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# Using Visualizations to Review a Group's Interaction Dynamics

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## Abstract

We present a visualization system for reviewing the turn-taking patterns in a face-to-face meeting. Without the need to directly observe a group, a user can use the system to gain insight into the interaction dynamics of a meeting. We evaluated the visualizations by asking outside observers to make qualitative judgments about the individuals represented visually, and then compared their assessments to our own, made from direct observation of the meetings.

## Keywords

Social visualization, meeting support, CSCW.

## ACM Classification Keywords

H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces – Computer-supported cooperative work.

## Introduction

Social psychologists suggest that one way a group can improve its interaction and consequently its productivity is by having a high-level understanding of its emotional and social interaction [4]. Furthermore, a group can gain insight into its interaction by viewing an aggregate report of its behavior [1]. We therefore postulate that an automated method for collecting

social dynamic information could similarly assist groups in understanding and improving its interaction.

Our previous research examined the impact of real-time displays of social information on the interaction of a group [3]. In evaluating these real-time displays, we realized that much of the information collected during a meeting is too complex to be interpreted peripherally, through an ambient display. Additionally, groups using our displays have suggested that having this information available after the meeting—in the form of a private report—would be useful for reviewing their own behavior and reflecting on it in a more contemplative, private manner.

To address these issues, we built a system that captures and visualizes the vocal patterns of a conversation for post-meeting review. The system, called Second Messenger, allows a user to view the turn-taking behavior of a group at different points of an interaction, replaying the patterns at ten times the speed of the original meeting. An individual can observe the dynamics without reviewing a videotape of a meeting or by intruding upon a group by directly observing it. In the following sections, we describe Second Messenger and present findings from a study evaluating the efficacy with which it conveys qualitative information about group interaction.

### **Visualizations of Meeting Interaction**

To capture a group's interaction, during a meeting, each person wears a noise-canceling microphone that detects *when* he or she is speaking, and the system aggregates these time-stamped moments of individual speech to create a record of *who spoke when*. The system then uses this record to build four distinct

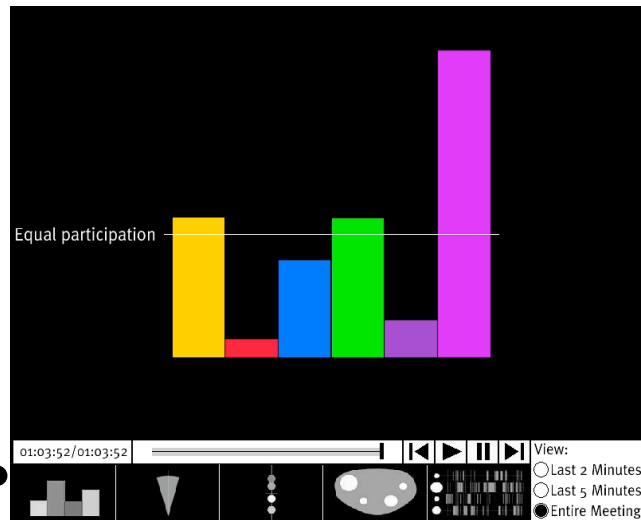
visualizations, each intended to emphasize different aspects of a social interaction: ongoing participation levels, turn-taking patterns, overlapped speech, and floor control. The system does not collect the audio content of the meeting, just the timestamps during which speaking occurred.

#### *The Visualizations*

Figures 1 through 4 show Second Messenger's visualizations, illustrating the same moment in a conversation of six individuals.

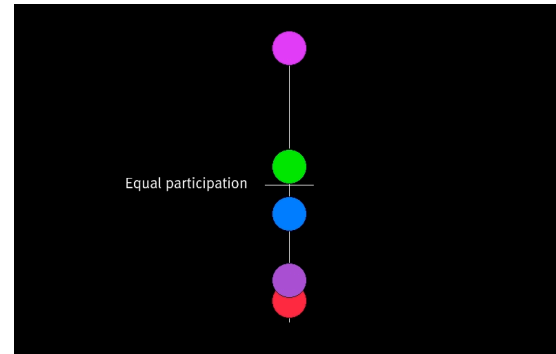
The first figure shows a histogram in which the vertical bars represent how much each person has spoken in relation to the others. This is similar to the interface we used in our previous study examining the impact of real-time feedback on group participation levels [3]. The second visualization represents each person as a ball of a fixed diameter where the ball's vertical position reflects the individual participation level. When viewed with a limited time window (a two or five minute range), this view provides a way of seeing who currently has the floor (a circle moving up) and who is falling away from the center of the conversation (a circle moving down). The third visualization represents each person as a circle that grows and shrinks in proportion to that person's participation level. Within each circle, pie slices reflect how much each *other* person spoke *while* that person was speaking. Overlapped speech, while commonly thought of as interrupting, also includes instances of simultaneous laughter, short verbal affirmations, and side comments made while someone is speaking. Irregularities in the patterns of overlapped speech can reflect unique roles and relationships between the people, for example, distinguishing friends from strangers. The grey shape

around the individual circles is a design element to reflect the intimate nature of a face-to-face meeting, while the other visualizations emphasize more direct comparisons of the individuals. The fourth visualization is a timeline revealing who spoke at each moment in the meeting. In this view, a user can see exactly who spoke when and who gained the floor at moments of overlapping speech. The circles down the left side of the display represent the individuals and the horizontal lines extending from the circles have vertical blue bars at the moments when that person spoke. To highlight moments of overlapping speech, transparent vertical red lines are drawn across the six speaker lines at moments where more than one person spoke. By watching a replay of the meeting with this Timeline visualization, a user can observe the flow and speed of interchange between people.

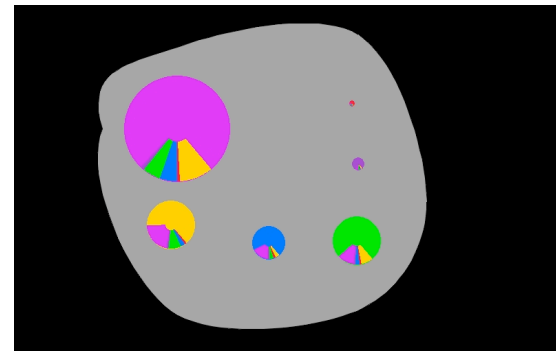


**figure 1.** Histogram visualization

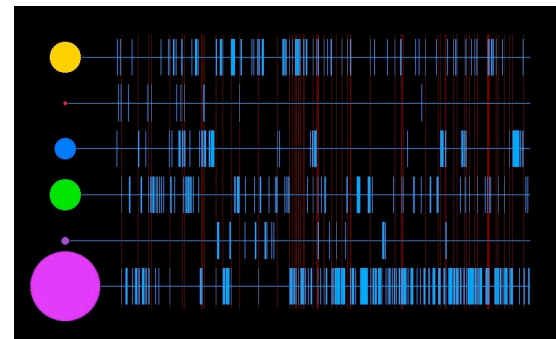
In this screenshot, the application window is shown, with the playback controls, the visualization selection menu and the temporal window selector.



**figure 2.** Turn-taking visualization



**figure 3.** Overlapped speech visualization



**figure 4.** Timeline visualization

## **Evaluation**

To determine if these visualizations effectively provide summarizing information about a group's interaction, we conducted a study asking subjects use these visualizations alone to evaluate two groups and make judgments regarding the behavior of individuals and the groups. The two meetings we asked subjects to evaluate had four members and lasted an average of 20 minutes each. The individuals in the meetings discussed a defined topic until they came to consensus, with no knowledge of how they would be evaluated.

### *Evaluation Procedures*

A total of eight subjects used the visualizations to make qualitative assessments of the groups' interactions. Each subject was given a 15-minute tutorial on how to use the application, viewing an example meeting to demonstrate the application features. After the subject was familiar with the application and the data, he/she then examined the two groups using the visualizations while filling out a questionnaire about the dynamics and individual behavior. The subjects were encouraged to fill out the questionnaire in any manner they found useful, and if desired, to directly compare the groups' visualizations to each other to answer a question. The subjects could use all of the visualizations and in most cases, used the overlapped speech and the timeline visualizations for the majority of the questionnaire.

The study subjects were affiliated with our department, but none had had prior exposure to the application or to the individuals in the recorded meetings. They spent an average of 40 minutes evaluating the two 20 minute meetings. Although this was not faster than watching a real-time video, we believe that this time would decrease dramatically once familiar with the tool.

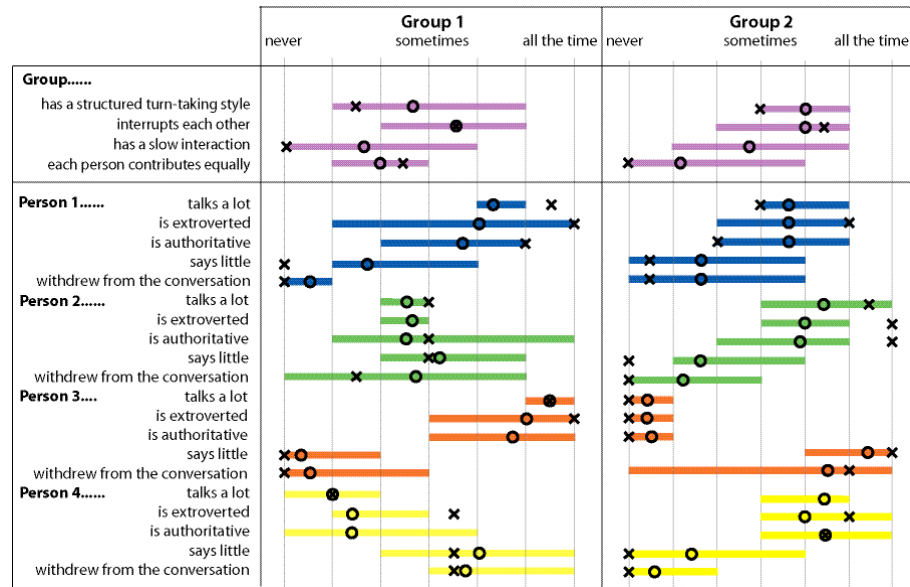
To evaluate the subjects' assessments, we compared them to our assessment of the groups based on watching videos of their meetings. To perform our assessment, two of the investigators separately filled out the subject questionnaire while watching the videos.

### *Findings*

The findings from the evaluation indicate that certain behavior traits are more effectively conveyed than others: personality traits that are expressed with explicit behavior were reported with higher consistency than those traits that imply an attitude or internal motivation. Table 1 provides a summary of this data.

In the group-level evaluation (the top part of the table), subjects were relatively consistent in how they rated the level of interruption and these ratings agreed with our video evaluation. But, they rated turn-taking as more structured and faster than it appeared on video, and the equality of contribution, a quantifiable measure, was rated as more balanced than the video in fact revealed.

The individual evaluation results (the lower portion of Table 1) show a distinct pattern in the responses, indicating that subjects correctly perceived that the individuals in the meeting exhibited unique personality traits. For example, in Group 1, the subjects correctly determined that Persons 1 & 3 spoke more, were more extroverted, and never withdrew from the conversation, as compared to Persons 2 & 4. In Group 2, subjects correctly determined that Person 3 was very different in demeanor than the other three, in speaking less, not being extroverted, not having authority, and withdrawing from the conversation.



- Each bar represents the range in subject responses and the ○ highlights the mean subject rating (out of 8 subjects). The X indicates the investigators' aggregate rating. When the investigators' ratings differed by more than 1 point, they were excluded from the results.
- Each questionnaire response was on a 7-point Likert scale ranging from "never" to "all the time."
- In some instances, subjects diverged greatly in their responses. This was usually in a case where a subject rated all Persons as identical to one other, rather than differentiating their behavior.

**table 1:** Responses to the questionnaire

In addition to the personality questions, the questionnaire also asked subjects if they could determine which side of the debate each person fell on during the meeting. Table 2 (on the next page) summarizes these results. Somewhat unexpectedly, subjects were able to correctly determine who was arguing with whom from the visualizations alone. In the one case where we, as the investigators watching the video of the group, could not determine which side an individual fell on, neither could the subjects. As a follow-up question, subjects were also asked to rate each person as cooperative or uncooperative, and most subjects reported that they could not determine this from the visualizations.

#### Evaluation Conclusions

We believe the strength of our visualization system is in revealing extreme behavioral differences between individuals in a meeting. Our subjects could pick out the extroverts, the quiet individuals, and the authoritative personalities. Subjects had more difficulty evaluating the group-level descriptives and were inconsistent in their assessment of individuals on traits that involve personal motivation and intention, such as "cooperating" and "withdrawing from the conversation." Most notable of the results is that based on speaking patterns alone subjects were able to detect which sides of a debate each person fell on.

Each number in the table indicates the number of subjects who placed that person on that side of the debate. **I** indicates what the investigators observed in watching the video-taped debates.

|         |    | Side A      | Cannot Decide | Side B      |
|---------|----|-------------|---------------|-------------|
| Group 1 | P1 | 8, <b>I</b> | 0             | 0           |
|         | P2 | 6, <b>I</b> | 0             | 0           |
|         | P3 | 0           | 0             | 8, <b>I</b> |
|         | P4 | 1           | 5             | 2, <b>I</b> |
| Group 2 | P1 | 6, <b>I</b> | 1             | 1           |
|         | P2 | 8, <b>I</b> | 0             | 0           |
|         | P3 | 1           | 4, <b>I</b>   | 3           |
|         | P4 | 0           | 0             | 8, <b>I</b> |

**table 2:** Who fell on each side of the conversations' debates.

### Related Work

The field of CSCW includes numerous examples of systems designed for summarizing meetings. Two examples of automated collection of audio information include: Kristjansson et al. [5] who developed a method for extracting meeting keywords through voice recognition to annotate a video of a meeting; and Chen [2] who built a system to provide feedback on who is speaking, gesturing, and fidgeting in a remote classroom. As with our work, they chose simple visualizations of activity to make different behaviors more salient. In addition to CSCW, our work draws from the field of social visualization for techniques on conveying social meaning [7].

### Conclusion

Second Messenger provides a method for reviewing a meeting, not for content, but for the social and behavior dynamics between individuals. We have demonstrated that several aspects of a meeting, such as who is dominating, who is quiet, who is extroverted, and who has sided with whom in a debate, can all be revealed through visualizations of speaking patterns. While not as complete a video analysis, our system conveys general impressions to an observer that can be used to examine group behavioral trends.

Our primary intention for this application is for groups to use it as a method for reflecting upon their *own* social interaction, to gain a better understanding of it. As an alternative to hand-coding group behavior [6], and as a less arduous task than filling out self-evaluation questionnaires, Second Messenger provides an automated method for gathering basic information about group interaction dynamics. This research will continue to explore these claims by providing these visualizations to many types of groups during their meetings, in both experimental and real-world settings.

### Acknowledgements

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