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# SOCIALSENSE: Graphical user interface design considerations for social network experiment software

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ABSTRACT

Using networked computers in laboratory experiments to investigate group dynamics currently requires the creation of special program application software. Design considerations for a useable graphical user interface (GUI) in such software are discussed in this paper. We describe SOCIALSENSE communication software created to experimentally test the effect of different social network configurations, group membership, and group integration on patterns of rumor self-organization. The software connected 16 participants using several different network configurations via a web-accessible Java applet, tasked them with making sense of rumors presented to them, enabled "neighbors" to synchronously or asynchronously communicate, and recorded their selections and beliefs. Four principles of design were followed: employ reading gravity, minimize cognitive load, use pre-existing mental models, and select color to direct attention. A description of each principle is presented, how it was applied to the GUI, and how it could be applied to other social network experiment program interfaces.



## 1. Introduction

Complex and dynamic theories of human action situated in social networks are playing an increasingly dominant role in understanding group dynamics (Foth, 2006; Mason, Conrey, & Smith, 2007; Smith & Conrey, 2007). The widespread availability of microcomputers has afforded group researchers promising new avenues and tools with which to study networked group behavior in the field (e.g., Huff & Rosenberg, 1989) and laboratory (Kerr, Aronoff, & Messé, 2000). One computer-assisted approach to this type of group research is to assign each member of the group to a station and allow members to communicate by means of network software application. This approach was used successfully in studies by Latané and colleagues (Latané & Bourgeois, 1996; Latané & L'Herrou, 1996) that investigated how attitudes spatially self-organize into homogenous clusters across social networks. This methodology was also used in a variety of investigations that explored network configuration effects, including: group performance in solving a graph problem (Kearns, Suri, & Montfort, 2006), cooperation in a prisoner's dilemma game (Cassar, 2007), and the dissemination of innovation in collective problem solving (Mason, Jones, & Goldstone, 2005).

These types of investigations use software specifically created for the study in question. To our knowledge, applications for the design of social network experiments are not yet available (Kerr et al., 2000). Researchers using this pioneering approach must still program their own applications from scratch.

A well-designed graphical user interface (GUI) is an important feature of any experimental software package. When programming experimental software to study complex and dynamic networked group behavior, researchers who program these applications can benefit by attending to established user interface design guidelines (e.g., Ozok & Salvendy, 2004). When designing computer interfaces for experiments, the primary goal should be making an interface that successfully communicates—and allows the user to complete—the experimental task (e.g., DiFonzo & Bordia, 1997; Hantula & Crowell, 1994a, 1994b).

To this end, the current paper focuses on the usability and design issues considered while creating an Internet-based social network experiment software tool—SOCIALSENSE—developed to study the dynamics of rumor propagation over social networks. The investigation consisted of three successive studies, and each involved different software and GUIs. In each study, SOCIALSENSE allowed participants to communicate with each other in a proscribed social network configuration. The investigation explored the effects of social space configuration, group membership, and network homogeneity on how diverse and clustered rumors became over time. Making the interface as intuitive and transparent as possible was important to prevent usability problems from interfering with the experiment. Four basic principles drawn from the usability literature were followed to create an aesthetically pleasing and highly usable interface: employ reading gravity, minimize cognitive load, use pre-existing mental models, and select

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color to direct attention. These four principles (explained below) were chosen on the basis of their applicability to this particular program's interface but they are also likely to apply to any social network experiment program.

We begin with a brief overview of the experiments and then describe each version of SOCIALSENSE. We next define and describe each design concept, how it was applied to the three versions of SOCIALSENSE, and how it can be applied in the design of other interfaces.

## 2. Overview of experiments

### 2.1. Network configuration factors in rumor transmission

The experiments described here explicitly test the impact of various network configurations on rumor transmission outcomes. These networks included torus, "family," "ribbon," and random spatial configurations. Sixteen-person torus, family, ribbon, and random networks are diagrammed in Fig. 1. Each of the circles represents an individual. Social connections are indicated when circles are connected with a line; each person in our networks was connected to four "neighbors." In the torus network depicted, each in a lattice-like uniform distribution; in three dimensions, the network assumes the shape of a torus (i.e., a donut). The ribbon configuration shows how an individual may be connected to four neighbors aligned as on a street—two on the left and two on the right. The family configuration depicted shows how the majority of one's social interactions may be with one's "family" or local cluster of contacts. The random configuration shown is one of many possible arrangements; it was obtained by constructing a 16-person network where the probability of being connected to any other node is randomly selected from a uniform distribution.

Three versions of SOCIALSENSE were created, one for each study conducted in this series. Readers may interact with a demonstration model of each version, or download the program code at http://sensemake.rit.edu/ (enter GroupID = 0, UserID = 1, Login Code = 12, and any Age and Sex). Each version configured networks of 16 participants connected by personal computers in a laboratory. Participants in these computer assisted panel studies (CAPS) communicated electronically regarding rumors that were presented to them. In each study, participants were first trained using a series of web pages specifically constructed for that purpose. The training involved familiarizing participants with the software GUI and the experimental task. Participants then registered for the study using predetermined login credentials. When all participants logged in, the study commenced.

In each experiment, participants were told that the study was on Internet communication. They were presented with a series of ambiguous situations or rumor statements and asked to make sense of these situations or to determine the truth of the rumor by discussing it with the people they were connected to. Using the SOCIALSENSE software, they communicated with their neighbors for each situation or rumor statement. Unbeknownst to participants, SOCIALSENSE also varied network configuration across these situations or statements. With the exception of the segregated conditions in Study 3, participants also had to be configured into one interconnected group. At various points, participants recorded which rumors made the most sense to them or their confidence that the rumor was true. For each situation or statement, SOCIALSENSE also calculated and recorded a number of group measures, such as the degree to which rumor choices were spatially clustered across the network. We describe each version of SOCIALSENSE below with special attention to the GUI employed by each.

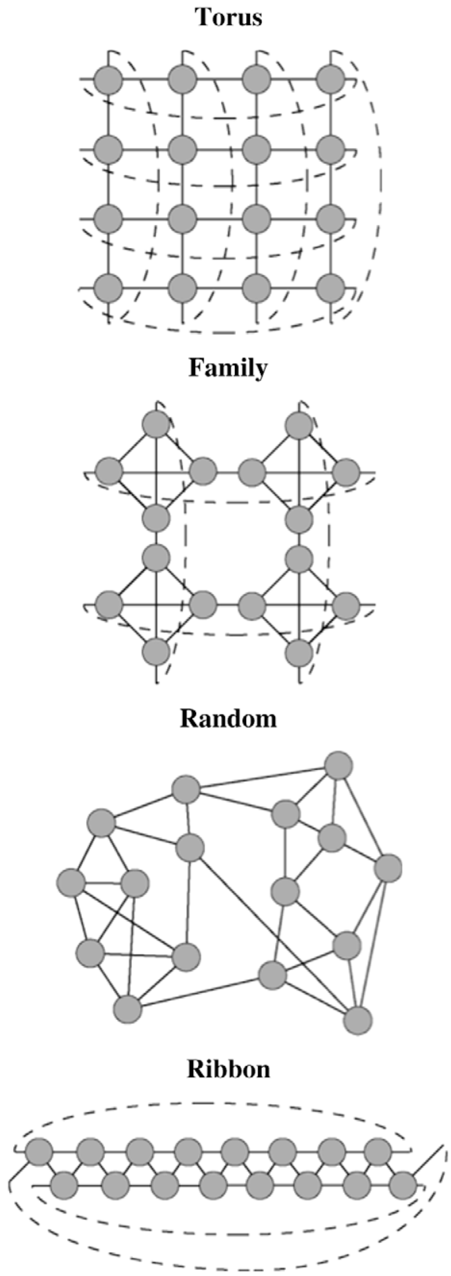


**Fig. 1.** Torus, family, random, and ribbon configurations for 16-person groups where each person is connected to 4 neighbors. *Notes*: When portrayed two-dimensionally, the torus (i.e., donut-like) shape appears as a lattice. The random configuration is one of many possible arrangements; random configurations are created by specifying a constant to the probability of any two persons in a group connecting.

### 2.2. SOCIALSENSE 1

In this experiment, each 16-person group was presented with a series of eight separate ambiguous situations. Each participant communicated via a computer terminal with four other individuals in the group. During each situation, participants were presented with four alternative statements (rumors) that made sense of the situation and were asked to determine through discussion which alternative made the most sense. Discussion proceeded over four rounds of synchronous (i.e., e-mail type) communication.

Fig. 2 displays an example of the GUI employed by SOCIALSENSE 1.

### 2.3. SOCIALSENSE 2

SOCIALSENSE 2 differed from version 1 only in that communication was asynchronous, that is, it used an instant messaging rather than an e-mail type format. This necessitated several key GUI alterations. Instead of communicating synchronously over four rounds where each participant could only send one message to each neighbor, communication occurred with each neighbor asynchronously in one long discussion round sandwiched between an initial and final private rumor choice and confidence measurement. For each situation, then, participants carried on four asynchronous conversations simultaneously.

### 2.4. SOCIALSENSE 3

We used SOCIALSENSE versions 1 and 2 to investigate how network configuration affected patterns of rumor propagation. The rumors (possible explanations) set forth in these studies were all pretested and designed simply to be moderately plausible to our participant pool. In the third study in this set, we were interested in the propagation patterns of rumors that often arise in situations of conflict between groups. As in Study 2, participants in this experiment experienced a series of simultaneous asynchronous discussions with four neighbors, again sandwiched between an initial and final private opinion measurement. However, participants were presented with only one rumor at a time, and they were asked to assess the truth of the statement through polite group discussion. We allowed 10 min for these instant messaging type discussions, sandwiched between an initial and final rating of how strongly the participant believed or disbelieved the rumor. Participants discussed nine different rumors in a series; two were Democrat-positive, two Democrat-negative, two Republican-positive, two Republican-negative, and the remaining rumor was systematically alternated between rumor types.

The GUI employed by SOCIALSENSE 3 is displayed in Fig. 3.

## 3. SOCIALSENSE GUI design principles

The development of each GUI employed a process that iterated between programming modifications and careful pilot testing. Three goals essential to achieving experimental validity guided this process, and the interface design principles presented in this manuscript were in service of these goals: First, the GUI had to enable users with varying degrees of computer experience to quickly apprehend the experimental task with minimal training. The validity of an experiment is enhanced when subjects spend as much time as possible in the experiment communicating with each other through the tool and as little time as possible teaching themselves how to use the tool. The purpose of this experiment was to study how rumors organize in social networks when people communicating with each other and not how quickly people learned to use a new computer interface. Thus, the interface had to be as "transparent" as possible. Second, the GUI had to enable an error-free ordered execution of experimental subtasks. Obviously, the validity of the study squarely rests on the likelihood that participants were performing the experimental subtasks properly. Third, the GUI had to clearly present and receive messages between networked individuals. Because social networking experiments study collective behavior emerging from individual communicative behavior, experimental validity hinges upon individual ease of communication; a GUI that obstructs communication would introduce a confounding—and probably systematic—artifact into the process.

The initial layout of SOCIALSENSE1 was conceptualized using the design principles described below, and then evaluated by the research team with the above goals in mind. After modifications, the GUI was then pilot tested in four pilot runs, first with two groups entirely composed of the research team, then with two successive groups of naïve participants. Research team participants first followed directions properly, and then intentionally contravened instructions in an attempt to discover programming errors

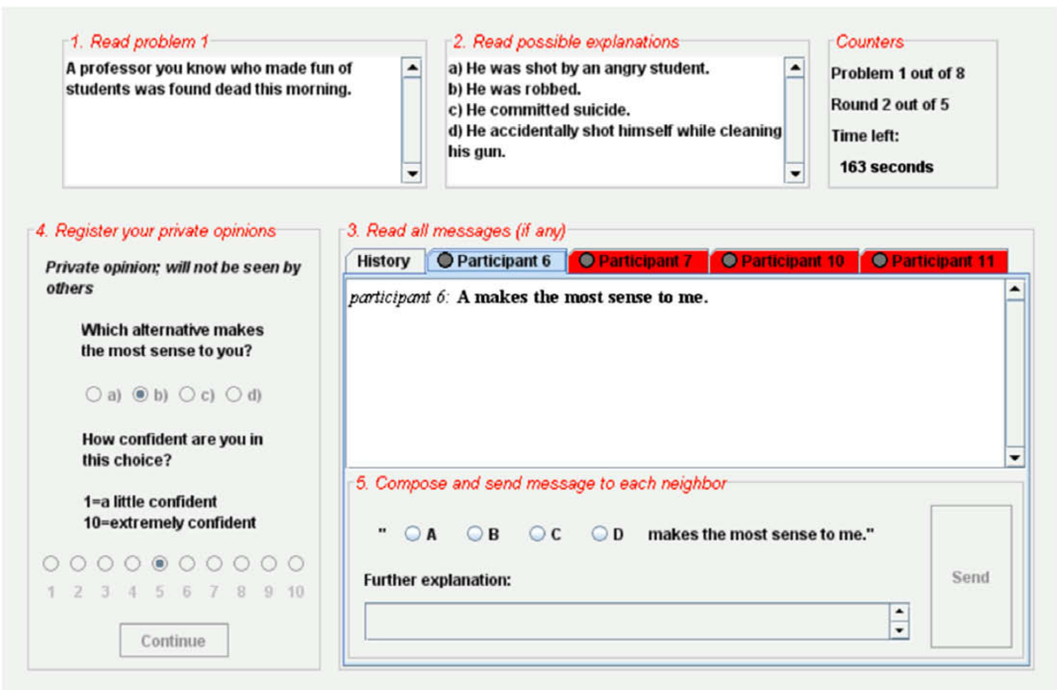


**Fig. 2.** Screenshot of the SOCIALSENSE 1 GUI. *Note:* This participant is on round 2 of Problem 1 and is reading a message from "Participant 6."

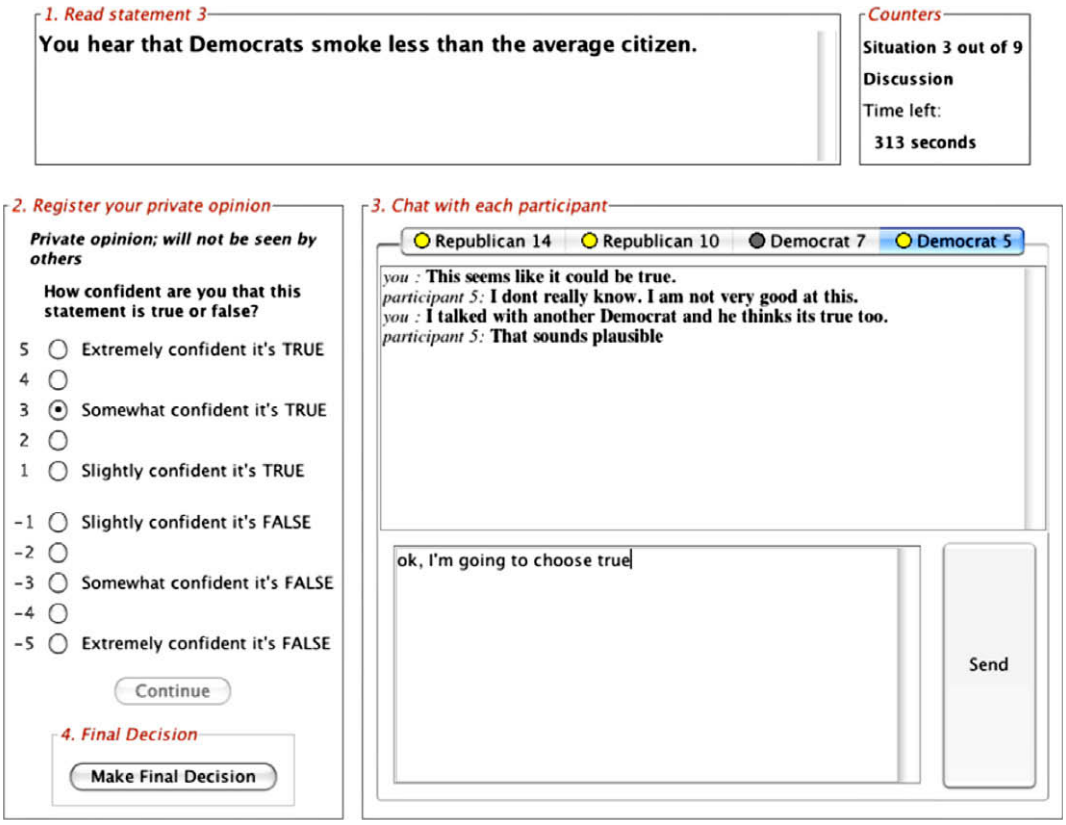


**Fig. 3.** Screenshot of the SOCIALSENSE 3 GUI. *Note:* The screenshot depicts a chat with participant 5, who is a Democrat.

and vulnerabilities. Naïve participants were informed that the program was in development. In a written feedback instrument, they were asked to record any thoughts they had about the study in general, and were specifically asked about the clarity of instructions and the degree to which the operation of the GUI was easily learned. They were queried about how the experimental training and tasks could be improved, and whether or not they had adequate time to perform these tasks. Finally, they rated how interesting, involving, and engrossing the study was on 9-point scales (e.g., 1—Not at all interesting, to 9—Extremely interesting).

Based on this feedback, successive modifications were made to the GUI. After two iterations of pilot testing, participants uniformly indicated that instructions were clear, learning to operate the program was easy, and that adequate time was allotted to perform the task. In addition, all participants' interest ratings exceeded seven, indicating that the experience was highly involving. The development of the SOCIALSENSE 2 and 3 GUIs followed similar paths. On the basis of these data, we judged each GUI to be useable and interesting. Observations by experiment administrators were consistent with this; participants typically required minimal assistance when performing tasks, attended closely to the experimental task, and in the case of SOCIALSENSE3, tended to actively communicate during the entire allotted time for discussion.

We turn now to a consideration of the interface design principles, and how they were applied to the SOCIALSENSE GUI.

### 3.1. Reading gravity

The Gutenberg diagram describes the directional pattern followed by a person's eyes when encountering a new set of information (Arnold, 1969; Wheildon, 1995). When a display is divided into four quadrants, Western readers expect to begin in the upper left area and end at the lower right. The upper left area is known as the primary optical area and should contain the most important information—that which should be viewed first—whereas the lower left is known as the "weak fallow" area and should contain the least important information—and therefore should be viewed last. The left to right, top to bottom method of reading is known as the direction of reading gravity. Reading gravity generally flows from the primary optical area to the terminal area.

The Gutenberg diagram is an effective tool for guiding the process by which users are oriented to a novel interface and reinforcing the experimental tasks required because it takes advantage of the natural order of attention given to that interface. In the three versions of SOCIALSENSE, the Gutenberg diagram guided the process by which the participant was introduced to and became familiar with the GUI. In addition, it was used to reinforce the ordered steps necessary to accomplish the experimental tasks.

For example in version 1, the direction of reading gravity coincides with the tasks required in round 1. Observe the SOCIALSENSE 1 GUI presented in Fig. 2. The Gutenberg diagram informs us that participants first encountering the GUI would instinctively attend to the primary optical area (the upper left corner); we therefore placed in that spot the first item they were required to read: the situation box. They then would naturally shift their gaze rightward to the strong fallow area; this area is primarily occupied by the alternatives box, the second task to be performed. Next they would tend to attend downward and to the left—the weak fallow area; this area is primarily occupied by the means to achieve the next task: choosing a rumor that makes the most sense to the participant and recording her confidence level. When this is complete, the user again would shift attention rightward, now to the terminal area; in this part of the interface the participant composes and sends messages to each of their neighbors. At this point, the user is now more familiar with the interface and more likely to perform the experimental task in the proper order. Because of this, the user can also now better tolerate small departures from the direction of reading gravity required in rounds 2 and 3, for example, as when they shift attention back and forth from the message boxes and private opinion registration. Layout of the GUIs for versions 2 and 3 were also similarly guided by the direction of reading gravity.

### 3.2. Minimization of cognitive load

Cognitive load plays an important role in interface usability. Cognitive load is the degree to which working memory is taxed during attention, perception, remembering, problem solving, thinking and reasoning. The general rule of thumb, obviously, is that less cognitive load translates into a more useable interface (Feinberg & Murphy, 2000; e.g., Seneler, Basoglu, & Daim, 2009). What GUI factors affect cognitive load?

Paradoxically, a text-based GUI is less cognitively taxing than an icon-based one and results in better performance overall (Thompson, Rantanen, Yurcik, & Bailey, 2007). A text-based interface, as the name implies, uses text to convey meaning, while icon-based interfaces use symbols. The print command in a word processing GUI, for example, may be signified by the word "PRINT" or by an icon depicting a printer. To investigate the effect of cognitive load Saadé and Otrakji (2007) studied the difference between new icon-based and text-driven interfaces and measured user disorientation along with cognitive load. They defined disorientation as the tendency to lose one's sense of location in a software interface, which has been shown to be a good measure of usability (McDonald & Stevenson, 1998). Disorientation was measured by time it took the user to complete a task, and cognitive load was measured with a questionnaire including the perceived ease of use of the interface. Participants found the new text-driven interface to be easier to use than the new icon-based one. For example, when using icons, participants needed nearly three times as much time to find the OPEN command. Participants showed disorientation with this simple task. Symbols are useful and save space, but they take time to learn.

Therefore, in order to reduce disorientation and cognitive load, and reduce time required to complete tasks, a text-based interface structure is preferred unless the symbol is well-known. In each SOCIALSENSE interface, no icons that could potentially confuse users were employed. Icons would have confused participants confronted with a completely new interface. Our GUI was strictly textual. For example, each box was labeled with words. Observe Fig. 3. The first box is labeled "*1. Read statement 1*." The textual label clearly indicates that this is the first task and that it entails reading the statement in the box. Creating a symbol to convey the same message, say of a person reading a book, or an icon of an eye, would not have been immediately apprehended. The resulting confusion would have led to difficulty in using the interface and a reduction in the validity of any data collected.

Because there is more to attend to, the proliferation of separate windows also increases cognitive load in an unfamiliar interface. In an initial conceptualization of the GUI, the four neighbor chat windows were placed next to one another as four panels in window pane fashion (northwest, northeast, southwest, southeast). This arrangement presented too much information to handle at one time and also necessitated smaller font sizes. We therefore used tabbed windows to convey which neighbor was being communicated with. An important advantage of the tabbed document interface is that it holds many similar windows under one another, instead of displaying a large and busy collage of separate windows. Using tabs instead of new windows to display content creates a smaller visual footprint and therefore reduces the load on the user. The history tab in version 1 (see Fig. 2) allowed users to see all messages sent to them since the beginning of the round, organized by round, then by neighbor. The user can then apprehend a quick summary of all communications received over the past round.

### 3.3. Pre-existing mental models

Mental models are representations in the mind of physical or situational realities. People create mental models for countless systems and objects they interact with (Norman, 1988). There are two kinds of mental models; system models represent how systems work overall while interaction models refer to how people interact with systems. Well-learned mental models can greatly facilitate new learning (Chalmers, 2003; Nadeau, 1996). For example, researchers invoked the mental model of "playing a game" to facilitate learning of an experimental task involving stock market trading (DiFonzo, Hantula, & Bordia, 1998).

When completing a task, users compare how they imagine the interface should behave—based on a mental model—with how it really behaves (Hillstrom & Chai, 2006). When these two outcomes match, users perceive the interface as accurate, useable, and even more aesthetically pleasing (Chalmers, 2003; Saadé & Otrakji, 2007). In the SOCIALSENSE GUIs, the interaction model that participants invoke was critical because the goal of the design was to facilitate valid user interaction with the application. Because chat programs are ubiquitous, the design of this application was guided by the well-known chat window mental model. Observe Fig. 3. Notice that the area reserved for asynchronous communication contains a large white box listing participant statements, the statements are listed in chronological order and labeled by source (you or your neighbor), a smaller area below the chat record is available for composing comments, and next to this is set a rectangular SEND box in portrait format. All of these features mimic conventional chat box elements widely in use today. Participants—all college-age students well-versed in technology—immediately apprehended the necessary subtasks involved. Conversely, deviation from this mental model would have hindered users from properly completing the communication tasks required.

SOCIALSENSE also capitalized on another well-known mental model: tabs. Many web and program interfaces use tabs to organize information and choices. Guided by this model, we formatted the tab elements of the communication interface. In this way, participants were able to apply their mental model of how tabs work to quickly understand how they could compose and view messages to and from individual neighbors.

If a standard mental model for a system or device exists, then that model should be used in the design. However, in cases where there is no standard model, drawing elements from models of similar or applicable devices may work well. Of course, deviations from a well-known mental model will hinder usability. One problem encountered in collecting data using version 1 came from the chat program mental model. Recall that version 1 used an e-mail (synchronous) communication format. During the first round of discussion, some participants waited for their neighbors to speak first because they believed the program acted like an instant messenger. The mental model of the chat program was strong enough to influence how people were interacting with the program. These participants had to be reminded that the program works in rounds, not instantly.

### 3.4. Use of color to direct attention

Color plays a valuable role in the design of any interface (Cardosi & Hannon, 1999; Preece et al., 1994; Xing, 2006). The most important functions of color are to draw attention to some elements and to enhance aesthetics (Albers, 1963; Hillstrom & Chai, 2006; Schneiderman, 2005).

In the SOCIALSENSE GUIs, color is used to help users attend to certain elements in the interface. For example, the headings of each box are colored red in contrast to the GUI background. By using color to attract attention to the headings of each box, the user is quickly oriented upon first encountering the application. Similarly, color is used to designate neighbor messages that need to be responded to. In version 1, neighbors that have not yet been sent any messages are signified with a red tab to draw attention to this task (see Fig. 2). More in keeping with a traffic light mental model, version 2 uses a yellow tab to signify that a neighbor needed a response, and a red tab to convey that the neighbor was no longer available for discussion. In version 3, the tabs have small icons (circles) that change color instead of the entire tab (see Fig. 3); a yellow circle signifies that the neighbor needs a response, and a gray circle that he was no longer available for discussion. This use of color affords quick recognition of communication tasks that still need to be completed. In addition, when there is only 30 s left in the round, the counter blinks red every other second. This draws the user's attention to the timer to notify them that there is a limited amount of time left.

Limiting the color palette to a few in number keeps the design simple and does not distract the users. Keeping the color palette simple is also important because relying too heavily on color to provide information would impair users with color perception deficiencies.

## 4. Conclusion

In this paper we have described three versions of the communications software SOCIALSENSE that were used in conjunction with laboratory experiments investigating rumor propagation. Principles used in the design of the GUI were given special attention. These were: employ reading gravity, minimize cognitive load, use pre-existing mental models, and select color to direct attention. The use of these principles helped to make the software useable; in pilot tests, participants universally indicated that they were able to quickly apprehend how the software functioned, were easily able to perform experimental subtasks and to communicate effectively with one another. This greatly enhanced the likelihood that the procedure was experimentally valid.

The ubiquity of personal computers has afforded a new opportunity to study group processes in networked environments, but this potential will only be fully captured with properly designed interfaces. Computer-mediated group-level dynamical experiments on live humans (as opposed to simulations), and specifically those that use modified e-mail and instant-messaging software to collect data, are very unusual. The GUI described here literally made this study possible. Two novel aspects of SOCIALSENSE GUI are particularly noteworthy. First, and key to the effectiveness of any social networking experiment, was that it "got out of the way"—participants were able to focus on the task at hand rather than the interface. It did this by creatively and elegantly capitalizing on well-known social idioms—e-mail and instant messaging—to experimentally study emergent group-level behavior related to rumor. Second, the GUI was the result of unusual cross-disciplinary and creative efforts by a team of computer science and social psychological researchers. Each of these disciplinary perspectives contributed to the joint focus on GUI usability and experimental validity. Such a bona fide collaborative effort is novel indeed.

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