Experimental Findings for Awareness Elements in Real-time, Distributed, Collaborative Authoring

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Abstract

Real-time, distributed, collaborative writing systems *allow a group of distributed authors to work on a document simultaneously. An important factor in achieving effective collaborative authoring is the incorporation of* group awareness. *Group awareness provides comprehensive knowledge about other authors and activities other authors perform upon the document. This paper reports results about awareness elements from an empirical study of group awareness. The four most important elements requiring support were found to be: communication support, knowing the tasks for which other users are responsible, the ability to comment on what other users have done and knowing where other users are currently working within the document.*

Keywords

Real-time collaborative authoring, group awareness, awareness elements.

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 (Ellis, Gibbs and Rein 1991), SASSE (Baecker et al. 1993) and ShrEdit (Dourish and Bellotti 1992). 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 Irvin n.d.). However, in a workplace situation, a RDCWS may not necessarily be used to write an entire document in one sitting. Participants could email or use workflow to write parts of a document in an asynchronous manner, whilst writing other parts together synchronously. Participants may have an initial meeting to agree on 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 this paper's first author work on a document at different times, only to come together *at the end of the process* to finalise the document. These researchers find greater efficiency in finalising the document together at the same time rather attempting to finalise it separately at different times.

Figure 1 shows *REDUCE*—Real-time Distributed Unconstrained Cooperative Editor (Yang et al. 2000)_used in this 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 group is a basic requirement for human interaction. Face-to-face, people find it naturally easy to maintain a sense of awareness about whoever 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 (Gutwin and Greenberg 2002). To support distributed collaborative authoring most effectively and efficiently, RDCWS must provide *group awareness* (GA) (Gutwin and Greenberg 2002, Grudin 1994).

GA is defined as "an understanding of the activities of others, which provides a context for your own activity" (Dourish and Bellotti 1992). GA plays an essential and integral role in cooperative work by simplifying communication, supporting coordination (Ellis, Gibbs and Rein 1991), managing coupling, assisting "anticipation" (Gutwin and Greenberg 2002) and supporting "convention" (Grudin 1994). In collaborative authoring, 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.

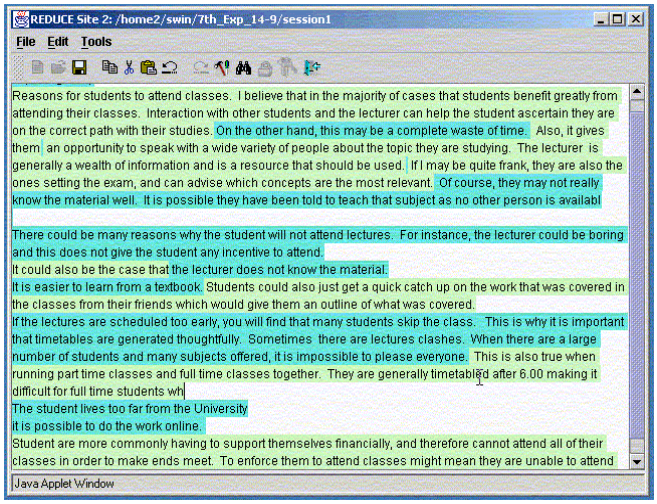

Figure 1: REDUCE collaborative editor

Gutwin and Greenberg (Gutwin and Greenberg 2002) 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 (Gutwin, Roseman and Greenberg 1996) or fisheye views (Greenberg, Gutwin and Cockburn 1996). Radar views, for instance, provide a "birds-eye" (overall) view of a document. Thus, if there is empirical support for the element, knowing others users' current actions, it 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.

Regarding awareness elements, 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 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 thus 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 less important awareness information. The consequent contribution is to apply these results to an explication of how a productive and effective collaborative authoring session can occur. This is because the results teach us about how awareness needs to be supported in an actual authoring session. This explication is found at the end of the paper.

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. As far as the authors know, these researchers have yet to provide empirical results for their awareness elements. Therefore, the various major awareness mechanisms that provide awareness support are covered here. Each of these mechanisms in its basic essence is providing information related to some awareness element(s).

Telepointers (Greenberg, Gutwin and Roseman 1996) are a mechanism allowing multiple cursors of users to be shown within the document. Telepointers are useful in showing all the sections of a document all users are working on in parallel. However, telepointers are only capable of providing other users' mouse positions when all users are located at the same portion in the document. Telepointers support the awareness element of knowledge of parts of a document on which other users are currently working.

Radar views are miniaturisation techniques that provide an overall view of a document to show where all users are working on a document. Radar views have been proven to be useful in maintaining group awareness (Gutwin, Roseman and Greenberg 1996). Radar views are used not only in document authoring, but also provide awareness

in other applications such as computer games or collaborative UML editing (Hansen and Ratzer 2002). The awareness element supported by this mechanism is that of knowing where others are working on the document by providing an overall view of the document.

To overcome a radar view's limitations, especially to bridge the gap between local details and the global structure of a document, a fisheye view can be used. A fisheye view is a distortion-oriented view that presents a single view displaying both local detail and global context on a continuous "surface". A fisheye view provides a seamless and smooth transition between local details and the global structure. When each user has a focal point, the location of other users and the details of their actions performed upon the workspace are provided. Awareness information provided by fisheye views includes knowing current actions of other users and knowing the parts of a document on which other users are working.

Multi-user scrollbars allow a user to see the parts of a document worked on by other users via scrolling within the document. In the literature, there are two different variations of multi-user scrollbars: version 1 in (Baecker et al., 1993) and version 2 in (Gutwin, Roseman and Greenberg 1996). In version 1, each remote scrollbar is located in a different vertical region; however, in version 2, all remote scrollbars are located in the same vertical region. An awareness element provided for by this mechanism is that of knowing where others are working on the document.

The Split Window View (Tran, Raikundalia and Yang 2002) allows the user to view both working and viewing areas of other members of the group. In some cases, a user's working and viewing areas can be different as the user may be working on a particular part of the document, yet be looking somewhere else in the same document. Therefore, this mechanism allows a user to see both areas of all other users. When any of these other users' working areas are exactly the same as their viewing areas, this one area is shown. The mechanism provides both knowledge about where users are working and knowledge about where users are viewing in the document.

The aim of the Modification Director (Tran, Raikundalia and Yang 2002) is to show to a user that another user is modifying their work. The mechanism is helpful in conveying who the other user is that is altering their work and how they are altering it. The mechanism provides a document-related form of group awareness. It works based upon a flashing colour icon indicating another user is modifying text, and clicking on the icon pops up a read-only window to show the modified text. Awareness information provided by this mechanism is:

- knowledge about which user is editing user *A*'s work, and
- one type of knowledge for user *A* to know that other users know what user *A* has been doing.

The Dynamic Task List (Tran, Raikundalia and Yang 2001) is a task-based technique for supporting document-related awareness. The mechanism provides a frequently updated list of group members' tasks. A user is able to comment on other users' tasks and the author responsible for a task is informed of which other users are viewing their part of the document. This mechanism may prove to be more difficult to implement. An awareness element supported here is that of being able to comment on the work done by other users.

RESEARCH METHODOLOGY

To produce a usable editor for supporting collaborative authoring, much research has exploited the user-centred approach in the study of how people write together (Baecker et al., 1993). Similarly, to provide usable *awareness mechanisms* for real-time collaborative editors, a designer must be directed by the principles of user-centred design. Therefore, this research conducted a laboratory-based experiment with REDUCE. At present, REDUCE supports almost no GA features; hence, conducting the experiment with REDUCE allows determination of awareness information users really need to perform a collaborative authoring task effectively and efficiently. Conduct of the experiment lead to the discovery of awareness software mechanisms that are potentially capable of supporting GA in real-time collaborative authoring. However, the focus of this paper is on awareness elements and finding results of an empirical study of the elements.

Usability Experiment

The usability experiment was carried out in the Swinburne Usability Laboratory of Swinburne University of Technology in Melbourne, Australia, in April 2004. The experiment involved twelve pairs of subjects working on three writing tasks, including *creative writing* (CW) (e.g., writing short essays from scratch), *document preparation* (DP) (e.g., writing a manual on REDUCE) and *brainstorming* (BS) (e.g., generating ideas). These three categories were used for two main reasons. Firstly, these categories represent a range of collaborative authoring tasks. Secondly, the categories require different styles of collaboration. The types of awareness mechanisms that are needed in different contexts of collaborative authoring are found by using these varied tasks.

Table 1: Experimental sessions with REDUCE

	Experimental sessions											
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12

Verbalisation first	CW	T1,T2									T1, T2		
	DP							T5, T6					T5, T6
	BS									T3, T4		T3, T4	
Silence first	CW				T1, T2		T1, T2						
	DP			T5, T6					T5, T6				
	BS		T3, T4			T3, T4							

The twelve pairs were allocated to perform the three tasks as such: 4 pairs worked on CW, 4 pairs worked on DP and 4 pairs worked on BS. The actual tasks used in experiments are shown in the Appendix. Table 1 shows the tasks used by each pair in the different sessions. For instance, in session E1, the first task given to the E1 pair is task T1 (see the "Experimental tasks" sub-section of the Appendix) of verbalisation, that is, communication via telephone. The second task given to this E1 pair is task T2 where there is silence during collaboration.

Subjects worked in pairs and each member of a pair was located in one of two separate subject rooms. Subjects could not see each other from their room as is the case in distributed collaboration. A research assistant observed each pair from an observation room. Each pair participated in a two-and-a-half hour session that included:

- *Training* (30 minutes): Each subject was trained in using REDUCE to ensure that they were familiar with the system and confident in collaboration.
- *Experiment* (1 hour): Subjects worked in pairs to work on one task with verbal communication (verbalisation) for thirty minutes and on another task without verbal communication (silence) for thirty minutes. 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 six-point scale (closed-ended) questions and thirteen open-ended questions. The closed-ended questions were questions asking subjects if they believed certain types of awareness were or were not important in collaborative authoring. *It is from these questions results for awareness elements were derived.* The open-ended questions sought mechanisms from subjects they desired for supporting group awareness. The open-ended questions are not shown since they are unrelated to this paper. Each subject filled in a questionnaire during an interview held by the research assistant where they could clarify the mechanisms they desired. Interviews were recorded onto audiotape for verification of subjects' responses during data analysis.

Data was also captured using HyperCam (Hyperionics 2004): all screen interaction occurring throughout an entire authoring session was captured into a movie and used for later analysis.

RESULTS OF AWARENESS STUDY

This section presents the results of analysing the close-ended questions. The results were useful in differentiating the importance and necessity of different awareness elements. The close-ended questions were analysed to calculate the mean of each close-ended question and then construct the distribution of responses for each question. It should be kept in mind that *each question represents one awareness element*. Thus, the importance of an awareness element is determined by the mean and distribution of responses of the corresponding question. The higher a mean is, the more important is that awareness element.

Table 2 shows the awareness elements sorted by their means. All closed-ended questions of the questionnaire are shown in the Table sorted according to decreasing mean. The top two most important awareness elements rated by subjects were: In the case of nonverbal communication, having a communication tool that supports communication between users (4.50) and Knowing the tasks for which other users are responsible (4.33). For both these elements, about half the subjects found that it was very important to have awareness support for these elements (that is, half the users believe awareness mechanisms should be available in collaborative authoring that provide these two types of awareness information). The distributions of responses for key elements are discussed in this paper.

The awareness element with the greatest mean concerns the use of a tool for communication between users when verbal/audio communication is not possible in a real-world authoring session. This means that for whatever reasons, a particular group in a real authoring session does not have telephonic facilities or such. This tool is usually understood as some form of chat tool that allows users to communicate textually. Thus, the experimental subjects indicated that communication is the most important aspect requiring support in order for them to author a document successfully. Interestingly, Having voice communication rated somewhat lower (4.04) in the rankings of mean, and Having video communication rated even lower (3.30). These results convey that subjects believed textual communication is more effective in authoring collaboratively, than hearing other subjects' voices, and much more so than seeing and hearing the subjects.

Table 2: Closed-ended questions about awareness elements and their results

Awareness elements	Mean	Awareness elements	Mean
In the case of nonverbal communication, having a communication tool that supports communication between users	4.50	Being able to view the list of past actions carried out by a specific user	3.72
Knowing the tasks for which other users are responsible	4.33	Knowing what actions other users are going to take in the future	3.70
Being able to comment on what other users have done	4.30	Knowing if other users can know what you have been doing	3.68
Knowing the parts of a document on which other users are currently working	4.22	Knowing to what extent a portion of a document has been completed	3.64
Knowing what actions other users are currently taking	4.08	Knowing which part of a document other users are currently looking at	3.36
Having voice communication	4.04	Having video communication	3.30
Knowing who is in the workspace	3.91	Knowing how long other users have been in the workspace	3.00
Knowing if other users are satisfied with what you have done	3.91	Knowing how much time has elapsed since other users have used REDUCE	2.78
Seeing the position of other users' cursors on the screen	3.78	Knowing where other users are physically located	2.04
Knowing to what extent you have completed your work compared to the extent others have completed their work	3.74		

It can be seen from the six highest means that support for communication and current activities are important. This suggests that from the experience of the twenty-four subjects, the most important aspects that need awareness support involve:

- inducing effective communication for subjects to discuss and understand the work they perform on the document, and
- allowing subjects to know what other users are doing currently at a given point in time in the session (which is also more important than what the users have done in the past or have yet to do).

It should be noted that a very large percentage of subjects rating an element as "Very Important" together with a very small percentage rating the same element as "Not at all Important" is not required to justify existence of an awareness mechanism supporting that element. If overall there is a larger proportion of subjects favouring the element, this suggests that an awareness mechanism would be worthwhile developing to support the element. Testing of the mechanism in real-world sessions to determine its effectiveness is required anyway before the

mechanism is made available for use. Any particular awareness mechanism is one of a set of mechanisms that should be provided to users for collaborative authoring. It is up to the user if they wish to choose a particular mechanism to provide them with a certain form of awareness support to assist them during authoring.

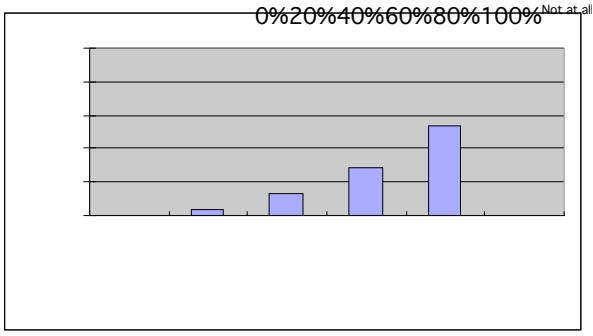

Figure 2: Knowing the tasks for which other users are responsible

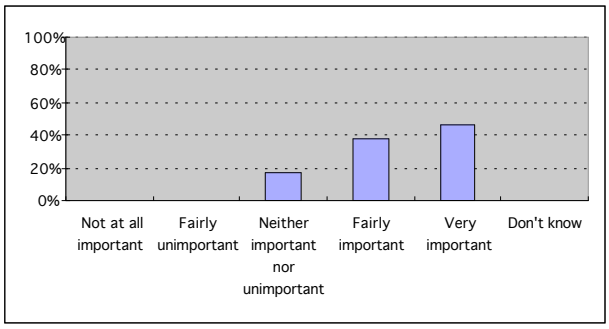

Figure 3: Being able to comment on what other users have done

Tasks of other users

Half the subjects believed that it is highly relevant to know what other subjects' tasks will be and 29% found it to be reasonably important to know this (Figure 2). Very few subjects found it to be irrelevant to know others' tasks (4%), and few found it didn't matter whether this information was available or not (13%). Thus, the results favour awareness support for knowing what tasks other subjects will carry out upon a document. Yet awareness mechanisms hardly address this form of awareness. Users spend a certain amount of effort discussing their strategy to complete an authoring task and in assigning responsibilities to each user. Clearly, it can be very important for each author to know what contributions other authors will be making to a document; indeed, in some cases it could be vital and fundamental to be fully aware of all work all other authors are going to carry out on the document. A mechanism supporting such awareness, the *Task Allocation Tree*, discovered from these same experiments is shown in the Appendix to exemplify how such support can be provided.

Commenting on other users' contributions

Almost half of subjects believed in the utmost importance of commenting on other subjects' work on the document (Figure 3). About a third of subjects felt it was still quite important to be able to do this. No subject found a definite lack of importance behind commenting on others' work. This need for commenting on others' work reflects the level of interaction required in collaborative authoring. Subjects generally feel they need to communicate to others their views on others' work and that they don't want to just "leave it up to them" to contribute to the document. Tools allowing this method of remarking on work are relevant according to these results. The Dynamic Task List mentioned in Related Work offers this ability, yet it is worth investigating other ways in which this ability can be provided since there is a lack of tools offering it.

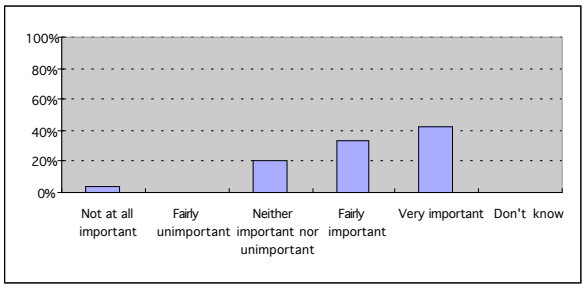

Figure 4: Knowing what actions other users are currently taking

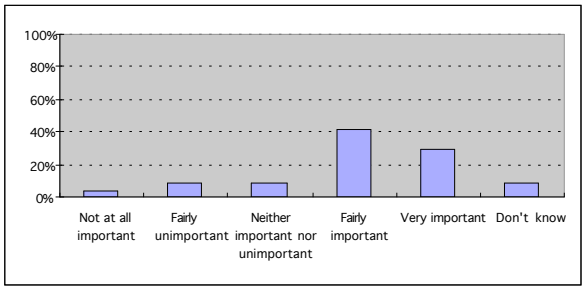

Figure 5: Knowing if other users are satisfied with what you have done

Other users' current actions

Figure 4 shows that 75% of subjects were in favour overall of knowing about what other subjects' are doing at the present. This means that most subjects were interested in knowing what other subjects were doing—were they deleting text or were they highlighting text or were they scrolling down the document? However, one-fifth of subjects didn't find it an issue to know what other subjects were doing whilst they were involved in an

authoring session and very few thought it was unimportant to know others' actions. Awareness mechanisms providing detailed understanding of exactly what other users are doing need development. Current mechanisms that provide information about other users' activities are more concerned with showing where users are working in a document or an overall view of the document.

Why would a user want such a mechanism showing what are other users' actions? Several reasons exist for this, and a few are covered here. First, users do not want to be ignorant of what other users may be doing with the document. Users, at the least, feel that having such a facility available to them will potentially come in handy in knowing what others are doing. Second, user *A* wants to know if another user, user *B*, may possibly be deleting text that belongs to user *A*. User *A* has the right to know if user *B* has changed user *A*'s contribution to the document, or may have accidentally removed user *A*'s contribution. Third, if user *A* has stopped work (no actions being carried out currently), it may be an indicator of an opportunity for user *B* to discuss issues with user *A* (recalling that users are, of course, distributed).

Satisfaction of other users

Although 70% of subjects placed importance in knowing that other users find their contribution to authoring satisfying, the majority of these particular subjects did not find such knowledge to be of tremendous importance (Figure 5). Generally, subjects felt their contribution to the document was not optimal without knowing what another subject thought of their contribution. Therefore, developing a mechanism for supporting this knowledge is reasonably worthwhile, but the mechanism may not be used to a great extent according to these results. Such a mechanism would prompt a user *A* to communicate with one or more other users who believed that user *A*'s contribution was not appropriate enough.

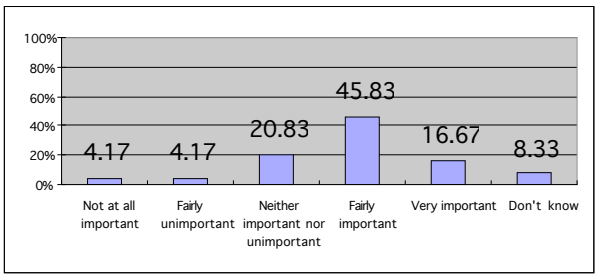

Figure 6: Being able to view the list of past actions carried out by a specific user

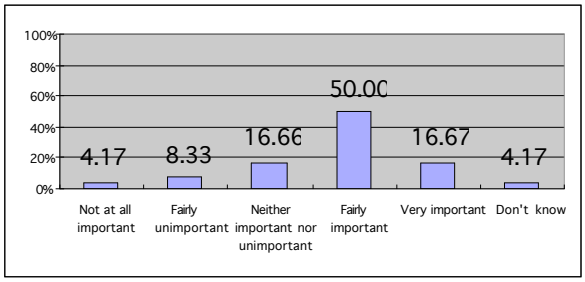

Figure 7: Knowing what actions other users are going to take in the future

Past and Future Actions

Results for knowing past actions (Figure 6) and future actions (Figure 7) were fairly similar. Overall, subjects felt a similar regard for knowing what other subjects have done in the past during an authoring session as knowing what other subjects plan to do in the future. Subjects felt that to the extent they would like to know or not know past actions of other subjects, to a similar extent they would like to know or not know what the other subjects will do in the future. In each case, about half the subjects believed that support for that particular type of action was reasonably useful. The same proportion in each case (16.67%) found great significance in supporting that type of action. These results indicate that if awareness support is provided for one of these types of actions, it should also be provided for the other type as well. Since the majority of subjects found support for a particular type of action worth supporting, this suggests that discovery of awareness mechanisms for past and future support is worthwhile pursuing. Clearly, the results of Figures 6 and 7 are not as strong as the results for current actions in Figure 4. Hence, current events occurring during authoring are more helpful to users than knowing what has happened some time ago in the past or will happen in the future.

OTHER RESULTS

Knowing which parts of a document other users are currently working on and Knowing to what extent you have completed your work compared to the extent others have completed their work will be discussed in a more relevant, future publication elsewhere.

Regarding the element, Knowing who is in the workspace, the mean was reasonably high at 3.92. It could have turned out to be much lower since each subject already knew who was the other subject in the session (although they didn't see each other during authoring). Many of the subjects could have easily given this question a low rating because of prior knowledge of who is in the workspace. However, it may be that most subjects looked beyond this and envisaged the situation where they did not know the other users with whom they were working.

Knowing if other users can know what you have been doing had a score of 3.68. This score indicates that the following would have applied to a number of the subjects when they were responding to this question. Assume user *A* has contributed to the document. Encouraging confidence in user *A* regarding the understanding of user *A*'s contribution by other users assists collaboration. User *A* would feel satisfaction knowing the other users are aware of what user *A* has done in contributing to the document. 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.

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 authoring. 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 a session.

Users need to be clear on what other users will contribute to the document—users will work out and agree on the various tasks that they will perform on the document. During the authoring session, users need to know exactly what parts other users are working on during the session.

The session involves effective communication amongst participants to achieve successful authoring of the document. This means both real-time discussion (…communication tool that supports communication between users) as well as asynchronous remarks given by users to one another (Being able to comment on what other users have done). If more than textual communication is required for discussing the document, users feel they can collaborate effectively mostly with voice communication, so would use audio/voice communication conveniently in the session.

Users need to access to the various actions that other users are carrying out currently (removing text, etc.). Users are assisted by an awareness mechanism in being highly knowledgeable of what others are doing in the session. Users exploit this information in diverse ways to interact with others in relevant ways to collaborate effectively.

Some users seek to be informed at different points during the session that other users are satisfied (to different degrees) with their contribution to the document. Knowing that others users are pleased with user *A*'s contribution may mean that user *A* feels much less need to communicate to others about the document, and this could improve the efficiency of collaboration.

Some users also seek to know various past actions and future actions of other users. These users access such details whenever relevant to their work on the document. Past actions of other users assist a particular user with their work on the current contents of the document; future actions allow a user to know how work yet to be done by other users will impact on their future work on the document.

CONCLUSION

Amongst the highest means for elements were those associated with support for communication and current activity. Thus, it can be concluded that the most important aspects of awareness to subjects in general included support for effective communication amongst users and the ability of knowing what other users are doing at the present. Hence, further research in knowing how to support these aspects and investigation of mechanisms that provide such support is indicated.

Regarding communication, it was clear subjects needed an appropriate communication tool, such as a chat tool, when audio and video facilities are unavailable. Also, subjects felt the importance to communicate to other subjects their views and opinions on the other subjects' contribution. Regarding current work, the following observation is made. Support for current work is provided by the *implemented* mechanisms of telepointers, radar views, fisheye views and multi-user scrollbars, however, they provide awareness that is too general. The intention behind these mechanisms is not to provide specific details about current work being undertaken by other users. For instance: if a user is currently altering another user's content, what is the exact and total content that has been altered so far together with what is being currently altered? Therefore, support for specific, current *actions* (e.g., highlighting text) is also not provided by these mechanisms. In addition, support for past and future actions was found to be important too.

Knowing other users' responsibilities in work to be carried out on a document also featured highly. Thus, more mechanisms like the Task Allocation Tree need discovery for providing this support.

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APPENDIX

Experimental tasks

Creative Writing

T1: "Fido is a dog living in Melbourne and owned by a boy, Jamie. Write a fictional story about the adventures of Fido."

T2: "Write a fictional story about the various events that occur in a sports team playing in a particular match. For instance, a soccer team or a cricket team or a basketball team, etc. playing a particular match."

Brainstorming

T3: "Stress affects people in modern life. There are clearly many different ways of escaping the stress and difficulties of modern life. Write down and explain various ways of reducing stress."

T4: "Write down different problems and difficulties that you feel occur when being taught in an educational setting (e.g., university lecture, workshop carried out in a company, etc.)"

Document Preparation

T5: "Write a research paper on an agreed topic with the other participant."

T6: "Write a manual or guide about REDUCE. This manual/guide must instruct and teach the reader how to use REDUCE."

Questionnaire

	Not at all important	Fairly unimportant	Important nor unimportant	Fairly important	Very important	Don't know
	1	2	3	4	5	6
Knowing who is in the workspace						
Knowing which tasks other users are responsible for						
Knowing how much time has elapsed since other users have used REDUCE						
Knowing where other users are physically located						
Knowing how long other users have been in the workspace						
Being able to view the list of past actions carried out by a specific user						
Knowing which parts of a document other users are currently working on						
Knowing which parts of a document other users are currently looking at						
Knowing what actions other users are going to take in the future						
Knowing what actions other users are currently taking						
Seeing the position of other users' cursors on the screen						
Knowing to what extent you have completed your work compared to the extent others have completed their work						
Knowing to what extent a portion of a document has been completed						
Knowing if other users can know what you have been doing						
Being able to comment on what other users have done						
Knowing if other users are satisfied with what you have done						
Having voice communication						
Having video communication						
In the case of nonverbal communication, having a communication tool that supports communication between users						

Task Allocation Tree