

Tracking Changes in Collaborative Writing: Edits, Visibility and Group Maintenance

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ABSTRACT

Systems for collaborative writing have long captured the attention of CSCW researchers, but have only recently come into widespread use. One issue in designing and understanding these systems is awareness of others' actions in a document. On the one hand, making edits and changes visible can improve collaborators' knowledge of who has made edits and what has changed in a document. On the other hand, studies of large scale editing systems such as Wikipedia have suggested that the visibility of certain edits can incite social conflict in groups. In this interview study, we aim to understand how people perceive and consider the potential impacts of their own and others' edits as they write together. Results suggest that edits embody not just changes to a document, but also social messages that have group maintenance implications. Many participants reported that they carefully consider how to make and explain edits so as to minimize social conflict.

ACM Classification Keywords

H.5.3 Group and Organization Interfaces

General Terms

Human Factors; Design

INTRODUCTION

Writing documents with others is a very common activity, and has become more common as teamwork has grown in popularity for work groups [18], research collaborations [39] and student projects in education. It is also possible to write together in new ways using a wide array of popular commercial tools such as Google Docs and the reviewing features of traditional word processors such as Microsoft Word and Apple's Pages, which are widely used [31].

Moreover, collaborative writing has long captured the attention of CSCW researchers. Writing together has been shown to be a complex process involving many discrete activities [32], working and coordination styles [30] and

adoption of varied roles in these activities. Early work experimented with the design of tools specifically for the writing process (e.g., [26, 29]), aiming to create taxonomies of processes and roles [32], and also to understand how to design for issues such as version control [25], concurrent access/control [30], change awareness [36] and real-time awareness of others' behavior [12].

Much of this early work involved lab studies of experimental prototype systems, so focused on identifying the utility of specific features in constructing documents together (e.g., [25]). In general, most existing work has focused on understanding and supporting the sub-tasks of the collaborative writing process, such as planning, writing and editing, and providing feedback.

In addition to effective task completion, however, theories of group behavior such as the influential Input Process Output model (e.g., [18]) point to the importance of group maintenance in effective groups functioning. This is further reflected in theories of conflict that distinguish between task and relationship conflict in groups (reviewed in [11]). Group maintenance behavior is targeted toward the maintenance of social relationships with others, as distinct from behavior aimed primarily at efficient or effective task performance. There have been few studies, though, of group maintenance behavior in groups writing together.

Nonetheless, there is reason to believe that group maintenance behaviors may be unique in collaborative writing, particularly when popular collaboration tools are involved. Studies of maintenance [7] and conflicts [24] on the popular Wikipedia site show that visible edits to documents can draw attention to and inflame conflict, often requiring resolution via discussion or moderation. To be fair, Wikipedia clearly differs from small group writing in terms of the number of editors and the coordination mechanisms, but the notion that changes can draw attention in group efforts applies to both scenarios. We know much less about how these processes occur in small groups writing documents together, however, or how we may better support them. Indeed, allowing for some ambiguity around certain changes may sometimes serve a useful social purpose [1, 5].

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In the paper that follows, we present data from an interview study of people who write documents with others using commercially available collaborative writing tools. We paid particular attention to how they managed group maintenance alongside task completion. Results suggest that simple edits can carry many messages, and participants took careful steps to ensure that edits were not misinterpreted, and also developed strategies to avoid misinterpretation of others' edits to their work.

BACKGROUND

There are two ways in which we might expect collaborative writing tools to affect group maintenance and performance.

Visibility & Awareness

The first is awareness of others' activities and the visibility of user actions to others. On the one hand, there is clear utility in drawing attention to certain changes via highlighting or other visual cues. Tam and Greenberg [36] discuss the example of a political document in which small, but highly consequential edits went unnoticed by many stakeholders because they were not highlighted as changes, so readers were unaware that changes had been made.

Many systems, including the framework by Tam and Greenberg, have focused on workspace awareness – that is, making users aware of others' actions by making them visible, and by tracking the history of the document [17].

Workspace awareness, however, is only one component. Theories of awareness are rooted in knowing what information people use to interpret what is going on around them, understand these activities, and try to predict likely future states [13]. Awareness has been shown to depend on sensitivity to a range of behaviors and activities [20]. Moreover, when one is building awareness of a situation involving other people, a key element of predicting future states is anticipating others' likely reactions to behavior.

The visibility and presentation of edits in collaborative document editing can affect the likelihood of these behaviors being noticed, and therefore impact others' reactions. The high visibility of edits on Wikipedia – via watch lists and trace histories – for example, can attract attention to a recently changed page [7] and re-ignite conflict among editors who maintain that page [24]. This can be true even if the changes are not substantial, simply by drawing attention to the page.

In this way, the visibility of edits can serve not just to facilitate awareness of changes to a document (along with the details of when these occurred and who is responsible), but also allows edits to act as signals of activity more generally or even be perceived as possible threats to a previously agreed upon way of presenting an issue.

We argue that complete transparency in change awareness may not always be the best option, and that there may be some value in not revealing all details about certain changes to documents, or in considering alternative means for presenting these details to users. Indeed, recent studies have

suggested that ambiguity surrounding the details of people's actions or context can serve as a resource in smoothing social relations [1, 5, 19]. Similarly, hiding certain edits in a document could enable minor changes to be made while avoiding unnecessary social conflict.

To design for a balance between transparency and ambiguity, however, we must develop a more systematic understanding of how edits to documents are interpreted by users. While there has been extensive study of edits and conflicts in Wikipedia, there have been fewer field studies of editing in small groups. Kim and Eklundh [23] discuss the importance of *how* changes are made visible, but they do not explore the social *consequences* of these decisions. The first question we ask in this study, therefore, is how people who write together interpret others' edits, and the roles that edits play in both the task and group maintenance components of writing together.

Coordination and Annotation

Beyond understanding how edits are interpreted, we must also understand how people view edits as components of the coordination and revision process. Several studies have examined media usage for commenting and annotating documents, noting that both the substance and interpretation of feedback can be affected by properties of the media being used [25]. In particular, participants using direct text annotation made more detailed comments, and feedback delivered by video has been perceived as less negative than feedback delivered via text [3]. This is an important point from a group maintenance standpoint, as Posner and Baecker note that critiquing work in the writing process can provoke conflict and requires “thick skin” [32].

Another way that visibility of actions can affect group behavior is in self-presentation. One of the ways that people preserve social relationships in the face of potential relationship conflict is by taking actions that are likely to be perceived positively by others [6, 16, 38], or offering explanations that aim to re-cast potentially negative actions in a more positive light [9, 33]. Important here for our purposes is that people are conscious in their actions of how their behavior may be perceived and viewed by others, and of the impact behavior may have on social relationships.

As such, the visibility of behavior can affect people's actions – and the ways in which they explain or present themselves to others [4]. That is, people behave differently when they know others are aware of their behavior [15, 34]. In the context of writing, for example, one might hesitate to change a shared document if it is known that edits will be visible and linked to a particular user. Visibility, as noted above, might draw unwanted attention to edits or spark conflict between collaborators.

Moreover, visible actions in collaborative editing tools reveal only the actions themselves, often leaving the rationale behind them ambiguous. There is evidence, however, that people overinterpret certain cues in impoverished environments, which can lead to exaggerated

interpretations or impressions [37], and affect how credit and blame are attributed [2]. This means that people may misinterpret edits to shared documents in ways that result in conflict. For example, they might misinterpret an edit as a sign of a strained relationship with a collaborator.

Large collaborative editing projects such as Wikipedia therefore have “talk” pages that allow people to explain and discuss edits [24], but such tools are not always provided for or used by small groups.

Despite these strong possibilities for effects on how groups are maintained, there has been little discussion of the social effects of change awareness and revision histories. This is the second question we aim to answer in this study. That is, how do people consider the ramifications of their behavior when editing, and what is the effect of edit visibility?

RESEARCH METHOD AND CONTEXT

We conducted an interview study with people who had participated in writing at least one document with others, using a commercially available writing tool with collaborative features. While any tool was acceptable, Microsoft Word and Google Docs were by far the most common. Word documents allow editing by only one user at a time, but the system includes features for tracking and rendering visible (via unique colors for each user) edits to documents, and comments that appear outside the body text. These features are not turned on by default.

Google Docs is web (“cloud”)-based and supports multiple concurrent editors in a single document. Real-time awareness of others’ changes and cursor locations are provided, but changes are not rendered visible by default in the document. A complete revision history is stored, however, that reveals all edits and who is responsible for them. The system also supports commenting on documents, with comments also appearing outside the body of the text.

Participants

Participants were recruited via a variety of techniques. Initial participants were recruited via: flyers posted on and around our university’s campus in the northeastern United States, emails to mailing lists at our and other US universities, speaking with existing contacts, and via advertisements on our university’s web-based recruitment system for human participants. Some additional participants were recruited via snowball sampling. All participants were compensated with ten dollars in cash or gift card credit.

Thirty-one people participated in this study between November 2010 and April 2011 (22 female, 9 male). These included eleven undergraduates, eight Ph.D. students, seven students in a pre-professional master’s program, three research university faculty, and two university librarians.

Procedure

All interviews were semi-structured and conducted by the second author, either in person or remotely via audio or video conferencing. In-person interviews were conducted in a private office or conference room. Remote interviews

were performed from a private space; interviewees were asked to be in a private setting.

The interview protocol was written prior to data collection, but refined through discussion of our own experiences and several pilot interviews (not included in the data set). The protocol was also iteratively refined during the initial interviews, though the set of items was reasonably stable throughout the process. Depending on the participant and context, the order and priority of interview items was sometimes adjusted to fit the flow of the conversation and the applicability of items to the interviewees. Participants were asked about their use of word processing tools, their personal preferences for specific tools and features, and the frequency and nature of their collaborative use of those tools. Interviewees were asked to describe at least one specific example of a collaborative writing project, and at least one example of conflict. Overall, emphasis was placed on change awareness and edit trace history features and related experiences, practices and preferences. Participants were also asked to discuss their interactions with co-authors and editors, and their impressions of specific experiences.

Data Analysis

Interviews lasted between 27 and 87 minutes ($M=48.6$ minutes). Nearly all were audio recorded and fully transcribed for analysis, with two exceptions: one participant declined to have the interview recorded, and another recording was of poor quality due to unanticipated background noise, so could not be accurately transcribed.

The data analysis process loosely followed a grounded theory approach [14, 21], but was also directed by our initial research questions and ideas. Researchers performed close reading of transcripts, making notes and engaging in constant comparison. Through collaborative discussion and separate memoing, an open coding scheme was developed via annotation of documents, and using a spreadsheet to track categories and relevant data. Throughout the process, the coding scheme was refined, and data were re-coded for the updated categories as necessary. While it is unclear whether we reached true theoretical saturation, there was clear repetition in what our participants told us by the end of the data gathering and analysis. We feel that we have sufficient data to make exploratory claims. Several themes identified in coding are used in presenting our results below. Pseudonyms are used for all participants.

We do not mean to give the impression that our participants’ collaborative writing experiences were riddled with conflict. Many had harmonious collaborations as well, but nearly all could recall and describe some conflict episodes. Our focus in analysis was on the management and origin of social conflict when it occurs in writing.

RESULTS

In analyzing our results, we found that participants described a wide range of experiences. Many of these highlighted the importance of being aware of changes to documents via visible edits or change histories, but that

they were also conscious of the possible social effects of these edits as they worked together. Awareness information about edits was often interpreted by our participants in ways that go beyond the technical and task-oriented information central to trace and revision history features.

The Many Roles of Edits and Annotations

One key theme in our results was that edits and annotations in documents played several different roles.

Insights about effort and contribution

One role of edits was to serve as a source of insight about collaborators' efforts, both in the aggregate and in understanding the behavior of specific individuals. For example, some users of Google Docs reported that real-time awareness of the amount of text in the document helped them stay aware of group progress. Josie, a graduate student, enjoyed being able to "see the work that's already been done" and "watching [the document] grow" while using Google Docs. This allowed her to monitor the group's progress without having to constantly query collaborators to see if they were doing their part.

Edit histories were also useful in assessing individual effort, in that they allowed for easy determination of who had contributed to a document and how much had been contributed. Some participants, like Carrie, a Ph.D. student, reported that this allowed them to become aware of a disparity or lack of contribution:

I've worked with people before where there's Track Changes and you get the document back and there's like one thing that has happened. That almost makes you feel like, 'did you read it?'

Mirah, a professional master's degree student, mentioned that even faculty in her degree program sometimes use the Track Changes feature for evaluation of group work, saying that "sometimes professors want to see the document with these changes so they know everybody has had an equal hand in the creation."

Making the details of changes visible also had the effect that participants could see exactly what had been edited – and thus contributed – by a particular collaborator. Sometimes the detailed nature of the changes affected perceptions of the value of a person's contribution. In reviewing the highlighted changes in a shared Microsoft Word document, for example, one participant saw that a collaborator had made significant edits to a document and was pleased. After a closer look, though, he realized that this person had made primarily grammatical edits to the document, and felt that this indicated a low level of contribution, which was disappointing. This is just one of several ways in which receiving edits on a document or viewing edit information can be alarming or upsetting, and lead to potential conflict as we will discuss further below.

In addition to edits, annotations to documents via commenting also served as indicators of others' activities around the document. Knowledge of these activities could have both positive and negative consequences.

Mirah, for example, said that she saw comments as an indicator that a collaborator had actively engaged with the contents of the document: "if there are comments I know that the person had actively engaged with my material."

Helen, a Ph.D student, referred explicitly to appreciating the amount of time and effort she assumed was behind the extensive editing and commenting performed by her advisor, saying "[it's] a very thoughtful practice that I really appreciate." On the other hand, a lack of comments could be interpreted as signs of disengagement or disinterest, which could have negative implications.

The role of edits in signifying the efforts of others sometimes also went beyond the literal meaning edits and comments in the document. Some participants reported that they could derive insights about what their collaborators were thinking about the work by reading the comments or edits. David, a Ph.D. student, noted that when his colleague gives verbose comments or an extensive set of edits, he "can really get to see what he's thinking, even if [he] can't talk," noting that this wouldn't be the case if he were to simply receive an unannotated revision.

Manipulation, judgment and threat

At the same time, many participants referred repeatedly to being alarmed at the appearance of edits, perceiving certain edits – or certain collaborators – as "overly critical." They said others' edits sometimes forced them to ask themselves "what am I doing wrong?" or referred to their ego being hurt. Participants sometimes used violent verbs (e.g., 'butcher,' 'hack,' 'tear,' and even 'rape') to describe others' edits to their text.

What all of this highlights is that writing can be an act of personal expression that can be hard to detach from the collaborative endeavor of which it is a part. As such, edits to a document can serve as more than mere alterations to content, and be perceived as an attack on one's self or acts of self-expression. This sentiment was common even on projects where responsibility for writing was acknowledged to be shared among all collaborators. This latter point foregrounds a key tension we wish to highlight: many people take their contributions to shared documents seriously, and edits to these sections can have relational effects. This is illustrated by Kaylee, a professional master's student who studied English in college:

[I was upset] because I cared so much about how my writing comes across, and I'm very careful with the way I write, I was very annoyed, when the person who was charged with putting this book together, didn't give the thing back to me and say, 'This is a little bit too long' ... instead of sending it back to me and saying, 'This is too long,' he just hacked it apart himself. The thing that had my name on it was completely like, 'That's a horrible piece of writing.' I, personally, was mortified – overreacting, sure – but it had my name on it, and it wasn't something I thought was good writing.

Kaylee's experience highlights another key theme that is important for our discussion of edits and group

maintenance. It was common for participants to report being upset when edits were perceived as reflecting unilateral decisions by another collaborator, without buy-in or consensus from others. Indeed, Kaylee was upset that editing had been done for her, without her consent or input.

This is about more than just ownership of work, or a challenge to something participants were proud of; there is a distinctly social element. One of Luke's group members made major changes the night of a deadline in a way that offended the rest of the group. He said that "it just didn't seem to us that it was very respectful of the time we had spent working on it for her to come through and just blow all that away," and wished she had discussed it with them.

These examples illustrate several ways in which editing signals had negative social effects, from being bothered by a lack of substantive contribution to being upset by manipulation of one's own work or somebody else's decision about something they felt they had a stake in.

Decisions around Edits: Messages and Relationships

Participants also reported being conscious of the possible negative social effects of editing other people's work. When using tools with edit history features, many described strategies for mitigating the risk of negative social interpretations of their edits.

Visible edits help, but also constrain

The first strategy that most participants described was being careful not to hide edits from collaborators and to use the edit history features available to them. Many felt that this implied that the edit was being presented as a possible revision for collaborators to consider, and not as a unilateral decision to change the document.

In reflecting on their use of these features, many participants discussed being concerned that their edits might be misinterpreted in a negative light. Some, like Kaylee, made direct references to their own experiences:

I think it's really useful to be able to see what other people have changed about my work, so then I can say, 'OK, I'm OK with this change,' or 'No, I'd like to go back to what I originally wrote.' In the same way, I like other people to see that, so that I feel freer to make more expansive changes, so that they have an easy way to go and reject all of those if they so choose.

As her example illustrates, a key element of this process is consent and respect for others' work. Several participants explicitly described using edit history features as a way of showing respect. Some described it as imperative. Irene, a faculty member at a research university, explained that she typically uses track changes features because "it just shows respect to the co-author. You want to make sure that they're comfortable with the revisions. You just have to use it."

Even though track changes features were a common strategy for softening the potential social impact of edits, many participants reported that there were times when they avoided editing others' text directly or visibly, even with

these features enabled. Often this was to avoid potential conflict. For instance, Zeb, an academic librarian, said he was careful to avoid manipulating text he sensed others might feel strongly about:

Sometimes you [can] tell by the way somebody says something that they're into it. Like that they added a little flourish or something that you think is just awful. I try to be careful about something like that.

Another factor governing whether or not participants would directly edit others' text was expertise in the subject matter. Alice describes a project she was working on that involved some content about therapy, a topic she knew little about:

I have no background in therapy and I don't understand all the issues that we're talking about there. So if a sentence didn't make sense to me, I wouldn't feel comfortable going and changing that, but I could make a comment.

Many of these responses reflect a common theme that was nicely summed up by Kaylee. In describing what was important to her in considering how her edits might cause awkward or unpleasant situations, Kaylee said, "you just have to try to figure out what value they care about in the actual written product."

Comments allow for explanation

Although refraining from directly editing content was a very common strategy for avoiding potentially relationship-damaging interpretations of their actions, many participants used writing tools as their primary medium for communicating and working with collaborators. That is, they often did not schedule face-to-face or other meetings to discuss the details of specific edits or changes.

Rather, discussions about revisions and negotiation around disagreements were often initiated via a commenting tool:

Well, he put the note in where he was like, 'Um, I thought, you know... I was thinking that we weren't going to include this.' And so then, yes, [others in the group] would leave a comment and back him up and be like, 'Yes, I really think we should take it out, too.'

Such discussions both facilitated and created the impression of a group consensus and decision process, which served to bolster agreement around edits and reduce conflict.

Participants reported several specific uses for comments, which served as a way of handling the tension between two desires: one to change a document and another to avoid conflicts that could threaten effective group maintenance. In addition to using comments instead of edits, several participants also used comments to explain their edits. Irene, for example, uses comments to explain deletions:

If I just delete that without telling them, it can be offensive. So, if I delete something, I will leave a reason. If I disagree, I will leave a reason because I want people to treat me the same way I treat them.

Another common strategy was to make general statements about the edits and feedback in an attempt to explain that they were being made without intending to attack others or

threaten group dynamics. Ulric, for example, said that he had recently begun to preface his criticism, with a note that he intends no offense and simply wishes to be straightforward and constructive. When asked if he believed if it made a difference, he responded, "Yes... people receive [my straightforward criticism] better." Tessa, a Ph.D. student, did similarly, saying:

throughout the process [of editing my colleague's masters thesis], ... I hoped that I expressed and I tried to express a couple times that I wouldn't be offended if none of my edits were appropriated.

It is interesting that Tessa used the word "express" in two ways here. The latter use refers to explicit statements, but the first references the way in which she was attempting to present herself via the tone of her communication:

I don't feel like I moderated my edits [by refraining from making some]. But I do feel like I made extra care to -- in my comments -- to defer to [the primary author] and be strength based, and not be too critical... positing [it] as her choice rather than being, 'this is what you need to do.' And I think maybe some of that deference would have been unnecessary in Google Docs because it's not as glaring. It is transparent because you can go back. But it's not as, maybe, confrontational a format.

Overall, our participants reported many techniques for addressing issues in ways that would not be perceived as overly assertive, disrespectful of another's expertise or effort, unilateral, or otherwise impolite, especially when they knew their edits would be visible.

In contrast, another participant, who used a tool that did not make edits easily visible, said that he sometimes deliberately made changes without telling a collaborator, to avoid a confrontation:

Like me and one other group member, we're pretty close friends, so we would talk about it. It'd be like "Oh, this person. I can't believe like, their writing is terrible. I don't want to be in a group with them ever again". But, it never got to the point where we confronted the person about it, necessarily. Because I would just go, and change it without her feedback. (Quintin, professional MS student)

Managing Relationships

In discussing these techniques, several participants explicitly noted the need for balance between actions focused on preserving relationships with group members – i.e., group maintenance – and actions aimed at improving the quality of their shared work. Richard, for example, was a student who discussed his attitude toward group projects:

So, my rule for group work is, generally, you're probably not going to get an A. There's always going to be someone who will want you to do something that will cause you to have a B. But it's much easier to get that B and remain pleasant with the group than it is to fight a long, hard battle with the group over something that, in the long run, will probably not be too effectual.

Mirah noted further that she uses comments and feedback to maintain a positive impression:

I always want to make sure that whoever I'm editing for knows that I've put time into reading their paper. I want to make sure that I've written comments, that I've given them useful feedback. At the same time, I don't want to hurt them because I'm being too harsh of their work. I'm always walking that line.

Some participants talked about managing social relationships by being conscious of others' impressions of them. David mentioned that he is conscious of when he makes edits, as he believes the timing of the edits in the trace history will inform others' impressions of him as an engaged and thorough collaborator:

I'm conscious of that when [my colleague] sends me a paper and he says ... I'll take a look at your edits on Monday. He'll be able to see if I did work on it Friday or Saturday or Sunday, or, you know, if I just did an hour's edits before giving it to him on Monday.

Finally, some participants referred explicitly to the impact of their editing behavior on their relationships with collaborators beyond the scope of the current project. For example, Ed, a professor, describes the lasting effect of an incident nearly eight years prior to our interview:

I had an incident in '03 where I was writing a paper, and the co-author and I didn't really talk very explicitly about how we were going to do the process. So I got the document. I spent like 20 hours one weekend doing a kind of major rewrite of it, because I thought we were sort of collaboratively authoring, and then she just rejected everything that I did as like, "It's my paper," and that led to a not very good collaborative feeling for a long time.

This was emblematic of several participants' feelings about edits perceived as rude or inconsiderate that impacted their relationship with collaborators, and often motivated them to seek other collaborators on future work. This can happen even in the absence of a strong emotional reaction:

If [a collaborator] changes my idea completely, then I'm like, 'I don't really want to work with them again.' But I'm not really unhappy about it, like "Oh my gosh. I can't believe they did this to me." I'm like maybe next time I shouldn't work with this person. (Vanessa, undergraduate)

Interpretation Strategies

We mentioned at the outset that reduced cues in online environments can affect the interpretation of messages and attribution of credit, blame, and motivation. We have seen that cues about a collaborator's edit actions can be interpreted in negative ways. While our participants described several strategies for mitigating the risk of having their edits perceived in such ways, it also was clear that several participants – especially those with more experience working with others – were able to reduce or avoid negative interpretations of edit actions taken by collaborators.

We found that there were three themes underlying the cases in which participants reported being able to do this.

Presentation style and habits of others

Some participants said they had to develop an understanding that something that might initially seem rude was actually the result of somebody else's routine, habit, or style; or even the way the software presented others' actions. Helen was one of several participants who noted that Track Changes often displays edits in red and that this contributed to a perception of them as harsh and negative in tone. However, she also noted that she's gotten used to this, and does not believe the edits are intended to be harsh:

especially when somebody has made all their comments red – there is the idea that you've done something wrong. But really, [that's] not [the case]; I think the more that I've done [the more] I've become used to it.

Tessa discussed how her adviser's blunt style of commenting upset her when she first began working with him, but after several terms of working together finds it easier to cope with. She cited knowledge of his habits as one of the reasons that she no longer gets as upset:

I just got used to [the fact] that that was his communication style. In the same breath he could make all of these sharp criticisms but then also send me an email that same day thanking me or making some other nice comment. So it was clearly separated for me in my mind.

Separating task from social relations

Other times, participants reported learning to assume that others' edits had been made with task-oriented intentions – that is, to improve the joint product. For Tessa, this meant taking her adviser's criticism “a little less personally”:

I think I'm able to have a little bit more of the perspective that he's taking on the role of a article reviewer and trying to help me by spotting out where other people would have criticisms or comments and kind of preempt those by helping me fill in the gaps. I mean I still regret that from the beginning it isn't more of a collaboration because I think that would be [more helpful than just acting as editor]. But I do appreciate that he's looking at it with a critical eye, like, ‘how would it be received by reviewers?’

Olivia had similarly positive thoughts about the value of feedback. She described it as an extremely important part of her interactions with collaborators and editors.

I feel like, I personally have a hard time making drastic changes to someone's paper just because I don't want to hurt their feelings. But as of now, being this far into my degree and studying information, I feel like feedback, receiving good feedback is really important. So now I'm not so concerned about that, because I would also want to receive the best feedback that I could.

Yolanda told us about a new member of her otherwise stable and established lab group, believing that he will adapt to receiving criticism in a more positive way just as she felt she did when she joined the group:

He's just new to the lab. He's not really that close to us. We try to be friendly. We can't break him in just yet. Whenever we break or rip apart his work, he takes it to heart. We tell him: listen, at the end of the day, the poster

is going to have all of our names on it. The manuscript is going to have all of our names on it. Don't take it to heart. We're doing this so that you can be a better writer in life, and that you could just learn from it. Then you could just be part of the team and build on it. I know he's having a hard time adjusting. Anybody would, just to have your work butchered. I was in that position when I was a sophomore and joined the team.

When asked about what she thought was important when writing with others, Helen said the following:

I think like the easy thing to say would be I don't want to seem like a loser to the person I'm coauthoring with. I want to find the mistakes that I've made before they find them. And be conscientious and upfront in our writing partnership about my own weaknesses and be willing to confront them so that we can be a stronger paper. I think for me one of the worst feelings is when someone feels like they can't critique your work because you're not going to be able to take it well. And so completely like putting the other writer at ease that you're willing to be critical ... in a way that sets up everybody to be critical.”

Helen's response also illustrates the fact that these issues (a) go both ways, and (b) are relevant not just to a single action or set of edits, but to a series of interactions or even a whole relationship. Indeed, collaboration often involves much more than a single editing pass, and often involves editing by multiple people. Helen discusses the focus on the task-oriented goal as setting the tone of a relationship, rather than a single interaction.

It is worth noting that it is apparent from participants' comments that focusing on edits as constructive criticism – rather than on their potential social meanings – was not their natural tendency when interacting in this way. Doing so required intent and learning.

DISCUSSION

We began with two questions about the social and relational implications of workspace awareness information in collaborative writing. The first was about how people interpret information about others' edits and behavior in shared documents; and the second was about how people take others' possible reactions into account in their own edits and behavior. Generally, we found that participants' reactions to others' actions were affected by social messages perceived in edits, and that many participants do consider how their edits will be interpreted. They try to mitigate the risk of conflict via annotation by ensuring that their edits are not perceived as excessive or unilateral.

Implications for Theory

From a theoretical standpoint, one key implication is that task-focused workspace awareness information – such as visible edits to a shared document – can have relational consequences. Our participants frequently saw edits, particularly when they were perceived as changes being made without the consensus or approval of the group, as a potential threat or personal criticism. This was exacerbated by the fact that edits are shown with little contextual information, so they can be (and were often) misinterpreted

as meaning more than the editor intended. As we think about awareness support for collaborative writing, we should therefore focus not just on task (as in [30] and [32]), but also on group maintenance.

Another point is that the conflicts participants described tended to be around relatively large or conceptual changes to documents. Some participants were sensitive to others' making changes to their grammar or spelling, but most were appreciative of these types of edits. Thus, simple change awareness may be suitable for smaller edits, but larger edits may require more attention to relationship management. Size, however, is only one way to assess the magnitude or impact of edits, so this issue merits further study.

Most commercially available systems used by our participants focus primarily on change awareness; that is, highlighting what was changed, when, and who made the change. This approach, in effect, takes "How did things get to be the way they are?" as its motivating question. This can be useful for minor changes and in cases described in [36], but relies on a conceptual model of the writing process that may not always be appropriate.

In contrast to this approach, the processes our participants described as being effective from a group maintenance standpoint had two closely related elements in common. First, they often sought to present changes to shared documents not as definitive revisions, but rather as options for moving forward along with some rationale. What is interesting here from a conceptual standpoint is that the purpose of the group editing features was not to track who changed what and when, but rather to signal attention to the document and frame *possible* changes.

We began the paper with a discussion of how awareness information is used to predict future behavior, and of the potential social value of ambiguity. We argue, in essence, that our participants appropriated the available tools (i.e., commenting) to increase ambiguity around the future state of the document, and then used this ambiguity as a way to propose changes without threatening their collaborators' autonomy. In other words, framing edits as possible future directions or tentative is a way to use ambiguity in being sensitive to others' possible reactions.

Second and relatedly, our participants described actions within shared documents that were shaped not only by awareness of what their collaborators had done in the past, but also anticipating their collaborators' future actions and reactions. This suggests that in thinking conceptually about collaborative writing we aim to ask not just "How did things get the way they are?", but also ask "What are we going to do next?" or "What will happen next?" A consequence of this shift is treating the shared document not just as a collection of past edits, but rather as information about a set of options for moving forward in multiple plausible directions. In the next section we describe some ideas for adopting this conceptual approach.

A second consequence of this shift is allowing for the anticipation of future action. That is, people act in shared documents not just to bring a document closer to its final state, but also because they believe others will react in particular ways or make particular changes. Their actions can also, deliberately or inadvertently, draw the attention of others. We therefore urge viewing the document as a negotiation space, in which all actions – not just explicit comments or feedback – are considered moves in the negotiation process that is the writing of a document together. We might generally frame actions in a document as moves in what Clark [8] describes as "joint action" – in which actions are understood (and assumed to be interpreted) within the larger context of a shared goal, which here is a complete document. As such, the way these moves are presented (as visible or invisible, for example), has significant consequences for the process.

Implications for Design

While much work has examined the functional problems involved in managing multiple versions [40] and resolving conflicts between them [35] – especially in contexts with parallel editing [22, 28], we argue that more consideration of collaboration's social dimensions is necessary. These include people's inevitable reactions to each other's behavior, and the management of relationships between collaborators. This can help avoid the negative social interpretations that our participants reported even in the absence of version conflict or explicit disagreement.

Consider Group Maintenance. Our results demonstrate clearly that participants were conscious not just of their writing tasks, but also of the relational consequences of these task-focused behaviors. They frequently took steps to avoid relational conflict by attempting to create ambiguity around the future state of the document, or by engaging in dialog (via face-to-face conversation or using commenting features) with collaborators. We urge designers to consider not just the task of writing, but also support for group maintenance activities such as conversation, explaining edits and sometimes hiding certain actions. Features in current systems such as chat (in Google Docs) and commenting are steps in this direction.

Additional steps could include hiding certain types of changes (e.g., grammar or spelling fixes) from other collaborators, or even the ability to make specific changes visible to only to selected collaborators. In some ways this is similar to Cohen et al.'s [10] suggestions for selective awareness in adversarial collaborations, but we believe these ideas would be useful in cooperative scenarios too.

This would, of course, necessitate some means for also making those collaborators aware of the possibility. This could be achieved, via options that collaborators could agree to such as "Only make me aware of major changes to this section" or "I agree that John can make changes to this section without notifying me." The fundamental point, however is that we consider ways to allow for some

changes to be made without drawing undue attention, while still allowing those who wish to make their edits visible (i.e., for a mentor editing a student's work) to do so.

Present Changes as Possibilities. First, we urge designers to think carefully about ways to visualize changes not as definitive alterations to a document, but rather as potentially ambiguous possibilities for moving forward. This could be as simple as changing a notification such as "John deleted XXX at 12:45 pm on June 3" to "John suggests deleting XXX..." or allowing users to classify certain changes as "suggestions" (or "strong suggestions").

It could also involve more sophisticated changes to writing systems, however. Documents could include multiple plausible versions, allowing for them to be visualized and manipulated with interfaces more akin to the "layers" metaphor in graphics applications (i.e., Adobe Photoshop) than to traditional word processing.

Consider features for new groups. As Leshed et al. [27] note, groups are frequently expected to work together with little knowledge or training about how to do so effectively. We saw that many of our participants developed strategies for interpreting the edits and feedback of others in ways that allowed them to work together more effectively – such as by learning about the habits of others and assuming that feedback was being presented constructively. These are skills that might be taught to new groups of collaborators.

Substantial intelligence has been built into software like Microsoft Word to anticipate common behaviors such as typing the date, misspelling a word or violating basic grammar. Similar features could be built in to help groups work together. Making substantial edits to text written by somebody else, for example, could automatically trigger the appearance of an optional comment box for explanation. Such features could help people anticipate the reactions of their collaborators and work more effectively together.

Limitations and Future Work

One limitation of this study is a limited range of participants. While we spoke primarily with students, many of our participants did have experience writing with others in both academic and professional contexts. Several of the professional master's students described prior work experience (though we did not ask them about this explicitly, so cannot report the exact number), and the librarians and faculty write as part of their current jobs. Undergraduates described writing mostly for course projects, but other participants described writing and editing academic (research) papers, film scripts, short stories, communications to the public, and product evaluations. It is possible that speaking primarily with students biased our sample somewhat and we do not claim our results generalize, but we do believe their breadth of experience provides exploratory lessons for others interested in collaborative writing. A systematically stratified sample for population and document types would be an excellent starting point for future work.

We also spoke with people who had worked in both voluntary and assigned collaborative groups; and spoke with more women than men. While we did not identify any systematic effects of either of these factors, it is possible that they could affect the prevalence of conflict. Finally, it is possible that people did not accurately recall their experiences, though we have no reason to believe this was the case, and this is common to all interview studies.

In future work we plan to use these results to develop a series of experiments that aim to identify specific sources of social and relational conflict in the group writing process. We also aim to work with system developers to improve and evaluate systems to support collaborative writing.

CONCLUSION

We have presented an interview study of how people write together, with a particular focus on the role of collaboration features in group maintenance. Results suggest that edits and comments often carry social meaning. They may be interpreted as harsh criticism or threats to autonomy, and can have emotional and relational impact. Moreover, participants reported being conscious of this as they work with others, but also noted that aspects of the way these edits are presented and visualized can affect their interpretation. Participants tried to present edits as possible changes, drawing on ambiguity about the future of the document. As such, we conclude by arguing that a conceptual shift may be warranted in how we support collaborative writing. We propose focusing less on answering "How did things get the way they are?" and more on "What is going to happen next?"

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REFERENCES

1. Aoki, P. and Woodruff, A. Making space for stories: ambiguity in the design of personal communication systems. In *Proc. ACM CHI* (2005), 181-190.
2. Bazarova, N. and Walther, J. Attribution of blame in distributed work. In P. Lutgen-Sandvik and B. D. Sypher, eds. *The destructive side of organizational communication*. Routledge, New York, 2009.
3. Bietz, M. J. Effects of communication media on the interpretation of critical feedback. In *Proc. ACM CSCW* (2008), 467-476.
4. Birnholtz, J., Guillory, J., Hancock, J., Bazarova, N. "on my way": Deceptive Texting and Interpersonal Awareness Narratives. In *Proc. ACM CSCW* (2010), 1-4.
5. Boehner, K. and Hancock, J. Advancing Ambiguity. In *Proc. ACM CHI* (2006), 103-107.
6. Brown, P. and Levinson, S. *Politeness: Some universals in language usage*. Cambridge Press, New York 1987.

7. Bryant, S., Forte, A. and Bruckman, A. Becoming wikipedian: transformation of participation in a collaborative online community. In *Proc. ACM Group* (2005), 1-10.
8. Clark, H. H. *Using language*. Cambridge Press, New York, 1996.
9. Cody, M. J. and McLaughlin, M. L. Interpersonal accounting. In H. Giles and P. Robinson, ed. *Handbook of language and social psychology*. Wiley and Sons, London, 1990.
10. Cohen, A. L., Cash, D. and Muller, M. Designing to Support Adversarial Collaboration. In *Proc. ACM CSCW* (2000), 31-39.
11. De Dreu, C. K. W. and Weingart, L. R. Task versus relationship conflict, team performance, and team member satisfaction: A meta-analysis. *Journal of Applied Psychology*, 88(2003), 741-749.
12. Dourish, P. and Belotti, V. Awareness and Coordination in Shared Workspaces. In *Proc. ACM CSCW* (1992), 107-114.
13. Endsley, M. R. Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors*, 37, 1 (1995), 32-64.
14. Glaser, B. G. and Strauss, A. L. *The discovery of grounded theory: strategies for qualitative research*. Aldine de Gruyter, Hawthorne, NY, 1967.
15. Goffman, E. *Behavior in Public Places*. The Free Press, New York, 1963.
16. Goffman, E. *The presentation of self in everyday life*. Anchor Books, New York, 1959.
17. Gutwin, C. and Greenberg, S. A descriptive framework of workspace awareness for real-time groupware. *CSCW*, 11(2002), 411-446.
18. Hackman, R. The design of work teams. In J. Lorsch, ed. *Handbook of organizational behavior*. Prentice-Hall, Englewood Cliffs, NJ, 1987.
19. Hancock, J. T., Birnholtz, J., Bazarova, N., Guillory, J., Perlin, J. and Amos, B. Butler lies: awareness, deception and design. *Proc. ACM CHI*(2009), 517-526.
20. Heath, C. and Luff, P. *Technology in Action*. Cambridge Press, Cambridge, UK, 2000.
21. Huberman, A. M. and Miles, M. B. Data management and analysis methods. In Lincoln and Denzin, ed. *Handbook of Qualitative Research*. Sage, Thousand Oaks, CA, 1994.
22. Ignat, C. L. and Norrie, M. C. Multi-level Editing of Hierarchical Documents. *CSCW*, 17, 5-6 (2008), 423-468.
23. Kim, H. C. and Eklundh, K. S. Reviewing practices in collaborative writing. *CSCW*, 10(2001), 247-259.
24. Kittur, A., Suh, B., Pendleton, B. A. and Chi, E. He says, she says: conflict and coordination in Wikipedia. In *Proc. ACM CHI* (2007), 453-462.
25. Kraut, R., Galegher, J., Fish, R. and Chalfonte, B. Task Requirements and Media Choice in Collaborative Writing. *HCI*, 7(1992), 375-407.
26. Leland, M. D., Fish, R. S. and Kraut, R. E. Quilt: A collaborative tool for cooperative writing. In *Proc. ACM CSCW* (1988), 206-215.
27. Leshed, G., Perez, D., Hancock, J., Cosley, D., Birnholtz, J., McLeod, P. and Gay, G. Visualizing Real-Time Language-Based Feedback on Teamwork Behavior in Computer-Mediated Groups. In *Proc. ACM CHI* (2009), 537-546.
28. Lukosch, S. and Leisen, A. Comparing and Merging Versioned Wiki Pages. In *Proc. WEBIST* (2009), 159-173.
29. Neuwirth, C. M., Chandhok, R., Charney, D., Wojahn, P. and Kim, L. Distributed Collaborative Writing: A comparison of spoken and written modalities for reviewing and revising documents. In *Proc. ACM CHI* (1994), 51-57.
30. Neuwirth, C. M., Kaufer, D. S., Chandhok, R. and Morris, J. H. Computer Support for Distributed Collaborative Writing: A Coordination Science Perspective. In G. M. Olson and T. W. Malone, ed. *Coordination Theory and Collaboration Technology*. Lawrence Erlbaum Assoc, Mahwah, NJ, 2000.
31. Noel, S. and Robert, J.-M. Empirical study on collaborative writing: what do co-authors do, use and like? *CSCW*, 13(2004), 63-89.
32. Posner, I. and Baecker, R. How People Write Together. In *Proc. HICSS* (1993), 127-138.
33. Scott, M. B. and Lyman, S. M. Accounts. *American Sociological Review*, 33(1968), 46-62.
34. Sudnow, D. Temporal parameters of interpersonal observation. In D. Sudnow, ed. *Studies in Social Interaction*. Free Press, New York, 1972.
35. Sun, C. and Chen, D. Consistency maintenance in real-time collaborative graphics editing systems *ACM TOCHI*, 9, 1 (2002), 1-41.
36. Tam, J. and Greenberg, S. A framework for asynchronous change awareness in collaborative documents and workspaces. *IJHCS*, 64(2006), 583-598.
37. Walther, J. Computer-mediated communication: Impersonal, interpersonal, and hyperpersonal interaction. *Communication Research*, 23(1996), 3-43.
38. Watts, R. J. *Politeness*. Cambridge Press, Cambridge, UK, 2003.
39. Wuchty, S., Jones, B. F. and Uzzi, B. The increasing dominance of teams in production of knowledge. *Science*, 316, 5827 (2007), 1036-1039.
40. Xue, L., Orgun, M. A. and Zhang, K. A Multi-Versioning Scheme for Intention Preservation in Collaborative Editing Systems. *CSCW*, 17, 5-6 (2008), 509-551.