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# What Are You Looking At? Newest Findings from an Empirical Study of Group Awareness

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**Abstract.** *Real-time, distributed, collaborative writing systems* are useful tools allowing a group of distributed authors to work on a document simultaneously. A very important factor in achieving effective and efficient collaborative writing is the incorporation of *group awareness* (GA). GA conveniently provides comprehensive knowledge about the status of a document and activities other authors perform upon the document. However, far more work needs to be carried out in determining exactly what *awareness elements* (awareness information, such as where users are viewing within a document versus where they are working on a document) are required in collaborative writing. This involves empirically determining which elements are more important than others for support.

The authors report results and findings of an empirical, laboratory-based study of GA elements. These findings are completely novel since no other empirical study of GA elements has been done. The findings guide designers in developing relevant mechanisms supporting GA.

## 1 Introduction

*Real-time distributed collaborative writing systems* (RDCWS) facilitate the task of joint authorship in a distributed environment. Various RDCWS have been produced over the years, such as GROVE [1], SASSE [2] and ShrEdit [3]. However, only a small number of such tools are widely used in the real world. A major reason for this lack of usage is that existing RDCWS have not yet been able to match the diversity and richness of interaction, which is provided in face-to-face interaction.

One example of the use of a RDCWS is in synchronous composition of essays. Collaborative essays may be used in teaching, such as in learning about negotiation of meaning (see [4]). However, in a workplace situation, a RDCWS may not necessarily be used to write an entire document in one sitting. Participants may use email or work-

flow to write parts of a document in an asynchronous manner, whilst writing other parts together synchronously. Participants may have an initial meeting to agree and work on the structure and content of the document together at the same time, leaving participants to finish the document separately at different times. On the other hand, medical researcher colleagues of one of the paper’s authors work on a document at different times, only to come together *at the end of the process* to finalise the document. These medical researchers find greater efficiency in finalising the document together at the same time rather attempting to finalise it separately at different times.

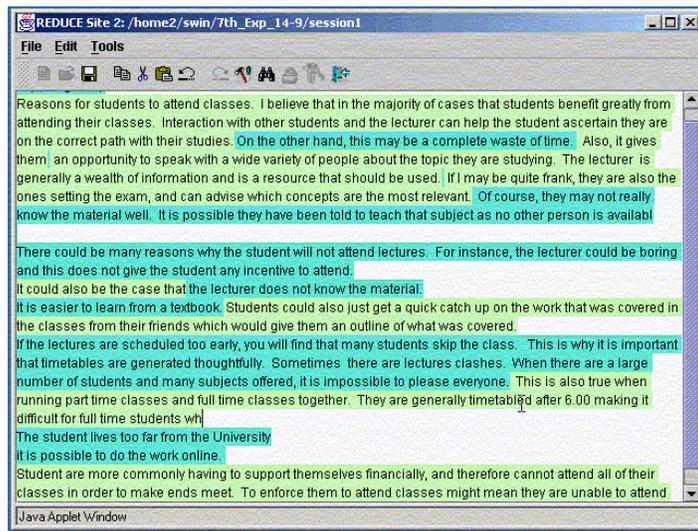


Fig. 1. REDUCE collaborative editor

Figure 1 shows *REDUCE*—Real-time Distributed Unconstrained Cooperative Editor [5]—used in our research. The Figure shows the tool being used by two users in writing a document. The two colours represent the text entered by each user. To be extremely brief for space reasons, the reader can understand REDUCE as simply being like a collaborative form of Microsoft Word or other word processor.

Perceiving and understanding the activities and intentions of other members of a collaborating ensemble is a basic requirement for human interaction. In face-to-face interaction, people find it naturally easy to maintain a sense of awareness about who-ever else is present in a workspace, what others’ responsibilities are, what others are doing and where they are located. However, when group members are geographically distributed, supporting spontaneous interaction is much more difficult due to various reasons such as limited capabilities of input and output devices, restricted views or weak communication [6]. To support distributed collaborative writing most effectively and efficiently, RDCWS must provide *group awareness* (GA) ([6, 7]).

GA is defined as “an understanding of the activities of others, which provides a context for your own activity” [3]. GA plays an essential and integral role in coopera-

tive work by simplifying communication, supporting coordination [1], managing coupling, assisting “anticipation” [6] and supporting “convention” [7]. In collaborative writing, GA provides users with sufficient knowledge about the status of a document itself and past, current or future activities other users perform upon the document.

Gutwin and Greenberg [6] have proposed various *awareness elements*. Awareness elements represent fundamental awareness information required in supporting group awareness. Examples of awareness elements include knowing others users’ current actions or knowing others’ working areas in a document.

It is highly important to study such elements as they indicate what information is required in providing group awareness. This information reflects how group awareness is supported during collaboration, and therefore what types of functionality *awareness mechanisms* can provide. Awareness mechanisms in the literature include those such as *radar views* [8] or *distortion-oriented views* [9]. Radar views, for instance, provide a “birds-eye” (overall) view of a document. Thus, the element of knowing others users’ current actions means that some sort of novel mechanism requires development to show whether all other users are either currently pulling down a scrollbar or entering text into the document or pulling down a menu, etc.

The objectives of this research are to:

- investigate what awareness information is important in supporting group awareness, and
- differentiate the importance of different awareness information (e.g., Is it more important to know past actions carried out by users or to know current actions being carried out?)

Although Gutwin and Greenberg [6] have proposed a set of awareness elements in their conceptual framework for workspace awareness, they have not experimented with these elements. Thus, they have not published empirical results related to the two objectives above. Hence, the novel contribution of this paper is to present experimental results for awareness elements and provide findings for awareness support based upon these results. These findings can therefore be used to develop new and more effective mechanisms beyond the current limited set available for supporting group awareness. The results reflect which awareness information is more important in designing mechanisms compared to other awareness information.

## 2 Related Work

As indicated in the last section, the closest work related to the authors is that of Gutwin and Greenberg who proposed awareness elements. These researchers have yet to provide empirical results for their awareness elements.

Apart from fundamental awareness information, the awareness mechanisms that represent this information are worth noting. The current set of mechanisms includes the most well-known ones of telepointers [10], radar views [8], multi-user scrollbars [2] and distortion-oriented views ([9]). For example, telepointers provide information about other users’ presence and their activities, and radar views convey information about other users’ locations in the workspace. Systems can also incorporate audio and video facilities for supporting communication [11].

### 3 Research Methodology

The research involved conducting laboratory-based usability experiments to determine the importance of different awareness information. REDUCE was selected as the editor for experiments because it has been adopted by the prestigious ACM SIGGROUP (Special Interest Group on Supporting Group Work) as a demonstration collaborative editor for trial worldwide and it provides almost no GA support, allowing determination of awareness information from scratch.

The usability experiment involved ten pairs of subjects, excluding the pilot pair, working on three writing tasks, including *creative writing* (CW) (e.g., writing short essays from scratch), *technical document preparation* (DP) (e.g., writing research papers) and *brainstorming* (BS) (e.g., generating ideas about a topic). An example of a BS task is for participants to write a document answering the question, “Why do or do not university students attend lectures?”. The document formed will then encapsulate problems with student attendance and may possibly contain solutions to this problem. An example of a CW task (like ones used at [4]) is an essay written in answer to, “To what extent do you agree/disagree with this statement? Parents are the best teachers”. These three categories were used for two main reasons. First, these categories represent a wide range of collaborative writing tasks. Second, the categories require different styles of collaboration. For instance, DP involves greater structure than the other two types of writing. The types of awareness information that are needed in different contexts of collaborative writing are found by using these varied tasks.

**Table 1.** Experimental task allocation

		Experiments									
		0	1	2	3	4	5	6	7	8	9
Verbal first	CW	☒									☒
	DP			☒				☒			
	BS									☒	
Silence first	CW				☒		☒				
	DP								☒		
	BS		☒			☒					

Key:  
**CW:** creative writing task  
**DP:** technical document preparation task  
**BS:** brainstorming task

Subjects performed collaborative tasks in pairs. In each pair, subjects were located in two visually-isolated subject rooms and participated in a two-and-a-half hour session, which included half-an-hour of training in REDUCE and the following activities.

*Experiment* (1 hour): Each pair performed two writing tasks of the same category, one task *with* verbal communication for thirty minutes and another task *without* verbal communication for thirty minutes. Five pairs started with verbal communication first (verbal first) and five pairs started without verbal communication first (silence first), as shown in Table 1. Conducting the experiments with and without support of verbal communication allowed identification of problems users had and the workarounds users resorted to when verbalisation was absent.

*Questionnaire and interview* (1 hour): Subjects filled in a questionnaire, which included nineteen five-point questions (ranging from 1-“not at all important” to 5-“very

important”) and seventeen open-ended questions<sup>1</sup>. Subjects also took part in an interview to discuss awareness information and awareness mechanisms they needed when performing tasks. The five-point scale questions allowed users to rank the importance of different awareness information. The open-ended questions allowed free responses and gave the subjects the freedom to suggest and comment on various awareness support mechanisms. This paper, however, focuses on the results of analysing the five-point scale questions.

The ten pairs were allocated to perform the three tasks such: 4 pairs worked on CW, 3 pairs worked on DP and 3 pairs worked on BS (Table 1).

The usability laboratory includes two subject rooms and one control-and-observation room. For each subject room, there is a one-way glass window between the observation room and the subject room. Apart from an observer making notes of observations, Hypercam [12] was used to capture entire sessions as movie files for analysis later. A drop-down blind over the window between the two subject rooms allows the two subject rooms to be separated visually. The laboratory contains auditory equipment allowing: verbal communication via intercom devices between the observation room and the two subject rooms, or between the two subject rooms.

## 4 Results of Awareness Study

This section presents the results of analysing the five-point scale questions. The results were useful in differentiating the importance and necessity of different awareness elements. The five-point scale questions were analysed to:

- calculate the mean, median and standard deviation of each five-point scale question
- construct the distribution of responses for each question

It should be noted that *each question represents one awareness element*. Thus the importance of an awareness element is determined by the mean of the corresponding question. The higher a mean is, the more important that awareness element is.

Table 2 shows awareness elements sorted by the values of their means. The top four most important awareness elements rated by subjects were **being able to comment on what other users have done** (4.53), **knowing actions other users are currently taking** (4.50), **having a communication tool** (4.50), and **knowing where other users are currently working** (4.50). Interestingly, these four elements were equally rated “very important” by 55% of the responses (as seen in Figure 2).

The distribution of responses to each element is examined. Figure 2 illustrates overwhelmingly the importance of the ability to comment on other authors’ work. No responses indicated it was unimportant to comment on what other authors have done, nor were there respondents who were doubtful about this issue. Merely 5% of the respondents were not sure whether it was important to know other authors’ current

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<sup>1</sup> Due to space reasons, the questionnaire could not be included in an Appendix. However, the five-point scale questions from it are found in Table 2. The open-ended questions are not relevant to this paper.

actions, or to have a communication tool (when they do not have the support of verbal communication) or to know other authors' working areas in a document.

**Table 2.** Scores of Awareness Elements

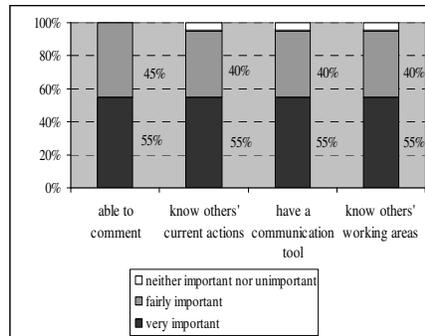
Awareness elements	Mean	Me-dian	Std Dev
15. Being able to comment on what other users have done	4.53	5	0.51
10. Knowing what actions other users are currently taking	4.50	5	0.61
19. In the case of nonverbal communication, having a communication tool that supports communication between users	4.50	5	0.61
7. Knowing parts of a document on which other users are currently working	4.50	5	0.61
2. Knowing tasks for which other users are responsible	4.35	4	0.75
14. Knowing if other users know what I have been doing	4.25	4	0.72
1. Knowing who is in the workspace	4.15	4	0.81
16. Knowing if other users are satisfied with what I have done	4.10	4	0.64
8. Knowing parts of a document at which other users are currently looking	3.95	4	0.83
13. Knowing to what extent a portion of a document has been completed	3.85	4	0.88
17. Having voice communication	3.80	4	1.11
9. Knowing what actions other users are going to take in the future	3.75	4	1.07
11. Seeing the position of other users' cursors	3.70	4	0.80
12. Knowing to what extent you have completed your work compared to the extent others have completed their work	3.50	3	0.76
6. Being able to view the list of past actions carried out by a specific user	3.40	4	1.14
3. Knowing how much time has elapsed since other users have used REDUCE	3.40	4	1.23
18. Having video communication	3.25	3	0.97
5. Knowing how long other users have been in the workspace	2.40	2	1.19
4. Knowing where other users are geographically located	1.68	1	0.95

Two of these elements concern communication. This reflects the importance of awareness mechanisms allowing suitable communication amongst users in order to author a document effectively. The results also show that knowing whatever the other users are doing currently in the task—be it entering text into the document, reading help on the tool, etc.—is one of the most important things that a user wants to know about other users. Knowing exactly the parts of a document where other users are working is also highly important.

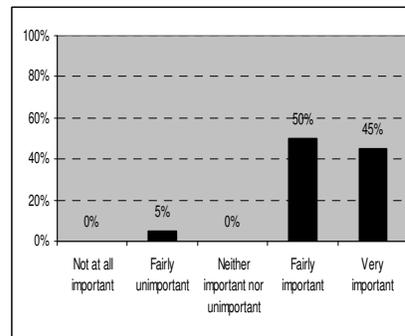
#### 4.1 Knowing tasks for which other users are responsible

Almost all subjects found this an important issue, of which about half consider support for knowledge of others' responsibilities to be extremely important (Figure 3). Yet

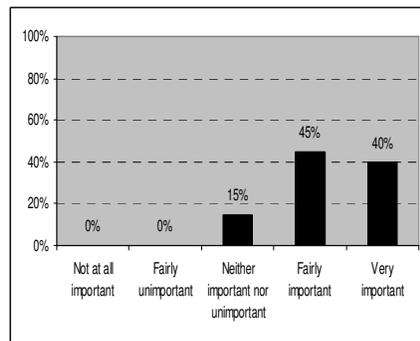
awareness mechanisms hardly address this form of awareness. In all of the experiments, the subjects spent a certain amount of time discussing their strategy to complete a writing task, and more importantly, assigning responsibilities to each subject. Hence, ignorance of others users' responsibilities is unhelpful in collaboration and thus new tools that conveniently present these responsibilities are required.



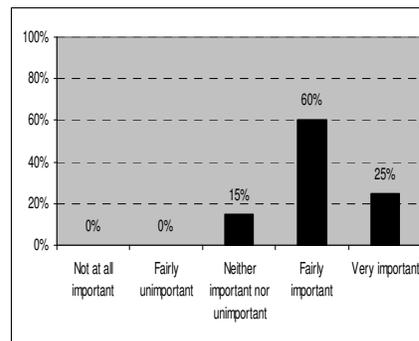
**Fig. 2.** Four most important awareness elements



**Fig. 3.** Knowing tasks for which others are responsible



**Fig. 4.** Knowing if other users know what I have been doing



**Fig. 5.** Knowing if others are satisfied with what I have done

#### 4.2 Knowing if other users know what I have been doing

The far majority of subjects' responses fell within the range from "fairly important" to "very important" (Figure 4). This result indicates that encouraging confidence in user A regarding the understanding of user A's contribution by other users assists collaboration. Therefore, a mechanism continually tracking the contributions of users can be used to provide assuredness to any user that the other users are collaborating effectively with that user.

#### **4.3 Knowing if other users are satisfied with what I have done**

As shown in Figure 5, most respondents believed it to be at least reasonably important to know whether other users are satisfied with what I have done. A positive result here is unsurprising as it would be expected that since a group desires to achieve synergy, then members would experience fulfillment in knowing other members are attaining the goals of collaboration. No existing awareness mechanism specifically supports this awareness element (although it can be achieved simply by using audio communication). This result also further justifies the element being able to comment on what other users have done.

#### **4.4 Knowing working areas versus viewing areas**

A comparison of elements 7 and 8 (see Table 2) is considered (Figure 6). A viewing area represents where in a document a user is looking. On the other hand, a working area represents where in a document a user is editing. In the literature, viewing and working areas have been considered as two separate aspects of conveying activity (e.g., [13]). In real-time collaborative writing, although viewing and working areas are usually the same, in certain cases they can indeed be different. Unfortunately, none of the existing, implemented awareness mechanisms distinguish between a user's viewing and working areas. For example, such widely used awareness mechanisms as multi-user scrollbars, radar views and telepointers show users' current viewing areas rather than their working areas.

This study found that the subjects considered that knowing working areas is only slightly more important than knowing viewing areas (the mean is 4.50 and 3.95, respectively). As shown in Figure 6, while 55% of responses believed that it is "very important" to know other users' working areas, only 15% of the responses considered knowing other users viewing areas "very important". This result could be expected, given that users are after all *working* on a document together.

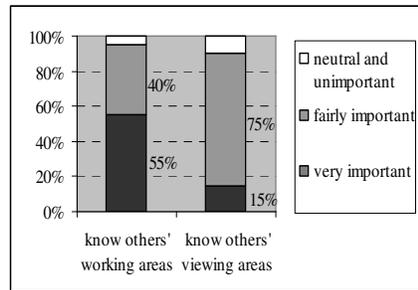
#### **4.5 Knowing past, current and future actions**

From Figure 7, knowing other users' current actions is much more important than knowing their past or future actions. Overall, knowing users' future actions is slightly more important than knowing their past actions, however, this difference is not significant.

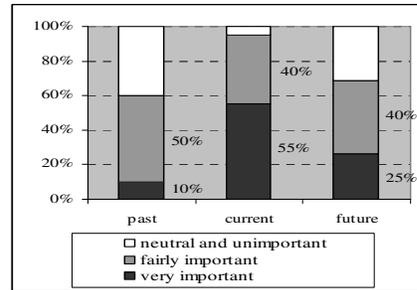
### **5 An effective co-authoring session**

From the results covered, it is now possible to gain an idea of what awareness is required for an effective, efficient and fulfilling session of collaborative writing. In summarising the results, a fruitful session involves the following use of awareness, although the use is not an exhaustive coverage of all awareness required for such a session.

The session involves effective communication amongst participants to achieve successful authoring of the document. This means both real-time discussion as well as asynchronous remarks given by users to one another. If more than textual communication is required, users feel they can collaborate effectively mostly with voice communication.



**Fig. 6.** Working areas versus viewing areas



**Fig. 7.** Knowing past, current and future actions

Users need to be clear on what other users will contribute to the document as well as exactly what parts other users are working on during the session. Users feel the need to have access to the various actions that others are carrying out currently with the tool. That is, users wish to be highly knowledgeable of what others are doing in the session.

Users want to know if other users are aware of what they have been doing with the document. This helps them to be reassured that other users are interested in or keeping track of what they have been doing. If user *A* knows other users are keeping track of what they are doing, one can infer that user *A* would feel much less need to communicate to others about what they are doing, which would improve the efficiency of collaboration.

Along with this previous awareness element, user *A* also wishes to know that other users are satisfied with the current state of their contribution to the document. This would suggest the user derives fulfillment and confidence in making their contribution to the document. This is understandable given that authoring is meant to be a collaboration, that synergy is required in working together and that members rely on one another's contribution to author the document successfully.

## 6 Conclusion

This paper has presented the results of an experimental study of group awareness in real-time distributed collaborative writing. To the best of the authors' knowledge, this is the first empirical study that has attempted to differentiate the importance of different awareness elements. The results yield a number of noteworthy insights.

The results suggest that knowing where others are working in a document, compared to where they are viewing, is worth further investigation. Current mechanisms

such as telepointers, multi-user scrollbars or radar views, do not achieve this. Hence, new mechanisms that address where users are working, and separate this from where they are viewing, may indeed be very useful.

The awareness elements with the highest and second-highest means and medians include the ability to comment on what others have done and to confer via a communication tool. These results reinforce that users truly felt they could not effectively author a document without suitable communication of ideas between themselves. In fact, subjects strongly believed their own comments on others' work were important for working on a document together.

Users like to know that the others are taking interest in what they are doing or following their work. They also wish to know how satisfied other users are about their work, which is relevant feedback in a group situation where members rely on one another to achieve a common goal.

The ability to view past actions is much less important than that of current actions. It can be inferred that keeping track of what other users' actions with the tool in the past were is of little relevance to the current state of the document. Users are more interested in what others have contributed, as a whole, so far to the document (as discussed in the last paragraph).

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