Collaboration between Writer and Reviewer through Change Representation Tools

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Abstract

Change representation concerns how changes of text are presented in writing tools. Change representation in collaborative writing can play an important role for the collaborators' understanding of changes of text. We have conducted a laboratory study where 10 pairs of a writer and a reviewer produced argumentative letters by using the change representation functions. We have also set different conditions in the experimental task: (a) two ways of representing changes, indication and display, and (b) two collaboration models, the writer- and the reviewer-initiative models. A primary source of the data was obtained through interviews with the participants. This paper reports their experience of collaboration in writing with change representation tools, relevant design conclusions, and our lessons learned from the study.

1. Introduction

In collaborative writing, mutual understanding of changes of text among the collaborators is essential to make their writing task successful. The more co-authors are aware of each other's changes of text, the more and better they can communicate about the writing task.

When a writing tool has a feature to visualize changes and their locations in the text, called a change representation function, co-authors' sense of the text history may be expected to increase which can facilitate negotiation about changes as well as further planning. Recent versions of common word processors such as MS Word and FrameMaker provide support for representation of changes of text.

Until now, however, little is known about how people use change representation tools. This is presumably not because the issue is unimportant, but perhaps because researchers have overlooked a potential of the role of change representation in the context of collaborative writing. In fact, people have already begun to make use of change representation tools for their collaborative writing tasks [7]. Against a gap between research community and the real world, this study was designed to help to increase understanding of the usage of these tools.

In our work, the notion of collaborative writing is more broadly taken, not being restricted to the cases where both a writer and a reviewer have co-authorship. We assume that the reviewer in the study does not mean an author of the document, but a helper of the writer to provide comments and possible revisions.

1.1 Need for empirical studies

A number of studies have been conducted on how to store changes of text, especially version management [1, 4, 9, 11]. To compare the contents of two different files, some programs have also been developed to produce an optimal difference report of changes [10,12]. However, these programs focused mainly on technical aspects, e.g. what algorithms are used.

The first study on change representation from a user perspective is Neuwirth et al.'s [13], addressing issues such as what changes to show other members of the group, how to present changes, and how to design the user interface. On the other hand, their study was discussed more theoretically. Since then, as a matter of fact, there have been no empirical studies carried out on the issue of change representation.

However, in that change representation tools are in actual use, there is a strong need for empirical studies on how people use these tools. It is also desirable that the issue of change representation should be given attention among researchers. Motivated by these facts, we conducted an explorative and experimental study, focusing on user experience.

1.2 Various forms of change representation tools

Change representation functions have various forms and names in different writing tools. In MSWord, 'Track Changes' is used as a general term for three different forms of change representation functions. The first type is the function called 'Highlight Changes' by which users can
start or stop recording changes of text, and make the changes shown on the screen or hidden while editing. The second is 'Accept or Reject Changes': for short Accept/Reject. The Accept/Reject function allows users to decide to preserve or filter out each change and remove change representation from the text, by accepting or rejecting it. The third function is 'Compare Documents' included e.g. by writing tools like FrameMaker and an experimental co-writing tool, Prep [13], as well as MS Word. By using this function, users can see changes between two different versions of the document. In FrameMaker, there is also another type of function called 'Change Bars'. This is similar to the function 'Highlight Changes' in MSWord in that users can see the changes while editing. However, its main difference from 'Highlight Changes' is that FrameMaker shows users the locations only where changes have been made with indication bars in the margin of the text, while MSWord presents both the contents of changes and their locations.

1.3 Research questions

A main aim of the study was to explore the usefulness and limitations of change representation functions in the context of collaboration in writing, and give some recommendations for the design of these functions.

(2) Writer- vs. reviewer-initiative models – ways of collaborating: As experimental conditions for the study, we have chosen two different ways of collaborating, namely the writer- and reviewer-initiative models. In the writer-initiative model, the reviewer suggests changes of text, but does not change the on-line text directly. The writer revises the text based on the reviewer's suggestions, and then the reviewer can inspect the changes made to the text by the use of change representation tools. In the reviewer-initiative model, on the other hand, the reviewer directly changes the on-line document, using these tools. After receiving the file of the revised text by the reviewer, the writer chooses either to accept or reject each change. The reviewer-initiative model can be regarded as more radical, in the sense that reviewers do not tend to directly change the text written by others (this has been suggested by interviews with collaborating writers, cf. [7]).

With respect to these two models of collaborating, we have investigated how useful writers and reviewers consider change representation to be. Also, we were interested in the importance of a commenting function as well as change representation tools during the reviewing process.

(3) Summary of research questions: In summary, we address the following issues in this paper:

1. What benefits can be gained through change representation?
2. What are the major limitations of current change representation tools?
3. In terms of two forms of representation: indication and display,
   a. In what context is each representation useful?
   b. To what extent does the reviewer understand the writer's rationale of changes?
4. In terms of two models of collaborating: the writer- and reviewer-initiative models,
   a. What general attitude to each model do writers and reviewers show?
   b. When can a commenting function be useful?

2. Three stages in this study

The study was carried out going through three different stages: (1) preliminary interviews, (2) an experiment with five pairs of a writer and a reviewer working according to the writer-initiative collaboration, and (3) an experiment with other five pairs by the reviewer-initiative collaboration.
2.1 Preliminary interviews

Before the experiment, we conducted one-hour interviews with two people in academia and one in industry who had used the change representation functions in their real collaborative writing tasks. The interviews focused on one particular writing task with the two academics, while the person in industry shared his experiences from several writing tasks. All interviews were tape-recorded and later transcribed. The academics were both FrameMaker users and had collaborated according to the writer-initiative model. The interviewee from industry, on the other hand, was a MS Word user and had worked by the reviewer-initiative model. These three interviews helped us understand how co-authors may use the change representation functions in collaborative writing tasks, and design an experimental task carried out at the next stages in the study.

2.2 Experiment in writer-initiative model

The experimental task involved 10 pairs of a writer and a reviewer. Among them, 5 pairs were instructed to collaborate according to the writer-initiative model, while the 5 other pairs in the reviewer-initiative model. Two subjects had PhD degrees, 11 were researchers or PhD students, and 7 were fourth year undergraduate students. They had not used change representation tools in real writing tasks before.

The procedure in the experiment where 5 pairs work by the writer-initiative model is as follows:

1) The writer writes an argumentative letter about one or two pages long (Four writers used MS Word, while one used FrameMaker on UNIX.)

2) The reviewer writes comments on the paper copy of the letter with a pen. The reviewer is asked to try to argue for or against the main point of the letter and criticize it, and check grammar and style, i.e. to act as a thorough reviewer.

3) The writer revises the text based on the comments from the reviewer, using a change representation function "Highlight Changes" on screen. The writer is also asked to make comments on the revised version of the text if he or she wants to. In case the writer likes to comment on a change, he or she is free to choose the medium of commenting, e.g. pen and paper, email, commenting functions, or other options.

4) The writer is interviewed about his or her experience of the use of the change representation function for an hour or so.

5) The revised text is shown to the reviewer one to two weeks after he or she had given the comments. (We set an interval of one to two weeks between the time when the reviewer comments on the first version of the letter, and the time when he or she receives the revised version with change representation. Thus, in the experiment we did not consider the situation of a close deadline that requires fast feedback in the communication between the writer and the reviewer).

6) When receiving the revised version, the reviewer is instructed to read the revised text through, and assign a number between 0 and 4 to each unit of change (every change indicating bar) to express the degree to which he or she understands the rationale of changes made by the writer, where 0 means "almost nothing" and 4 means "almost all". The reviewer does this twice to the document: first with changes shown in the indication mode, and subsequently with changes shown in the display mode. At this stage, the comments made previously by the reviewer are not shown, and so he or she has to assign the degrees only based on the change representation.

7) A post-session interview is performed with the reviewer. (All interviews conducted were tape-recorded and later transcribed.)

2.3 Experiment in Reviewer-Initiative Model

In the second experiment, other five pairs collaborated according to the reviewer-initiative model. The procedure of it was similar to the previous experiment. However, a main difference was that instead of giving comments on the paper version of the document, the reviewer changed the on-line text directly, using a change representation function, "Highlight Changes". The reviewer was also allowed to comment on the document, if they found it necessary. In the same way as in the writer-initiative setting, the reviewer was free to choose the medium that they wanted for commenting. Every subject in this condition used MSWord. After completing the given task, the reviewer was interviewed about the experience.

Next, the writer went through the text, and either accepted or rejected the changes made by the reviewer using the Accept/Reject function. The writer could also make other changes at will. Afterwards, an interview was performed with the writer.

This final, changed version of the text was now shown to the reviewer.¹ He or she read the revised text and assessed her understanding of the rationale for each unit of

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¹ We produced both the text with changes in the indication mode and the one in the display mode, by using the function 'Compare Documents' in MSWord which finds and presents the difference between the original version of text and the revised one.
change in the two different conditions in the same way as in the writer-initiative setting. All interviews conducted were tape-recorded and later transcribed.

3. User experience

Subjects have shared many interesting experiences, while being interviewed. This section describes them in relation to the research questions posed in section 1.

3.1 Benefits of change representation tools

(1) Decision of where to review and how. The interviews showed that, by use of the change representation tools, the sense of changes regarding where and how changes have been made helps reviewers decide where to review carefully and where to review roughly. The direct benefit from this is that reviewers can locate changes quickly, and thus save time when trying to understand changes made in text. A subject said in the interview:

"When I supervise master thesis students, it would be great to see what they actually changed. … When you read page after page that you’ve already read and they have made no changes in it, then you lose interest and concentration."

Change representation also seems useful to enhance the writers' sense of revisions when they review their own texts. In the preliminary interview, an academic who wrote his PhD thesis mentioned that he could confirm what he had revised and plan what other revisions to make later while reviewing by the use of change representation.

(2) Recollection of previous comments. Some reviewers have reported that their recollection of comments made on the previous text is largely benefited by change representation, particularly in the display mode. Reviewers are likely to forget what they have suggested about changes of text. For example, a week after a reviewer commented on the letter, she said that she could hardly remember any of her comments. However, change representation helped reviewers improve their capability to remember their previous comments.

(3) Sense of overview of changes. The sense of changes does not mean only awareness of where and what have been changed, but also awareness of the extent to which the text has been changed. By help of change representation, users can quickly see if substantial changes have been made, and what types of changes were mainly made, and so on. This enables both writers and reviewers to get an overall grasp of changes of the text.

(4) Expression of reactions to comments. When reading the revised text with change representation, reviewers can judge the extent to which the writer has taken account of comments and suggestions that they gave before. This is of importance, because knowing the reactions of the collaborators is a basis for further negotiation about changes. "I don't need any other comments about the changes from the author. I can understand his reaction to my comments", a reviewer said. Conversely, writers could also express their reactions to reviewers' opinions or suggestions by using change representation. "He will see that I've actually considered his comments", a writer said.

3.2 Limitations of change representation tools

(1) Clutteredness of text. A main source of skepticism of real use of change representation is the clutteredness of text caused by lots of strikethroughs and different colors to represent changes. About half of the subjects pointed out this problem. A reviewer in the reviewer-initiative setting said that he alternatively switched on and off the mode of 'Highlight Changes' on the screen about ten times so that he could avoid the problem of cluttered text. Most subjects have also reported that they turned it on and off at least once.

We believe that change representation would be used when the degree of clutteredness is not so high. As a matter of fact, Neuwirth et. al. have speculated that people use change representation functions at later stages of the writing process in terms of revisions of expression [14, pp. 146], because there are usually few substantial changes that cause clutteredness such as structural changes and paragraph level changes of text at the final stages of the writing process.

However, the attitudes of the reviewers in the writer-initiative setting were relatively generous with respect to this problem. They did not regard the cluttered text as a problem but as acceptable. We believe that this is because they did not revise the text, but only needed to check the changes made by the writers. But when subjects had to revise the text, the clutteredness became a problem because they needed to sense the flow of the text in order to feel how the parts to be revised harmonized with the unchanged text.

(2) Representation of moved text. Subjects reported that moved text should be distinguished from newly added or deleted text. Technically, a moved text is interpreted as a combination of a deleted text and an inserted text. However, when a moved text is long, it can also increase the clutteredness of the text in display mode, and lead users to misunderstand the moved text as either a newly inserted or a deleted text (see Figure 2).
Can change representation tools be widely used? Change representation functions are not used as widely as other reviewing tools like spelling checkers, word count, and so on. According to subjects, there are three main reasons. First, change representation tools are unknown to users. Subjects seem to believe that people do not even know the existence of such tools, and even so, they are not aware of how to use them.

"The major reason I think would be that most writers have not been informed or trained to use such a function."

"I think it might have to do with the fact that people aren’t aware of how the function works and how you can use it, and of what use it would be for you."

Secondly, using change representation functions does not belong to people’s current practices of reviewing. Subjects expressed the belief that reviewing on screen and/or with the document having change representation is not yet settled enough as a culture of reviewing.

"We don’t have this culture of reviewing. That’s the problem. I don’t think the problem is the structure of the function."

"I think the main reason is that it’s an unfamiliar way of working. … the effort to learn these new functions may be too much. People are lazy.”

"Knowledge, interest and use of distributed tools, commenting and Track-Changes functions etc, by top management and other people who are in a reviewing position - I think it’s important."

Particularly, the reviewer-initiative model is a new and unknown culture of reviewing. However, we believe that if people are more aware of change representation tools and become familiar with the reviewer-initiative model, such collaboration can be found useful in certain situations. As an evidence for this from the pre-study, the writer from industry mentioned that about 80% of 110 employees in his working place were aware of and used change representation tools.

Third, change representation functions are hidden in the interfaces of word processors. This is a more technical aspect, complementing the social and cultural dimensions of the use of collaboration tools:

"I think people have not used it because it’s difficult to reach the function. You go to the menu bar and go … "

"It is completely hidden in the MSWord interface. MS Word has about one million different functions "

3.3 Two representations

(1) Indication mode for reading and display mode for checking changes. The interviews showed that subjects had distinct purposes for the use of change representation functions in the indication mode and in the display mode, respectively. The indication mode was preferred for reading either the whole text or some paragraphs to sense the flow of the text. The document in the display mode, on the other hand, was used for understanding and checking changes. Concerning reading in the display mode, a reviewer said, "I don't want to read both the original and the changed text in the same place. It's not for the purpose for reading. It's rather intended for comparing changes with the original.”

(2) Understanding of rationales of changes. To what extent do reviewers understand changes of text in the indication mode and in the display mode, respectively? How large is the gap between these two conditions in their understanding of the rationale of changes? The results of the experiment showed that with indication of changes only, reviewers had considerable difficulty understanding why changes were made, while they understood it quite well with display of changes. As Figure 3 shows, the average ratings for understanding of changes in the indication mode in the 0 to 4 scale are 1.32 and 1.92 in the writer-initiative and in the reviewer-initiative collaboration respectively, while they are 3.33 and 3.97 in the display mode.

We did not perform a full statistical treatment of the results for the following reasons. A quantitative assessment of the degree of understanding in the two modes was not planned from the beginning of the experiment. Accordingly, the first three reviewers in the writer-initiative model were asked to grade their understandings of changes only in the indication mode, but to assign the numbers to each unit of change several weeks after they finished the experiment which means that those estimations are less reliable. However, the experiment was mainly designed to explore how people use change representation functions by using a qualitative analysis of interviews and observations.
Reviewers' general attitudes to change representation in the indication mode were more or less negative. The reason reported was that the reviewers could not remember the original text or even their comments, since the indication bars do not actually convey anything more than the locations where changes were made. Reviewers could only vaguely guess why each part has been revised in the indication mode, while, in the display mode, the degree of reviewers' understanding of changes was quite high even without their previous comments and writers' comments.

Figure 3. Degrees of understanding the rationale of changes of text

However, we do not believe that this facts claims the superiority of the display mode. Rather, it is important to point out that there are the tradeoffs between the two modes. While the display mode makes people understand changes well, it inhibits the reading process due to the problem of clutteredness. On the other hand, whereas the indication mode is good for reading and making sure of where changes have been made, there are some problems of understanding changes.

3.4 Two models

(1) Usefulness of change representation. Our results suggest that change representation tools are more useful for the reviewer in the writer-initiative model, while they are mutually beneficial between the writer and the reviewer in the reviewer-initiative model. In the writer-initiative work, reviewers showed a very positive attitude towards the change representation tool, because they found it helpful to understand why changes were made, especially in the display mode. But the writers did not experience it as useful, mainly because text with strikethroughs and colors disturbed their reading process. For example, when one writer revised the text highlighting changes on screen, he had a great feeling of achievement and progress of the text at the beginning stage. But soon he became disturbed in sensing the flow of the text by many strikethroughs representing deleted text. He then just switched off "Highlight Changes". In fact, three of five writers in the writer-initiative setting reported this problem, and expressed that change representation tools would be more useful for reviewers.

In the reviewer-initiative setting, however, even writers were positive to change representation tools, because they experienced that they could save an effort to formulate precise words when revising, as reviewers suggested changes by changing the text directly. In fact, they seemed to experience much more help from reviewers than the writers in the writer-initiative setting. Four of five writers in this setting expressed a positive attitude to the tools. In particular, one writer finished her revising task in 10 minutes only, saying that the reviewer's suggested changes were well-suited for the task and the comments were very easy to understand. Moreover, since the signs and colors representing changes disappear whenever the user accepts or rejects each change suggested, the writers might feel more and more comfortable with each disappearance of the disturbing factor to read the text.

(2) Change representation and commenting functions. Previous research has shown that the commenting function is rarely used in real collaborative writing [7]. However, our results suggest that the reviewer-initiative model for collaboration may lead co-authors to use the commenting function more.

In our experiment, reviewers working in the reviewer-initiative setting reported that they needed to write comments as well as change the on-line text directly. Among five pairs in this setting, four reviewers used a commenting function. Although we told them that it was not obligatory to write comments, they kept doing so during the task. One reviewer commented, "I find it very useful. Whenever I changed something, I felt like attaching a comment to it. Maybe a good design idea is.. when you have this 'Track-Changes' function... somehow, you have to have a box to explain why you have changed or something like that. At least for me it would be a natural way of doing it." Apparently, reviewers needed to write comments, to tell the writers why they made changes. Furthermore, reviewers often face a difficulty of formulating exact words when changing the text. In that case, writing comments is as useful as using change representation tools. Two reviewers quite often used this strategy.

Another interesting finding was that three of five writers also used the commenting function. This phenomenon just occurred as the form of the writer's response to the reviewer's use of the commenting function, "He has used the commenting feature. Why not me?" (a writer). As the reviewer uses the commenting function, this can also
4. Design implications

4.1 Easy transition between indication and display Mode

The indication mode is more adequate for reading the text than understanding the rationale of changes, while the display mode is mainly used for checking and understanding changes. When the writer and the reviewer evaluate the text, both the process of reading the text and that of understanding changes are essential. Further, these two processes are iterated and alternating during the course of reviewing according to the subjects. As Flower and Hayes mentioned it by their cognitive process model of writing [3], such an iteration of different cognitive processes is frequent due to the recursive character of writing. Therefore, technical support for easy transition between the mode of reading and that of understanding changes is required when people use change representation tools.

It is also important to support a dynamic transition between the indication and the display modes about each unit of changes. That is, the transition can be needed not only over the whole document, but also over only a particular unit of changes. Some subjects reported that they switched off the change representation function to read only a paragraph without change representation rather than the whole text. In such a case, they need to go back to the indication mode for a particular part of the document, while preserving other parts still in the display mode. One way of doing this would be by double-clicking a change indication bar, so that if users clicked the bar, it would hide the details of changes associated with the bar, and if they clicked it again, it would show them.

4.2 Representation of different types of changes

There are four types of changes in terms of keystroke actions: deleting, inserting, replacing, and moving a text. By the current techniques for change representation, however, users can see only two types of changes: insertion and deletion. Replaced and moved texts are just represented as a combination of a deletion and an insertion of text. A question is: do we need a new representation for replaced and moved texts in order to provide users with a better sense of changes?

While no subject expressed the need for a separate representation with respect to replaced text, some did so for moved text. Users seemed to perceive a replaced text well, though it is represented by a deletion and an insertion. But a moved text often led to misunderstanding, and it was perceived either as a newly inserted or as a deleted text. Moreover, it also increases the clutteredness of the text that can inhibit reading performance. Our data thus suggest that representation of moved text has higher priority than that of replaced text, though the issue of how to represent moved text needs further investigation.

4.3 What trivial deletions should the computer filter out?

We have previously carried out research on detection and filtration of typing error corrections from the history of revisions of text [5, 6]. The tool used in this research, Trace-it, displays the complete revision history of a text using a format called S-notation. It has been used to help researchers analyse writers' behaviour and cognitive processes of revising through the revision history [8, 16]. In this context, typing error corrections were seen as trivial revisions of unintended errors that do not reflect writers' cognitive processes of writing. Therefore, we implemented a function to filter out typing error corrections from the revision history. A question in connection with the present study was therefore: if a writing process analysis tool facilitates such filtration, is it then relevant in the context of collaborative writing as well?

We asked the subjects as writers in this study about what changes could be filtered out automatically by the
computer from their revised texts. The assumption was that if the computer can reduce some kinds of changes automatically in a way that does not deteriorate mutual understanding about changes, it can increase the collaborators' reading performance. However, we failed to identify particular types of changes that can be reduced by the computer automatically. About half of the writers actually wanted to preserve even typing error corrections. A main reason reported was that they needed to express their reactions to reviewers' comments on typing errors in the text. Therefore, we suggest that computer support for filtering out certain kinds of changes should be optional choices on the part of writers, rather than automated functions in the context of collaborative writing.

### 4.4 One common place for the reviewing process

In the experimental task, one writer in the writer-initiative setting, and three writers and four reviewers in the reviewer-initiative setting used the commenting function as well as change representation functions. This fact tells us that the design of a function for reviewing should be understood in relation to the use of other functions, and not in isolation. As a matter of fact, the act of reviewing does not include only one particular type of activity. Rather, it consists of several activities such as reading text, understanding and checking changes, revising text, and writing comments, and so on. Such activities are related, iterated, and harmonized during the writing process to improve the text. Therefore, a design challenge is how to support the reviewing process on the whole.

A fundamental basis for this is, we believe, provision of a common place for reviewing tools, e.g. the same window or toolbar. A problem in current interfaces is that various reviewing tools are scattered at different places that actually may make users perceive the functions as hidden. In FrameMaker, for example, writers are able to use the tool "Changing Bars" by taking the path Format/Document/Change Bars, from the menu bar, while to use "Compare Documents" as other path is used: File/Utilities/Compare Documents. To write a comment, users have to take yet another more complex path. MSWord also has different paths to the commenting function and to change representation functions. Thus, users travel different ways to reach different types of reviewing tools. An analogy would be that customers have to go to a grocery store to buy tomatoes and to another store for carrots.

There are in fact ways in the current MSWord interface to mitigate such scatteredness of reviewing tools. By selecting 'Reviewing' through the path View/Toolbars, users can gather different reviewing tools on the toolbar, and keep them at the same place while writing and reviewing. Consequently, users can make less effort to find and reach those functions, which eventually makes them more usable. However, since the reviewing tools are present in the tool bar not by default but by users' optional choice, these tools can be still hidden unless users are aware of the reviewing tools.

We believe that building a common space for the reviewing tools is key to further development of those tools as an entity. This means that it is an essential step to support the reviewing process, but at the same time an opening step towards further development. Therefore, admitting that much work still remains, we anticipate more research on how people use different reviewing tools and how to design a better common space for reviewing.

A place for everything, and everything in its place -- if only you can keep track of the places. [15, pp. 159]

### 5. Conclusions: Lessons from the study

Work practices are not repetition. They are evolved and renewed over time. New technology transforms our practices. Techniques for change representation and comments thus have a potential to change our ways of reviewing documents. We have learned a great deal about the usage of change representation tools from the study. In this conclusive section, we would like to present some lessons gained from the study.

#### 5.1 Understanding changes is crucial in the reviewing process

Understanding changes means awareness of changes such as a sense of what changes were made, where they were, why they were made, and the overview of changes. Before change representation tools were invented, processes of reading and evaluating text seemed only central in the reviewing process, as Flower and Hayes discussed them in their model of cognitive processes [3]. However, the use of change representation tools may highlight a dimension of the process of understanding changes in text as a separate process from that of reading and evaluating text.

What is important to designers at the current status is perhaps how to support different cognitive processes while reviewing with change representation tools. Typically, reading and understanding changes are two major processes, and they are often switched during the reviewing process. Therefore, change representation is not only an issue for helping understand changes. But its support should be also investigated without disturbing the process of reading for reviewing. As we suggested it before, a smooth transition between these two processes is essential to support the interactive nature in the reviewing process. The relationship between these two cognitive
processes in the context of usage of change representation tools should also be more explored.

5.2 Building a common ground

People cannot understand others’ state of mind unless it is expressed in an appropriate way. Participants in the study have shown that change representation provides awareness of the partner’s reactions to previous discussions about changes. It also makes them understand what other people think about changes. Clark and Brennan have put an emphasis on the role of common ground for the sake of group coordination [2]. In fact, change representation tools themselves are not communication systems like text-chat functions, but tools for building a mutual ground for further communication about revisions. When verbal communication is not good enough to express detailed information such as every change made in text, change representation plays an important role to convey people’s ideas about changes, which eventually helps establish a mutual ground on changes in text among the collaborators.

5.3 How to reach critical mass

Many subjects have mentioned that the use of change representation tools is not yet settled as a working culture in collaborative writing. Sharing their opinions, we have found that although we discussed how to make tools usable, a more important dimension to consider is how to reach critical mass, i.e. how to gain a sufficient number of users of tools. Because a collaborative technology needs members who are aware of the technology and know how to use it, it is difficult that a group of people uses it when it is new to all or part of group members.

While the number of users of change representation tools grows, when and if we can arrive at critical mass is uncertain. That is the reason why we have only selected some design issues that we think are realistic at this point, avoiding the discussion of other issues, which may be far beyond the current state of people’s understanding change representation tools.

5.4 Need for understanding of real world context

An advantage gained by conducting experimental tasks was to capture a “general” understanding of the role of change representation tools, in that we learned users’ experience from 10 cases of collaborative work rather than only a few cases. Further, while we adopted experiments, because we analyzed the data qualitatively, we could gain descriptive knowledge of how people understand and use those tools.

Among the limitations of this study, however, a major limitation was that experiments had difficult aspects to reflect realistic context. In fact, there are presumably various writing contexts where change representation tools can be used in reality. An interviewee has mentioned that people in industry review documents less thoroughly than academics due to time constraints. Different writing cultures certainly lead to different ways of working with change representation tools.

As a matter of fact, people have gradually used them in different contexts. For example, an editor of a book can use the tools to suggest some changes in the text written by other authors by the reviewer-initiative collaboration. Language consultants can help their customers in the same way. For a pedagogical purpose, composition teachers may also use change representation tools to teach students writing. What we think is important after conducting our study is the need for understanding of real world context that is quite diverse and complex.

In conclusion, however, while believing that more studies remain to look into real world cases, we feel that the need for additional research on the issue of change representation does not diminish the value of the present study. Rather, it reflects the diversity and the complexity of ways of collaboration in reality. Finally, hoping that the discussions done in this paper will help to increase understanding of the role of change representation tools in collaborative writing, I believe that our study can be a start for further empirical studies on the issue of change representation.

6. References


