How Small Groups React to Distorted Social Feedback

Tony Bergstrom and Karrie Karahalios
Computer Science Department
University of Illinois at Urbana-Champaign
{abergst2, kkarahal}@cs.illinois.edu

ABSTRACT
Real-time visualization of conversation alters small group dynamics and encourages balanced participation. Visual feedback acts as an automatic moderator that encourages people to balance their relative contribution with that of other group members, but can their contribution be actively shaped by distorting the visualization? To better evaluate the effect of visual feedback during conversation, we purposefully distorted the apparent balance in a shared visualization of conversation, the Conversation Clock. We present a pilot study examining various distortion strategies followed by two studies applying distortion to group discussion in a co-located and a remote setting. Our results indicate that participants will trust and accept a significantly distorted visualization as an accurate representation of conversation. However, we found the distorted feedback minimally impacts the dynamics measured in these groups. These findings suggest that the mechanism driving individuals towards balanced conversation lies outside the specifics of the visualization. Identifying that mechanism remains an open problem.

Author Keywords
Visualization, Group Dynamics, Social Mirrors

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Shared real-time visualizations of group conversation influence the behavior of individuals in small groups. Numerous researchers have designed visualizations depicting a speaker’s contribution in face-to-face co-located interaction [1, 2, 9, 23]. While the purposes of these projects vary from mediating a meeting, to providing anonymous feedback, to generating more ideas; studies have repeatedly shown that visualizations of face-to-face participation encourage a balanced conversation. This change in dynamics is not entirely unexpected as people purposefully control their appearance and mannerisms to project a certain persona to others [16]. Visualizations of conversation publicly display characteristics that reflect on the participants’ engagement in conversation. Anecdotally, people want to appear engaged but do not want to appear to talk the entire time, and they use the visualization to evaluate themselves [2]. These visualizations can be collectively called Social Mirrors as they provide an unbiased, third-person, real-time perspective on social information in much the same way that a traditional mirror reflects a third person real-time perspective of visual information [21]. Capturing ephemeral social interaction, these Social Mirrors reveal perspectives on conversation domination and interruption that one might consciously miss.

This work investigates a more nuanced view of the social mirror’s influence on group dynamics. Specifically, we contrast the use of accurate feedback versus distorted feedback with a specific social mirror, the Conversation Clock (e.g., distorting the feedback to indicate a participant spoke much more than in reality) [2]. In this paper, we first demonstrate four distortion strategies and their effectiveness at misleading the viewer before applying them to group conversations. In group the group studies, we show that people will trust and accept a significantly distorted social mirror as a representation of conversation. However, only a small change in participation can be attributed to this distortion. In dyadic conversation, distortion suggesting a person speaks 60% more produces only changes the conversation balance by 8%. In groups of three the same shift was not detectable. We conclude that the driving force of a social mirror is not directly tied to the accuracy of the visualization it displays.

In the following sections, we describe the theory and a set of three distortion studies using a social mirror. We conclude by discussing the implications for feedback in social visualization and regulation of group dynamics.

SOCIAL SELF
Our work builds upon Goffman’s theory of “face” [16]. Establishing a good face is a combination of revealing and hiding information to produce a positive persona in the minds of others. Social signals such as actions, words, and gestures all influence one’s face. A person chooses appropriate responses to fit the context and social protocol. For example, a sales clerk might always choose to always convey a polite demeanor by offering help, smiling, and showing respect to the customer. These signals are not always trustworthy. The same clerk might be frustrated but hide that frustration behind a smile and polite words to fulfill his role. The proper face keeps the clerk employed
and the customer satisfied. However, many unconscious cues can reveal emotions of which we are unaware [12, 26]. An astute customer might notice and incorporate this knowledge into their further interactions.

Goffman’s work on maintaining face also applies in the digital domain. Research on social network sites demonstrates the active control of digital cues to present a desired image. In the dating world, these cues might be purposefully misleading in representing height, weight, age, and interests to attract a certain type of person [17]. More general audiences in social networks provide cues through posted pictures, favorite music, movies, books, and recent activities to friends and acquaintances [8, 24]. The degree to which a person manages their identity varies by personality and goal. For example, whereas the average college student might be more open to sharing pictures and personal comments, a person seeking a job might choose to remain more professional in public dialog.

These subtle aspects of presentation unconsciously influence how other people chose to respond and appear to others. Accommodation theory suggests individuals converge on a predictable interaction style during an exchange. In friendly circumstances, people will adopt similar sentence grammar, accent, tone, word choice, etc. to establish a cohesive group [15, 31]. Conversely, differences in the same cues, such as emphasizing accent or word choice, show social distance by indicating the other is not a part of the ingroup. Increasingly, empirical work has applied technology to automatically model and detect the nuances of conversation activity [14]. This work categorizes the area into topics of capturing, understanding, and predicting subtle patterns in interaction. These works have focused on broad categories of such as modeling interaction management through turn taking and addressing; inferring internal states showing interest, anxiety, embarrassment, boredom, etc.; detecting personality traits of dominance and extraversion; and understanding roles in conversation. The subtle aspects of conversation can determine the larger patterns of interaction.

To present the best face, a person must be aware of their own signals. In a theatre, the actors must work to convey the appropriate characters to the audience, no matter what occurs on stage. With technology we can see this backstage area by fostering the awareness of interaction.

**VISUAL SIGNALS**

Computer mediated communication research strives to improve and explore communication interfaces. Particularly in video based chat, visual signals often replicate face-to-face interaction. These signals include body language, facial expressions, eye contact, and gestures - feedback that is desirable but often lacking in traditional remote conversation [4, 20, 27]. In a collocated environment, these same signals are already present and naturally used.

In a different vein, abstraction expands the potential cues that can be provided in interaction. This imagery can range from virtual environments, to social visualizations, to activity indicators [10, 11, 13, 22, 28]. As in an avatar enabled virtual world, this imagery provides a grounded environment that sets the rules on how to interact and what is allowed. In many cases, information is presented in a novel visualization that reveals interaction patterns that are otherwise not available. These types of signals are useful in remote environment, but they also add to the face-to-face environment to signal activity, dominance, and history that is nonexistent in face-to-face conversation.

Applying similar abstracted feedback in face-to-face conversation influences group dynamics by encouraging and discouraging participation [1, 2, 9, 23]. DiMicco et al. examined visualization as a way to encourage idea generation through discussion. The shift toward a balanced conversation was seen as a result of the visualization [9]. The group continued studying the effects of real-time and post-meeting visualizations and found these visualizations encourage information-sharing behavior [7].

Similar to DiMicco, work by Bachour et al. and Bergstrom et al. further examined balance in settings with integrated displays. Both groups used the table as the display either by embedded lights or overhead projection. Both visualizations balanced conversation. The Conversation Clock visualization differed from previous work in that it depicted subtle changes in turn-taking behavior. As a result, it showed how behavior differed in people who spoke above the average from those who spoke below the average. Work by Kim et al. tested a handheld feedback device that provided conversation feedback in addition to sensing features of speech, body movement, proximity, etc. Their work further demonstrated the use of group dynamic feedback in remote scenarios has a similar effect. Anecdotal evidence from these groups suggests the details of the visualization had an effect; however, the changes might be attributed to heightened internal self awareness rather than a reaction to the visualization’s feedback.

Others have used visualization to support or discourage specific interactions outside of on contribution. Leshed et al. demonstrated that visual feedback based on language

---

Figure 1. The Conversation Clock captures conversation via microphones and produces a visualization demonstrating the patterns and balance of conversation.
can encourage more positive language in text-based chat environments [25]. The public awareness and resulting accountability for negative comments discouraged overly negative criticism. Others have worked to redirect both positive and negative feedback into anonymous backchannels by allowing participants to voice their opinion via real-time voting [3, 19]. The explicit positive and negative feedback uses the visualization to show the group’s aggregate approval. Participants using the visualizations reported increased satisfaction with the interaction when their feedback was publicized.

CONVERSATION CLOCK
This work extends the work of the Conversation Clock tabletop visualization by contrasting the effect of accurate and distorted visualizations of vocal contribution. In this section we briefly overview the interface and discuss the distortion strategies we explored.

The Conversation Clock visualizes conversational speech by monitoring people around a table. Dedicated lapel microphones identify each participant’s captured speech which is then rendered onto the tabletop. The rectangle color indicates speaker while the length indicates volume. The rectangles appear along a concentric circular timeline, each ring capturing one minute of time (Figures 1 and 2). The outermost ring shows the most recent conversation while completed rings are compressed, in a brief animation, toward the center of the table. Throughout the conversation, simultaneous speech appears as overlapping rectangles with the quieter participant represented by a smaller rectangle. For the purpose of analysis, we define a lead as a moment when a person is the loudest speaker, whether simultaneous or solo.

Quantitative feedback from prior studies indicates that the Conversation Clock affects the talkative individuals more than the quiet ones [2, 21]. Participants cite salient patterns in turn-taking and conversation dominance as the motivations to change. Our distortion strategies seek to emphasize these patterns to have a greater effect on individual participation.

Distortion Strategies
We distorted the Conversation Clock to make people appear more talkative and dominating. We chose to increase the salient moments by showing more contribution throughout conversation and generally make the visualization dominated by a single speaker’s color.

We began with a list of four potential distortion strategies for testing in a pilot study: amplitude (volume), speed (sample rate), color brightness of rectangles, and color replacement in past samples (i.e. swapping the color of rectangles from other participants’ assigned colors to the emphasized person’s color). Low, Medium, and High conditions of each strategy were tested. Descriptions of each strategy appear in the following paragraph; simplified renderings are shown in Figure 3.

Speed changes the sampling rate of the Conversation Clock. When the emphasized person leads the conversation, the sample rate increases and more bars are drawn for this person. Low through High conditions vary the sample rate to a lower and higher frequency, respectively.

Amplitude increases the length of the speaker’s rectangular bars. This implies the speaker was louder throughout the conversation. Low through High Conditions vary the amplitude multiplier with low being a slight increase to high being the largest increase in size.

Brightness emphasizes one participant by decreasing the color brightness of all other participants. Low through High Conditions vary the percent of reduction in brightness with low being a subtle difference to high being the largest difference in brightness.

Color Replacement changes the rendering of the person speaking in previously drawn history. The emphasized person’s color is used to recolor it’s neighbors 30 seconds after they are drawn. Low through High conditions vary the number of neighboring bars affected: a low condition will affect the two nearest bars on both sides whereas the high condition changes four bars on both sides.

The distortion strategies leverage natural deficiencies in visual cognition such as change blindness and awareness blindness [29, 30]. People cannot attend to all of their surroundings concurrently. Therefore, many of the changes remain unnoticed. In this setting, participants attend to the others at the table, their own discourse, and the table visualization. They are less likely to notice the distortion as it happens. In the case of color replacement, they do not notice the distortion as in changes right in front of them. As feedback from an incorrect visualization is apt to be ignored, we designed the graphical distortions to be subtle and trusted in the short term, yet largely suggestive of dominant participation in the long term.

For analysis, the non-emphasized participants in a distortion condition are labeled underemphasized as their contribution is visually lessened as a portion of conversation.

EXPERIMENTAL STUDIES
To investigate the effect of emphasis distortion on face-to-face conversation participation, we designed a set of three studies. The first provides a pilot study of the distortion conditions. Participants viewed a pre-recorded conversa-

Figure 2. The Conversation Clock structures conversation history as a set of concentric rings. The current moment progresses clockwise around the outermost ring.
often. In addition to changing behavior in H2, we expect dominating conversation should happen sooner and more awareness of the visualization affected conversation. With to speak less due to the public feedback. H3: 

Behavioral change.

Prior work indicates talkative people will defer to the visualization to gauge their participation from that speaker.

Hypotheses

We began with the following hypotheses:

H1: A speaker will perceive they are contributing more when their contribution is emphasized via distortion. People will defer to the visualization to gauge their participation in conversation rather than trusting their instinct or memory.

H2: Emphasizing a speaker's contribution decreases participation from that speaker. Prior work indicates talkative people are conscious of appearing to dominate the conversation and specifically cited the visualization's role in their behavioral change.

H3: When emphasized, people will report feeling pressure to speak less due to the public feedback. In prior work, awareness of the visualization affected conversation. With distortion applied to an individual, the same awareness of dominating conversation should happen sooner and more often. In addition to changing behavior in H2, we expect that that the increased dominance will manifest as a social pressure attributed to the visualization.

PILOT STUDY

We began by testing the four distortion strategies to narrow the experimental conditions for a larger study. We predicted our intended strategy would lead a viewer to overestimate the amount of time the distorted individual spoke without the viewer being aware of that distortion. For this pilot study, our selection of distortion strategy was chosen based upon participants' written estimations of participation and Likert scale feedback.

Participants were presented with 4.5-5 minutes of video recorded conversations selected from interview segments of “The Daily Show” while the Conversation Clock visualization was projected synchronously on the table. The video was displayed on a screen opposite the participant. Prior to the study, each video was hand-coded for speaker participation to provide the volume and turn-taking parameters for the Conversation Clock. The interviewer or the interviewee from the video clips were randomly selected for the distortion emphasis.

Participants observed a total of 13 total conditions: a Low, Medium, and High condition for each of the four emphasis conditions and one control condition. The Low condition was a subtle distortion and would only be noticed if one paid close attention. The High condition was extremely distorted and it was easy to notice they were distorted and the Medium condition fell in the middle. The conditions were randomly shuffled, however the High conditions were never adjacent.

At the end of each condition, the study participants estimated the proportion of time each person spoke during the conversation and indicated the accuracy of the Conversation Clock's depiction of conversation. The variable, Overestimation, was measured as the percent error relative to the distorted person's speaking time. Eight people participated in the pilot study (5 males, 3 females). They were told all visualizations would differ, though the distortion strategies were not revealed until after the study. The session lasted approximately 1.5 hours, participants were remunerated with gift certificates to Amazon.com.

Pilot Study Results

Figure 4 shows the results of the participant estimations as reported in the surveys. All four strategies showed a tendency to deviate from the control condition estimates. We examined the conditions that maximized overestimation for each strategy (High Amplitude, High Speed, Medium Brightness, and Medium Color Replacement) and found that they differ from the control condition via pairwise t-tests. All paired t-tests showed significance (p < 0.04): with our small sample of 8 individuals the effect size is large enough to indicate the conditions were effective.

1 Popular News Entertainment Program
Aggregate Likert scale data indicated that no distortion strategies were misleading. Individuals voiced a few concerns that varied over the conditions. With the amplitude emphasis strategy, some participants remarked “the bars seem bigger” while in the brightness emphasis condition some participants noted, “It’s harder to see [the underemphasized speaker’s] color.” The High Color Replacement condition was the only condition to illicit any extreme distrust vocally; a single individual commented “I don’t know how, but it’s wrong. It’s just wrong.” He further explained that he had explicitly watched the bars as they appeared to determine what was going on, and he found no error.

The pilot study demonstrated these distorted social mirrors were trusted and accepted as accurate in a real time situation. As participants reported all strategies to be accurate, we chose the distortions that maximized the overestimation. The two distortion techniques with the highest overestimation percentage were Color Replacement and Amplitude. We applied these two techniques in the following group study. To conserve space, in some charts we refer to the emphasized and underemphasized as CR+ and CR- respectively for Color Replacement and AM+ and AM- for Amplitude.

GROUP CONVERSATION STUDY

This group study investigates how our two distortion strategies affect a real-time conversation. We solicited groups of friends to leverage their familiarity. We explained the Conversation Clock visualization, and the participants were given time to familiarize themselves with the colors, time structure, and animation. They were not told about the distortion of the representation by emphasizing individuals until after the study concluded.

A full session consisted of eight 10-minute conditions followed by Likert scale questions. Conditions included a no visualization condition (No Vis), a traditional Conversation Clock visualization, three Amplitude distortion visualizations, and three Color Replacement distortion visualizations. We randomly ordered the visual conditions such that the same person was never emphasized twice in a row. The 10-minute conversations were based on hypothetical questions selected from Gregory Stock’s “The Book of Questions,” and were assigned randomly to the experimental conditions. Participants were informed they could change the question however they liked or migrate onto tangential topics. Two example questions follow:

If you were able to live to the age of ninety and retain either the body or the mind of a thirty year old for the last sixty years of your life, which would you choose?

If you could spend one year in perfect happiness but afterward would remember nothing of the experience would you do so? If not, Why not?

We gathered 12 groups of three people (10 male / 26 female) for the sessions. Participants were undergraduate students, graduate students, and staff from the local university. Full sessions lasted between 1.5 hours to 2 hours, and participants were remunerated with gift certificates to Amazon.com.

Interaction Measures

For each person, we recorded the duration of speech, the number of turns taken, the length of those turns, and the degree to which an individual was emphasized. This data was automatically captured and normalized by the Conversation Clock. We also collected the following qualitative data with a Likert scale survey:

Q1: I found that I spoke ___ compared to others. 
(Agree / Disagree)

Q2: I found that I spoke ___ than usual during conversation. 
(Less / More)

Q3: I found it ___ to make my viewpoint known in conversation. 
(Easy / Difficult)

Q4: I felt pressured by others to speak more or less. 
(Agree / Disagree)

Q5: I felt pressured by the visualization to speak more or less. 
(Agree / Disagree)

Q6: Others were affected by the visualization. 
(Agree / Disagree)

Q7: I felt others understood my viewpoint. 
(Agree / Disagree)

Q8: I understood other participants viewpoints. 
(Agree / Disagree)

Q9: The conversation was natural. 
(Agree / Disagree)

Group Study Results

Overall, people measured their participation based on the Conversation Clock visualization. However, we did not detect additional behavioral change that could be attributed to the distortion. For analysis, we applied a linear mixed model with repeated visualization conditions and hierarchical group modeling. This model acknowledges that the data collected from individuals are not independent observations and accounts for the variation that naturally occurs between groups.

As in prior work [2, 3, 9], we categorized our participants as Talkative and Quiet. We labeled individuals based on
their contributions during a preliminary No Vis. The first column of Table 1 demonstrates how our two participant divisions differed from each other. The column highlights the intuitive differences between the Talkative and Quiet participants: they differed in how much they lead conversation (F1,253=14.12, p<0.001) and how long they speak in a turn (F1,253=11.78, p<0.002). Talkative individuals speak more overall. Specifically, they speak more per turn than their Quiet counterparts. While the designation of Talkative and Quiet was made at the onset of the study with no visualization present, we found the labeling held through all sessions - not just the No Vis trial.

The remaining columns of Table 1 show where the visual conditions made an impact. The second column compares the changes made across all the distortion conditions. The feedback provided with Q1 (I found I spoke [less/more] than others) changed significantly across conditions (F5,242=5.39, p<0.001). The third column compares how the Talkative and Quiet individuals changed differently across the conditions. Significance in Leads (F2,48=2.7, p<0.02) and Q1 (F5,242=2.33, p<0.04) indicate that the Talkative and Quiet participants’ reactions to the distortion conditions differed (Figures 5 and 6).

Though Talkative and Quiet participants alter their speech patterns differently throughout the conditions, their changes do not clearly indicate a connection to the distortion conditions. Examining Figure 5, the tendency to balance is still apparent. Overall, the Talkative speak less with a visualization present, and the quiet speak up. We also see that different individual conditions are more effective for Talkative and Quiet participants. That is, Talkative participants were most affected by the Color Replacement emphasis condition. Oddly, we also saw Talkative members spoke less when the other participants were emphasized via amplitude. Conversely, Quiet participants spoke up when others were emphasized (Amplitude and Color Replacement), though no effects were detected in their own emphasized conditions.

Analysis of Q1 suggests the perception of the visualization was altered by the distortion. Figure 6 shows that the perception of Quiet participants is more directly influenced by the emphasis conditions than the perception of Talkative participants. Quiet individuals report they speak more when emphasized and less when underemphasized. The Talkative participants’ highest perceived contribution is in the No Vis trial. The presence of the visualization appears to lower the amount they think they speak.

**Group Study Discussion**

Distorted visualizations impacted the perception of behavior. In both the pilot study and this study participants accepted the visualization feedback as a faithful depiction of conversation. Combining results from this study and the pilot, we were able to validate H1: a speaker will perceive they are contributing more when their contribution is emphasized via distortion. In the pilot study, each of the distortion strategies skewed the viewer’s estimation of speech contribution. In the group study, self report estimates coincided with their respective visualization condition. Participants, particularly the quiet, felt they spoke more when emphasized and less when underemphasized.

Though distortion effectively altered perception, very little measurable effect was detected in conversational patterns.
H2 stated that emphasizing a speaker's contribution results decreases participation from that speaker. We predicted the distortion would mitigate participation and allow other participants to speak more. With the amplitude distortion, some participants were aware of being distorted. Most commonly, people thought it was a miscalibrated microphone. Some participants adjusted the microphone or ask the experimenter to check the audio controls. This issue hadn't arisen in the pilot where the visualization reflected the contribution of the television speakers. In this group study, participants were more concerned about the details of their own appearance.

H3 stated that emphasized people will report feeling pressure to speak less due to the public feedback. We could not prove or disprove this hypothesis. It is not clear whether the emphasis distortions as rendered in the visualization provided any additional pressure to change one's behavior.

**Post-study Concerns**
During the experiment, it became apparent that selected groups began to pay less attention to the visualization as the experiment progressed. Post-experiment analysis identified three concerns with the study setup after the fact: group familiarity, topic interest, and group size.

As the recruited groups had a history of conversation with their group members, participants could better judge the degree of changes made to conversational patterns. However, the potential benefit was lost as familiar group dynamics took over. Combined with the interesting topics for discussion, the groups were comfortably "shooting the shit" as one participant said. The visualization became just a decoration to some, who noted "I didn't really look at it that much." If the conditions had not been done in one sitting, we may have seen more distinct changes in participation.

The group size and the short study duration influenced the study results. As each session was limited to 10 minutes, a fully equal or balanced conversation would allow all members to speak no more than 3.5 minutes. In that time, participants may not have the time to notice and adjust their behavior before moving on to the next condition.

To further explore distortion techniques, we designed a follow up experiment to focus on the visualization and the effect of that distortion. We simplified the study design and focused on the visualization without other collocated cues such as eye contact, gestures, and facial expressions. To accomplish this, we adapted the Conversation Clock so that it could be used between participants that are in remote locations. The participants did not know each other prior to the study. In this manner, participants would focus on the visualization for cues rather than just past interaction history.

**REMOTE CONVERSATION STUDY**
The remote study of the distorted Conversation Clock differed from the group study in the following ways:

1. Participants were remote and could not see each other.
2. Groups were reduced from three to two people.
3. Condition were lengthened to 15 minutes.
4. Speed was used as the distortion technique.

During a session, participants sat in different rooms with a monitor in front of them. The Conversation Clock visualization was rendered on the monitor with each participant seeing the same visualization.

Following the introduction to the Conversation Clock, a full session in this study consisted of fifteen minute conditions: No Vis, Normal, Emphasized, and Underemphasized. For this study we distorted conversation with Speed emphasis to forgo the "calibration" concerns of Amplitude distortion. Conditions were randomly ordered for this session.

The 15 minute conditions used the same questions from the previous study though each conversation had three questions to ensure there was always something to talk about. Participants were free to answer the questions in any order or deviate from questions as a topic progressed.

Thirteen groups of two participated in this study (10 male / 16 female). Participants were drawn from a similar population at local university, though all were new participants. Full sessions generally lasted about 1.5 hours. Participants received gift certificates from Amazon.com for their participation.

**Interaction Measures**
Similar to the group experiments, we recorded the aural participation in terms of amount of speech, number of turns, length of turns, etc. The survey at the end of the study was slightly modified to fit the new two person design from the original group study. The questions following each condition appears below:

- **Q1**: I spoke ___ than others (Less / More).
- **Q2**: I spoke ___ than usual (Less / More).
- **Q3**: My partner pressured me to speak more or less (Agree / Disagree).
- **Q4**: The clock pressured me to speak more or less (Agree / Disagree).
- **Q5**: My partner was affected by the clock (Agree / Disagree).
- **Q6**: My partner understood my viewpoint (Agree / Disagree).
- **Q7**: I understood my partner's viewpoint (Agree / Disagree).
- **Q8**: The conversation was natural (Agree / Disagree).
- **Q9**: I was aware of my depiction in the clock (Agree / Disagree).

**Remote Study Results**
This study demonstrates a change in participation as a function of the emphasis distortion condition. People ad-
justed the total amount of their speech when distorted with speed; however, the change was small compared to the amount of emphasis being provided. Analysis indicates most of this change occurs early and stabilizes afterwards.

The second column of Table 2 indicates the emphasis condition significantly affected overall contribution to conversation ($F_{(2,48)} = 4.2, p < 0.02$). Figure 7 makes this effect apparent: emphasized people speak less and underemphasized people speak more. However, the difference is minimal. The aggregate results across all participants show an emphasized individual will speak 1.9 seconds less in a minute than when in the corresponding underemphasized condition ($t_{(25)} = 2.8, p < 0.01$). This small difference was the result of a 60% distortion of the chosen speaker. For every 10 seconds of time an emphasized individual spoke, the speed distortion would render their appearance as 16 seconds of speaking.

Exploring the conversational balance on a minute by minute basis (Figure 8), the conditions differ over time ($F_{(2,1133)} = 8.166, p < 0.003$). Specifically, the relative balance between emphasized and underemphasized shifts and becomes stable at approximately the sixth minute of conversation. Beyond that, the the two progress in an essentially parallel manner. Figure 9 demonstrates deviations in minutes 6-8. For the emphasized condition, these minutes are consistently lower than the rest of the minutes in the emphasized condition ($t_{(130)} = 3.08, p < 0.002$). As groups were given three questions to discuss, minutes 6-8 were a common time to end the first question and move to the second. Our own observation indicates that at this point, the emphasized speaker has time to observe their depiction in the Conversation Clock during the lull in conversation.

Though we continued to categorize participants as Talkative or Quiet as in past work, Table 2 indicates that the Talkative and Quiet participants reacted relatively similarly to the visualization in this setting. In spite of the focus on the visualization and removal of other conversational cues, our participants did not report notable pressure from the visualization or from their partner. There were changes in interaction, specifically in the length of turns. Though they provide a slight change in interaction, the emphasis in the social mirror remains relatively unnoticeable.

Table 2 demonstrates the changes that occurred. The number of turns consistently increased when a person was emphasized ($F_{(2,48)} = 16.2, p < 0.0001$) with each person taking an additional 6.2 turns per minute, up from 5.8 turns in a normal condition.

**Remote Conversation Discussion**

Dyadic conversation can be shaped by distorted conversation visualization. With H2 we had hypothesized that emphasis would decrease the emphasized speaker’s participation. This study validates our hypothesis, though with a small aggregate difference of a few seconds.

Interestingly, as seen in Figure 9, the most salient moment of change consistently occurs roughly 6 minutes into conversation. This uniformly corresponds with the first major question transition. Most pairs chose to answer one question at a time and discuss it in depth before moving on. The first question often ended around 5 or 6 minutes into the session. These transitions are where balance in conversation changes. After that point in conversation, very little occurs in terms of balance (Figure 8).

The switch to dyadic conversation impacted the types of results we could detect due to the dynamics of two person conversation [5, 18]. A two person conversation has only a single speaker and a listener, there is no third of fourth person to share the speaking load in conversation. The lack of contrasts between Talkative and Quiet participants can be attributed to this change. In a dyad, one cannot remain quiet and still be a part of conversation. The only distinctions made between the Talkative and Quiet in this study, is that the two groups were appropriately split into Talkative and Quiet participants (Table 2). The above table shows the results of a repeated measures analysis comparing between conditions, the Talkative/Quiet split, and the two combined.
Quiet as the Talkative consistently dominated measures of Leads, Turns, and Turn Length.

IMPLICATIONS AND CONCLUSION
People will trust and accept a distorted image of their interaction. They will react to their distorted images. However, our results indicate this is not the primary mechanism that motivates the balance conversation in other social mirrors. Heavily emphasized conditions saw no reported change in social pressure and only a small change in participation attributed to that distortion.

The three studies bring both practical and theoretical implications to the study of group dynamics and social computing. Validating two of our three hypotheses, we showed that people would trust a visualization over their own perception and that people would participate less when emphasized. Though we set out to demonstrate a malleable link between distortion and participation, we found there must be other mechanisms that must account for the push towards balance in conversation. We expect the dominant mechanism for change is the knowledge that one could be held accountable by the visualization. People change because they feel they are being observed and are more self-conscious of their actions.

Using abstract visualization as feedback, a distorted visualization produces an effect very near the undistorted visualization. The accuracy of the visualization has a minor impact as long as the visualization remains trustworthy. At 60% emphasis with speed distortion participants shifted 8% in individual contribution. Though we did not test visualizations that were so far skewed to be untrustworthy, we anticipate they would be ignored based on the ability of familiar groups to ignore the visualization and the negative reaction when the visualization was notably wrong in the pilot study.

Visualizations like the Conversation Clock articulate and help people realize what may not be readily obvious to them or to their conversation group (i.e. “I really have been talking too much,” or “I should speak up”). In the colocated group study, participants were familiar with each other and entered the study with a history of conversational patterns. In this setting, the social mirror may not be effective. Although more study is needed, we suspect that once these patterns are known by the individual and group (i.e. John talks a lot; Mary and John know that John talks a lot) and are accepted by the group, the social mirror does not provide added incentives for viewing or for modifying conversation. Once one learns the patterns from a specific group using the Conversation Clock, they may not need to keep viewing it as was the case in the second study.

Future applications of distorted mirrors would benefit from directed goals. People deferred to the visualization over their own judgement of conversation as shown in the pilot study and group study. As a motivational tool the use of distorted feedback could be an effective means to challenge people in achieving a targeted contribution goal. Work in physical therapy has been able to appropriate similar feedback to encourage recovering patients to push their muscles harder by underreporting their performance [6]. Though the work presented here was done with participants without a specific motivation to alter their interaction, a similar approach could be taken to use social pressure as a motivation: teaching social skills directly in conversation, conserving energy compared to one’s neighbors, or increasing exercise relative to one’s friends. Distorted feedback could help to drive individuals when a goal is in mind.

In the final study, we found the social mirror was most useful at a specific time. The Conversation Clock played a role in between questions at roughly 6-8 minutes into the conversation, a time when participants took a moment to break from speaking. Past work also indicates the clock is most useful when less actively engaged at the moment (not speaking or returning eye-contact). Future work might further study moments of social mirror utility to gauge if a person is watching others or specifically checking themselves. The change occurring between questions in the dyadic condition seems natural as both participants are engaged throughout the rest of the conversation. Though, an extensive categorization of the gaze direction in social mirrored environments has yet to be done, it could show when people are most interested in feedback and potentially why.

9 (remove for camera-ready copy)
Viewing personal social data alongside others’ personal data reveals subtle nuances of personality. Upon viewing that data, context determines how a person responds: assimilate into the crowd, to stand out as an individual, or simply know where they fit. A person can shape themselves based on what aspects they value in that context. Social mirrors have explored a subset of applications in meetings, conferences, the workplace, and therapy; they show that feedback can be used to promote characteristics that are desirable in the group. As more social interactive data becomes accessible with sensors and personal data collection, the settings for social mirror feedback only expands.

LIMITATIONS
Our work is limited to the exploration of the Conversation Clock and our varied set of distortion strategies in relatively short conversations. We cannot make strong claims as to how this setting affects individuals over long periods of regular use. We expect that if a person is comfortable with the visualization, its effect would decrease unless there were a specific social reason to attend to one’s representation.

REFERENCES