliefs represent different dimensions of the evaluation process, because everyone possesses different perspectives and views. To evaluate the ideas we have to analyze them with certain methodology or approach. Hence, based on the bibliography [9], the ideas were analyzed qualitatively using the three following methods: Fluent-flow of ideas, Flexibility of ideas, and Originality of ideas. Details of the criteria of evaluation are described below.

Fluent-Flow of ideas

This is the total number of input ideas. In this stage of analysis we eliminate all ideas which at this stage appear to be useless and impossible. For instance, related to the topic "Apart from avoiding rain, write down the other uses of an umbrella," if some one input "Jump from the helicopter and use umbrella as a parachute," practically this is an impossible task, and technically that kind of idea is eliminated. We also eliminated redundant and off-topic ideas. At last, remaining ideas were counted as fluent ideas.

Flexibility of ideas

Broadness and range of ideas and perspective of participant cognition were graded in this phase. To evaluate the flexibility of generated ideas, for every topic used in the comparison experiment, an idea-rating table was drawn up as shown in Table 3 and was divided into two columns: idea viewpoints and idea number. Ideas generated by participants were then observed carefully, and appropriate ideas were input in the appropriate column of idea viewpoint and the number of that particular idea was input in the column of the idea number. The detailed method of the evaluation process is described below by using Table 2 and Table 3 as examples. The topic used as an example in Fluent-flow of ideas was also adopted in this method as an example to describe the idea evaluation process.

The ideas presented in Table 2 were observed carefully, and we decided into which idea viewpoint of Table 3 they should be placed. Therefore, we listed them as in Table 3, and at last only the number of idea viewpoints was counted as flexible ideas.

Originality of ideas

In this phase, we evaluate original and unique ideas. Ideas that are not alike to each other are counted as original ideas. The specific grading method of the originality of ideas, is that the ideas that are not similar to any other ideas in the idea table are sorted-out. Next, to ensure originality, already sorted ideas were rechecked and selected. At last,

only the remaining ideas were assumed to be original and unique ideas.

18 Masters students from JAIST were selected as participants. Participants were then split randomly into three groups of six individuals. All sets of three groups used all three modes ([1s-3+i], [6s-3+i], and [1s-3i]). Each participant sat in front of a personal computer in distributed locations, and all the computers were connected together through a local-area network. All of the computers run on the same system. Table 4 shows the formation of the experiment by group, system-modes and topics for BW. For all experiments, the time frame was 20 minutes.

Three different topics for BW are selected, and they are:

- Topic one: Apart from avoiding rain, write down any other uses of an umbrella.
- Topic two: If all human beings had a third hand on our back, write down the advantages of that hand.
- Topic three: What steps should the concerned authorities take to increase the number of foreign tourists in Japan?

Before each experiment participants were told to assemble in one room. They were told about the system they would use. They were not given any warm up sessions. Before leaving the room they were given a sheet with the topic they were going to brain write on. A number of studies have found that anonymity resulted in more inputs from participants. Researchers also found that the ideas produced were of a higher quality when groups worked anonymously [10]. So in each test participants were told to login with Ids which were unknown to other participants. After they finished their first test, they were again asked to assemble in one room, and were told about the next test, and the next mode they were going to brain write on. The topic of the second test was given before they left the room. In this order, three tests were conducted with all three groups. After the test was concluded, each participant was asked to answer a questionnaire. At last every participant was given a five-hundred-yen phone card as a gift, and they were sent off.

Table 2 List of the ideas generated by participants.

Idea Number	Ideas generated by participants
1	Use it to draw a line on field
2	Use it to pull things from distance place
3	Use it to practice golf
4	Turn it upside-down and use it to store different objects
5	Use it as a shovel to throw snow
6	Paint different pictures and hang on to the wall for decoration
7	Use plastic to wrap different items
8	Use it in dance
9	Use it to perform different skills
10	Use it as a hanger

Table 3 Idea-rating table.

Idea Viewpoint	Idea Number
Furniture	
Tool	1, 2, 5, 9
Recycle	
Accessories	
Interior	6
Plaything	3, 8
Container	4
Implement materials	7, 10
Clothes	

Table 4 Formation of groups, in accordance with experimental modes, and topics.

Exp:Modes	Group One	Group Two	Group Three
Mode	[1s-3+i]	[6s-3+i]	[1s-3i]
Topic	1	1	1
Mode	[6s-3+i]	[1s-3i]	[1s-3+i]
Topic	2	2	2
Mode	[1s-3i]	[1s-3+i]	[6s-3+i]
Topic	3	3	3

5. Results

Groups generated totals of 346 ideas in 20 minutes using mode [1s-3+i], 273 ideas using mode [6s-3+i], and 229 ideas using mode [1s-3i]. Group One generated the largest number of ideas in the order of [1s-3i], [6s-3+i], and [1s-3+i]. Group Two generated the largest number of ideas in the order of [1s-3+i], [1s-3i], and [6s-3+i]. And, Group Three generated the largest number of ideas in the order of [6s-3+i], [1s-3+i], and [1s-3i] respectively.

According to this result, the order of modes, which generated the largest number of ideas differs from group to group. Moreover, if we compare the above result with the formation of groups in Table 4, we can verify that every group generated the largest number of ideas when they used topic three, topic two and topic one respectively. From this result, we can presume that the numbers of ideas were dependent on the topics used by groups to generate ideas, rather then the different modes of the prototype system. With the above conclusion, we equate every idea in accordance to the topic used to generate those ideas to standardize the result. The results of the total number of ideas generated by different groups using different modes and the value of ideas after the standardization is presented in Table 5.

For instance, 65 ideas were created using mode [1s-3+i] by Group One, thus the number can be standardized as ratio ($0.32 = 65/(65 + 87 + 49)$) that includes the entire number of ideas generated by Group One, Group Two

Table 5 Original number of ideas and the value of ideas after the standardization of the topics.

Modes	Group 1			Group 2			Group 3		
	Idea	Topic	StadVal	I	T	SV	I	T	SV
[1s-3+i]	65	1	0.32	174	3	0.48	107	2	0.38
[6s-3+i]	72	2	0.28	87	1	0.43	114	3	0.31
[1s-3i]	78	3	0.21	102	2	0.38	49	1	0.24

and Group Three using modes [1s-3+i], mode [6s-3+i], and mode [1s-3i] respectively while using the same topic one. After the standardization of the topics, the evaluation value of the ideas shows that each group generated a large quantity of ideas in the order of [1s-3+i], [6s-3+i], and [1s-3i]. The qualitative results of the ideas generated by different groups using different modes are given below.

Fluent-Flow of ideas

The total number of the Fluent-flow of ideas and the value after the standardization of topics is presented in Table 6. The standardized value shows that each group effectively generated a large number of ideas in the order of [1s-3+i], [1s-3i], and [6s-3+i] respectively. Hence, groups showed that modes [1s-3+i], [1s-3i], and [6s-3+i] were effective in that order in generating Fluent-flow of ideas.

Flexibility of ideas

The total number of flexible ideas, and the value after the standardization of topics is presented in Table 7. To verify the effective mode, when we compared groups and evaluated the flexibility of ideas, the order of experimental modes was not confirmed, because the order of effective mode was different in each group.

Originality of ideas

The total number of original ideas, and the value after the standardization of topics is presented in Table 8. When we compared groups to evaluate the originality of ideas, the order of effective experimental modes was not confirmed, as the order of effective experiment modes of each group was different.

Ideas in correlation with time

The total number of ideas generated by each participant using different experimental modes is presented in Table 9.

The largest contributor generated 45 ideas in 20 minutes using [1s-3+i]. Whereas, 5 was the smallest number of ideas, contributed in 20 minutes using the same [1s+3+i] mode.

Group One generated 3.25 ideas in one minute using mode [1s-3+i], 3.6 ideas using mode [6s-3+i], and 3.9 ideas using mode [1s-3i]. Individually, they generated 0.54 ideas in one minute using mode [1s-3+i], 0.6 ideas using mode [6s-3+i], and 0.65 ideas using mode [1s-3i].

Group Two generated 8.7 ideas in one minute using mode [1s-3+i], 4.35 ideas using mode [6s-3+i], and 5.1 ideas using mode [1s-3i]. Individually, they generated 1.45 ideas in one minute using mode [1s-3+i], 0.72 ideas using mode [6s-3+i], and 0.85 ideas using mode [1s-3i].

Group Three generated 5.35 ideas in one minute using mode [1s-3+i], 5.7 ideas using mode [6s-3+i], and 2.49 ideas using mode [1s-3i]. Individually, they generated 0.89 ideas in one minute using mode, [1s-3+i], 0.95 ideas using mode [6s-3+i], and 0.41 ideas using mode [1s-3i]. Difference in numbers of ideas generated in a particular interval of time by the three different groups using [1s-3+i], [6s-3+i], and [1s-3i] is presented in Figs. 3, 4, and 5.

As the total time allocated was 20 minutes, our result shows that every group using each mode generates ideas smoothly in every interval of 300 seconds, although the number of ideas differs from group to group. Generally, in each mode the number of generated ideas decreases as time passes. However, in some Groups namely, One and Two using [6s-3+i] mode, and Group Three using modes [1s-3+i] and [1s-3i], some irregularity in the numbers of ideas gener-

Table 6 Total number of Fluent-flow of ideas, and the value of ideas after the standardization of the topics.

Modes	Group 1			Group 2			Group 3		
	Idea	Topic	StadVal	I	T	SV	I	T	SV
[1s-3+i]	20	1	0.29	56	3	0.48	29	2	0.34
[6s-3+i]	21	2	0.25	27	1	0.39	30	3	0.26
[1s-3i]	31	3	0.26	35	2	0.41	22	1	0.32

Table 7 Total number of flexible ideas, and the value of ideas after the standardization of the topics.

Modes	Group 1			Group 2			Group 3		
	Idea	Topic	StadVal	I	T	SV	I	T	SV
[1s-3+i]	8	1	0.20	43	3	0.55	11	2	0.28
[6s-3+i]	14	2	0.36	13	1	0.33	15	3	0.19
[1s-3i]	20	3	0.26	14	2	0.36	19	1	0.48

Table 8 Total number of original ideas, and the value of ideas after the standardization of the topics.

Modes	Group 1			Group 2			Group 3		
	Idea	Topic	StadVal	I	T	SV	I	T	SV
[1s-3+i]	10	1	0.26	21	3	0.41	12	2	0.34
[6s-3+i]	10	2	0.29	15	1	0.39	18	3	0.35
[1s-3i]	12	3	0.24	13	2	0.37	13	1	0.34

Table 9 Total number of ideas generated by participant.

	[1s-3+i]			[6s-3+i]			[1s-3i]		
P	G1	G2	G3	G1	G2	G3	G1	G2	G3
1	6	31	20	9	15	18	13	18	9
2	12	40	13	12	12	16	13	18	8
3	12	21	21	13	15	19	12	15	8
4	18	45	16	11	15	21	12	18	8
5	12	19	24	17	15	27	14	17	8
6	5	18	13	10	15	13	14	16	8
T	65	174	107	72	87	114	78	102	49

P = Participants, G = Group, T = Total

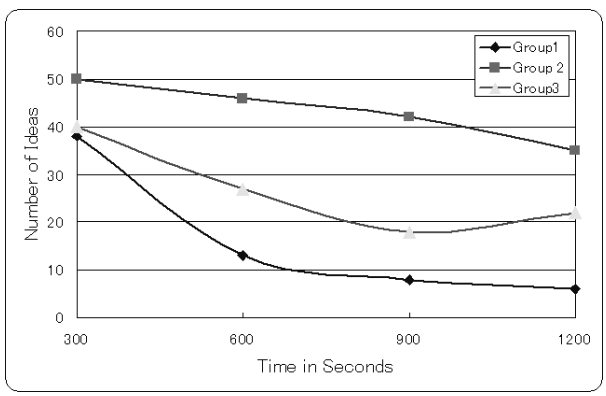

Fig. 3 Ideas generated by groups in a particular interval of time using [1s-3+i] mode.

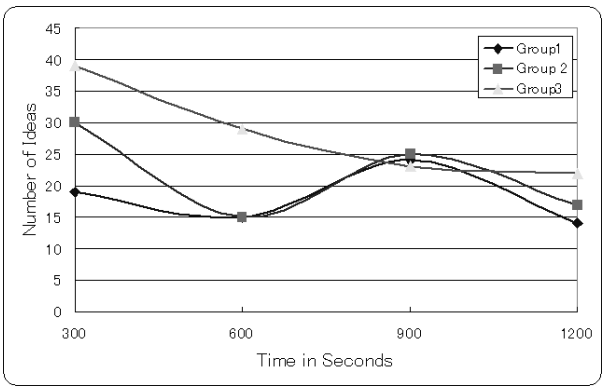

Fig. 4 Ideas generated by groups in a particular interval of time using [6s-3+i] mode.

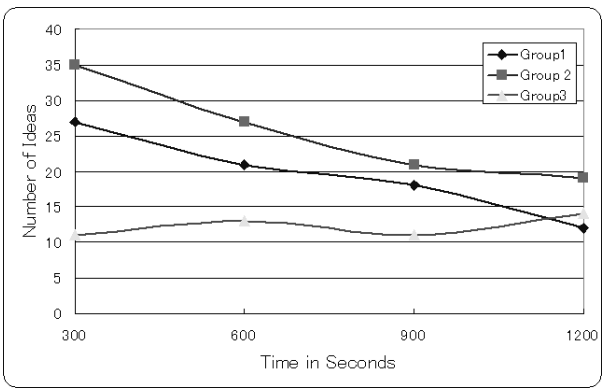

Fig. 5 Ideas generated by groups in a particular interval of time using [1s-3i] mode.

ated occurs.

According to the questionnaire conducted after the experiment, for 61.1 percent of participants, mode [6s-3+i] was an ideal system to generate ideas. Only 22.2 percent of participants thought mode [1s-3i] was an ideal system to generate ideas, and for only 16.7 percent of participants mode [1s-3+i] was an ideal system to generate ideas. For 66.7 percent of participants mode [6s-3+i] was easier to use compared to the other two modes. Only for 16.7 percent of participants were modes [1s-3+i] and [1s-3i] easy to use. As for the topic, for 55.5 percent of participants topic one was easier than topics two and three. For 27.8 percent of participants topic three was easier, and for 16.7 percent of participants topic two was easier than the other two topics. Ironically, they generated fewer ideas when they used topic one. As far as quality is concerned, 72.2 percent of participants emphasized the quality of ideas, whereas only 27.2 percent of participants gave importance to the quantity of ideas in idea generation process.

6. Discussion

In the quantitative evaluation of ideas, the result shows that each group generated a large quantity of ideas in the order of [1s-3+i], [6s-3+i], and [1s-3i] respectively. The feature functions like unrestricted input of ideas in [1s-3+i], and [6s-3+i] are considered effective in order to generate quantity, rather than [1s-3i] which restrict inputs in each turn.

When ideas were evaluated qualitatively, in the Fluent-flow of ideas, the tendency of effectiveness was seen in the order of [1s-3+i], [1s-3i], and [6s-3+i], respectively. On the other hand, in the qualitative evaluation of flexibility of ideas, and in originality of ideas the dominance of a feature function was not confirmed among the three experimental modes, as different groups generated ideas in different orders. However, from the result it was understood that new functions inherited in [1s-3+i], and [6s-3+i] will not exert a big influence on the quality of ideas, compared with [1s-3i], that inherits the concept of traditional technique.

As far as the functions that support viewing and sharing of ideas was concerned, it was observed that participants spent more time reading other ideas and not inputting their own ideas. As the environments to input ideas in [1s-3+i], and [6s-3+1] are similar, the total number of ideas in [6s-3+i] where participants can view all ideas, are less than in [1s-3+i] where participant were restricted from viewing all ideas. Moreover, for more than 60 percent of participants, [6s-3+i] mode was an ideal platform to generate ideas, as well as easy to use, but their performance decreased when they used that particular mode. The results clearly show that synergy is not always an advantage in generating ideas. At times, it reduces the performances of participants, as they will be absorbed only in reading other ideas and not inputting their own ideas. Moreover, if we view Table 9 then we can see that effects of synergy vary from individual to individual. Participants who had generated fewer ideas in [1s-3+i] and [1s-3i], but had generated a large number of ideas in [6s-3+i], help us to state that, those participants gain help from synergy and thus generate a large number of ideas. On the other hand, participants who generated a large number of ideas in [1s-3+i] and [1s-3i], but had contributed fewer ideas in [6s-3+i], help us to state that they are affected by synergy, and thus spend more time reading others' ideas and not inputting their own ideas.

Results show that the largest contributor generated 45 ideas in 20 minutes using [1s-3+i] mode. Whereas, the lowest contributor generated only 5 ideas using that same [1s-3+i] mode. This fact helps us to state that a support system alone cannot make individuals generate large numbers of ideas. The potentiality to generate ideas is highly dependent on individuals.

The time-log we had taken at the time of the experiment shows that average of all group generated 5.77 ideas in one minute using mode [1s-3+i], 4.55 ideas using mode [6s-3+i], and 3.83 ideas using mode [1s-3i]. Individually, they generated, 0.96 ideas in one minute using mode [1s-3+i], 0.76 ideas using mode [6s-3+i], and 0.64 ideas using mode [1s-3i]. Regardless of the mode, this clearly shows that individuals were unable to generate a single idea in one minute. The finding helps us to state that using [1s-3+i] mode, participants generated ideas faster then using any other modes. The above correlation of ideas with time also supports the

finding that when participants are exposed to a large number of ideas, they take more time to input their own ideas. Moreover, the finding shows that the newly- implemented functions are more time-effective than the mode that inherits traditional process functions.

For all groups, we allocated 20 minutes to undergo the experimental test. Figures 3, 4, and 5 show that, although the number of ideas generated decreases as time passes, each group generally generated ideas throughout the allocated time. Although the pattern was different in all intervals in each mode, we can clearly see that the number has gradually decreased after the interval of every 300 seconds. In Fig. 4, where they used mode [6s-3+i], the number of ideas gradually increased in Group One and Two after 600 seconds and then again decreased after 900 seconds. The reason behind this phenomenon is still unclear, but it may be due to the large number of ideas generated by participants, numbering five in both groups.

As the numbers of ideas decreased rapidly in the last interval of 300 seconds, and the participants were able to generate only a few ideas, it is easy to estimate that the allocated 20 minutes time was appropriate. Even a large number of participants in their questionnaires state that 20 minutes time was appropriate for them to generate ideas in distributed BW environment. From the results, we can conclude that for small groups (like six individuals in this experiment) 20 minutes time was appropriate to conduct BW in distributed environment.

7. Conclusions

The experimental system proposed in this paper is composed of three modes ([1s-3+i], [6s-3+i], and [1s-3i]) with all-different functions regarding the sharing and input of ideas. We conducted an experimental test with three groups of six participants each, and analyzed the quantity and quality of ideas. We also try to verify the effects of synergy, and correlation between time and ideas.

From the obtained results, it was clearly observed that the approach to make an unrestricted number of inputs was more effective in generating a large number of ideas than the traditional process, where participants had to take turns to input new ideas. Therefore, while designing the BW support system for distributed environment, it is highly recommended that the number of inputs should be made unrestricted, in order to generate overwhelming outcome. However, the qualitative ideas generated by groups using different modes are in different orders. Thus, this makes it difficult to justify the effectiveness of the modes.

Results clearly show that synergy is not always an advantage to generate ideas in groups; at times it has negative effects, as participants will be absorbed only to read other ideas, and not input new ideas of their own.

Individuals took more time than we expected to generate ideas. On average they took more than one minute to generate a single idea, once again making us realize how difficult it was to be creative, or to generate simple and new ideas. However, it was concluded that a 20-minute time was appropriate to conduct BW in a distributed environment.

In future, more research and experiments should be undertaken to clarify the actual numbers of ideas that should be made available for viewing, so that participants will still have time to generate new ideas. For the progress of BW support systems, in future, we should not only concentrate on the number of ideas, but we should take initiative to design an environment that supports participants to generate better quality ideas. We should create an environment in a way so that everybody can use it according to his/her needs, and we hope it can play a key role in enhancing group creativity.

References

[1] S. Kunifuji, "A survey on creative thinking support system and the issues for developing them," J. Japanese Society for Artificial Intelligence, vol.8, no.5, pp.552–559, 1993.
[2] R. Davison and R. Briggs, "GSS for presentation support," Commun. ACM, vol.43, no.9, pp.91–97, Sept. 1993.
[3] C. Sweet, Expanding the qualitative research arena: Online focus groups, Quesst Qualitative Research, New York, 1999.
[4] T. Kawaji and S. Kunifuji, "A prototyping and an evaluation of an idea generation support groupware Hasso-tobi," J. Japan Creativity Society, vol.4, pp.18–36, 2000.
[5] M. Nagasundaram and R.P. Bostrom, "The Structuring of creative process: Implications for GSS research," HICSS, vol.4, pp.51–56, 1992.
[6] A.R. Dennis and J.S. Valacich, "Computer brainstorms: More heads are better than one," J. Appl. Psychol., vol.78, no.4, pp.531–537, 1993.
[7] A.R. Dennis, A. Pinsonneault, K.M. Hilmer, H. Barki, B. Galupe, M. Huber, and F. Bellavance, "Patterns in electronic brainstorming," Int. J. e-Collaboration, vol.1, no.4, pp.38–57, 2005.
[8] M. Takahashi, The Bible of Creativity, pp.294–296, JUSE Press., 2002.
[9] M. Takahashi, "The research of idea generation method compare with group and individuals," J. Japan Creativity Society, vol.3, pp.116–147, 1993.
[10] T.L. Conolly, L.M. Jessup, and J.S. Valacich, "Effects of anonymity and evaluative tone on idea generation in computer-mediated groups," Manage. Sci., vol.36, no.6, pp.689–703, 1990.

Ujjwal Neupane entered Kansai University, Faculty of Informatics and received his B.I. degree in 2004. Then, he entered Japan Advanced Institute of Science and Technology, School of Knowledge Science and earned his M.S. degree in 2006. Currently he is a Ph.D. candidate at the same institute. His current research topics include developing computer-mediated support systems for group work and collaboration. He is a member of IPSJ, JCS, and ACM.

Motoki Miura was born in 1974. He received B.E., M.E., and D.E. degrees in electronics engineering from University of Tsukuba, in 1997, 1999, and 2001 respectively. From August 2001 to March 2004, he worked as a research associate at TARA Center, University of Tsukuba. He is currently working as a research associate at School of Knowledge Science, Japan Advanced Institute of Science and Technology. He is a member of JSAI, IPSJ, JSSST, ACM, JSET, and HIS.

Tessai Hayama received his B.E. degree in Knowledge Engineering from Doshisha University in 2001, and M.S. and Ph.D. degrees in Knowledge Science from Japan Advanced Institute of Science and Technology in 2003 and 2006 respectively. Currently he is an Assistant Professor in Knowledge Science at Japan Advanced Institute of Science and Technology. His research interests include creative support systems and human interface. He is a member of JSAI, IPSJ, and JSCE.

Susumu Kunifuji was born in 1947. He received B.E., M.E., and D.E. degrees from Tokyo Institute of Technology, in 1971, 1974, and 1994 respectively. He worked as a researcher at International Institute for Advanced Study of Social Information Science, FUJITSU Ltd. (1974-1982), was Chief Researcher at Institute for New Generation Computer Technology (1982-1986), Manager at International Institute for Advanced Study of Social Information Science, FUJITSU Ltd. (1986-1992), and Professor at School of Information Science in JAIST (1992-1998). Currently, he is a professor at School of Knowledge Science, Japan Advanced Institute of Science and Technology. He is a member of JSAI, IPSJ, SICE, JCS etc.