VISUALIZATIONS FOR COMPUTER MEDIATED GROUP CONVERSATIONS: EXPLORING THE INFLUENCES OF AGGREGATED AND ARTICULATED DATA VISIBILITY ON GROUP DYNAMICS

BY

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Computer Science
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2013

Urbana, Illinois

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ABSTRACT

Groups are becoming increasingly geographically distributed and consequently, computer mediated group conversations are also becoming increasingly distributed. There has been much research that has focused on visualizations that would best assist such computer mediated conversations. Additionally, several theories about group conversations and visualizations have also been developed. In this research, we explore the applicability of one theory in particular called the *Social Translucence Theory*, which, amongst other things, advocates that individuals in group conversations attempt to conform to the group's dynamic when individual level information is made available publicly to the entire group. The theory also states that one of the main reasons behind such behavior is the sense of accountability that accompanies making individual level information public. We present a study designed to investigate if the effects of Social Translucence theory can co-exist with anonymity and if group conformity occurs even without individual level information being made public. We found that user behavior patterns did not exhibit significant differences in the two conditions with different levels of data visibility, which suggests that anonymity and accountability in group conversations might not be as key a factor as previously thought to be. In this thesis, we discuss the following: 1) Group conversation theories 2) Experiment rationale and design, 3) visualizations to accompany group conversations and 4) study results.

To my parents and my brother

ACKNOWLEDGEMENTS

I would first like to thank my adviser, Professor Karrie Karahalios, who has been an amazing source of support, encouragement and guidance throughout graduate school. If not for her, this research would have never succeeded. I am also grateful to Professor Brian Bailey for all his guidance throughout my stay here at UIUC.

I am also grateful to John without whom I could have never completed the user studies, and to Jessica for all her help with the design aspects of the system. I'd also like to thank Pooja, Mary, Jennifer, Motahhareh, and Liam for being the awesome fellow researchers that they are.

Last but certainly not the least, I have to thank my parents and my brother for always being there for me when I most needed them. I wouldn't be where I am today without them.

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CHAPTER 1

INTRODUCTION

It has often been said that a picture is worth 1000 words. Images and visualizations minimize shifts of attention and help convey information in a much simpler manner. From media outlets such as the New York Times to large corporations to universities, visualizations are used everywhere to help end users understand data better.

In everyday interactions, people don't realize patterns and trends in the way they communicate with others. Reflective interfaces, or social mirrors, are interfaces that help people understand just this. In this thesis, we investigate the effects of visualizations on group conversations and how it affects user behavior. We discuss the design and implementation of the visualization and we also present a study conducted to ascertain the effects that visualizations could possibly have on users engaged in distributed text-based group conversations.

We also discuss the theory of social translucence and analyze each of the social design aspects that it consists of, namely visibility, awareness and accountability. Specifically, we investigate the influence that visibility and accountability have on participants of a group conversation who are shown visualizations that help them reflect on language use and participation.

The thesis is structured as follows; Chapter 2 discusses related work, Chapter 3 presents the experimental design, Chapter 4 discusses results and Chapter 5 concludes this thesis.

CHAPTER 2

LITERATURE REVIEW

The following sections discuss related work in the fields of group dynamics and visualizations for group conversations.

2.1 Group Dynamics

In one of his most seminal works on group dynamics, Forsyth describes the different sizes of groups and how most groups usually consist of two members [7]. He mentions that members of such dyads are also sometimes linked by a unique and powerful type of relationship love that makes their dynamics more intense than those found in other groups. Forsyth also mentions that larger groups have unique qualities, such as members rarely being connected directly to all other members, and likelihood of subgroup formation being low, and that one or more leaders may be needed to organize and guide the larger groups.

Forsythe also brings up interesting theories on group loafing. He mentions that even when factors that produce group loafing are eliminated and when members are made identifiable and when each individual is promised a substantial reward for performing well and when group cohesion is high, smaller groups performed better at group tasks as compared to larger groups. This is an interesting finding in the area of group dynamics as it shows that smaller groups are more effective than larger groups.

Kiesler and Sproull compare differences between triads and quads. One of the key differences reported by them is that it takes approximately 4 times as long for a three person group to

make a decision in a real-time computer conference as face-to-face [12]. They also report that it takes 10 times longer in a four person group that lacks time restrictions [11]. They explain three possible causes for these effects. First, the network could have been slower because of heavier usage. However this problem is not relevant these days given increased network speeds. Second, despite simultaneous sending and receiving, it takes people longer to type and read than to talk and listed. Third, the lack of nonverbal backchannel feedback [13] in electronic discussions causes members to have trouble figuring out how others are taking their messages, how confident others are, and when the group is ready to come to final agreement. In this thesis, we present a system that allows users to communicate with each other through a browser based chat interface, and not a system that aids face-to-face conversations.

Kiesler and Sproull also talk about the time to consensus. They mention how electronic communication could disrupt group process but also mention ways to deal with the problem. For instance, they mention that groups could use voting techniques or explicit decision rules rather than to talk things out and systems such as Conversation Votes [6] are good examples of this. Otherwise if electronic decision required consensus, then an electronic group has to work harder to get consensus than a comparable face-to-face group does.

In her doctoral work, Leshed discussed several aspects of group conversations and specifically focuses on aspects related to teamwork in a group setting [1]. She discusses different styles of visualizations to support group conversations and also discusses experiments that were conducted to determine if feedback effects change in participants. She focuses on two specific aspects of group conversations; participation and linguistic features characteristic of teamwork

oriented behavior. Using peer evaluations based on the SYMLOG definitions for teamwork behavior [14] and linguistic feature usage extracted from conversation transcripts, she was able to determine what linguistic features defined teamwork behaviors.

2.2 Visualizations for Group Conversations

Visualizations for group conversations have been designed either as feedback interfaces for personal reflection, or as feedback interfaces to effect change in participants' behavior. That said, different visualizations have focused on different aspects of participants' behavior. The following paragraphs will discuss a few such systems.

One of the most influential and pioneering works in the area of visualizations for groups and social networks stemmed from Erickson and Kellogg's work on laying down the foundations of the theory of Social Translucence [3]. In a nutshell, socially translucent systems are those that have the characteristics of visibility, awareness and accountability. The authors also present Babble, a system that was designed to support long term conversations between members of groups by using textual and graphical representations to augment existing conversations [3].

In Babble, each conversation was supplemented with additional information such as timestamps and participant names. It was one of the earliest systems that embodied the principles of social translucence as it improved the visibility of conversations and also allowed for asynchronous browsing and discovery of conversational contexts and conversational norms. Babble also introduced a visualization that represented conversations and the participants associated with conversations. The authors discuss social proxies and provide examples for the

kind of information associated with group conversations, which can be represented by social proxies. An example of such a social proxy is shown in the following figure.

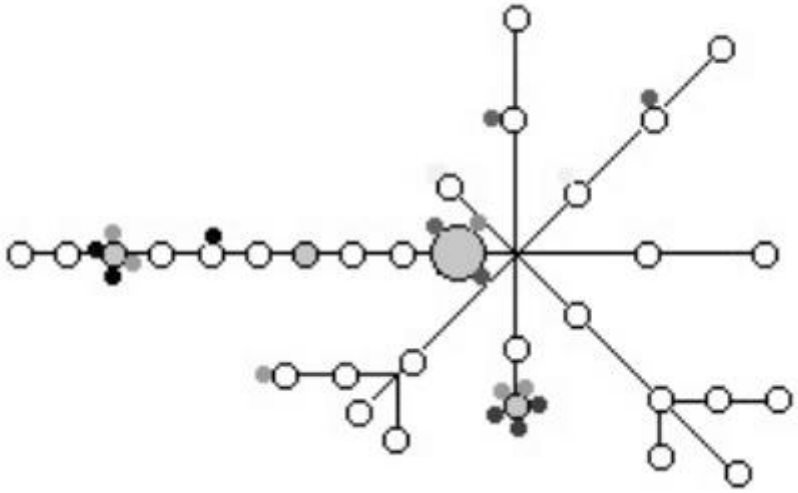

Figure 1. An example of a social proxy [3].

In this figure, larger circles represent conversation topics, and filled circles indicate new information. Participants are represented by smaller dots. Another example of a social proxy is shown in the figure below.

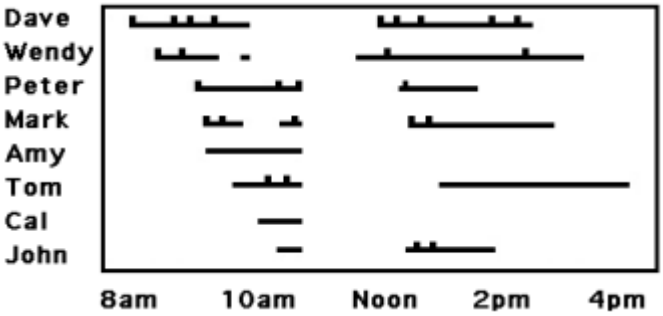

Figure 2. Another example of a social proxy [3].

Participant activity in a conversation is displayed by lines and dots, with a line indicating presence and a dot indicating speaking. These are a few examples of early social visualizations that have paved the way for newer and more graphically advanced visualization systems.

Leshed discusses GroupMeter, a chat system that analyzes group conversations and provides visual indicators of participation and language use [1]. Her findings indicate that providing dynamic real-time feedback can help participants to improve their teamwork behaviors.

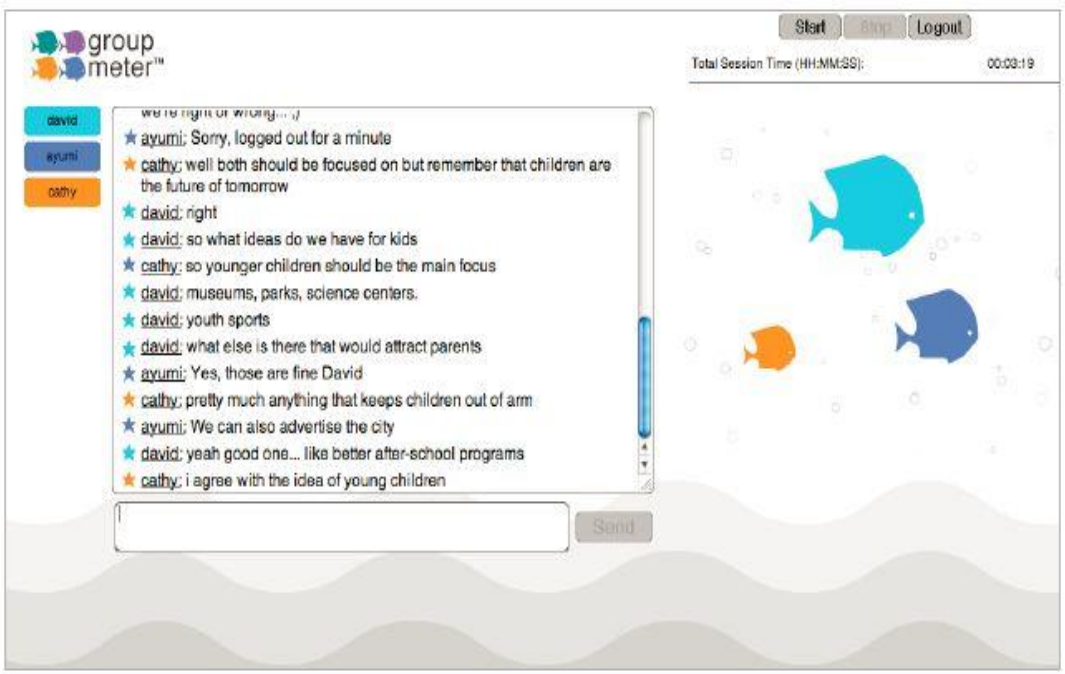

Figure 3. The GroupMeter interface [1].

DiMicco conducted experiments to determine if a participation feedback display would have any effect on participants and found that over-participators reduced participation [2].

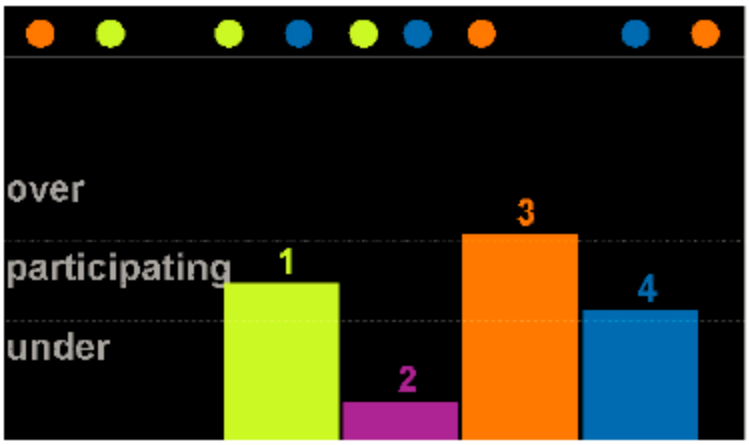

Figure 4. DiMicco's interface [2].

Her studies also showed that under-participators, although not substantially affected by the real-time participation feedback display, did change their behavior when exposed to a replay visualization that allowed them to reflect on their behavior in an asynchronous setting.

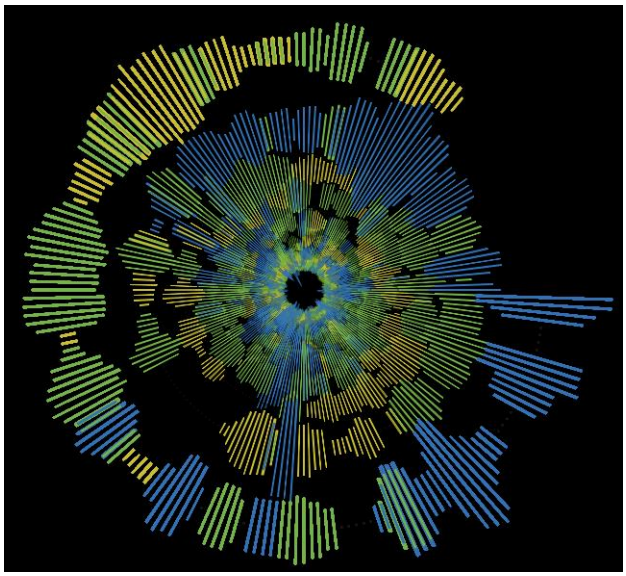

Figure 5. Conversation Clock [5].

Bergstrom and Karahalios introduce the concept of social mirrors in Conversation Clock [5], a system that displays participant contribution in a group conversation. The Conversation Clock visualization consists of concentric circles of bars which vary in size based on decibel level of audio input from the conversation. By glancing at the visualization, one can easily identify the over-participators as well as the under-participators in the conversation. The Conversation Clock visualization system was specifically built for co-located groups engaged in face to face conversations. Some salient features of the visualizations include its ability to represent simultaneous speakers as well as its ability to represent silence in conversations.

Conversation Votes by Bergstrom and Karahalios is a system that supplements face-to-face collocated interaction [6]. It builds on the concept of social mirrors, and introduces a backchannel that enables users to visualize their contribution to a group conversation. In addition to this, the system also takes in feedback from users in the form of votes, which signify

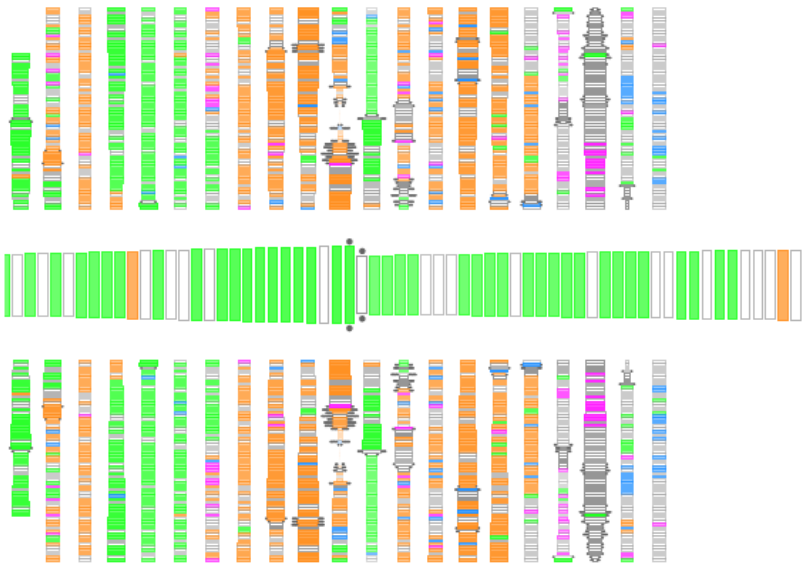

Figure 6. Conversation Votes [6].

what users think of what is being said at that moment. If users wish to encourage the current speaker, they can provide a positive vote, and if they wish to discourage the current speaker, they can provide a negative vote.

By incorporating user feedback, the Conversation Votes system extends the idea of a social mirror by not only serving as a reflective visualization system, but also serving as a supplementary communication medium that enables users to convey additional information to other users in the group conversation.

Conversation Clusters by Bergstrom and Karahalios, is a visualization system that represents salient moments of a co-located conversation in the form of word clusters [10]. The backend system detects topics based on latent semantic analysis, and this information is used to create a real-time stream of word clusters, that represent the current 'state' of a conversation. This is an

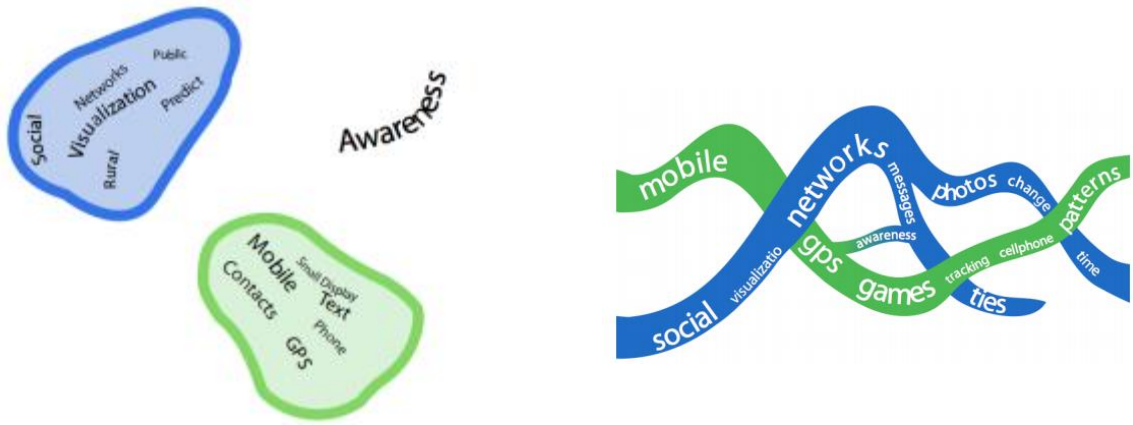

Figure 7. Conversation Clusters [10]

example of a reflective visualization that uses a combination of text and graphics.

Taking a look at earlier systems in this domain, Chat circles, by Donath and Viegas was one of the earliest systems to exploit shapes to represent activity in chat conversations [4]. The visualization represents participants as unique colored circles and each message associated with a participant causes the corresponding circle to grow. Silence in the conversation is represented by the fading of circles. Chat logs are stored in the form of abstract shapes as well as shown in Fig. b below. Each participant is represented by a unique colored thread and the lines on the thread represent moments of activity and inactivity.

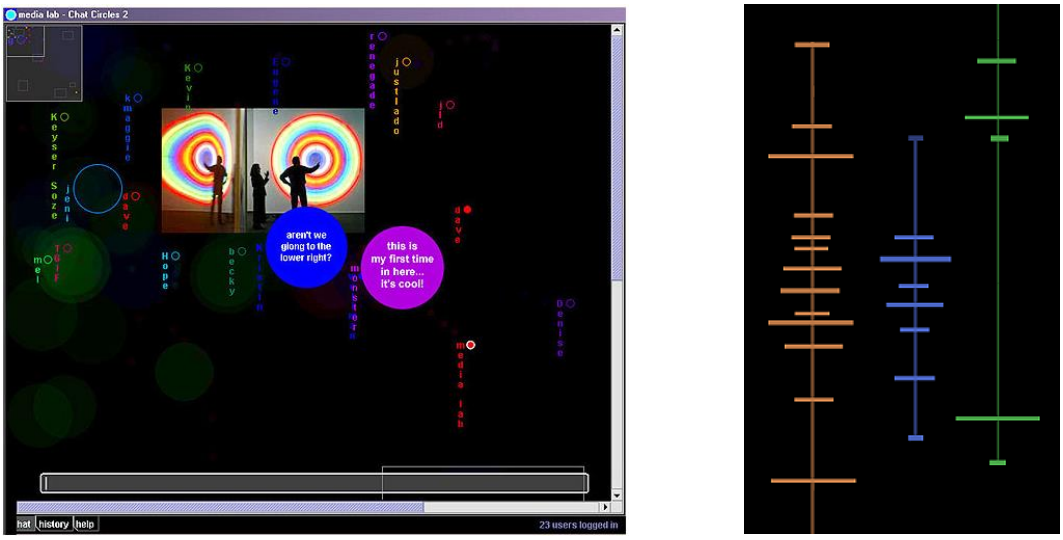

Figure 8. Chat Circles [4].

CHAPTER 3

EXPERIMENTAL DESIGN

3.1 Visualization Design

3.1.1 Evolution of Visualization Designs

This section discusses the evolution of the visualization design and discusses the rationale behind moving from one design to another.

3.1.1.1 The Circles Visualization

The first visualization design was designed around circles. In short, the color of a circle would

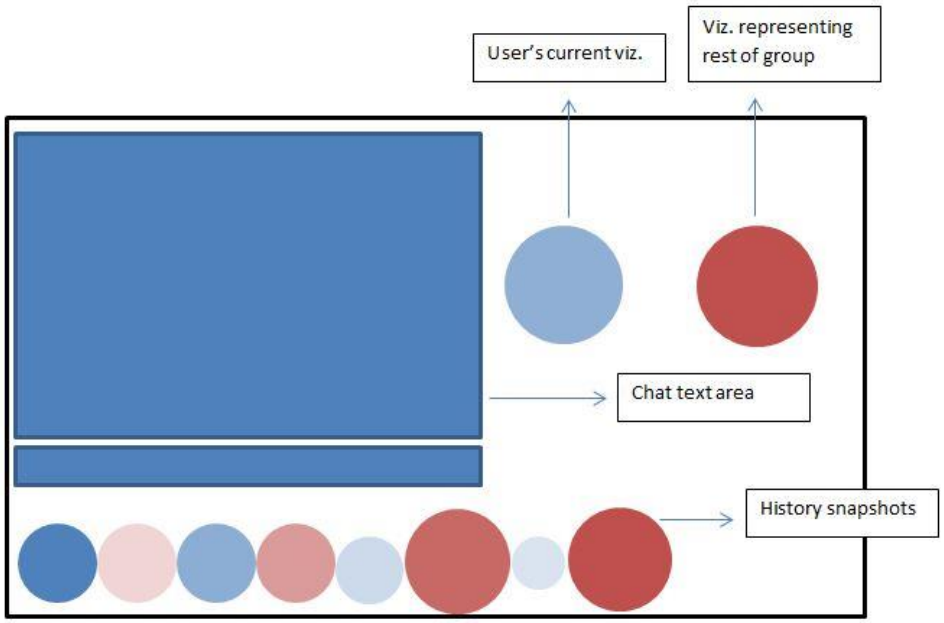

Figure 9. A mockup of interface with circles visualization. The two circles on the top-left represent the current 'snapshot' and circles on the bottom represent a flowing history of 'snapshots'.

represent a unique person, its size would represent participation percentage corresponding to the person, and its transparency would represent linguistic use behavior. In addition to a cumulative display, there would also be a history section where users could browse through visualization snapshots at different instants of time. This visualization however had shortcomings.

Firstly, the visualization did not have any indicators that would enable participants to infer their participation and linguistic behavior relative to the maximum possible attainable value. Secondly, the visualization seemed complex and was not intuitive enough to use. The interface also seemed cluttered with the history visualization on the bottom. All these factors collectively suggested that a new design would be needed.

3.1.1.2 Horizontal Bars Visualization V.1.

The second iteration of the visualization design focused on overcoming the shortcomings of the circles visualization. This design used horizontal bars to represent the data. Participation was represented by the length of each bar, and linguistic behavior was represented by the thickness. The main shortcoming of this design was that the change in thickness was not very intuitive and participants would not be able to get a sense of the limits of thickness of the bars.

Figure 10. Screenshot of a conversation in progress. Thickness of bars represents linguistic behavior and length of each bar represents participation.

3.1.1.3 Horizontal Bars Visualization V.2.

The third iteration of the visualization design focused on making the visualization more intuitive. We kept most of the design the same from the earlier iteration. However, all bars remained the same width at all times, and the transparencies of the bars were changed to reflect change in linguistic behavior. In addition to this, we also applied a 5px border to each bar, as shown in the figure below, to enable users to understand what the maximum possible attainable saturation was.

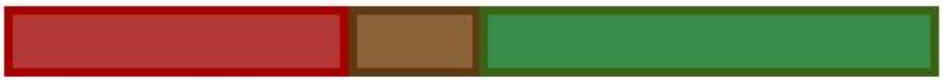

Figure 11. Visualization with 5 px border

3.1.1.4 Horizontal Bars Visualization V.3.

One issue that we had with the previous iteration of the design was that there was no way of explicitly telling whom each bar represented. To overcome this, we explored multiple options.

In our first attempt to link each bar with its corresponding participant, we explored the possibility of exploiting the positions of bars. The first iteration involved representing each user's bar in the center, with a triangle above it to indicate that that was the user's bar, as shown in the figure below.

Figure 12. Visualization with user's bar in the center.

However, we did have the concern that representing the user in the middle would not be the best option since research has shown that users generally scan from left to right.

To overcome this, another design that we explored displayed the user's bar in the left most position, and also used a triangle to represent the user's bar, as shown in the figure below.

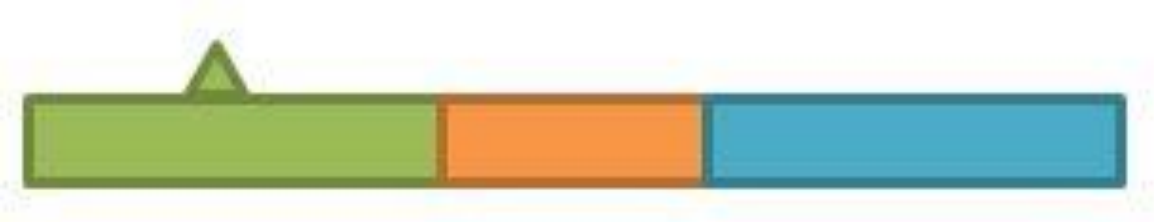

Figure 13. Visualization with triangle to represent user

However, the design lacks symmetry, and this led to the next iteration, where we discarded the idea of using a triangle marker and went instead for a traditional legend representation, as shown in the figure below. As for position, we decided to represent the current user's bar at the left most position instead of displaying it in the middle segment.

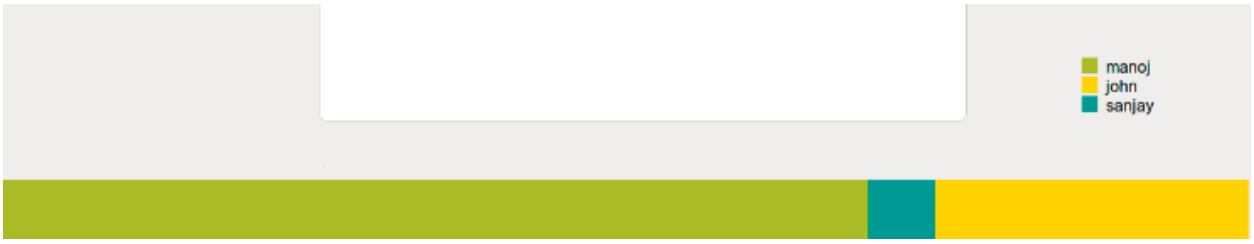

Figure 14. Shows what the visualization would like for user 'Manoj'

3.1.1.5 Horizontal Bars Visualization V.4.

The visualization design was further updated in the next iteration with the objective of making the interface more inviting and user-friendly. The interaction flow was redesigned to make it more user-friendly. In addition to this, the user interface was also redesigned to make it more user-friendly and to make it more accessible to users with color-blindness. Shown below are the control and treatment visualizations representing the same point in a conversation. As is evident, the control visualization makes individual statistics public to all members of the group,

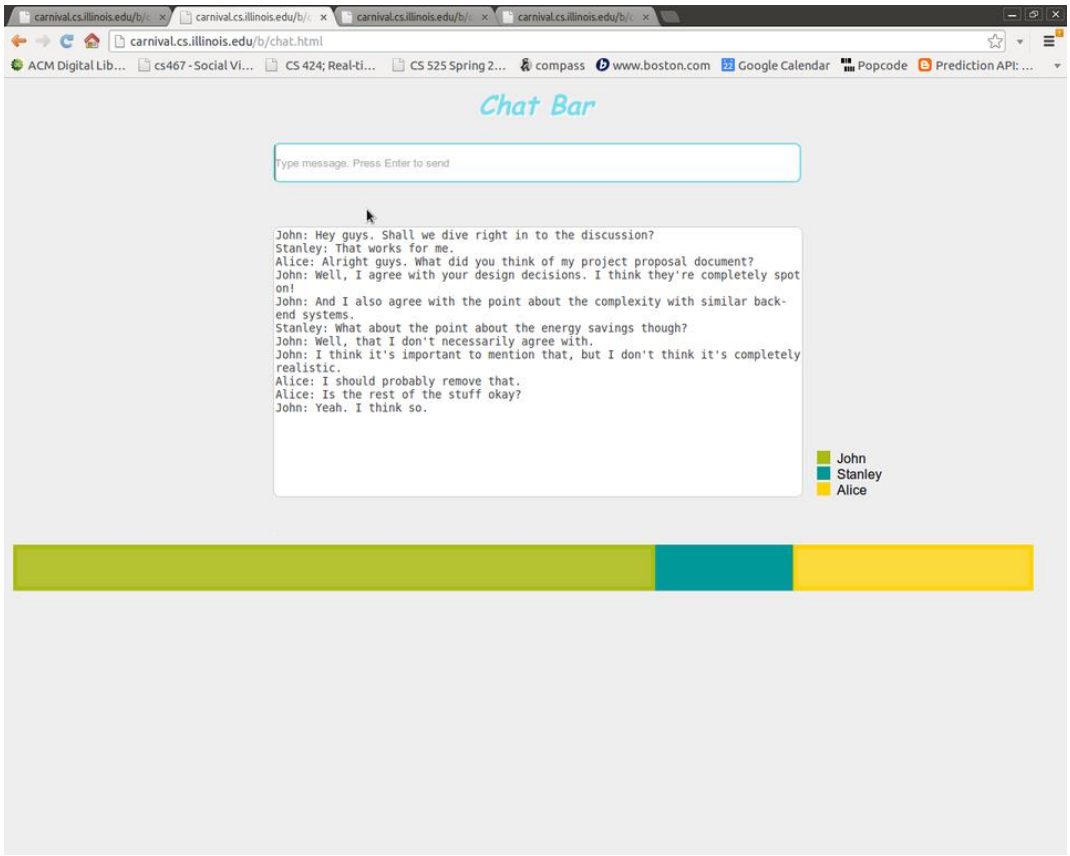

Figure 15. Control Visualization

whereas the treatment visualization shows every user only the user's stats and the rest of the group's stats.

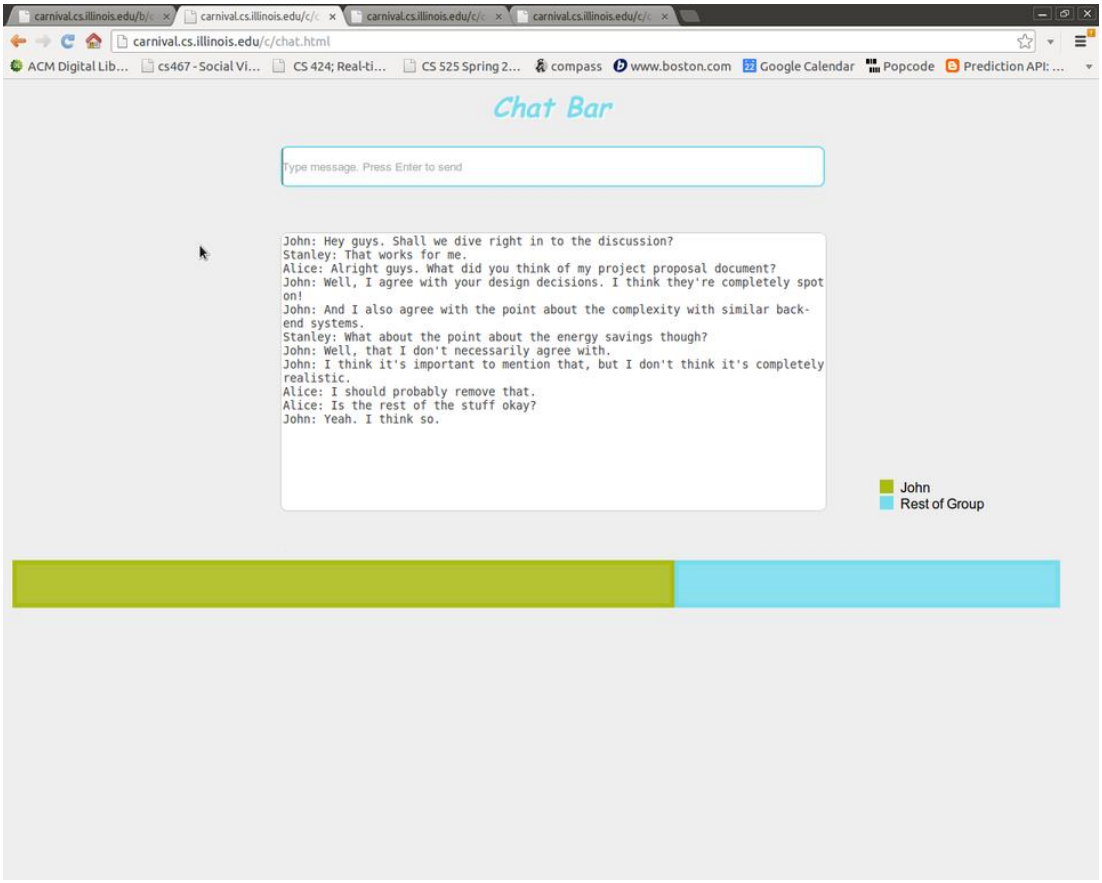

Figure 16. Treatment Visualization

3.2 Experimental Design

The study involved participants chatting with each other through our browser based interface, engaged in a decision making task. Decision making tasks were chosen specifically as they have been shown to cause groups to conflict rather than cooperate [7]. In addition to this, groups with higher levels of disagreement during the group process have been shown to promote better discussion between group members [9].

The study involved groups of three people each. While this may seem like a small group on the outset, it is important to note that research has shown that conformity and the influence that one member's decision has on another member's decision within a group, rises only until group sizes of 4, after which it increases only slightly [16]. That said, there would likely not be a significant difference between studies involving groups of sizes 4 and groups of size 16, as is evident from the Asch tests [16].

Prior to the commencement of the study, we used power statistics theory and estimated that the number of participants we would need to obtain statistically significant results was approximately 35 participants. We recruited 48 students for the studies and each participant was offered $15 in exchange for participation. Each study session involved a three member group of participants. The students came from different schools within the university and did not know each other. Each study session lasted about 1 hour and 40 minutes, and consisted of four different segments of 20 minutes each.

There were three unique conditions that we had in the study:

A : no visualization (baseline)

B : individual level information available to entire group (control)

C : group level information available to entire group (treatment)

Each study session was either labeled "ABCA" or "ACBA", with the order of letters representing the order in which the different visualizations were shown to participants. The rationale behind repeating the no visualization condition at the end of the each study was to test for any

carryover effects that the visualization might have had. The rationale behind mixing the order of visualizations was to eliminate any novelty effects that any of the visualization conditions might have had.

Once all participants had arrived for the study, they were requested to sign the necessary consent forms. They were told that they would be helping us investigate the effectiveness of different styles of visualizations in computer mediated group conversations. They were also told that they would be engaged in web-based chat conversations with the other participants, and that the study would be divided into four different segments, interspersed with questionnaire filling sessions.

Participants were also told that the chat system would be monitoring their participation and language use. They were told that higher disagreement with group members would constitute better language use and that higher agreement would be considered as non-ideal language use. Before they began a segment with a visualization, they were shown printed screenshots of the visualization through the progression of a sample conversation. We then explained to them what the size and transparency of each rectangle, or bar, represented. After this, participants were seated in different rooms to simulate a distributed environment.

3.3 Queries by Participants

Through the course of the study, participants shared some of their insights into the study, the system and the discussion topics. Some of these are discussed in this section.

We heard from multiple participants that the discussion topics that were provided were very good and that it really engaged them in meaningful conversation with the rest of the group. Another interesting question that we were asked by a participant was if we were explicitly asking him to disagree with the other group members. We then clarified that we were just providing him with information about research on group processes and that he could use and interpret this information in any way he wished to.

Other participants seemed interested in how exactly agreement and disagreement usage was being tracked by our system. Some even seemed pretty amazed at the fact that the tracking could be done automatically. Another interesting question that was asked was whether participants were supposed to be looking at the visualizations and using that information, despite being told that they could interpret and use the visualizations in any manner they desired, and that the visualizations were simply portraying information about their participation and language use. Another participant asked us if he was supposed to be trying to ensure that his bars were large and opaque and that if he should be trying to game the system. This is interesting because it brings out the factor of competitiveness that such social mirrors usually effect, albeit not purposefully.

Two groups felt that the time provided for two of the tasks was excessive and the group arrived at consensus before the expiry of the 20 minute period.

3.4 Data Analysis

To analyze the data, we used a nested ANOVA model. Instead of splitting up the data into two individual groups representing the 'ABCD' and the 'ACBD' conditions, we decided instead to treat it as a single data set. We decided to use actual participation and language use numbers instead of percentage change between conditions. Task order was treated as a between subjects factor and group was treated as a nested factor.

We modeled all the participants as nested under their respective groups and this was possible using some native libraries of R. We then analyzed how participation and language use were affected by each type of visualization, and if they were affected by visualization ordering. In the following section, we discuss the results of the data analysis in detail.

CHAPTER 4

DISCUSSION AND RESULTS

The first aspect of this thesis that we'd like to discuss here is that of the motivation behind this study. Much of the existing literature on reflective interfaces and the influences that they have on users in group processes are based on the theory of social translucence, and they advocate that accountability and visibility in a group conversation can alter user behavior. Our hypothesis for this study was that the influences of the visualizations on participation and language use would not be significantly different in the two different conditions, one where individual user data was shown to all participants and one where only group aggregate data was shown to the participants. In other words, our hypothesis was that visibility and accountability in a group conversation would not have a significant influence on participation and language use of users.

One of the main questions that we asked ourselves as we were building the system was about the potential use cases for the system and when and where it could be used. We envision the system potentially being used as a supplement to group meetings where participants aren't very familiar with each other, and when the conversation is happening in a distributed or non co-located setting. We even envision the system being used in environments such as discussions within the UN and EU, apart from being used in meetings in typical corporate settings. If used in a replay mode, the system can also be used in a post-hoc manner to help users understand more about how they 'performed' in the conversation and how they could potentially improve their performance. While 'performance' might mean different things to different people, the fact that it is a reflective interface means that it could still help users

interpret their performance better, thus equipping them to alter their characteristics as required.

The study had 48 participants, each assigned to a group of 3 participants, thus totaling 16 groups. Each group was randomly assigned to either an ABCD condition or an ACBD condition, to account for task ordering. Since participants were in different groups, we applied a nested ANOVA model during the analysis to account for any influences that group dynamics might have had on each participant's participation and language use. After ensuring significance from the ANOVA, we applied post-hoc tests to compare the distributions.

In the following parts of this section, we present detailed results of our study and explain the approach taken in performing the data analysis.

4.1 Influences on Participation

We were interested in determining how participation varied based on the type of visualization shown to participants.

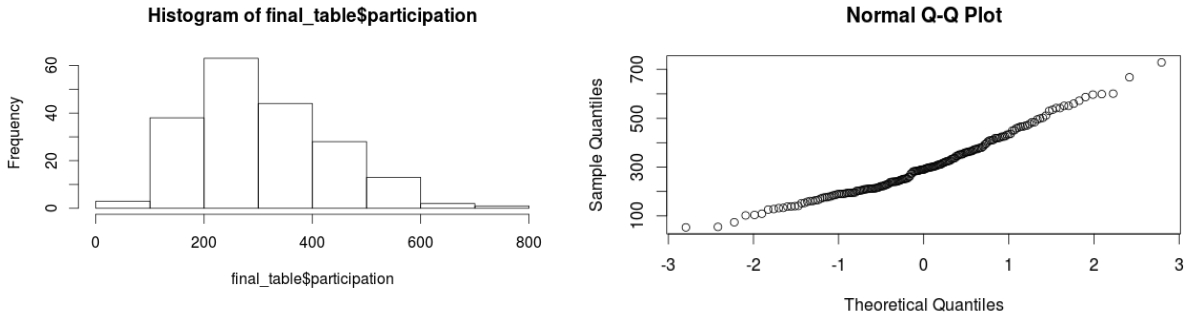

Figure 17. Distribution of participation data

Since participants were assigned randomly to specific groups each of which either showed the visualization in the ABCD order or the ACBD order, we also included order of visualizations in the analysis that we performed.

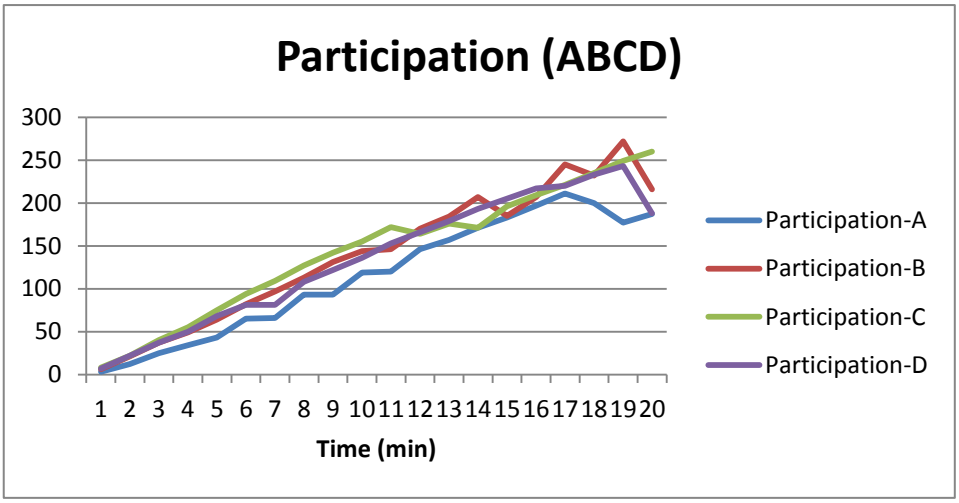

Figure 18. Graph showing how participation varied on average across a conversation in the ABCD condition.

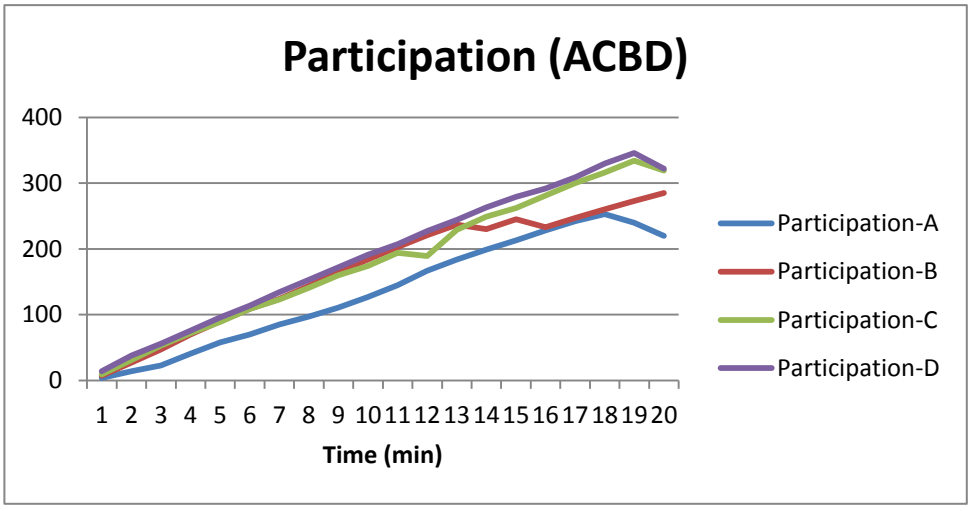

Figure 19. Graph showing how participation varied on average across a conversation in the ACBD condition.

We found that the visualization ordering by itself seemed to have an effect on participation ($p = 0.05$). Participants in the ACBD condition seemed to have greater participation than those in the ABCD condition(ABCD: 276 words, ACBD: 335 words, $p<0.05$) . However, visualization ordering did not seem to affect the influence that the individual visualizations had on participants. That is, the interaction effects between the two factors were not significant.

We also found that the type of visualization had a significant effect. There was a significant difference between the A and C conditions(A: 264 words, C: 336 words, $p<0.1$), but not between the B and C conditions, which confirmed our hypothesis that aggregated data visibility would have the same effects on participation as would articulated data visibility.

Condition	**Mean**
A	264.1
B	308.9
C	336.6
D	315.1

Table 1. Visualization conditions and their participation means (word count)

4.2 Influences on language Use

We found that visualization ordering did not have an effect on either disagreement or agreement words. However, the type of visualization did have an effect on both. We found that the disagreement word usage was higher in conditions B and C as compared to that of A (A: 5.52 words, B: 8 words, C: 7.75, p=0.01), but did not observe a significant difference between conditions B and C. This provides support towards our hypothesis since both the visualization conditions seem to have similar influences on language use, as far as disagreement phrase usage is concerned.

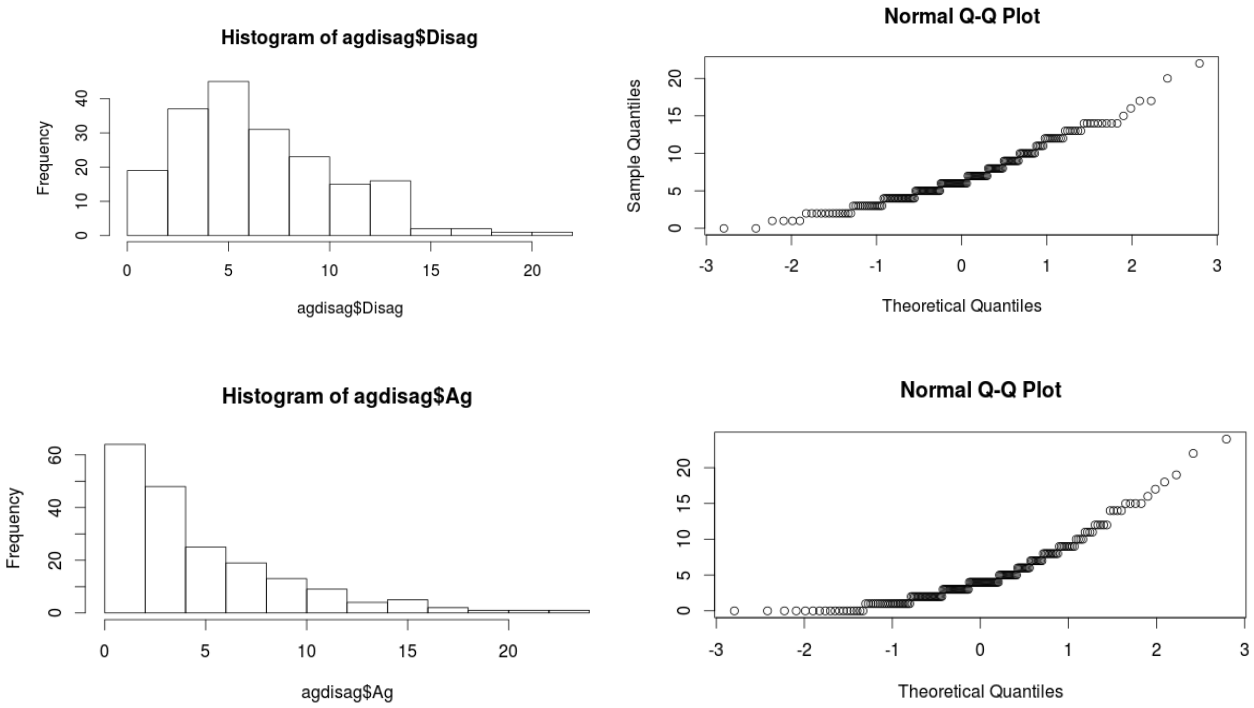

Figure 20. Clockwise from top-left: The first two images describe the distribution of the disagreement statistics. The second pair of images describe the distribution of the agreement statistics.

As for agreement words, we did not find any significant differences between conditions A and B or A and C. However, we found that participants seemed to agree more in condition D than in condition A (A: 3.3 words, D: 6.9 words, p=0.004), which could have been because of the fact that condition D was towards the end of the study.

Condition	Disagreement mean	Agreement mean
A	5.52	3.31
B	8.08	4.62
C	7.75	5.37
D	6.95	6.97

Table 2. Visualization conditions and corresponding agreement and disagreement phrase usage.

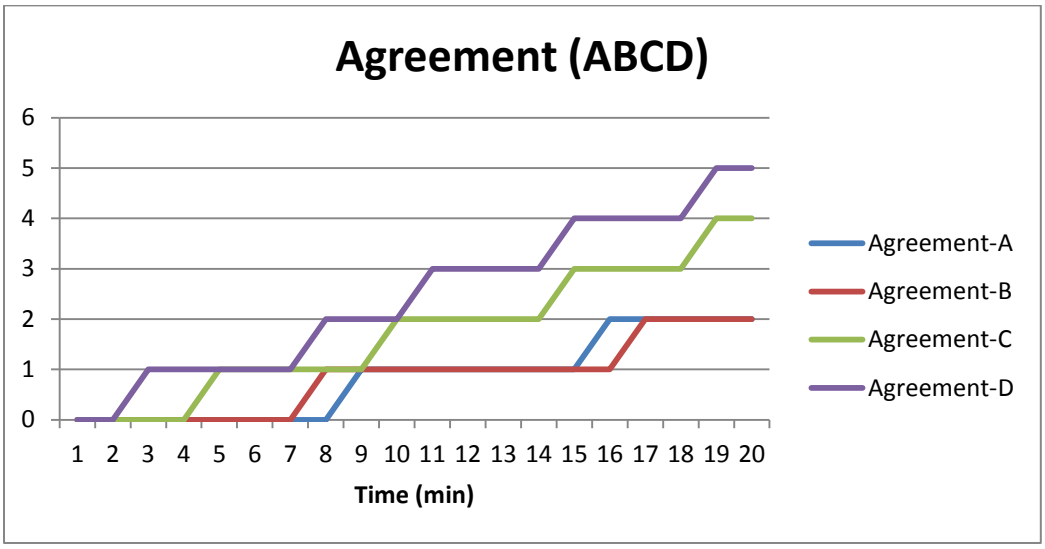

Figure 21. Graph showing how user agreement phrase usage varied on average across a conversation in the ABCD condition.

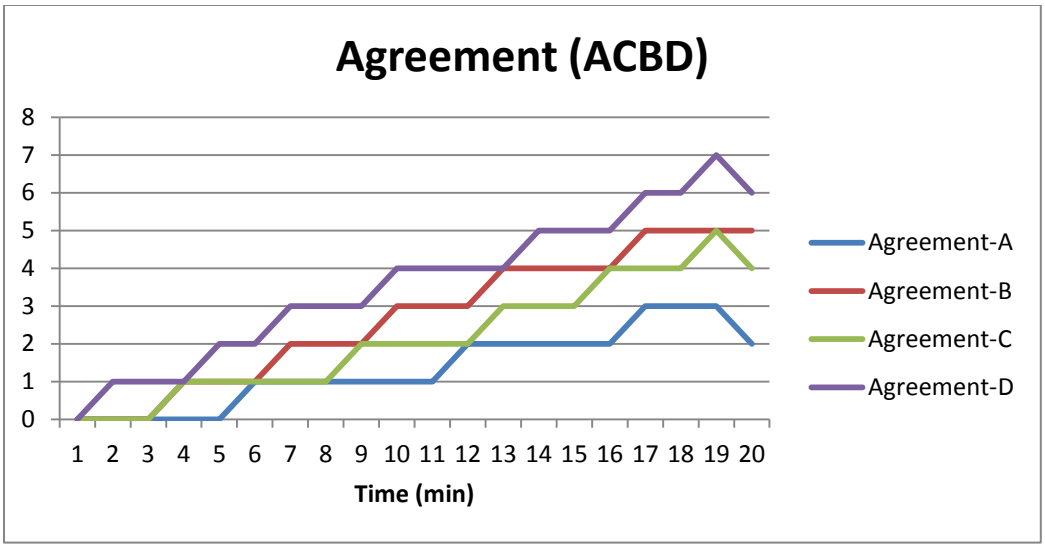

Figure 22. Graph showing how user agreement phrase usage varied on average across a conversation in the ACBD condition.

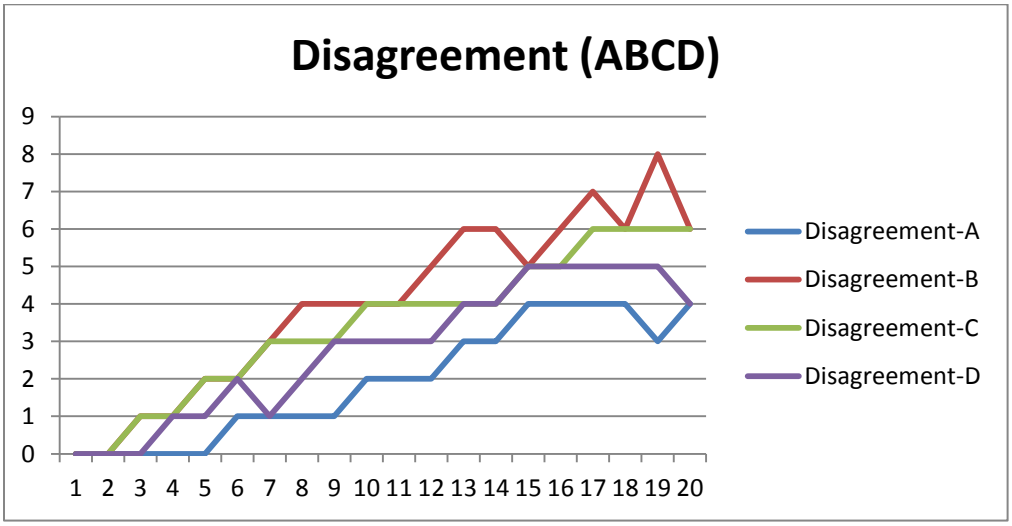

Figure 23. Graph showing how user disagreement phrase usage varied on average across a conversation in the ABCD condition

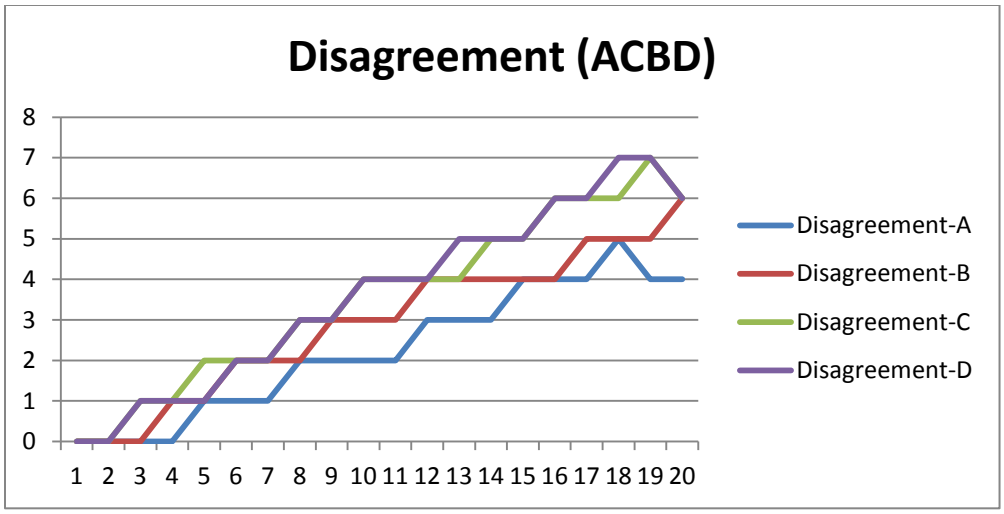

Figure 24. Graph showing how user disagreement phrase usage varied on average across a conversation in the ACBD condition

4.3 Analysis of Self-Report Questionnaire Data

In the section, we discuss the results of the analysis of the self-report questions from the questionnaire. The entire list of questions in each questionnaire is available in Appendix B.

Question	Visualization		Mean
How satisfied are you about your language use and team-oriented behavior?	ABCD	B	5.3
		C	5.7
		D	5.9
	ACBD	B	5.9
		C	5.3
		D	5.6
How often did you look at the visualization?	ABCD	B	5.1
		C	4.5
	ACBD	B	4.9
		C	5.0
How satisfied are you about your participation in the discussion?	ABCD	A	5.4
		B	5.6
		C	6
		D	5.8
	ACBD	A	5.4

		B	6.1
		C	5.7
		D	5.9
Was the visualization helpful?	ABCD	B	4.3
		C	3.4
	ACBD	B	4.3
		C	4.2
How comfortable were you with individual data being shown to the rest of the group?	ABCD		5.4
	ACBD		5.5
How much did the visualization influence your participation and language use?	ABCD	B	4.5
		C	3.3
	ACBD	B	4.2
		C	4.3
Do you think having your data shown to the rest of the group influenced you?	ABCD		4.3
	ACBD		4.3

Table 3. Summary of questionnaire responses

The questionnaires were 7-point Likert scale questions, and as is evident from the table above, participants' participation and language use satisfaction seems to be greater in the visualization that comes later in their study session. That is, participants in the ABCD condition seem to have higher satisfaction with visualization C, and those in the ACBD condition seem to have higher satisfaction with visualization B.

Another interesting observation that can be observed is that participants' satisfaction about their participation is greater in visualization conditions as compared to non-visualization conditions. Between conditions B and C, the condition that comes later in the study session seems to have higher satisfaction, similar to the result discussed above. Another interesting result that we observed was that participant satisfaction in condition D was greater than that of

condition A, which suggests that even though condition D did not have a visualization accompanying it, some of the influencing effects from earlier visualization segments had carried over to condition D. We also observed that the perceived influence of visualization C, is slightly lesser than that of visualization B, which is interesting given that the data obtained from the study sessions suggests otherwise.

A surprising finding in the questionnaire data was that users seemed to be fairly comfortable with their individual level data being shown to others in the group, and they didn't seem to think that having their individual data exposed influenced their behavior too much. This made us wonder about the influences of anonymity in small groups. While anonymity could possibly have strong effects on larger groups, we suspect that the dynamics of smaller groups cause these effects to be less pronounced.

4.4 Limitations of system

One of the key limitations of the system is that its influences might change as groups become more familiar with each other, because the group dynamics also change accordingly. In our study, participants did not know each other, so an interesting area of future study would be to analyze how the influences of the system change as participants become more familiar with each other. We suspect that familiarity between participants could cause changes in group dynamics and that it would be important to incorporate a 'familiarity measure' in the data analysis to ascertain any effects that it might have.

Another limitation of the system is that although it has been tested for small groups, predicting if it would scale well is hard. Group dynamics change as group sizes increase and the influences of the system could change as group sizes increase.

From a system design perspective, the current version of the system uses tri-gram analysis of phrases being used in conversations. While this was sufficient for the purposes of our study, real-world systems should ideally use a higher n-gram approach to ensure better accuracy.

4.5 Future Work

One of the questions that we asked ourselves was how this system could be extended so that people could view a history of their interactions over extended periods of time. A history feature where users could see how they have interacted with different people over several years could be a very useful reflective interface. In addition to this, another interesting avenue of future work would be to determine if such a system could be integrated with existing group communication tools such as Skype and Google+, and if so, if the results match those obtained from our study.

Yet another feature that would make this system more interesting would be a 'people filter'; a filter that enables users to analyze how their interaction has varied with different people over different periods of time.

Another potential avenue of future work worth mentioning is that of testing new modalities. While this study focused on text based conversations, it would be interesting to determine if audio-based or video-based communication systems would also deliver similar results. While

text based systems are very different from audio and video based communication systems, a significant portion of communication these days is via audio and video and extending our system to these modalities would certainly be an interesting study.

One aspect that we wish to clarify is that more participation and more disagreement is not always the best equation for a successful group conversation. This varies based on the objectives of different group conversations. This study is more focused on showing how users behave with specific types of reflective interfaces and how such interfaces influence group dynamics. An interesting avenue of future work would be to deploy such a system in a real-world longitudinal setting, without giving users any specific instructions, and simply letting them interpret the visualization in whichever way they please. It would be interesting to see how user behavior changes when a 'desired behavior' of sorts is not defined, and when such a tool is incorporated in to their daily workflow.

CHAPTER 5

CONCLUSION

While this thesis does not advocate best practices for group conversations and group processes, it strives to understand how individuals function in groups and how individual user behavior is influenced by reflective interfaces. The study focused on determining how user behavior varied based on different types of visualizations shown and also tried to determine the extent of such an influence, should it exist. We explored the influences of aggregated and articulated data visualizations on the dynamics of groups engaged in computer mediated conversation. Specifically, we designed a study that randomly assigned participants to groups that were shown aggregated and articulated data visualizations in different orders. We then simultaneously measured participation and language use data and found that aggregated data visibility yields results similar to that of articulated data visibility.

Apart from measured data, we also presented self-report data from questionnaires that were handed out during the study. We found that users' perceptions of the influences of each of the visualizations differed from observed data. Lastly, we addressed the limitations of our system and discussed potential avenues of future work.

The observed data showed us that participation and disagreement phrase usage patterns did not exhibit significant differences in the two visualization conditions, although there were significant differences when compared to the baseline condition with no visualization, as explained in earlier sections. This suggests that anonymity and accountability in group conversations might not be as key a factor as previously thought to be.

While we are not sure if these results will scale with increases in group sizes, such studies are certainly worth exploring. If the results do scale, it could really change the way we look at groups and social networks and could potentially lead to new ways of designing for social networks. On the other hand, if the results do not scale, we could use insights from this study to design better for smaller groups and to also understand more about group dynamics.

On a closing note, humans are highly unpredictable unlike machines, and this makes the task of theorizing with humans in the loop, an especially difficult one. That said, we certainly do hope that this work opens up a new avenue of research, that will help us understand a little more about humans in groups, and why they behave the way they behave.

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APPENDIX A: DISCUSSION TOPICS

1. You are a group of scientists that has discovered a new source of energy that is so cheap, all households could afford it. However, the same technology could be used to make weapons that could cause mass destruction. Do you tell the world of your discovery or destroy the evidence? Decide what course of action you would take and try to come up with 5 reasons in support of your decision.

2. The three of you are the founders of a large Internet company and are the main members of its board of directors. Your comopany is currently running into money trouble. Another large Internet company has offered to buy you out, thus ensuring that no lay-offs will be necessary. Your company's current worth is $6 Billion and you have been made a buyout offer of $4.9 Billion. The offer also guarantees that none of your employees will be fired for unfair reasons.

However, the buyout deal has been structured such that you will not have control over your company and the technology that you built, nor will you have control over the direction in which your company will head in the future.

The other option would be to reject the buy-out, in which case you would have to lay off about 22% of your workforce and also implement 8% salary cuts for the rest of the workforce, but that would help you retain control over your company, and take it in the direction that you want. Discuss and decide what option you would prefer to take, and try to provide strong reasons in support of your decision.

3. The three of you are a group of famous producers and directors, of a highly-anticipated and expensive movie that is just about to be released. You have put in nearly all your money into the production of this movie, and the movie is expected to bring in heavy profits. The certification board however has banned the movie's release because it feels the movie hurts religious sentiments. The board has stated that nearly 25% of the movie's scenes would need to be removed if it were to be allowed to be released. As the producers and directors of the movie, you have the following options:

a. Accede to the certification board's orders and remove 25% of the scenes, but that would mean you're giving up artistic integrity and releasing a movie of lower quality and impact.

b. Protest against the board's decision, but that would mean the board's decision on your future movies could be impacted.

c. Maintain artistic integrity and go ahead with release in other countries alone, but that would mean reduced profits from ticket sales.

Discuss what you as a group would do in such a situation, and provide strong reasons for your decision.

4. The three of you are trekking through a dangerous forest in Asia. The forest is infamous for its bear and tiger attacks. One night, one of you falls into a ditch and breaks a leg, and subsequently can't walk anymore. The injured person is bleeding and needs medical help as soon as possible. Any delays in the arrival of medical help could be fatal. It is essential that help is sought at the earliest since the forest is dangerous.

In addition to this, you have run out of ammunition for your weapons, and the only defense you have against animal attacks is to wave a burning wooden stick at any attacking predators. In this situation, you need to decide between these options:

a. One possible option is for one person to go seek help, while the other person stays with the injured person. However, this would take longer for rescue to arrive since only one person is out seeking help. Bear in mind that the forest is dangerous and that the longer you stay there, the greater the dangers are.

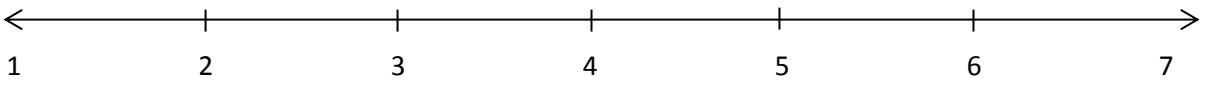
b. Another possible option would be for both non-injured persons to seek help while the injured person stays back in the same spot, but this would mean he/she would have no defense against any possible bear or tiger attacks.

Decide what you, as a group, would do in such a situation, and provide strong reasons for your decision.

APPENDIX B: QUESTIONNAIRES

Post Segment 'A' Questionnaire

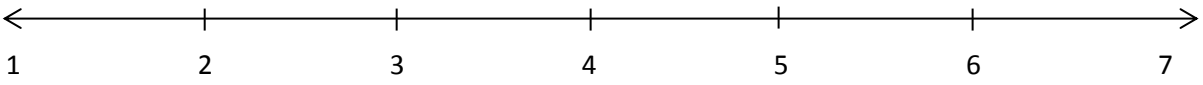
1. How satisfied are you about your participation in the discussion?



Not satisfied Very satisfied

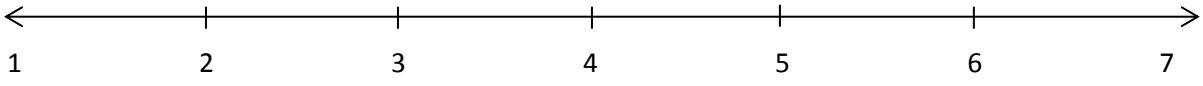
Post Segment 'B' Questionnaire

1. How satisfied are you about your participation in the discussion?



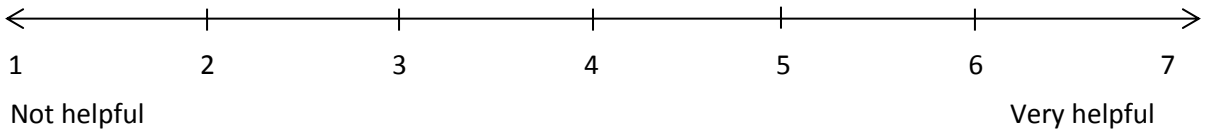
Not satisfied Very satisfied

2. How satisfied are you about your language use and team-oriented behavior?

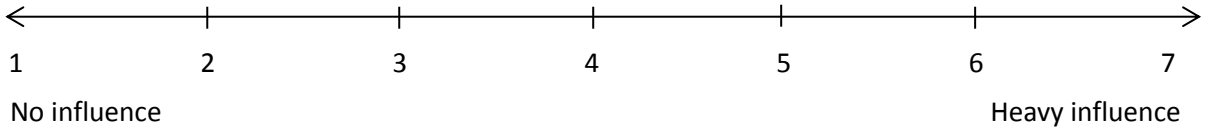


Not satisfied Very satisfied

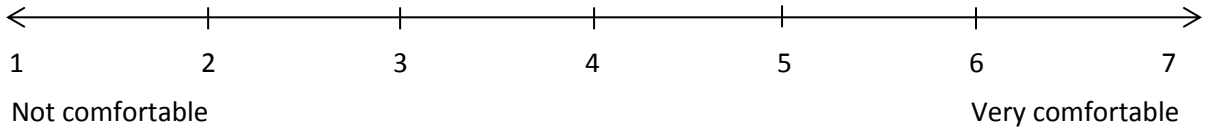
3. Was the visualization helpful?



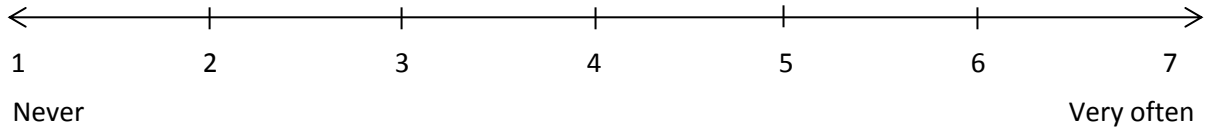
4. How much did this visualization influence your participation levels and your language use?



5. How comfortable were you with having your participation and language use data being shown to the rest of the group during the discussion?

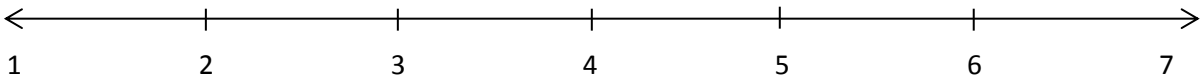


6. How often did you look at the visualization?



Post Segment 'C' Questionnaire

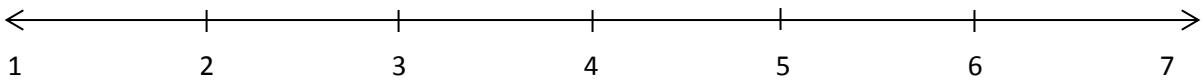
1. How satisfied are you about your participation in the discussion?



1 2 3 4 5 6 7

Not satisfied Very satisfied

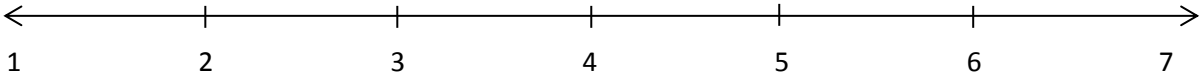
2. How satisfied are you about your language use and team-oriented behavior?



1 2 3 4 5 6 7

Not satisfied Very satisfied

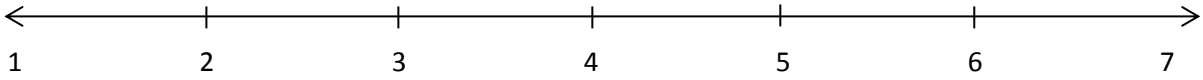
3. Was the visualization helpful?



1 2 3 4 5 6 7

Not helpful Very helpful

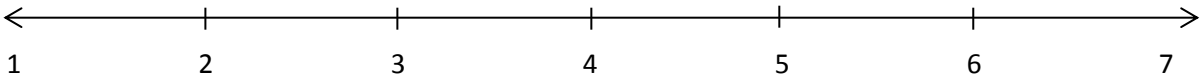
4. How much did this visualization influence your participation levels and your language use?



1 2 3 4 5 6 7

No influence High influence

5. How often did you look at the visualization?

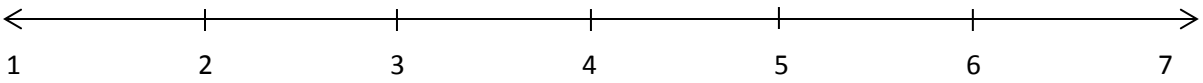


1 2 3 4 5 6 7

Never Very often

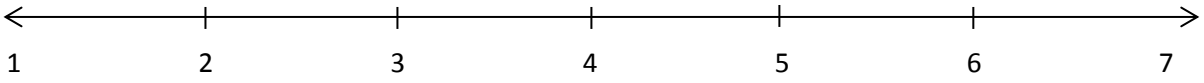
Post Segment 'D' Questionnaire

1. How satisfied are you about your participation in the discussion?



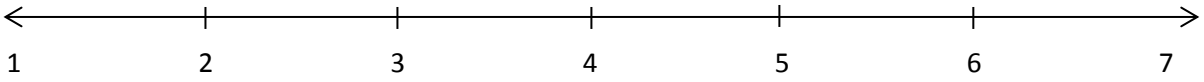
Not satisfied Very satisfied

2. How satisfied are you about your language use and team-oriented behavior?



Not satisfied Very satisfied

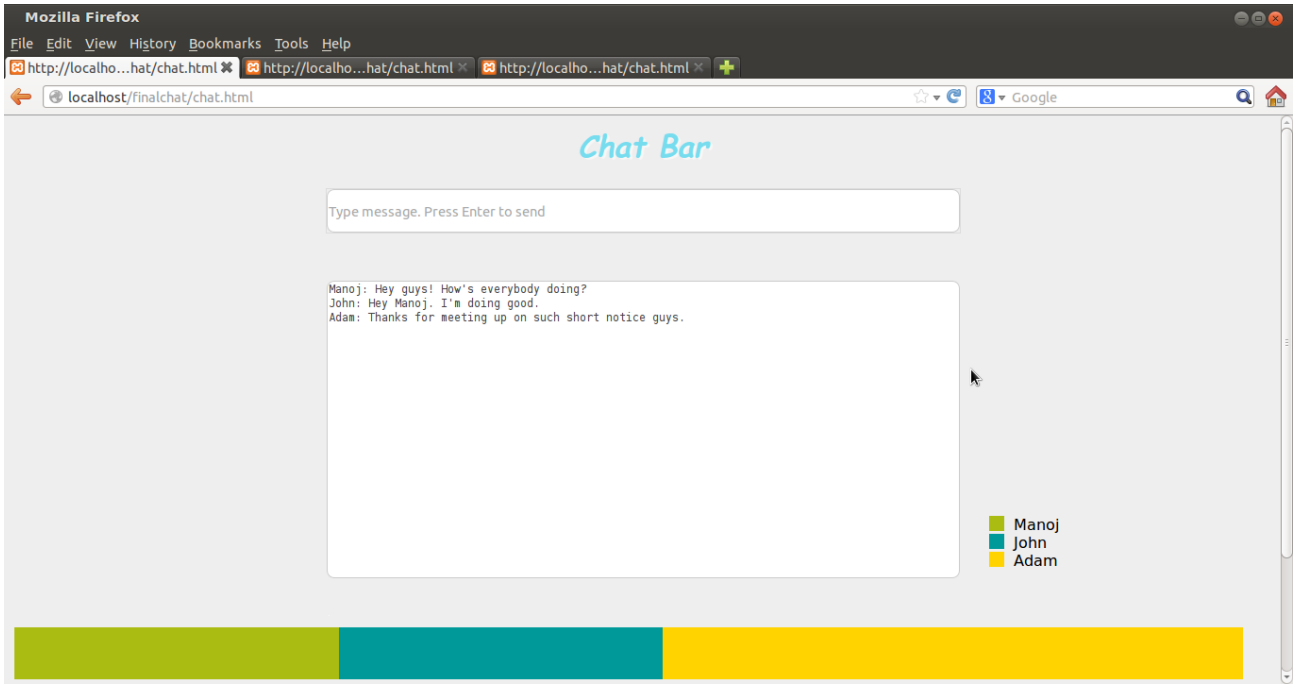
3. Do you think having your individual data available publicly and shown to the rest of the group, in turn, influenced your participation and language use?

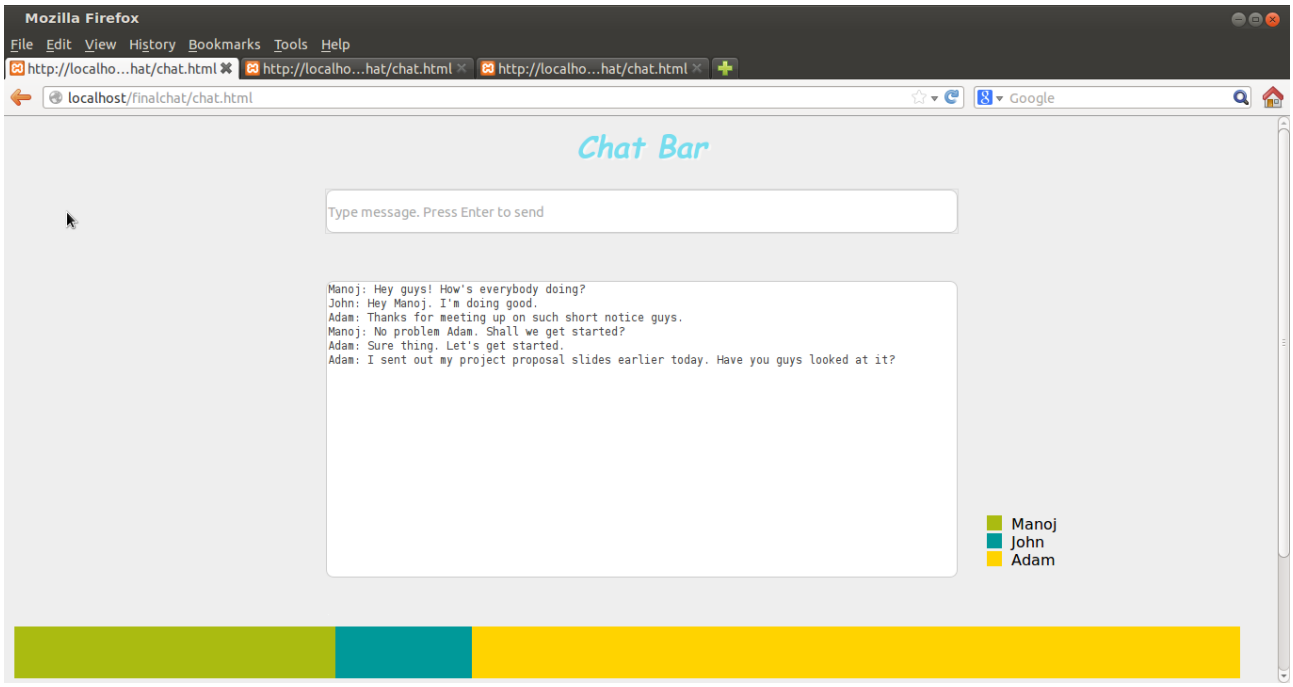


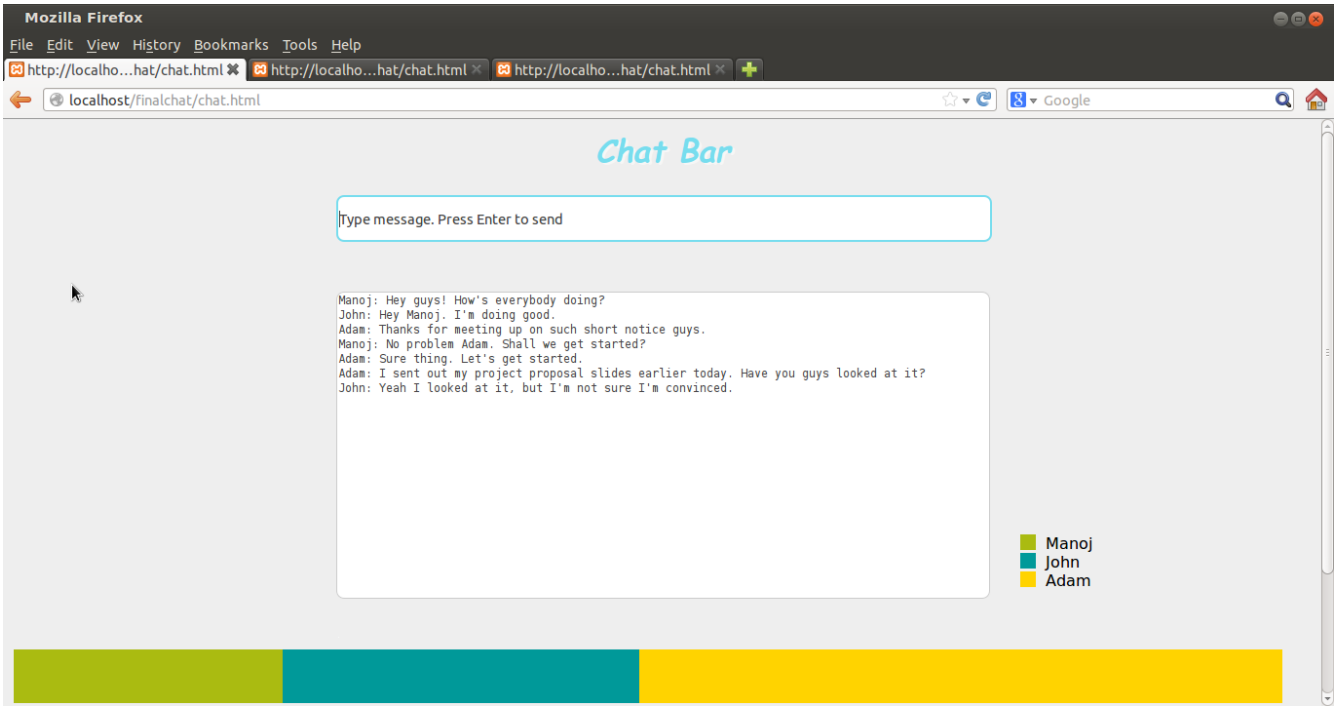
No influence Heavy influence

4. Any additional comments about the visualization and/or the interface.

APPENDIX C: EXAMPLE OF VISUALIZATION DESCRIPTION HANDOUT (CONTROL)



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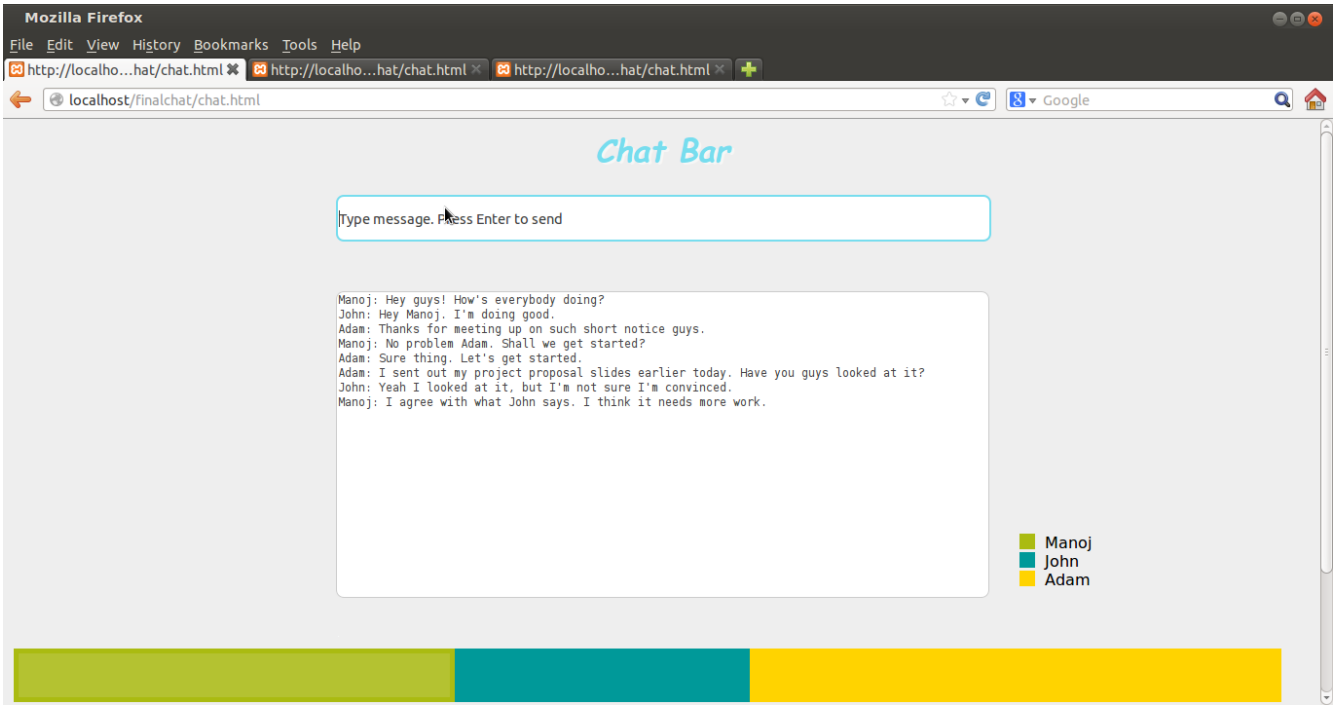
http://localho...hat/chat.html
http://localho...hat/chat.html
localhost/finalchat/chat.html
Google
Chat Bar
Type message. Press Enter to send
Manoj: Hey guys! How's everybody doing?
John: Hey Manoj. I'm doing good.
Adam: Thanks for meeting up on such short notice guys.
Manoj: No problem Adam. Shall we get started?
Adam: Sure thing. Let's get started.
Adam: I sent out my project proposal slides earlier today. Have you guys looked at it?
John: Yeah I looked at it, but I'm not sure I'm convinced.
Manoj
John
Adam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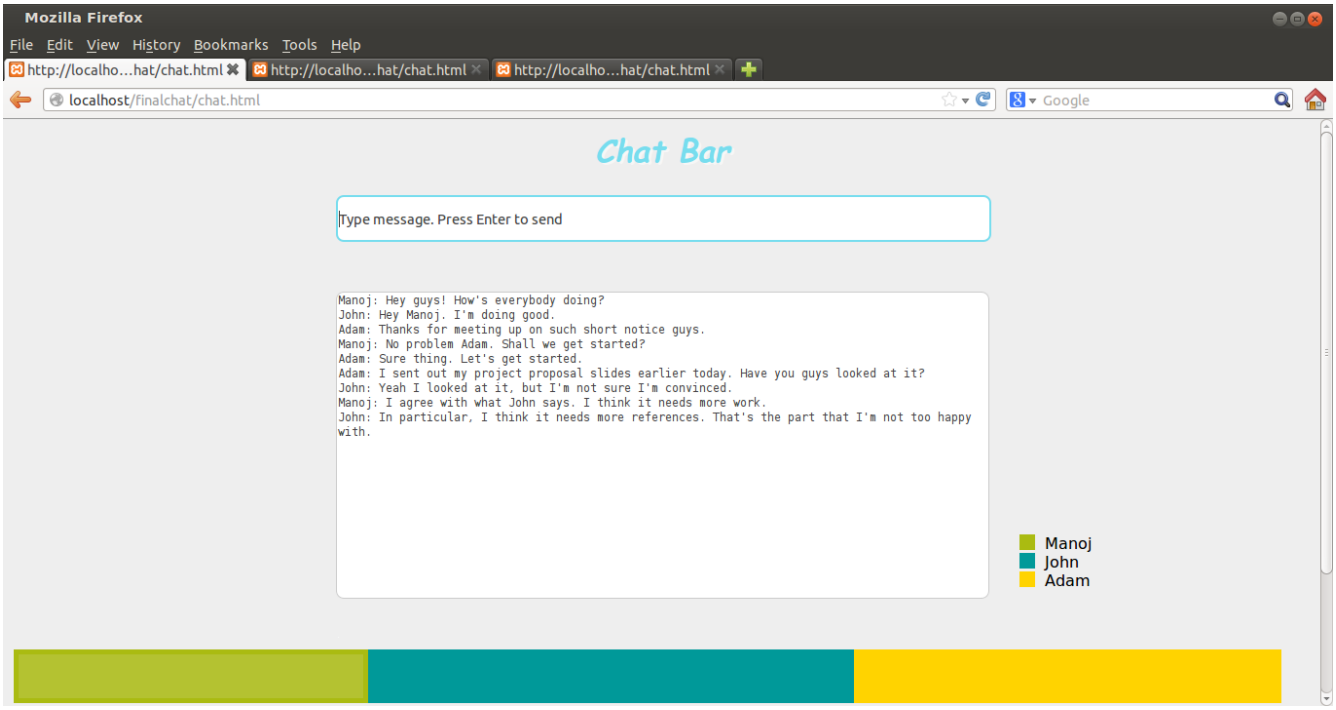
John: Yeah I looked at it, but I'm not sure I'm convinced.
Manoj: I agree with what John says. I think it needs more work.
Manoj
John
Adam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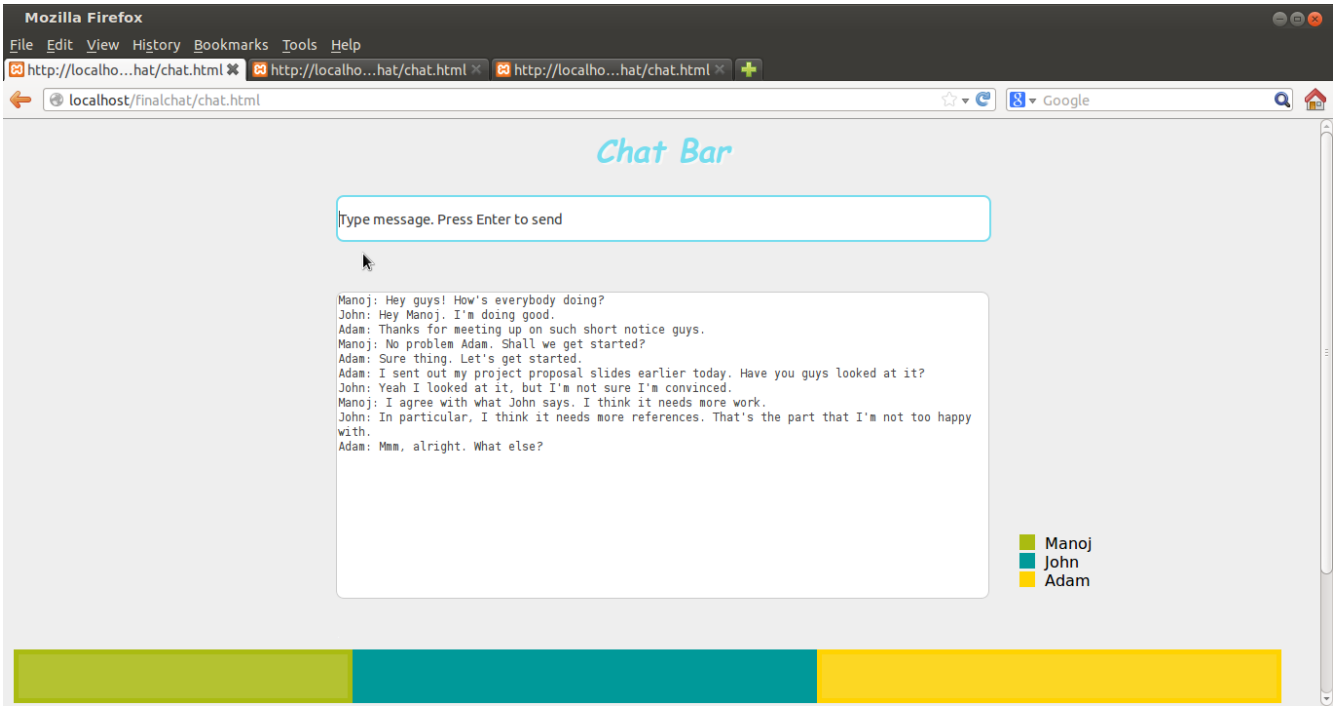
Manoj: No problem Adam. Shall we get started?
Adam: Sure thing. Let's get started.
Adam: I sent out my project proposal slides earlier today. Have you guys looked at it?
John: Yeah I looked at it, but I'm not sure I'm convinced.
Manoj: I agree with what John says. I think it needs more work.
John: In particular, I think it needs more references. That's the part that I'm not too happy with.
Manoj
John
Adam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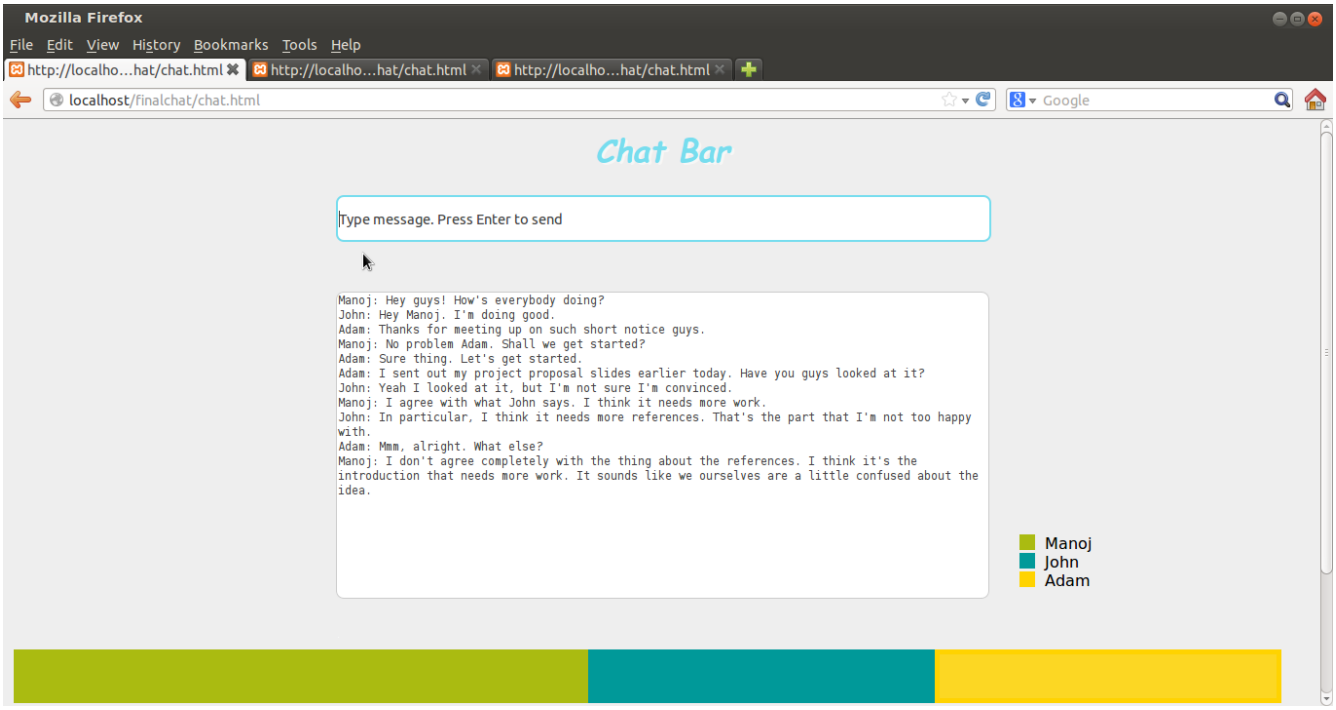
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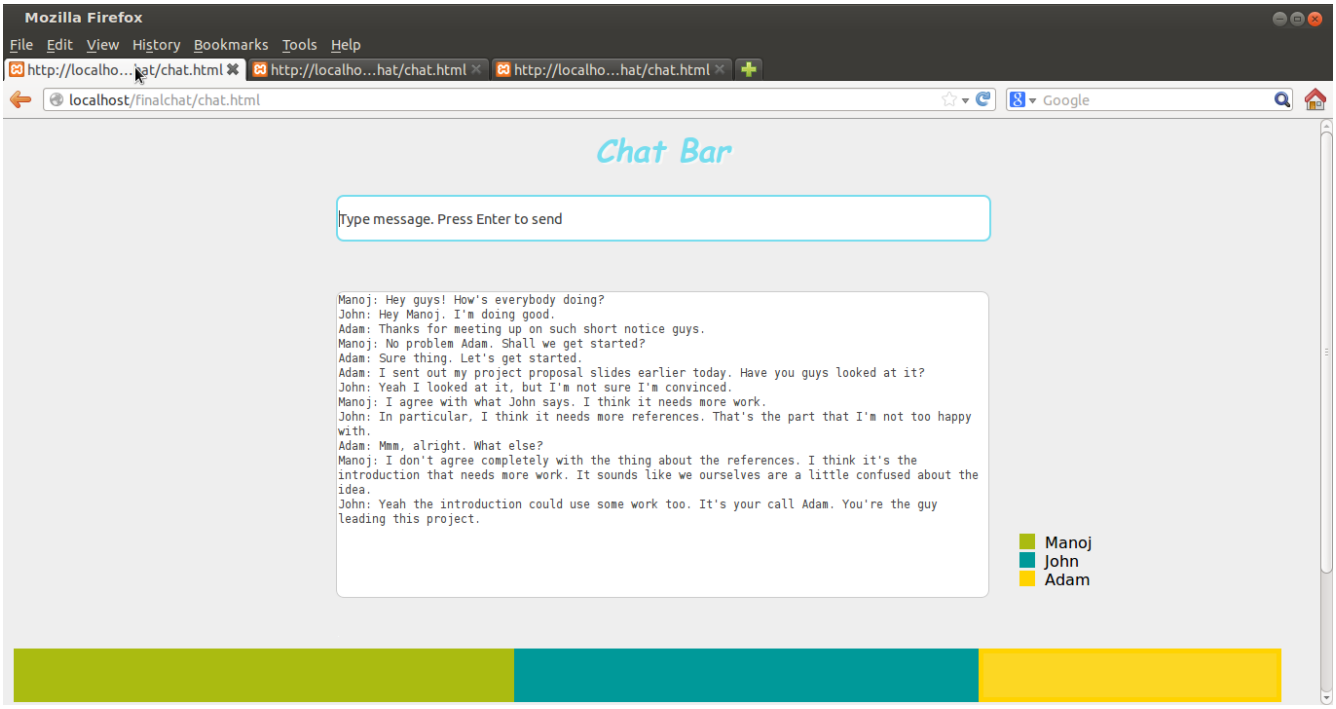
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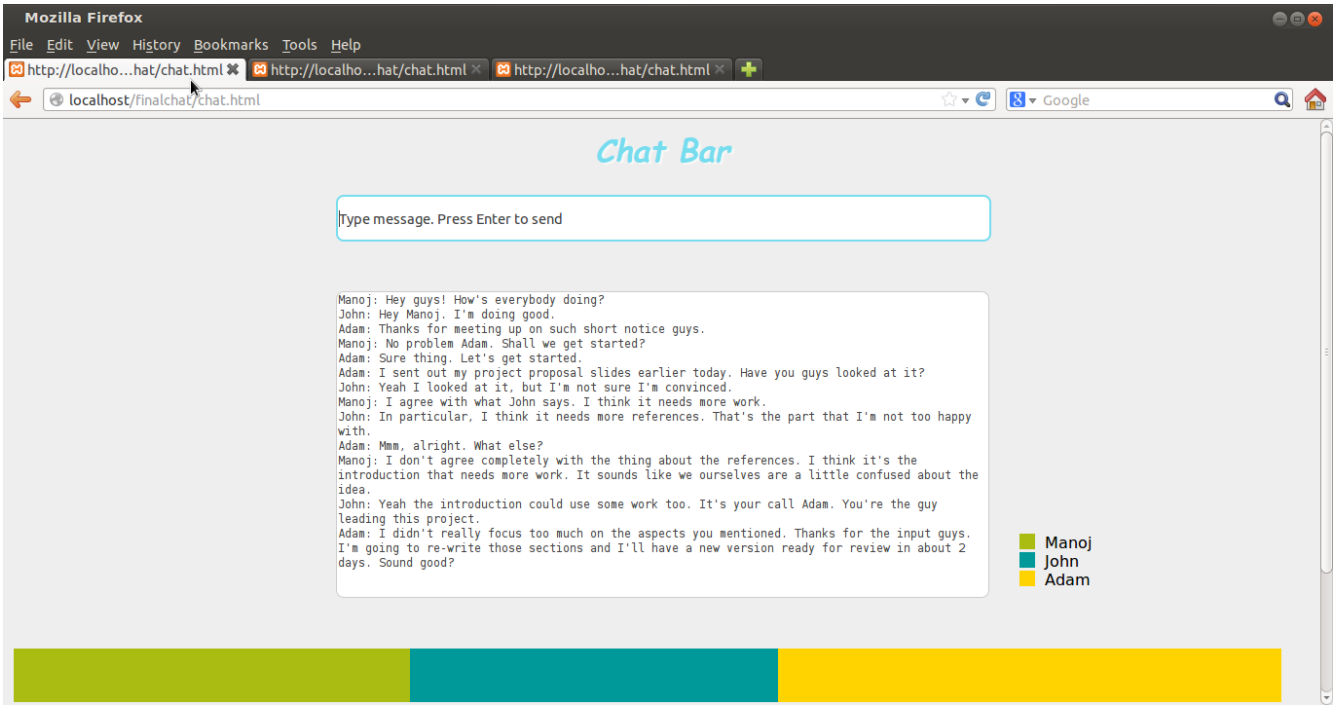
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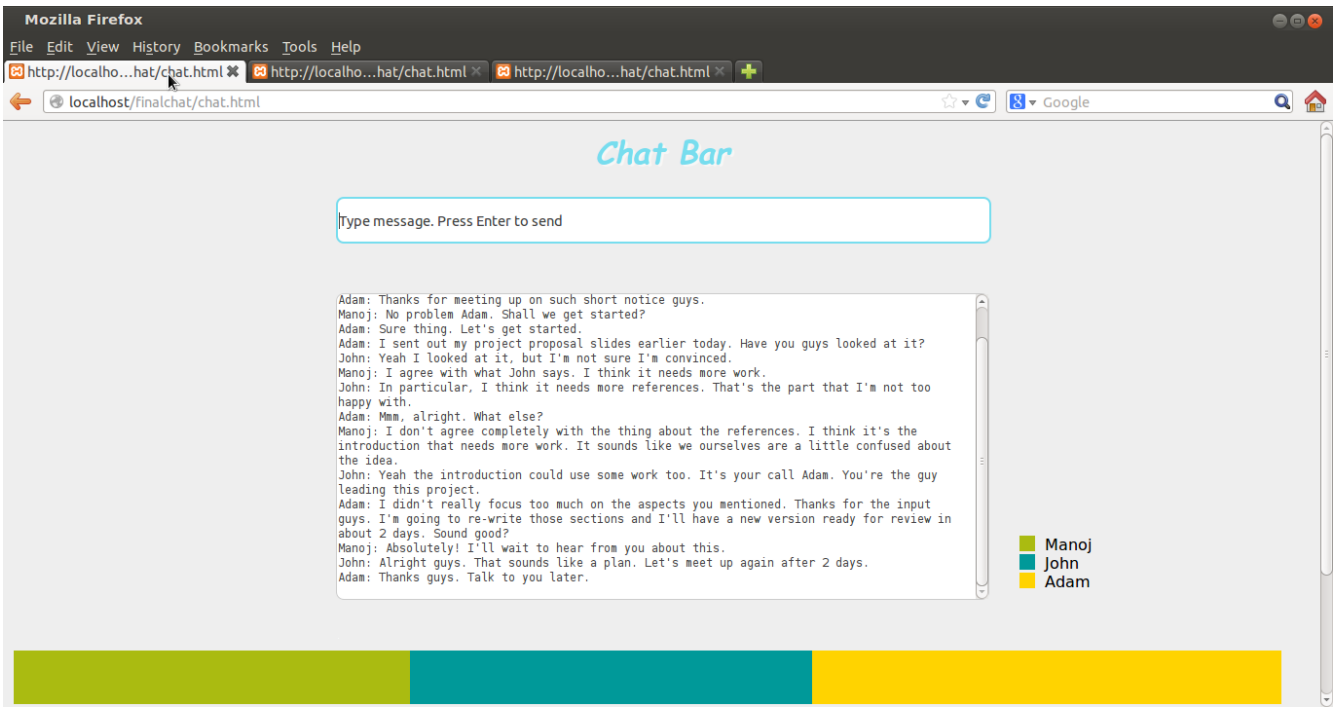
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Manoj: Absolutely! I'll wait to hear from you about this.
John: Alright guys. That sounds like a plan. Let's meet up again after 2 days.
Adam: Thanks guys. Talk to you later.
Manoj
John
Adam