Anthropomorphic Visualization:
Depicting Participants in Online Spaces Using the Human Form

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B.A. Computer Science
Yale University, 1995

Submitted to the Program in Media Arts & Sciences, School of Architecture & Planning in Partial Fulfillment of the Requirements for the Degree of Master of Science in Media Arts and Sciences at the Massachusetts Institute of Technology
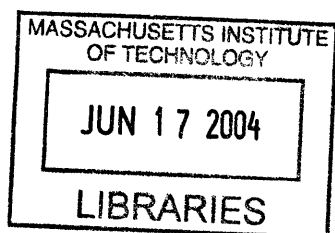
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Abstract

Anthropomorphic visualization is a new approach to presenting information about participants in online spaces using the human form as the basis for the visualization. Various data about an individual's online behavior are mapped to different parts of a humanoid yet abstract form. I hypothesized that using a humanoid form to visualize data about people in online social spaces could serve two purposes simultaneously: communicate statistics about the individuals and evoke a social response.

Using the human form in this way has both benefits and drawbacks. Users can quickly scan a set of humanoid representations and get a sense of the character of a group, and may respond socially to the other participants in the group. However, the information we are able to represent is somewhat limited, and a humanoid representation style might lead users to make incorrect assumptions about the people being represented. To investigate these tradeoffs, I created a test-bed application that visualized data from messages written in Usenet newsgroups. I conducted user studies to evaluate how users interpreted the data from the visualizations and responded to messages shown with visualizations. In this thesis, I discuss the challenges of designing effective anthropomorphic visualizations and offer guidelines to consider when using the human form to visualize information about participants in online conversations.

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Chapter 1: Introduction

1.1 Presenting information about authors of online messages

When we encounter new people face-to-face, cues about their past are immediately visible. We can gain a sense of a person's age, social status and mood simply by looking at them. Aspects of people's history, reputation, and social roles are expressed in their body and clothing (Goffman, 1967). Although online spaces such as message boards and chat rooms have been in use for several decades now, in these spaces it is difficult for users to glean information about the past behavior of the participants. People are sometimes identified with just a name or a short profile. While "insiders" in online communities may have detailed beliefs about the other participants, someone who is new to the community may have much more difficulty making sense of the roles people play and gaining a sense of the history of past interactions within the space than they do in physical world situations.

Although few current online spaces depict historical data about participants, a source of data is available for this purpose – the archives of messages from these spaces. A variety of data can be mined from these messages. Several scholars have researched which data may be most feasible and useful to analyze and present (Whittaker, et al., 1998)(Smith, 1999)(Fiore, et al., 2002). Past attempts to visualize historical information about users have represented them with abstract graphical forms such as simple shapes (Donath, 2002). These abstract visualizations are intriguing but do not convey the kind of social cues we experience in face-to-face interaction. As human beings, we internalize many social rules that influence our behavior when in the presence of others. But online communication often distorts these reactions by transmitting only a limited set of cues from one person to the other (Walther, 1996).

In order to investigate whether we could enhance online communication by utilizing users' social reactions to other people, I developed a visualization approach that represents information about an individual in a form that looks like a person. Various historical data about an individual are mapped to different parts of a representation of their "body", resulting in an abstract yet humanoid depiction of a person (called an "Anthropomorph") [see fig. 1] (Perry and Donath, 2004). My goal was to incorporate elements of participants' history into an information visualization with the following properties:

- Information about participants' past behavior is legible.
- The overall visual figure generated for participants serves as a memorable depiction of them that becomes associated with their identity in the online space.

Many years of sociological theory and social psychology research have investigated how individuals are influenced by others' appearance and behavior. A number of researchers have discussed how identity and exchange of social cues impact online communication (Turkle, 1995)(Donath, 1998). Yet few researchers have empirically studied how visual representations of users impact the communication that takes place in online spaces. This thesis contributes an initial understanding of the social impact of visual representations of users by evaluating the Anthropomorphic Visualization approach. My studies both tested users' ability to comprehend the information represented in the visualization and examined whether users' responses to messages and impressions of message authors change when accompanied by an Anthropomorph visualization.

Several key questions about the appropriateness of using the human form to represent historical data were present as I developed and tested this visualization approach. One key risk is the tendency of people to form impressions of others based on stereotypes that come from limited information about the other individual. In the following section, I will discuss the rationale for the approach and the potential advantages and disadvantages of the human form.

1.2 Using the human form to depict information

While a number of different visual approaches have been used to visualize historical information about individuals in online spaces, the human form has rarely been used. In my research, I wanted to use a compact format that would obviously refer to a particular person and allow for the easy comparison of information about multiple people. The human form seemed a natural choice for these purposes, despite the potential issues with this approach. The most similar visualization technique is the approach known as "Chernoff faces" (Chernoff, 1973), which will be discussed in the Visualization section of Chapter 2.

The human form seems to have several advantages:

- It looks like a person, and thus may be more intuitive to associate with a person than a more abstract representation.

- People easily recognize facial expressions.

- It is flexible as a graphic format – various information values about the person could be mapped to different body parts.

- It evokes social responses. Various research has examined human reactions to representations of faces and images of people on computer screens. This research has shown that people often respond with seemingly innate social responses such as being more polite and making judgments based on appearance as we do in the physical world.

- It lends itself to the comparison of large numbers of people since we are able to quickly scan through multiple depictions of humans.

However, there are also several potential issues with the human form:

- The limited data used to generate the visualization may result in a representation that may not be sufficient to provide useful information and yet it seems to be more realistic since it looks like a person.

- The depiction could be considered a caricature of their true identity, misleading, irrelevant and unacceptable to the person being represented.

- People may find it difficult to interpret more than 3 or 4 values represented simultaneously in the form because of limits to our ability to perceive multiple visual elements.

- The representation may encourage people to make assumptions about people based on the stereotypes that are visually apparent from their appearance with risks of overgeneralization and bias.

In Chapter 2, *Foundations*, of this thesis I will discuss prior work that includes the findings that informed this list of advantages and disadvantages. In Chapter 3, *Design of the Visualization*, I will explain how my own design decisions emerged from this prior work as well as guidelines from the information visualization tradition. In Chapter 5, *Evaluation*, I will report my own findings based on people's use of and reactions to the visualization. Clarifying the tradeoffs between these benefits and potential issues is the core of the evaluation of this visualization.

1.3 Example visualizations

To illustrate the Anthropomorphic Visualization approach, here are two example visualizations. They were generated from actual messages written by authors in Usenet newsgroups.

Figure 1. Information about two example authors depicted as humanoid visualizations (known as "Anthropomorphs").
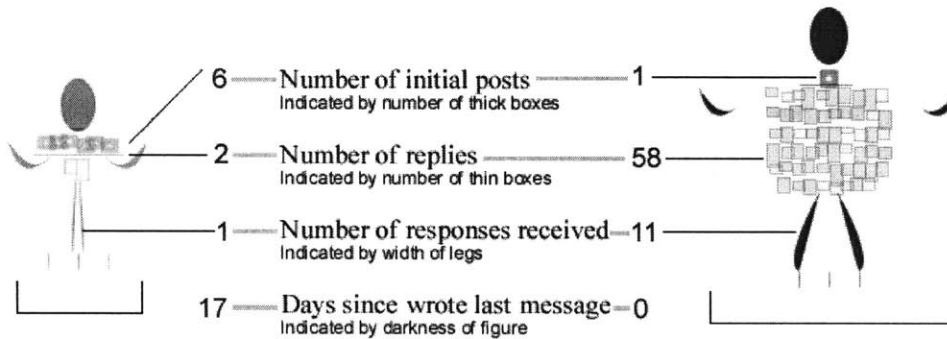
Here is a "landscape" view of the participants in a particular newsgroup with more "central" members of the group appearing in the center of the image.

Figure 2. Landscape view of a group of authors from a single newsgroup.
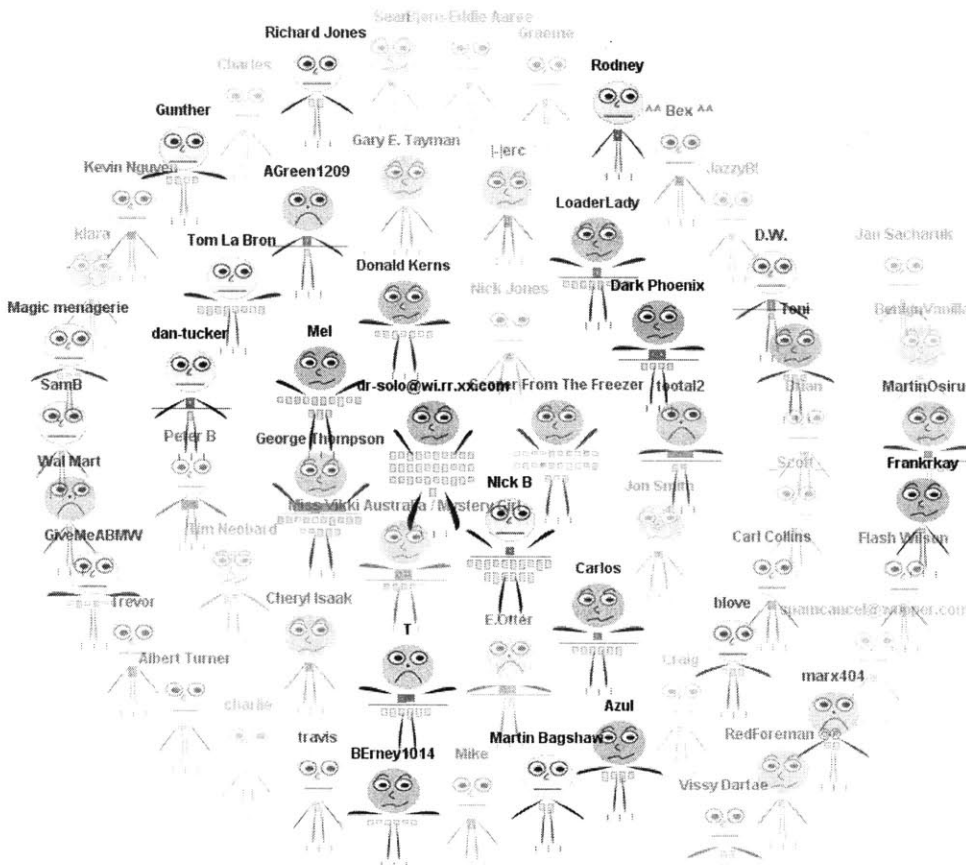
For details about the selection of data represented and the visual design choices, see Chapter 3, *Design of the Visualization*.

1.4 A note about the contents of this thesis

In order to provide the foundation for this research, I became familiar with the literature for a number of relevant areas. The *Foundations* chapter highlights relevant research from the following topic areas:

- Social perception of others

- Social data mining

- Design of online spaces

- Information visualization

- The use of the face in user interfaces

The remaining chapters in turn cover:

- the design of the visualization,

- the implementation of the test bed system,

- the various evaluations of the research,

- conclusions and potential future work.

Chapter 2: Foundations

At the core of this thesis work are several key questions about presenting information about authors of online messages:

- What information about authors can and should we visualize?

- How should we depict the information?

- How will users interpret and perceive the anthropomorphic representations of participants in online spaces?

In order to place these questions about my own work in Anthropomorphic Visualization in a broader context, this chapter will be devoted to reviewing the literature from a number of fields. Research about which information about individuals from message archives is most useful is discussed in the Social Data Mining section. Lessons from the information visualization literature are discussed to shed light on how we should depict information. A survey of online spaces is also important for identifying the state of the art in how individuals are depicted in other systems.

Research regarding the way individuals perceive and present themselves to each other offline can be helpful in understanding how similar interactions occur online. In the Concepts of Identity and Perception of Others section, I discuss a number of relevant theories and studies that highlight how individuals communicate with each other both online and offline. I also cover past research on the use of faces in user interfaces. All of these topics are relevant to understanding how users will interpret and perceive the Anthropomorphs.

2.1 Concepts of Identity and Perceptions of Others

2.1.1 Self-presentation and Text Communication

In order to move towards the goal of enhancing users' perceptions of each other in online spaces, it is important to review the research about individuals' perception of each other offline and the way relevant theories have been applied to online spaces. While the experience of interacting with others in online spaces differs from our interactions in the physical world, many studies of interpersonal and group communication from the physical world can shed light on the way in which we interact online.

Goffman's theory of self-presentation is a primary example of a theory that is relevant to apply to online interaction. The theory introduces the idea that people shape their behavior towards an individual in response to the information they gather about that person. Depending on the situation, the individual may make more or less of an effort to influence others' perceptions through physical appearance and comments. The degree to which an individual is strategic about self-presentation is determined by the social conventions for the situation at hand, as well as the individual's personality. Regardless of how actively an individual presents himself, others still receive information based on his behavior and appearance (Goffman, 1967). Similarly, visual representations of users online may send signals to other users who view them regardless of how much users have been proactive about their online appearance.

Online the tendency to make judgments about others based on the information at hand also occurs, but the information we receive may be more limited. Using text communication has been shown to have a number of strengths and limitations. In "Computer-Mediated Communication: Impersonal, Interpersonal, and Hyperpersonal Interaction", Joseph Walther examined how text communication online differs from communication in the physical world. He points out the following qualities of computer-mediated text communication:

- Groups with no prior history of communication have been shown to be "significantly lower than FtF [face-to-face communication] on certain social categories of conversation" and "significantly higher than FtF on certain types of hostile or profane speech acts, leading to characterizations of CMC as uninhibited and depersonalized." This may be because CMC provides less "social information per message" than FtF because of the absence of nonverbal cues so that relationships in online environments may take longer to develop than in FtF environments.

- In field research "where interaction time was not constrained", CMC *has* been shown to produce "emotionally rewarding exchanges", e.g. friendships, romances and other emotional support developing in online communities.

- In "certain common circumstances, CMC message receivers inflate the perceptions they form about their partners...they build stereotypical impressions of their partners without qualifying the strength of such impressions in light of the meager information – misspellings, typographical errors, or excessive punctuation on which they are built." (Walther, 1996).

One way to explain the sometimes more impersonal nature of online text communication and the incorrect impressions people form online is the reduced opportunity for self-presentation and exchange of information about others. Adding visual representations of participants in online communication may change users' perceptions of each other, however. It may be the case that the lack of a visual reminder of the other people's presence leads to a lack of social interaction. Presenting images of users may encourage more socializing. By adding additional information about others, users may also be less likely to build stereotypes based on a lack of information, and instead may be influenced by the visual appearance of the others they interact with. But if these appearances are not accurate or are based on superficial information, they may mislead users.

2.1.2 Prototypes and Stereotypes

In his study of impression formation in text-based virtual communities, David Jacobson also found that inaccurate impressions of other individuals encountered online could be partially explained through the stereotypes people employ to fill in the details of the images they have of each other when presented with incomplete information (Jacobson, 1999). Jacobson draws upon theories of categorization and Rosch's notion of "prototypes" to account for people's incorrect assumptions about others met only online.

When individuals perceive the world, they tend to group the objects and people they encounter into categories. One theory of how we form these categories is through prototypes – notable examples that possess the distinctive characteristics that define the category. For example, a robin might be a prototypical example for the category "bird" (Rosch, 1978). While we might assume that grouping people into categories in this way might minimize our ability to accurately understand the social atmosphere around us, in fact the reverse seems to be true. Without an ability to summarize the characteristics of individuals into preconceived packages of personalities, we are left with a flood of ambiguous characteristics that are difficult to make sense of. Our understanding of the social norms that are acceptable in particular social contexts is limited if we can't discern the type of social actors around us. So while there are negative costs to the human tendency to form prototypes such as overgeneralization and stereotyping, the human tendency is to form these generalizations in able to assist our ability to make sense of our social worlds.

Online, however, individuals participating in online spaces have had a difficult time forming impressions successfully. Their impressions of others have come from perceptions of textual writing styles, the names used by the other participants, and contextual cues such as geographic places mentioned. Not surprisingly, while some of these impressions may be accurate, many are not. If we add visual representations of users, these may lead to other types of stereotypes. If users with a particular type of appearance consistently behave in similar ways, these may lead to a different set of stereotypes than those based on lack of information, but they still may results in misperceptions, especially if the appearance is generated from irrelevant or superficial information. If the visual appearance is based on information that is useful for generalizing about individuals' behavior, it may be more likely to be a "useful" stereotype. So if, for instance, more active participants tend to be more helpful, a visualization that shows active users as larger will in general enable users to find the more helpful participants by looking for the larger ones.

2.1.3 Reputation Management Online

Within groups, members occupy particular roles partly because of their status level within the group. Contributions that members make to the group may help to elevate their reputation so that they are more trusted and respected than newcomers. Kollock explains how individuals manage the risk of interacting with an unknown party by getting a sense of the other's reputation. Websites like Slashdot.org and Ebay.com enable users to rank each others' performance. In the case of Slashdot, users can rate the quality of a message an individual posts to the site. On E-bay, users rate a seller or buyer's effectiveness, with users exchanging very positive ratings for the most part, since a small negative rating can have a large adverse impact on others' willingness to do business with the individual.

Kollock discusses explicit mechanisms for rating individuals, providing a reputation with an active evaluation by other users. He also mentions how aspects of a user's identity such as an AOL email address contribute to others' perceptions (Kollock, 1999). When providing historical information about participants, as this thesis proposes, users may also infer reputation based on the information provided by the individual. If particular historical information is unduly highlighted that may be perceived as negative, this may have an adverse impact on the interactions that take place within the group.

It is also possible that an individual's online ranking could be used as a piece of data to be shown in his or her visual representation. Although out of the scope of the research in this thesis, a natural next step for

Anthropomorphic Visualization would be to incorporate user opinions of each other's contributions as a visual element so that users can quickly discern the most valued members of the group. There is a risk, however that users will attempt to manipulate a system that attempts to show the most valuable members. As documented in (Donath, 1998) and (Turkle, 1995), users of online systems have often deceived others by posing as someone they are not and have even gone so far as to impersonate particular individuals to defame their image.

Users might also exploit a reputation system to gain additional "reputation points" by creating multiple personas and providing very positive opinions of the contributions by their other personas, resulting in a distorted picture of their true contributions. While some safeguards and moderators can prevent these types of deception, administrators of such a system will need to be aware of these issues. Users will likely need to learn about the risks of relying on potentially distorted information when viewing representations of individuals in a humanoid format.

2.2 Social Data Mining

The source for anthropomorphic visualizations of individuals is data gathered about the individuals' behavior. The messages that people write are a record of their past. As more and more information is exchanged online, it is feasible to analyze many aspects of the data that are generated from this communication. By looking for patterns in this data, it is often possible to uncover "implicit, previously unknown, and potentially useful information" in a "data mining" process (Frawley et al., 1992). In the last several years, scholars have applied data mining techniques to large online social spaces, analyzing messages in Usenet newsgroups, for instance. "Social data mining" is used to make generalizations and identify trends about patterns of communication (Terveen and Hill, 2001) and is a source of data for visualizations of social behavior.

Social data mining can also be used to recommend or filter messages or documents to users by presenting information that has been used or created by similar users. Incorporating historical data about individuals' behavior in a group into a visual representation of those individuals may help users identify participants who they find interesting. If an individual is especially activity in a set of conversations that a user finds relevant, she might be interested in other conversations that individual has participated in.

2.2.1 Analyzing Overall Attributes of Online Communication

In order to determine which data to include in visualizations of online individuals, we can draw upon past research about mining data from online archives. Marc Smith has conducted an ongoing social data mining project where he tracks the statistics of contributors to almost all Usenet newsgroups. Usenet newsgroups are message-board like forums in which various participants post information, comments, disagreements and the like around numerous topics. Newsgroups exist to discuss everything from sports teams to politics to hobbies of various types.

Smith's Netscan system catalogs the messages that people post per group and calculates how many messages are replies, how many are cross-posts, how many messages are written on average per contributor, etc. Smith's paper "Invisible Crowds in Cyberspace: Mapping the Social Structure of the Usenet" described how he attempted to characterize "successful" newsgroup social environments. Many Usenet groups seem to be unlikely candidates for high levels of social interaction. To begin to understand the range of social behaviors present, Smith analyzed quantitative measures of the groups such as messages posted and numbers of participants

Most Usenet posters contributed only a single message over a ten-week period, with only 4% of posters contributing more than 30 messages during this time. A tiny number of posters contributed a huge quantity of messages, possibly automatically generated spam, not written by individual people. Smith suggests that the measure of poster-to-post ratio is a useful way to assess the level of interactivity or social turn-taking within groups. 40% of groups have poster-to-post ratios that are either too high or too low to indicate much social interaction (Smith, 1999). We can imagine a "healthy" newsgroup from a social perspective being one that has participants who respond to each other's messages and have some awareness of each other. So both *activity level* and *responsiveness* are elements to measure that provide useful information about a user's past.

Steve Whittaker and his colleagues also used quantitative measures to study social interaction in Usenet, testing hypotheses from the "common ground model of communication" to examine what newsgroup conditions were conducive to establishing common ground for sustaining conversation. They found that 40% of messages were failed attempts to initiate conversation, yet 33% of messages had "2 or more threads, indicating frequent extended conversations." Groups that were larger in size with fewer posters contributing more than one message were somewhat less likely to have extended conversations (Whittaker, et al., 1998). There is a disparity between the posts that do not receive responses (perhaps indicating a lack of social capital on the part of the poster) and the messages that spawn more extended

discussion. More research is needed to understand why certain messages fail and others lead to additional conversation.

Initial studies by Smith and Andrew Fiore show that users' opinions about other newsgroup participants correlate to some extent with aspects of the participants' behavior (Fiore, et al., 2002). For instance, the more groups an author posts to, the less likely other individuals are to be interested in the author's messages. This is likely because authors who post to many groups may be posting advertisements, spam, or other disruptive messages. The more replies and the more frequently an author posts, the more likely they are to be trusted and respected by other group members. They also found that the more messages an author writes, the more likely the messages are to be replies to other authors, indicating that more active posters take a greater role in maintaining the discussion in a particular group, again validating that activity level is a worthwhile data element to measure and visualize.

2.2.2 Content analysis

One potentially revealing type of analysis for examining online messages is the use of natural language processing (NLP). By analyzing the words and phrases used in text, computer scientists have attempted to automatically infer some things about the tone and subject matter. While an entire set of journals and conferences are devoted to making progress in this field of information retrieval and natural language processing, some specific research is relevant to the question of analyzing the messages in online spaces:

- The BOW project at Carnegie Mellon University was used to categorize messages according to subject matter, by looking at the similarity of the most frequent words used in each message (McCallum, 1996).
- Ellen Spertus's SMOKEY project looked for common words and phrases used in "flames" or abusive messages, and was able to correctly categorize 64% of the flames and 98% of the non-flames (Spertus, 1997).
- Janyce Wiebe's group studies how to use to natural language processing to identify patterns that indicate how subjective a text is, that is whether it includes statements of opinion. (Riloff and Wiebe, 2003).
- Hugo Liu and his colleagues have utilized a "real-world" knowledge approach, leveraging the Open Mind database of information about the world to infer when the content of a particular text emplies a specific emotional state. (Liu et al., 2003).
- Pennebaker and Francis have created a dictionary of words that indicate a variety of emotional, cognitive and other psychological qualities. Their system counts the occurrence of words in a text and indicates the presence of each category. (Pennebaker, et al., 1999).
- Warren Sack's Conversation Map analyzes the semantic content of Usenet messages and retrieves keywords and then highlights messages based on their relevance to a particular keyword. (Sack, 2000b).

While not always precisely accurate in this subjective type of assessment, natural language analysis nonetheless provides useful cues about a person's writing. Because of these systems are able to categorize text automatically, they are worth considering as data sources for automatically-generated profiles of participants in online spaces. However, a number of issues are worth considering depending on the accuracy and subjectivity of the inference being made about the text. In the Discussion section of the Evaluation chapter, I will consider some guidelines for when it is appropriate to include data generated from automatic content analysis in a visualization. It is also necessary to be able to efficiently use the NLP technique to analyze the data. This requires integrating the NLP system with the system that is used to gather and display the messages.

2.2.3 Social network analysis

Another relevant source of techniques for analyzing data from messages is the field of social network analysis. By analyzing the relationships among individuals, we can reach some conclusions about some aspects of the structure of the discussion group. For instance, if a particular member of a group has more connections to other members of the group than anyone else in the group, that person is likely a central figure in the group. By identifying each response to another person's message as a connection or "tie" between two individuals, we can construct a network graph of the relationships that exist among all members of the group. We can use the data from this graph to show who the most central group members are. Social network analysts have a variety of techniques for analyzing these graphs from a sociological perspective. Techniques can be used to analyze the group as a whole as well as individuals within the group. The following techniques have some relevance for gathering social data that could be used to provide information about participants in online spaces (Wasserman and Faust, 1994):

- Centrality measures: A number of calculations are possible to determine how much particular individuals or "actors" have a central place in the social network. "Degree centrality" is the measure of how many connections or ties an actor has. "Closeness centrality" is the measure of how close an actor is to the other individuals in the network. "Betweenness centrality" is the measure of how many other individuals an actor is between, where being between two people may indicate certain capabilities or power. Centrality is often associated with prestige or status in a group. Higher status individuals are more likely to have ties to a larger or more significant group of members in the group.

- Cohesive subgroups: By looking at which sets of individuals in a group are most closely tied to each other, we can identify significant subgroups. Sets of particular individuals who are closely connected to each other may indicate subdivisions in the group in terms of common interests, comfort or access to each other. A variety of calculations can be used to determine which individuals constitute a subgroup including identifying sets of individuals who are all connected to each other, or who are all reachable within a certain number of steps from each other.

- Structural equivalence: By examining the connections different individuals have to the entire group, we can identify when two or more individuals are "structurally equivalent" or connected to the same set of individuals. Various approximations have been defined for calculating the degree to which two actors have equivalent placement in the network structure.

2.2.4 Using Social Data Mining to Support User Goals

In Terveen and Hill's discussion of recommender systems, they consider how social data mining can be used to suggest content that will be of interest to someone. This can be done by identifying documents that have been read by people with similar interests or by identifying individuals who are interesting to a user and then displaying documents or messages from that individual's history. Terveen and Hill contrast this type of system with other types of recommender systems:

- Content-based systems that provide suggestions by using the user's preferences to analyze the content in the system and find similar content

- Recommendation support systems that facilitates human recommendations

- Collaborative filtering systems that anonymously track all users' preferences and recommend content preferred by similar users without revealing who they are. (Terveen and Hill, 2001).

We could potentially incorporate data that relates a user's content preferences to the past messages written by participants in a group into anthropomorphic visualizations of the group. For instance, we

could color code individuals' bodies according to their relevance to the user's content preferences. This might allow users to more efficiently identify participants whose interests match theirs.

2.2.5 Privacy Issues Raised By Social Data Mining

This process of analyzing data generated by individuals raises questions about privacy – should all the data generated by this kind of communication should be publicly available or should participants have some control over who views the information that has been recorded about them? Currently, it is much easier to mine the data about individuals than it is to prevent access to this data since so many online spaces are in the public forum. In addition, archives of the messages accrue over time, so that participants who wrote messages in Usenet newsgroups many years ago may not even be aware that their messages are still available online.

Designers of systems that mine data from messages have a responsibility to consider the ethicality of using this data when it reveals information about users that they did not intend to reveal. This complex issue will be discussed further in the Evaluation chapter.

2.3 A Survey of Online Spaces

Since the anthropomorphic visualization technique is meant to enhance the communication in online spaces, it is important to review the relevant online spaces that have been developed to date. There are a variety of ways in which these spaces depict individuals and structure conversation. It is useful to discuss the user interfaces of the different types of online environments in terms of several criteria so that we can better understand how these environments influence the communication that takes place within them. The following criteria are relevant for examining the way individuals interact with each other:

- *How participants are depicted* – via name, profile, avatar, or visualization

- *What information about participants is included* – via user selected representation, user-written profile, historical information, or nonverbal cues

- *How conversations are depicted* – via list of messages or threads, or some type of visual representation

- *How users can select or enter conversations* – via chronological list, search criteria, or some kind of spatial representation of the environment

At a larger scale, the following distinctions are useful for characterizing online environments:

- Text-based vs. Graphical

- Abstract vs. Literal/Representational

- Type of spatial configuration: 2D/3D

Of interest to this thesis are the spaces that are good sources for visualization data and the spaces that extend online communication in some interesting way. The following sections provide a summary of text-based online spaces, graphical representational spaces, and graphical abstract spaces.

2.3.1 Text-based Online Spaces

Many environments rely purely on the exchange of text messages with the author's name attached. Notable text-based online environments include Usenet newsgroups, chat rooms, and instant messaging services such as AOL Instant Messenger. Usenet newsgroups are message-board like forums in which various participants post information, comments, disagreements and the like around numerous subjects. Newsgroups exist to discuss everything from sports teams to politics to hobbies of various types. Because newsgroup messages are publicly available and cover a wide variety of topics, they make a good source for visualizing many different types of group messages.

2.3.2 Graphical Representational Spaces

Visual spaces enable and influence communication in a more complex fashion. In addition to the text of the communication, users automatically make assumptions about others that they encounter based on the visual information they receive. Beginning with services such as Habitat, the Palace and AlphaWorld, users were able to interact with each other in a visual environment (Morningstar, et al., 1990)(Rossney, 1996). Each user was depicted as a visual representation of a person, animal or other object that could move around a 2- or 3-dimensional environment. Users selected avatars from a menu of choices, or uploaded an image. When an online space depicts a user with a visual representation, other users viewing this person form some kind of impression based on what the user looks like.

Another approach to representing users in a graphical fashion drew from the tradition of comic books. Kurlander, Skelly and Salesin's Comic Chat allows users to select a comic character and places the text they type in text "balloons" arranged in panels that resemble a traditional comic strip. The program automatically positions the characters and generates suggested emotional expressions and gestures and places the characters in a comic book scene. Users can also override the expressions and gestures with

their own selection (Kurlander, et al., 1996). While an entertaining way to view messages, the stylized nature of the representations of the users and unlikely environments they inhabit seem to make it less likely that they refer to the actual individuals typing the messages. Instead, the pictures take on the feel of a fantasy that adds a layer of visual interest and novelty but may not reflect much actual information about the people participating. A key question for anthropomorphic visualizations are the degree to which they appear to actually represent the users being depicted as opposed to taking on more of fantastical feel as Comic Chat does.

Figure 3. Microsoft's Comic Chat User Interface where users are represented as comic characters.
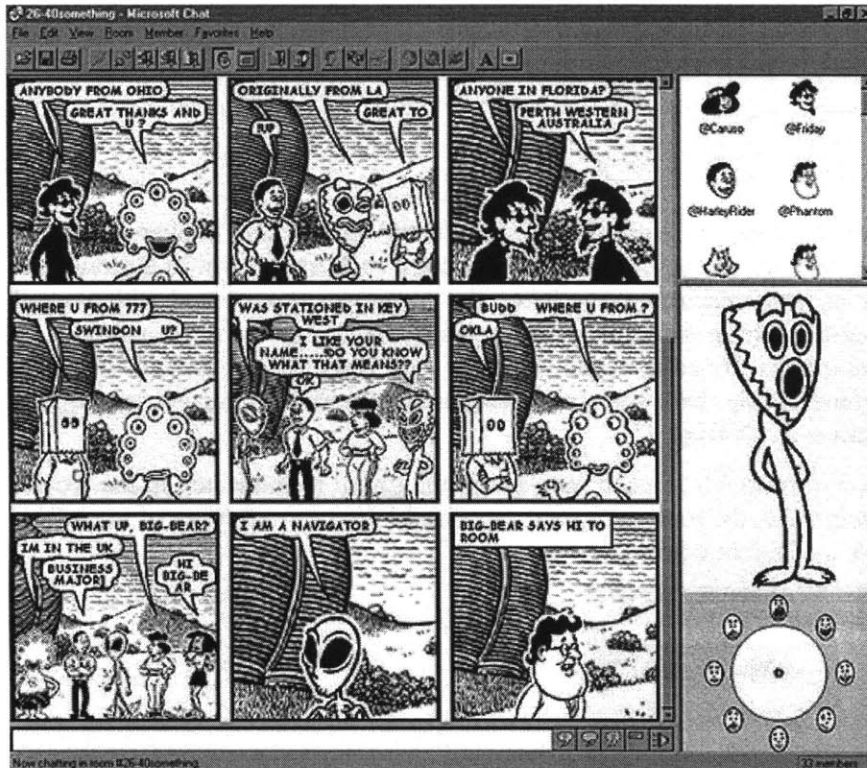
Cassell and Vilhjalmsson's BodyChat and Spark systems automatically generates detailed gestures and facial expressions for avatars in conversation, timed to occur at a particular point in an utterance when they are semantically appropriate. This project is interesting in that the online participants begin to present themselves with a greater amount of non-verbal cues. Vilhjalmsson found some evidence to support the idea that conversations that incorporated avatars with these cues led to better conversational quality than equivalent conversations using text chat. Users reported that the interaction felt more like a face-to-face conversation (Vilhjalmsson, 2003). This thesis also investigates whether users also have a different experience in a conversation with anthropomorphic figures compared to a text-based discussion.

2.3.3 Graphical Abstract Spaces

Abstract visualizations represent individuals in a format that is not humanoid but instead use shapes and colors to represent data about users. In order to provide information about participants in Usenet newsgroups, Xiong and Donath developed "data portraits" which visualized information about individuals. The PeopleGarden application displayed a set of users from a particular group as plants in a garden, with various pieces of information about each participant represented as a different element of the plant (Xiong and Donath, 1999).

Figure 4. PeopleGarden visualization of two different newsgroups with each author represented as a plant.
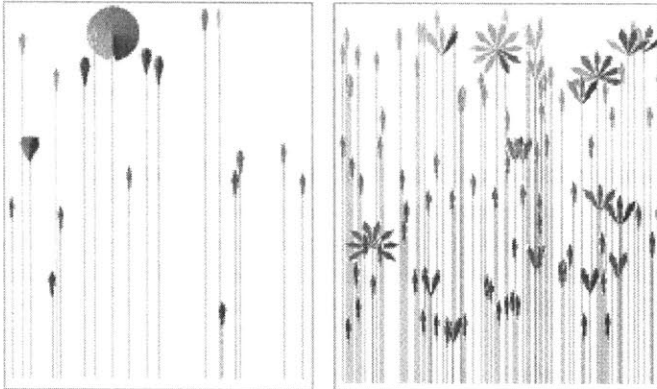
Loom is a series of visualizations of Usenet newsgroups in which entire groups and conversations are depicted using a variety of abstract visuals. In the first version of Loom, each participant in a group was represented with a horizontal row in which each message he or she wrote was represented with a small square. Lines connected the messages in a particular conversation, creating a woven tapestry of intersecting conversations in active groups. By color-coding whether a message is an initial message or a reply, different types of users become visible, with some users responding to many messages, and others just posting a few questions (Donath et al., 2001a).

Figure 5. Loom visualization of newsgroup where each message in the group is connected in the woven "threads" of the conversation. In this view, the messages are categorized into different types of messages. Each type of message is coded with a different color.
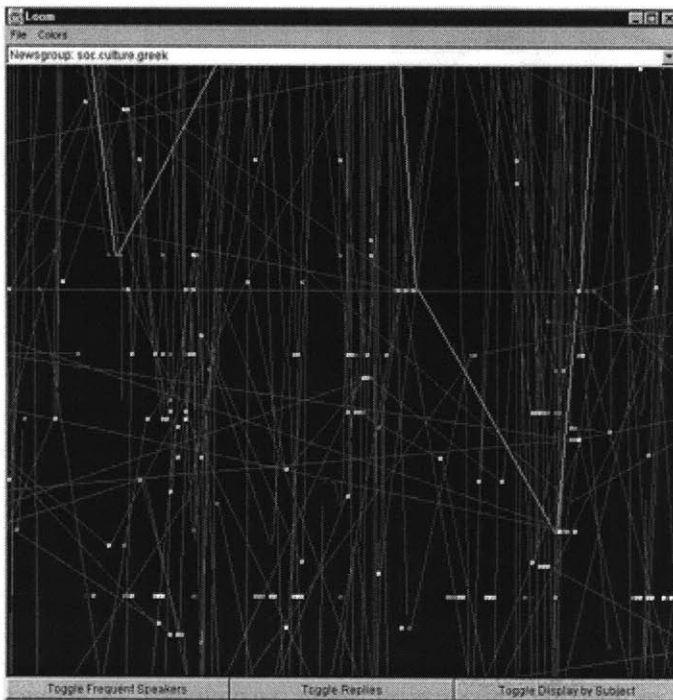
A later version of Loom depicted conversations as circles, making groups with lengthy conversations appear with a collage of intersecting circles, while groups with spam and little social interaction having just a spotted landscape of initial posts.

In a similar vein, Warren Sack's Conversation Map system visualizes conversations in Usenet newsgroups with several complementary views. A social network view shows the connections among the different participants in the group. A semantic network view shows the connections among the subject matter of the messages written by the different participants. Next to this is a listing of the "themes" prevalent in the messages. At the bottom is a view of the message threads, in which a grid of messages is laid out with linkages to messages written in the same discussion thread (Sack, 2000b).

Anthropomorphic visualization draws upon these past Usenet visualizations in some of the choices of data to depict and some of the visual techniques used to display information. Minimal evaluation has been done on those systems, so it is unknown to what degree users benefit from them. While all of these views depict more detailed information about users and groups than are usually present in Usenet displays, they do not provide much sense of human presence. Anthropomorphic visualization attempts to combine this more abstract approach to representing information about people with the lessons from systems that depict individuals in a humanoid form.

Other systems use abstract representations of people to provide an overview of individuals taking part in an online conversation. Chat Circles is a chat environment in which individuals are represented as abstract colored circles. Users can control their own circle with the mouse, and can move closer or farther away from other circles in the space. Only when a circle moves close enough to be within "hearing range" of another circle is the user able to see the text typed by that owner of that circle (Viégas, 1999).

Babble is a system with synchronous chat and asynchronous message board functionality. All conversations persist and can be viewed by anyone in the group at a later time. Users who are currently connected are represented as a small colored circle and when they type a message or otherwise interact with the system, they move to the center of a two-dimensional "Commons Area" panel in the interface. As time goes on, they drift away from the center (Erickson, 1999).

Figure 6. Babble social visualization interface with users represented as circles in the "Commons Area".
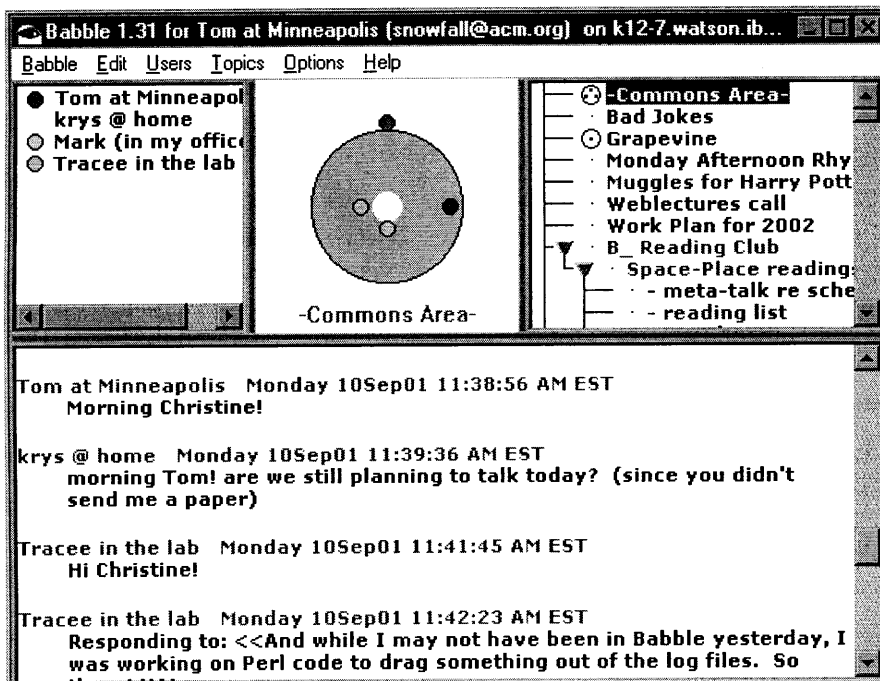
Just as these systems use a two-dimensional layout to show the relationships among users, the Anthropomorph test-bed system has been developed to represent users so that their position on screen provides some useful information about them. Like Babble, the system determines position based on their activity, rather than allowing users to move themselves in the application as Chat Circles does.

2.4 Information Visualization Guidelines and Techniques

As discussed in the survey of online spaces, a number of ways to depict individuals are feasible. In order to decide the best way to design these depictions, it is useful to consider a number of guidelines and findings from the information visualization research. Ideally the design of the anthropomorphic visualization should be both legible and communicate some sense of social presence. In order to communicate multiple pieces of data in a compact format, it is necessary to take into account lessons from information design as well as visual perception. The following sections highlight research and recommendations relating to these areas.

2.4.1 Information Graphics Guidelines

Edward Tufte has suggested many guidelines for the clear and informative presentation of information graphics. At the beginning of his book, *The Visual Display of Quantitative Information*, Tufte proposes that "Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency." He goes on to state that graphical displays should:

- "Induce the viewer to think about the substance rather than about methodology, graphic design, the technology of graphic production, or something else

- Avoid distorting what the data have to say

- Present many numbers in a small space

- Make large data sets coherent

- Encourage the eye to compare different pieces of data

- Reveal the data at several levels of detail, from a broad overview to the fine structure

- Serve a reasonably clear purpose: description, exploration, tabulation or decoration

- Be closely integrated with the statistical and verbal descriptions of a data set"

He also suggests that "a large share of ink on a graphic should present data-information" so that "nothing can be erased without losing information." In other words, he advocates a minimalist approach in which every visual element has meaning. So for instance, he states that "Half-faces carry the same information as full faces".

Consistent with his desire for high information density, Tufte proposes the concept of "small multiples" in which each information element has several pieces of data that are visually presented together as a compact unit. The "same design structure [is] repeated for all the images. An economy of perception results; once viewers decode and comprehend the design for one slice of data, they have familiar access to data in all the other slices. As our eye moves from one image to the next, this constancy of design allows viewers to focus on changes in information rather than changes in graphical composition." (Tufte, 1983).

While a number of these guidelines are relevant and have been observed in the design of the anthropomorphic visualizations discussed in this thesis, our purpose is not only to communicate statistics clearly, but also to play a role in conversation with the display of social non-verbal cues. So for instance, half faces would have a very different effect socially than a full face. In the Design chapter we further describe our response to these guidelines.

2.4.2 Appropriateness of visual representations for particular data types

In his attempt to automate the design of information graphics, Mackinlay discussed the appropriateness of different types of graphical variables. Modifying a prior framework suggested by Cleveland and McGill, Mackinlay suggests that the appropriateness of particular graphic elements depends on the type of data.

He proposes that nominal, ordinal, and quantitative data have different rankings of appropriateness for the graphic elements. He also suggests that the most important attribute should be represented with the most effective technique for representing the data (Mackinlay, 1986). See Figure 7 for his ranking of the appropriateness of "perceptual tasks" with certain visual elements for particular types of data.

Figure 7. Mackinlay's ranking of visual attributes' appropriateness for perceptual tasks.
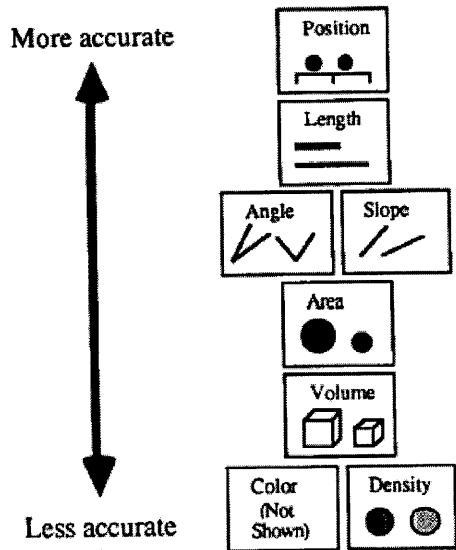
Fig. 14. Accuracy ranking of quantitative perceptual tasks. Higher tasks are accomplished more accurately than lower tasks. Cleveland and McGill empirically verified the basic properties of this ranking.
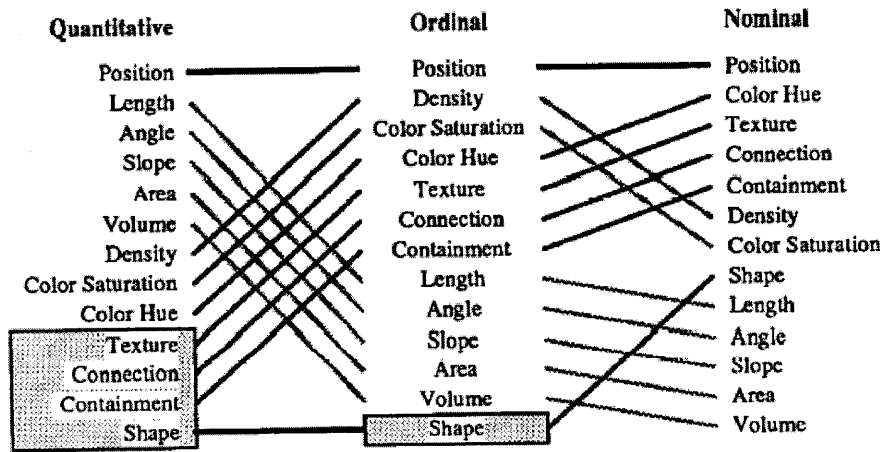
Fig. 15. Ranking of perceptual tasks. The tasks shown in the gray boxes are not relevant to these types of data.

These guidelines are useful in the design of anthropomorphic visualization forms. For instance, while color hue is useful for displaying items falling into different categories such as different emotions, it is not appropriate for displaying quantitative values.

2.4.3 Visual Perception

Certain target visual elements can be recognized preattentively, that is within 250 milliseconds of viewing, regardless of how many "distractors" (visual elements that are not targets) are present. It is

desirable for information visualizations to take advantage of pre-attentive processing so that the data can be instantly discernible. Many features have been shown to "pop out" preattentively from a visual field such as the length, width, size, number, and color of a set of visual elements. However, this is only the case if the visual elements have only a *single* feature that varies. If two or more features are required to identify the target, the process is no longer preattentive (Healey, 1993).

Preattentive recognition can be a useful quality for social visualizations in which it is desirable to be able to pick out users of a particular type. So if all the angry individuals have red faces, they are immediately recognizable. However, in order for the visualization format to support this quality, it is necessary that each target element have only one feature that "pops out". For multivariate data, if multiple pieces of data are mapped to different visual aspects of the same element, they will no longer be recognizable preattentively. The choice of whether to create a format that is best for preattentive recognition versus one that provides a denser set of information in a "small multiple" is discussed further in the Design chapter.

Some visual attributes have some intrinsic meaning such as increased size or length indicating increased quantity. Other attributes such as hue do not have any universal meaning but may be subject to cultural interpretation. It is desirable that the design of a visualization format takes into account intrinsic meaning. The format must correlate increased size with increased quantity, for instance. Being aware of cultural interpretations of visual elements is also desirable so that the format does not go counter to users' expectations in the way it depicts data.

2.4.4 Gestalt theory

German psychologists Wertheimer, Kohler, and Koffka suggested explanations for a variety of human perceptual phenomena with a set of ideas known as gestalt theory. The essential idea was that rather than perceiving individual visual stimuli as different parts, we perceive them as a single element based on the overall form. They identified a number of "laws" which determined how people would interpret different compositions of visual elements (Koffka, 1935)(Kaufman, 1974). The following "laws" are relevant to the design of Anthropomorphic Visualization:

- The law of proximity suggests that when elements are close enough to each other, they will be perceived as a single entity.

- The law of similarity suggests that elements that appear similar (e.g. the same color) will be perceived as a single group.

- The law of good continuation suggests that when two elements are connected in such a way that one appears to continue into the other, they will be perceived as a single element.

- The law of familiarity suggests that we perceive members of a set of visual elements as single entity if they resemble something visually familiar or meaningful.

Because anthropomorphic visualization combines multiple visual elements into a single figure, it needs to incorporate many of these laws of interpretation into the design approach.

2.4.5 Visualization Techniques

A specific data visualization technique that is relevant to anthropomorphic visualization is the approach known as Chernoff faces (Chernoff, 1973). This format varies the size of various facial features in a depiction of the human face, where each feature represents a different piece of data. There are challenges in using this format in that if the data values that change the expression of the face are arbitrarily mapped to the various facial features, the visualization may lead to a distorted face that has an unexpected emotional impact on the viewer and can be hard to decipher (Loizides, 2002). In the design of the

Anthropomorphs, I am not depicting individual facial features completely independently, but instead have a set of templates for particular facial expressions. We have designed the visualization format to avoid distortion for all potential values of data.

Criticism of Chernoff faces has also suggested that the novelty of the format is a distraction (especially where the information being presented has nothing to do with faces). But for social visualizations, in which the information is about people, it seems more natural to use a face and a human body. It is important, however, that we consider the social meaning of the data that is mapped to the visual components of the face and body. The potential of distorting the social significance of messages that a participant has written is a key risk of using the face to visualize an individual's information (Loizides, 2002).

A variety of visualization techniques have been used to portray social network diagrams. A history of these representations is covered in Linton Freeman's review of "Visualizing Social Networks". Most of these diagrams include lines drawn to shown the linkages between nodes in a network (Freeman, 2000). In its own way, anthropomorphic visualization can be used to extend social network visualization by representing additional data about the individuals at the nodes in the form of Anthropomorphs that are then displayed at a location in the network.

Several researchers in the information visualization community have also looked at a number of visual approaches to representing multivariate data, referred to as "glyphs". Matthew Ward reviewed many of these approaches in "A Taxonomy of Glyph Placement Strategies for Multidimensional Data Visualization" (Ward, 2002) and Chuah and Eick created several circular glyphs for use in project management for software development. Their "infobug" glyph took an approach similar to anthropomorphic visualization by using different body parts such as wings, head and tail to represent information about code from different software components. The authors found some challenges in arranging the different body parts so that they appear to be an integrated whole. Anthropomorphic visualization has the advantage of using a more familiar humanoid body format that seems to read as a single object.

2.5 Use of the face in user interfaces

Since the use of the human form and the face are key elements in the anthropomorphic visualization approach, it is important to understand their impact in user interfaces. Experimentation with the use of the face in user interfaces has caused a variety of debates over the last two decades. While some scholars have created interfaces with humanoid characters and investigated user responses to these characters, other scholars have pointed out the pitfalls of disappointing users by displaying something that looks like a human but often does not have the intelligence or nuance that would be expected. A notable example of this failure is Clippy, the Microsoft Paper Clip character that is intended to help users but often annoyed instead.

A framework for investigating different aspects of faces in user interfaces and a broad review of research on the use of faces in user interfaces is found in Catrambone, Stasko, and Xiao (Catrambone, et al., 2002). While much of this research about the face relates to a humanoid representation of a *computer* software agent, it is nonetheless relevant to consider for the purpose of creating humanoid representations of *people*. The tendency of individuals to respond to humanoid representations of computer agents in a more social fashion seems likely to carry over to representations of people as well. Rickenberg and Reeves found that people experienced social effects from the presence of animated characters, especially when they perceived the characters to be observing them (Rickenberg and Reeves, 2000). This effect is similar to the social facilitation effects seen in studies of face-to-face interactions (Zajonc, 1965).

As discussed in Donath's examination of "Mediated Faces" (Donath, 2001b), faces in a user interface can result in people behaving more politely and spending time on small-talk. They rapidly convey details about individuals that may result in stereotypes, allowing us to make assumptions about people we have limited experience with. These effects may be desirable in certain discussion groups, perhaps discouraging flaming, and making it clear to newcomers who the most active and responsive members are. Conversely, they may encourage some of the negative aspects of social behavior we experience offline such as discrimination against others who are unfamiliar. The degree to which the use of anthropomorphic visualization is appropriate for particular groups may be somewhat dependent on how much members desire more social interaction.

Online spaces that use humanoid avatars with faces have been studied to a limited extent. In their ethnographic study of "The Social Life of Small Graphical Chat Spaces", Smith, Farnham and Drucker studied people's use of avatars in the Microsoft V-Chat system, an environment which enabled users to move in a 3D space. Users appeared to use their avatars to move close to others who they were conversing with. When users had created custom avatars, other random participants were more likely to be looking at them (Smith, 2000). A number of issues exist in terms of evaluating the relationship of the avatar to the individual who controls it. If a user has certain reactions to an avatar, it is not known to what extent the user attributes these reactions to the individual who controls the avatar as opposed to the avatar itself. By investigating user reactions to the use of faces and human forms depicting historical data about individuals, this thesis contributes some initial understanding of their impact on users.

Chapter 3: Design of Anthropomorphic Visualizations

In this thesis I will be presenting a design approach for individuals in an online social space that depicts the individual with a small visualization (an "Anthropomorph") which is an abstract yet humanoid representation of a person. Different components of the Anthropomorph's "body" are based on different data about the person's online behavior – the frequency of messages they write, the content of the messages, and the flow of communication across their social network – that is, who they write to, who writes to them and so on. Two key questions need to be addressed in the design of this visualization:

- Which data are most relevant to capture and depict about the participants?
- Which visual approach is most appropriate for the depiction of the individual?

Each will be addressed in the following two sections. For both sections I will describe the approach I selected for the Anthropomorphs design. Then I will discuss the approach selected and consider the issues that influenced my decisions. Last I will mention some alternate approaches that might be implemented as well.

It is also important to consider how the visualization would be used by groups in the real world. The final section in this chapter will discuss how the visualization was designed to be helpful in specific situations for individuals learning about participants in a group.

3.1 Selection of Social Data

3.1.1 Design Approach for the Anthropomorphs

In order to determine which data to include in visualizations of online individuals, I drew upon past research about mining data from online archives. Marc Smith has conducted an ongoing social data mining project where he tracks the statistics of contributors to almost all Usenet newsgroups (Smith, 1999). Smith and other scholars have identified several data attributes that are relevant to depict including how active and how responsive each author is (Fiore, 2002). I selected three key metrics that captured newsgroup authors' activity level and responsiveness:

- How many messages the has author written
- How many of those messages are replies and how many are initial posts in a thread
- How recently has the author written

A number of potential metrics could have been used that capture more subtle variations in authors' activity level such as how many messages an author writes per thread on average. I chose to keep the metrics very straightforward so that they were not too esoteric for end-users.

To identify how "central" an individual's placement was in the discussion group, I counted the responses an individual receives. Calculating how many "ties" or connections an individual has indicates how "central" he is in the group, using the "degree centrality" metric from the social network analysis literature (Wasserman & Faust, 1994).

To detect emotional tone, I used the LIWC natural language package. This analysis tool was developed by Pennebaker and Francis at the University of Texas for use in diagnosing psychiatric patients by analyzing their writing samples and has been used for several other types of analysis (Pennebaker & Francis, 1999).

3.1.2 Discussion

In considering what to depict in the anthropomorphic format, I chose data that were accessible and that I felt would be useful for users to get a sense of the participants' activity level, responsiveness, emotional tone, and centrality in the group.

Activity level and responsiveness are useful metrics for identifying the total population of the group, the most active participants, and individuals who frequently respond to other participants' questions. Certain profiles of typical users emerge such as the newbie who asks a few questions but does not respond, or the extremely active participant who almost exclusively replies to others and who identifies himself as a core member of the group. By making these metrics explicit, users who are new to the group can more quickly get a sense of the population. While users may want a general sense of how many messages an author has written and how many of those were initial posts as opposed to replies, most users do not seem to be concerned with knowing the precise number of each of these values. Nonetheless, generating the visualizations based on these data is a worthwhile step to provide a sense of the trends in the population.

The emotional tone estimate is a rough indicator of the words the participant uses, and while sometimes inaccurate, it can be helpful to know who uses more negative words or more positive words. Emotion is an intriguing quality to be able to sense in online environments but can cause confusion if it is improperly communicated. When it is shown on the human face, it can attract a strong response, sometimes too strong if the valence of the emotion is not accurately represented.

One of the key questions I wanted to evaluate was how users would respond to the display of emotion in this way. Results are discussed in the Evaluation chapter.

When information about individuals' past behavior in the group is made transparent, a number of issues arise that affect the social dynamics of the group. When considering which data are the right data, we need to consider how different types of data impact different types of groups. Groups that are very information-based have different needs than groups that are purely social in nature. Participants in each type of group may or may not want historical accounts of their behavior constantly visible to the rest of the group. These issues will be addressed in the Evaluation chapter of this thesis, including a discussion of the results of a series of surveys presented to newsgroup members reviewing anthropomorphic visualizations of threads from their own groups.

3.1.3 Other Possible Approaches

Activity Level
Some pieces of data relating to activity level involve the author's participation over the lifespan of a particular group as well as across multiple groups. Both of these types of data are worth considering as elements to be visualized. While some authors only participate in one newsgroup, others participate in dozens of groups at a time. In order to simplify the design of the Anthropomorphs, I refrained from including information about messages from multiple groups simultaneously. Since the visualization needed to retain a compact humanoid form, a limited amount of visual space was available to list the names of groups or to incorporate visual elements summarizing messages across multiple groups. Nonetheless this additional information may be desirable to incorporate in anthropomorphic visualization approaches eventually.

While a historical view of an author's participation over the lifespan of a group would be desirable, two tactical concerns prevented me from incorporating messages from the complete lifespan of the newsgroup. The database I used had a limited number of messages that dated back less than a year. The Java-based client I developed also generated the depictions of each author in a newsgroup in real-time by reading in data about the complete set of messages from the group. When reading in more than a few thousand messages at a time, system performance was too slow. If these issues could be addressed, it would be worth analyzing a larger set of messages to calculate the length of time an author had posted messages to the group and to show changes over time in the author's participation. For more technical details about the test-bed system, see the Implementation chapter.

Social Network Analysis
Identifying subgroups of participants from a newsgroup population is possible by looking at which sets of individuals are most connected to each other. This can be useful for assessing whether there are "clusters" of participants who mostly respond to each other but not as much to the rest of the group. In developing the design of the test-bed system, I experimented with arranging the group into clusters using a spring-based visualization algorithm. I also incorporated the ability to view each participant with the set of people to whom he has some connection. In the end, I decided to depict the group members by placing the most central members in the center, and did not use the spring-based approach. This makes it easier to identify the most active core group members.

Natural Language Analysis
While it seems natural to depict emotions with a facial expression, it is less obvious whether it is appropriate to use the human form to depict other more abstract information garnered from

natural language processing. Although these types of information may be less natural to show in the human form, they may be interesting to integrate into this type of visualization, especially if the information relates to some potential user question. Some example information that could be used includes:

- *Topics addressed:* Using natural language processing to identify topics of conversation as Sack does with his Conversation Map application might be useful for online discussion participants (Sack, 2000b). Participants could be positioned spatially based on the topics they take part in or some system of visually distinguishing different types of topics such as color coding could help users to differentiate between different types of participation.

- *Point of View:* Sack also identified techniques for assessing the ideological point of view of a news story. He developed an analysis tool that draws upon a knowledge base about the most common "actors" for a particular type of story or topic. The system can make inferences about whether a story is written from the government's point of view, for instance (Sack, 2000a). This concept could be extended to identify different ideological positions that are commonly held in a particular discussion group.

- *Assessment of content value:* This could take the form of how much of the message is opinion vs. factual or how much it builds on prior messages as opposed to presenting new information. This type of natural language analysis is in early research stages.

Because of time limitations, these types of data were not integrated into the test-bed system I developed, but they would be interesting to incorporate at some future date.

Other Data to Visualize

While the Usenet messages I chose to visualize do not offer a facility for users to rate each other's and their own messages, integrating some kind of social evaluation into the system could be useful. The following elements should be considered but were not implemented due to time constraints:

- *Reputation:* Reputation systems that allow users to rank each other's contributions would also provide data that might be useful to depict so that users could find the most highly regarded contributors.

- *Self-assessment:* Users also might rank their own knowledge of the subject matter being discussed. This could be factored into the visualization.

3.2 Visual Design Approach

Figure 8. Mappings of data to visual elements in the Anthropomorphs
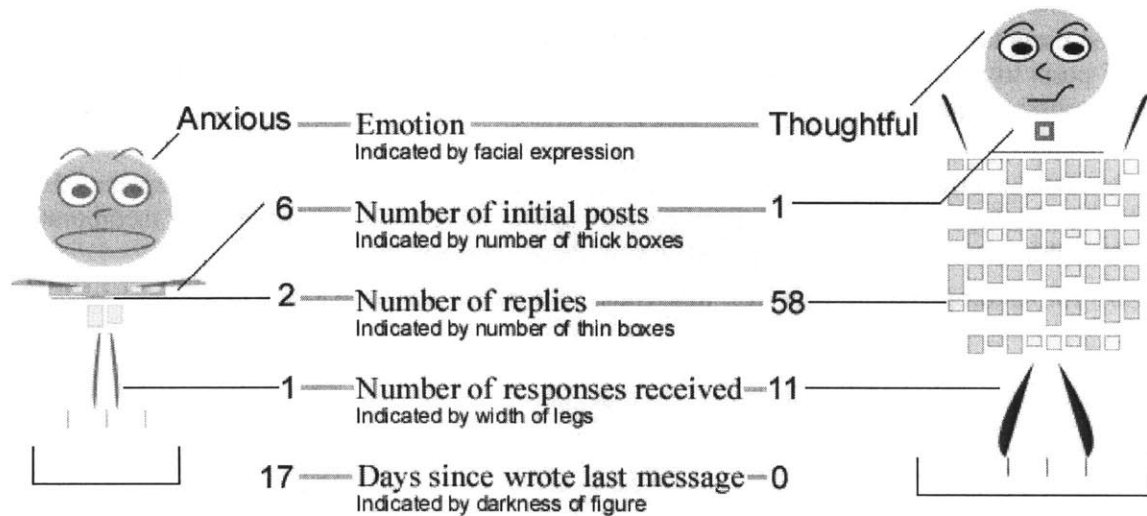
3.2.1 Design Approach For the Anthropomorphs

For the design of the Anthropomorphs, I selected the several mappings between data and visual form. Each is described below.

Message boxes: Each message the author has written is represented with a box in the torso of the body. In this way, the more active participants become larger, consistent with the intrinsic meeting of using size as a visualization parameter.

Each box's height is based on the length of the message, and the color hue of the box is based on the average emotional tone of the message. Color hue is identified by Mackinlay as an appropriate attribute for representing nominal values such as which emotion is dominant in the message (Mackinlay, 1986). For the Anthropomorphs, I used a spectrum of hues from red to blue, where red was mapped to the negative emotion anger, and blue was mapped to the negative emotion happiness. Yellow was mapped to neutral indicating that minimal emotion was expressed. A light orange was mapped to anxious, and green was mapped to the presence of thoughtful text.

Figure 9: Boxes in the body of the Anthropomorph represent messages the author has written.

2 messages   8 messages   16 messages   32 messages

Replies vs. Initial Posts: In order to distinguish users who mostly responded to other users from users who mostly initiated new conversation threads, I first adjusted the size of the Anthropomorph's eyes to make more responsive authors appear with more open eyes, using the

metaphor of attentiveness. However, this interfered with the emotional expression on the Anthropomorph's face and users found it difficult to differentiate between the different size eyes. So in the later version I gathered all of the author's initial posts together and gave them thick outlines and also gathered all of the author's replies and gave them thin outlines [see Fig. 9]. This enabled users to view the size of each segment of the author's torso to get a sense of the ratio of initial posts to replies. Thus the design was consistent with the visualization guideline of using size to represent quantity.

Darkness/Recentness: When an author has written a message recently, their body appears dark and crisp. As days go by without a message, they appear more and more faded. This incorporates the metaphor of someone fading away as he participates less and less.

Figure 10: Anthropomorphs fade over time if the author does not write a new message.

| Within 4 days | 5-8 days | 9-15 days | 16-25 days | 26 days or more |
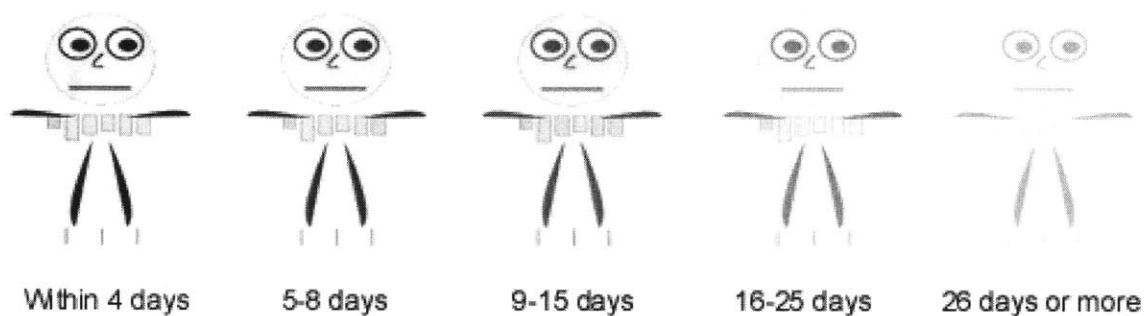
Facial expression/Emotion: The expression on the person's face indicates the average emotional tone of their messages. The color of the face is also determined based on which emotion is represented, making it easier to recognize Anthropomorphs with particular emotions when they are represented in a group.

Figure 11: Several different facial expressions were selected

| Happy | Thoughtful | Neutral | Sad | Anxious | Angry |
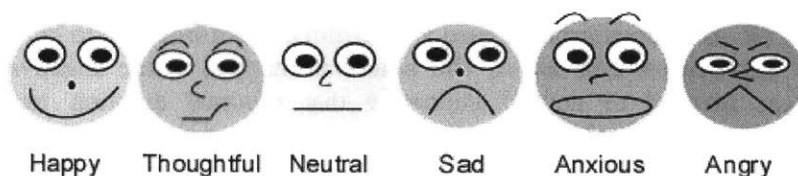
Legs/Centrality in the group: When their legs are spread apart and larger, this means that many people have responded to their messages and they play a central role in the group (i.e. they are planted in the group). When their legs are small and close together, this means that they've received few responses from others. Using the angle and thickness of the legs in this way makes it slightly harder for users to discern the value represented than if the size of the legs had changed more, but I felt that using the metaphorical idea of the user being "planted" in the group with spread out legs was appropriate instead of having some users with very large legs who might look disfigured or unnatural because of the lack of the proportions. In order to reinforce the value represented in the legs, three hash marks were added below the legs to indicate the angle that would represent the author receiving 10 responses.

40

Figure 12: The more central an author is to the group, the more "planted" he or she is in the group, which we represent visually by displaying wider and thicker legs.
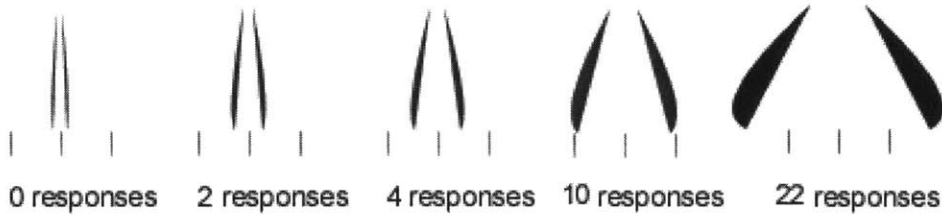
0 responses   2 responses   4 responses   10 responses   22 responses

Since the natural language processing technique to detect emotions I am using is not always fully accurate, users could be misled by viewing a facial expression that is not a good reflection of the users' personality. Therefore, one variation of the design did not include emotional information at all, presenting only a black silhouette of a head instead of a facial expression.

Figure 13: Silhouetted versions of the Anthropomorph have no facial expression.
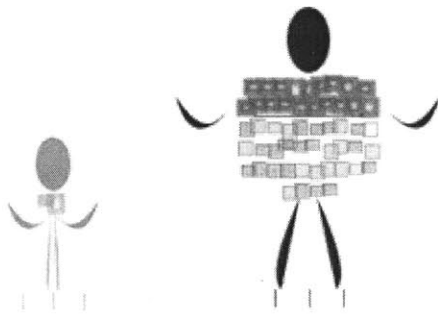
3.2.2 Discussion

As mentioned in the Introduction chapter, there are a number of reasons why I was motivated to visualize information about individuals using the human form. The use of a visualization that looks like a person might be more intuitive to associate with a person than a more abstract representation. The various body parts can each represent a different piece of data, providing flexibility as a graphic format. Facial expressions are relatively easy and immediate to recognize and evoke social responses. Finally, a number of people can be compared quickly since we are able to scan and differentiate among multiple representations of individuals with a humanoid appearance.

There are several areas to consider in selecting the visual approach. The design needs to clearly communicate the information, maintain an anthropomorphic appearance, and also be visually appealing and appropriate. In designing the Anthropomorphs, I went through several iterations, first coming up with the initial concept, and then fleshing out potential data to use for various elements in the "body" of the visualization. I also received critiques of my design approach from colleagues at the Media Lab. After running several user studies via online surveys, I refined the design based on user feedback. In this section I will discuss the various considerations that went into the design of the Anthropomorphs including the legibility and style of the visuals as well as the social impact of the human form. Results of the studies are discussed in detail in the Evaluation chapter.

Creating an Anthropomorphic Appearance
In order to have an anthropomorphic appearance, the visualization format needs to contain a head, a body, and limbs. If these elements are arranged to be near each other, the visualization can take

advantage of the Gestalt "Law of Proximity" to be seen as a single object. The "Law of Familiarity" also makes it likely that we will interpret the visualization appearance to be a person, since a body and limbs are almost always displayed in the context of representing a person.

A range of visual styles could be considered in depicting a human. The designs I explored incorporated abstract visual elements that could be used to visualize data. While additional detail in the body might further indicate that the depiction is of a person, relatively abstract visual forms can still convey a sense of a person. By including simpler visual forms, I hoped to limit the likelihood that users would infer unintended connotations from the style, posture or cultural associations of the depiction. Nonetheless I did not want to make the depiction so abstract so that it not longer appeared to be a person. As a result, the bodies are composed of shapes and lines that manage to retain a sense of personhood.

Figure 14. Even relatively abstract depictions of the human form are interpreted as humanoid
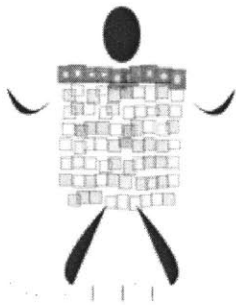
One of the most evocative elements of an anthropomorphic depiction is the face. The face has been shown to prompt a stronger social reaction in user interfaces, and must be used with great care since people are very sensitive to subtleties in expression and attention (Donath, 2001b). I experimented in an early design approach with using photographic facial expressions to represent emotional state, but the realistic detail of the photograph was misleading in that it gave the impression that the person being represented looked like the face in the photograph. The photograph also provided a strong sense of gender than I had managed to reduce in the cartoon faces. While some online discussions have a stronger sense of gender than others, visual depictions that get the subtleties of gender wrong seem inaccurate in a way that discredits the visualization.

In using cartoon-style faces, I had more flexibility to depict users without needing to be as accurate, since the cartoon is understood to be an abstraction. Nonetheless, the details of the facial expression are still important. A criticism of Chernoff faces has been that the changing of facial elements such as eyes, nose and mouth independently of each other results in distorted faces that produce unintended emotional responses (Loizides and Slater, 2002). While I did not want to repeat this mistake, I thought that perhaps if I just changed the degree the eyes were open but kept the rest of the expression constant, I might encode additional information into the face. However, the faces that resulted from this approach were confusing to users, so I eventually used pre-drawn faces with highly articulated expressions so that they would not be misinterpreted.

Figure 15. Original faces (top) were too subtle for users to interpret correctly, so I revised the design to have more exaggerated expressions (bottom).
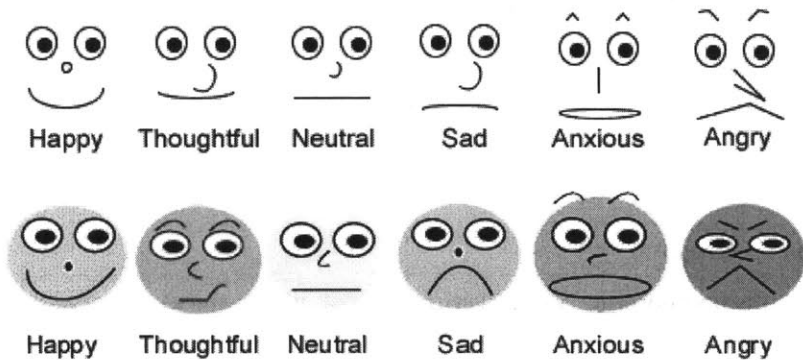
| Happy | Thoughtful | Neutral | Sad | Anxious | Angry |

Since the natural language processing technique to detect emotions I am using is not always fully accurate, users could be misled by viewing a facial expression that is not a good reflection of the users' personality. Therefore I also created a design approach that included a silhouette head without any facial expression that could be used to investigate users' responses to Anthropomorphs without the emotional information [see Fig. 13].

Legibility of Anthropomorphic Visualizations

In order to clearly communicate data about an individual, each element in the anthropomorphic visualization needs to be legible, and the quantity of elements should not overwhelm the user. By containing multiple pieces of data in a single form, Anthropomorphs function as "small multiples". According to Edward Tufte, small multiples are a series of "shrunken, high-density graphics" that allow viewers to compare the same pieces of data with the design approach remaining constant for each graphic. This can be useful for noticing trends across a population or for comparing changes over time.

Although Tufte has suggested that higher data density is desirable for information visualizations (Tufte, 1983), I have found that presenting more data elements is not always better. Anthropomorphic visualizations are targeted at end-users who may have limited interest in learning how to interpret many pieces of data from a somewhat unfamiliar visual form. While the Anthropomorphs do present several pieces of data in a compact form, I have found that 4 or 5 visualization elements may be the most that a user can easily learn. In an initial user study, with 7 or 8 different elements to learn, many users complained about the amount of data contained in the visualization and had trouble learning the elements quickly. In a follow-up study, with 4 or 5 elements to learn, most users did not have trouble remembering the significance of the different elements.

In addition to containing a digestible number of data elements, the visualization must also include only elements that are themselves comprehensible. Mackinlay has identified visual attributes that are appropriate for particular types of data (Mackinlay, 1986). As discussed in Hearst's Information Visualization tutorial (Hearst, 2003), certain of these attributes are assumed to have intrinsic meaning. For instance, larger objects are assumed to represent larger quantities, and darker elements in a grayscale format are also assumed to represent larger quantities.

It is desirable to enable users to efficiently pick out particular Anthropomorphs from a group if they are looking for individuals with particular qualities. So incorporating visual qualities that lend themselves to pre-attentive recognition would be preferable. However, because I am visualizing multiple pieces of data into a small multiple design approach, the multiple visual

attributes interfere with each other, limiting the capability for pre-attentive recognition. While a thorough empirical examination of the pre-attentive qualities of the design of the Anthropomorph is out of the scope of this thesis, I informally evaluated the design in order to include visual qualities that lent themselves to faster recognition. Using color, darkness, and size as visual indicators seems to enable users to identify target Anthropomorphs more quickly than if we rely on shape, angle, or symbols. So, for instance, I incorporated color into the faces since color is more recognizable pre-attentively in a group of elements than black and white sketched facial expressions.

Using Anthropomorphs to Depict a Group

One of the strengths of the Anthropomorphic Visualization format is its ability to depict a relatively large population of participants in a group. By depicting Anthropomorphs in a "landscape" of participants, users can scan the group to get a sense of the types of participation and population of the group. Anthropomorphs with particular emotional states or high levels of activity are discernible. The Anthropomorphs can be arranged spatially so that participants with particular qualities are placed in a particular location. For the test-bed system group view, I place the most "central" members of the group in the center of the screen, enabling users to quickly identify the group's core members.

Figure 16. Group view of newsgroup with central group members depicted in the center of the group.
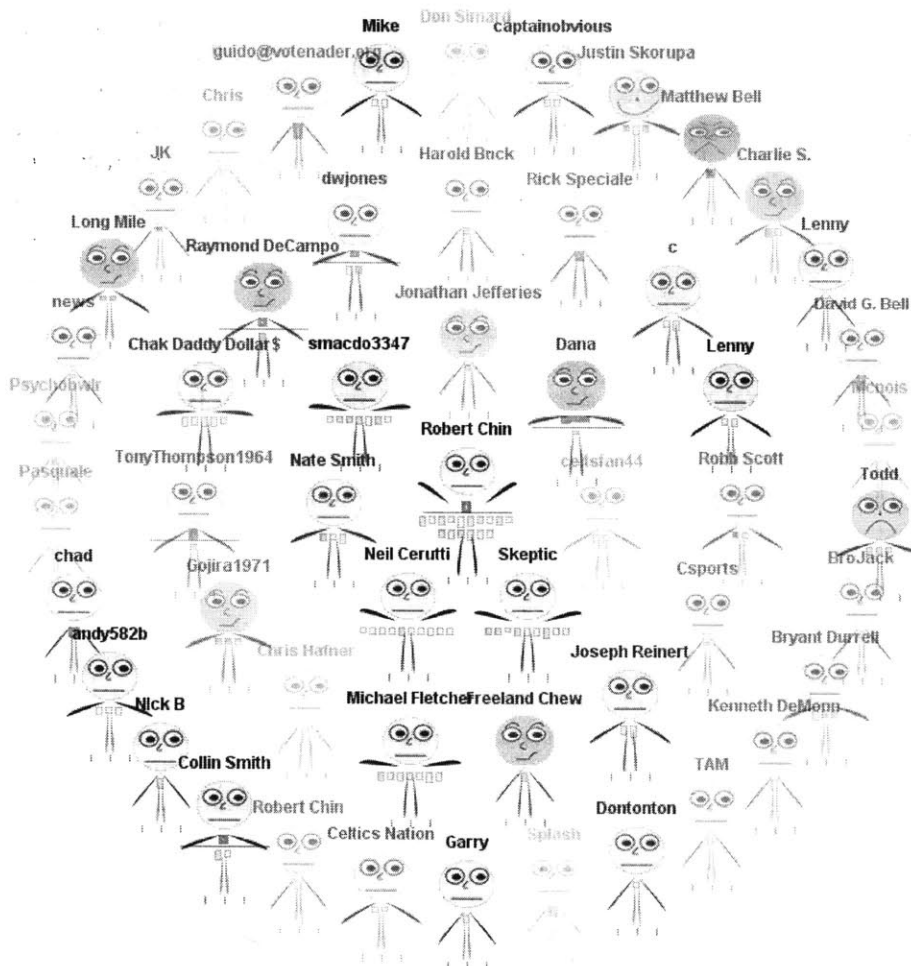
In an early design study, I also created an animation of the participants in a landscape. This evoked a sense that the participants were interacting with each other and could be used to depict how the group interactions change over time.

Anthropomorphic visualizations would also be useful for getting a sense of the distribution of topics and categorizations across the population of participants. By color coding some element of the Anthropomorph based on which topics he participated in, subgroups among the population can become visually apparent.

I also created a Calendar view which depicts the threads in a group in chronological order. Each thread is shown with small silhouettes of the posters who write messages. This is described in more detail in section 4.3.3 in the Implementation chapter.

3.2.3 Other Possible Approaches

Both the cartoon style and the silhouette style I created are evocative in their own way. The cartoon style was referred to as "cute" by users and the silhouette style looks more unusual, bordering on abstract. For users who might want something that looks more appropriate for a serious discussion, it would be interesting to develop a style that was still an illustration yet did not evoke the playful nature of cartoons. This style might be drawn from illustrations used in a business context.

Another possibility would involve using more figurative imagery such as clothing to differentiate among the Anthropomorphs. Different styles of hats or gloves might indicate something about the individual represented.

Animations in which the Anthropomorphs moved to indicate something about themselves might also be engaging and could communicate changes over time in the data about the individual. Users do seem to have trouble perceiving patterns when viewing multiple animated elements simultaneously, but animating individual Anthropomorphs one at a time can provide some sense of the changes over time in that individual.

3.3 Anthropomorphic Visualizations in Use

I envision two different types of scenarios when users would benefit from anthropomorphic visualizations. First, some users may seek information about a set of discussion groups and want to use a tool to give them a sense of the character of the group, perhaps comparing them with each other. Alternatively, users may be interesting in participating in an environment in which users are always depicted with Anthropomorphs, providing a more informative and possibly more social experience on an ongoing basis.

3.3.1 Seeking Information About a Group

In the first scenario, the visualization could be used as a tool to select a group to participate in. The user might be looking for conversation, for information about a particular topic, or for a community of interest within an organization. He or she might have several questions about the nature of the group, as groups that discuss similar topics are sometimes very different in character. The user might want to know whether the group has a social atmosphere or business-like information-seeking character. He or she might want to know how often newcomers post messages, and try to get a sense of how inviting the group is.

The anthropomorphic visualization system could serve these needs with several different functions:

- The Calendar view shows all of the threads in the last month with the posters participating in each thread. This allows the user to see what the largest threads are, and how many of the posters in each thread are active members as opposed to infrequent posters.

- Looking at the Calendar view also enables the user to see the activity level of the entire group. Groups with one or two threads per week appear different than those with several messages a day.

- The Group view shows all of the posters including their average emotional tone, enabling the user to get a sense of how emotional the group is. While some groups have almost all "neutral" Anthropomorphs representing authors whose messages have minimal emotional content, other groups have several angry, sad, or happy authors.

- The Group view also arranges posters based on how central they are to the group. This allows users to see whether the core members are all extremely active participants writing several messages a day, or whether there is more of a diversity of participation levels. Central group members who reply frequently to other posters are often considered the experts of the group, so users seeking advice can more quickly identify who to address their questions to.

- The Anthropomorphs' bodies contain message boxes which can be selected to display the messages the poster wrote. By reviewing the messages that the central members of the group have written, the user can more quickly get a sense of the atmosphere of the group. Some users might be seeking purely informational messages to answer a question while others might want companionship or even emotional support. Reading the messages with more information about the posters who wrote them than simply their name helps to provide a stronger sense of what is considered appropriate for the group.

- By looking at a poster's ratio of initial posts to replies, a user can get a sense of whether the poster likes to start conversations or if they purely respond to others, maintaining the community.

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While many of these functions might be provided with lists of text, there is a qualitatively different experience when viewing the anthropomorphic representations of the author. Large discussions look more like large discussions that take place in the physical world. Posters with similar characteristics look visually similar as well. Anthropomorphic visualization is appropriate for someone searching through several discussion groups with a desire for a more visual way to experience the groups than by reading text messages or looking at statistics.

Researchers studying different online groups might also benefit from this functionality when comparing them. If someone was trying to identify informal communities of interest within an organization, viewing the online discussion groups that exist there would enable them to look through the population of those groups and identify who are the leaders and facilitators. A researcher interested in a population of people with a particular interest could view the appropriate discussion group. For instance, to get a sense for a musician's fan-base, a user could view discussion groups who are interested in the musician, identify who starts conversations, is most knowledgable, or influences others.

3.3.2 Participating in a Group with Anthropomorphs

Alternatively, users might want to participate in a group in which everyone was represented with an Anthropomorph. This could allow users to learn some information about unfamiliar participants more easily. The discussion group would be based in a software application or web site where posters were always displayed with their Anthropomorph. They might be members of a club, an online organization or even an offline organization with an online presence.

Displaying participants' Anthropomorphs on a regular basis would more strongly communicate how central, active, and responsive they are. This might influence participants to be more social or make users feel a stronger sense of connection to the group. Using content analysis that indicated a participant's topical interests or point of view might help users to find other people with common interests, or people with opposing views to debate. More research needs to be conducted in order to assess the impact the anthropomorphic visualizations would have on the group.

Chapter 4: Implementation of the Test-Bed System

4.1 Overview

The Anthropomorph test bed system was developed to generate visualization of posters from newsgroups based on their messages. The system utilizes a newsgroup database created by members of the Sociable Media Group that collects messages from USENET newsgroups. A Java-based front-end client connects to the database via the JDBC connection protocol, and reads in a set of messages from a particular group, building a set of poster, thread, and message data objects. All of the diagrams and visualizations are drawn in real-time using the Java 2D graphics library.

Figure 17. Overview of the user interface
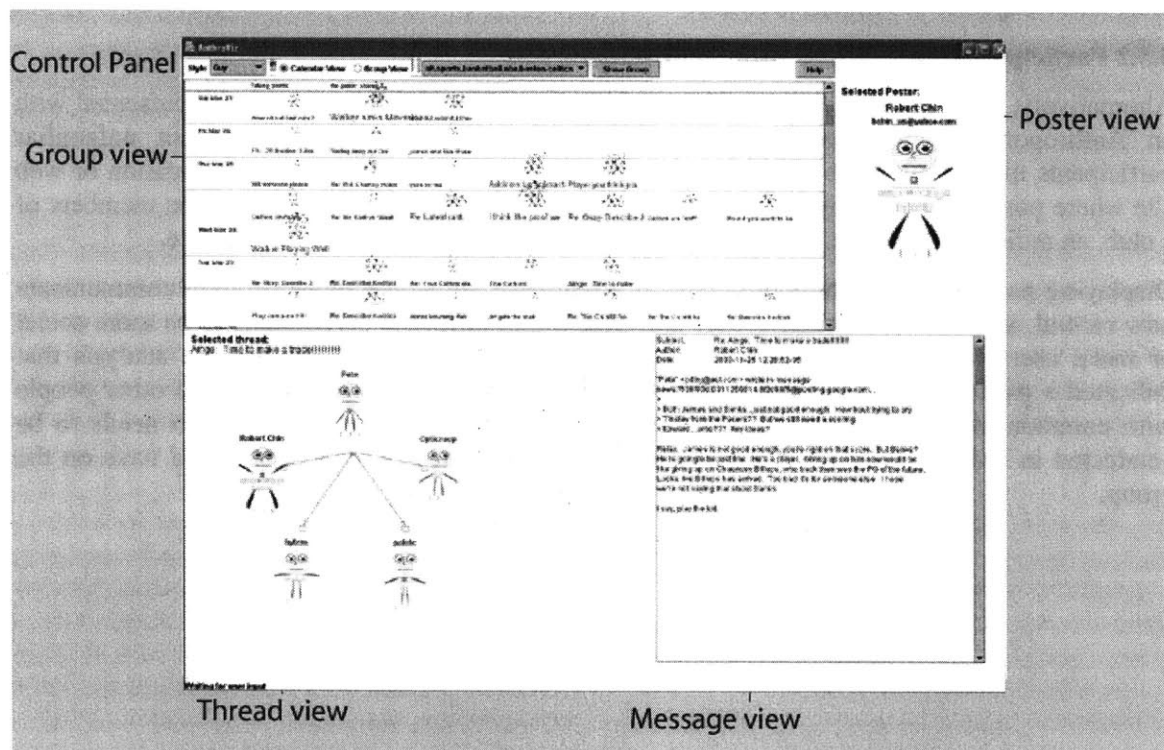
The control panel allows users to select a group to view and which visual style to use for the Anthropomorphs. It also allows users to switch between to group views:

- A calendar view showing conversational threads in chronological order on the last day they were discussed with a small representation of the participants in each thread [see Fig. 18 below]
- A group view showing anthropomorphic visualizations of each of the posters in the group [see Fig. 16 in section 3.2.2 above]

The Thread view displays a diagram of Anthropomorphs of the participants in the thread that has been selected as well as boxes that represent the messages written. The Poster view shows an Anthropomorph of the message that is currently selected. The Message view displays the text of the message that is currently selected.

Figure 18: Close-up of calendar view. Each row is labeled with a date and depicts the threads that were most recently active on that day. Each thread is depicted with the beginning of the subject of the thread and small silhouette representations of the posters who participated.

Sat Mar 20	Re: trying to identi WTD--Westclox & Dieh	WTB: 1200 Ohm, 10	Re: Christmas lights
Fri Mar 19	Ted Rogers Radio Wia Re: I found a Boy's	Re: The future of ou Dampers	Where o Where in Rid Re: Question about f
Thu Mar 18	Re: The future of ou New To The Chicago A Chicago Area German	Re: Rare RCA HF8 con Simon Automatic Tape	Re: Help ID early on Re: PLEASE FOLLOW D
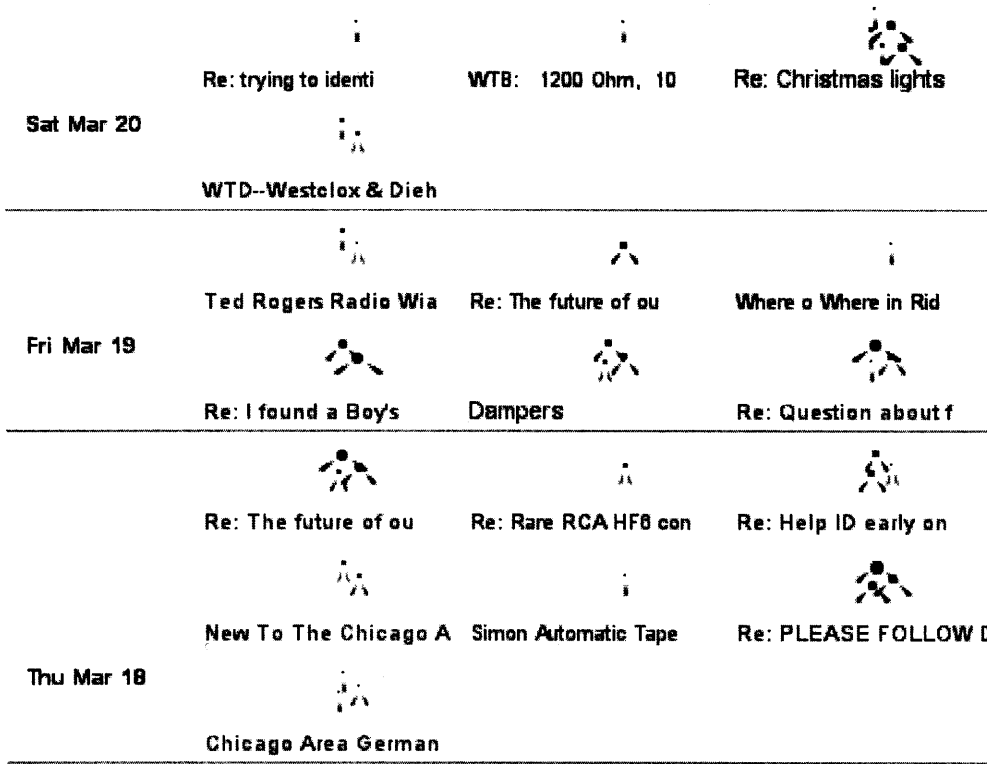
Users can select threads, posters, and messages to view the details. Clicking on threads in the calendar view loads the thread diagram into the thread view [see Figures 19-20]. Clicking on the message boxes in the thread diagram loads the text of the message into the Message view panel.

Alternatively, users can browse through the group by looking at Anthropomorphs of all of the participants shown in the group view. Clicking on posters in the group view presents a larger version of the poster in the Poster view [see Figures 21-22].

This larger Anthropomorph is interactive and clicking on the boxes in its body loads the Thread view panel with a diagram of the appropriate thread.

Figure 19: When the user clicks on a visualization of thread such as the one outlined by the blue box below, the diagram of the thread appears in the Thread view as shown in Figure 20.
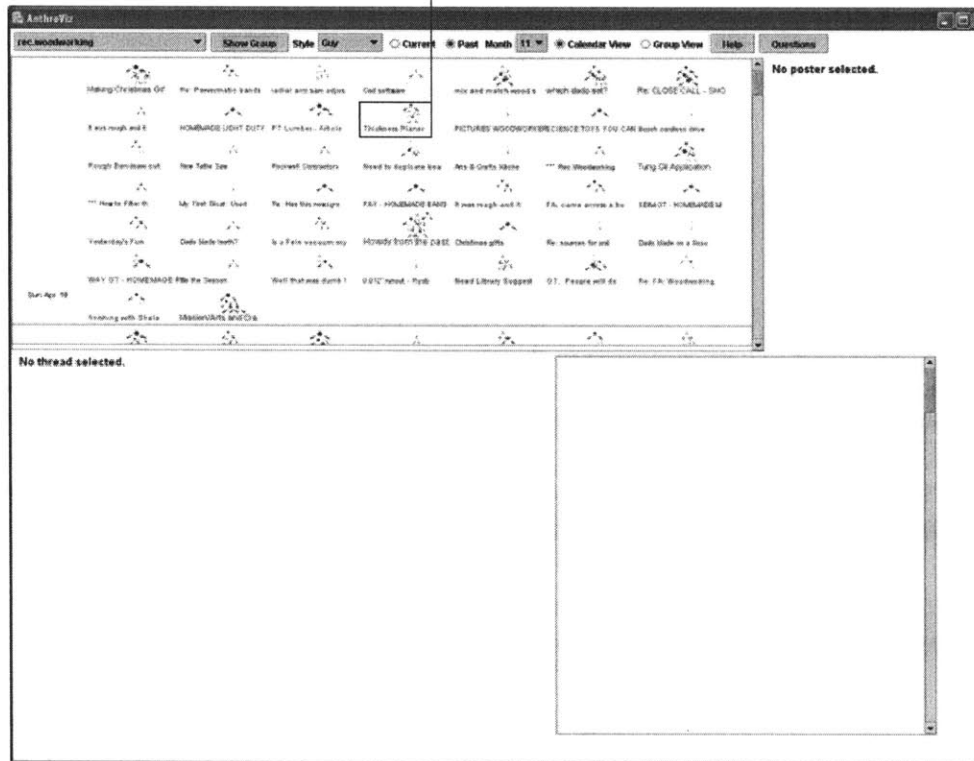
Figure 20: The thread diagram is loaded into the Thread View panel.
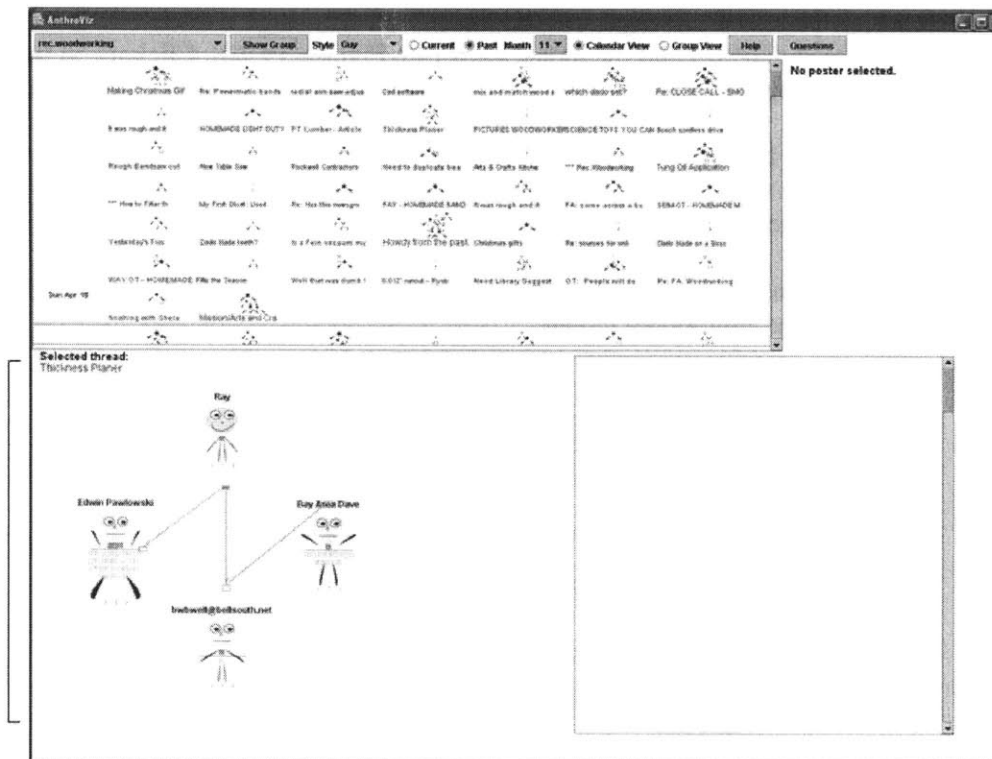
Figure 21: When the user clicks on an Anthropomorph in the group view such as the one outlined by the blue box below, a larger version appears in the Poster view as shown in Figure 22.
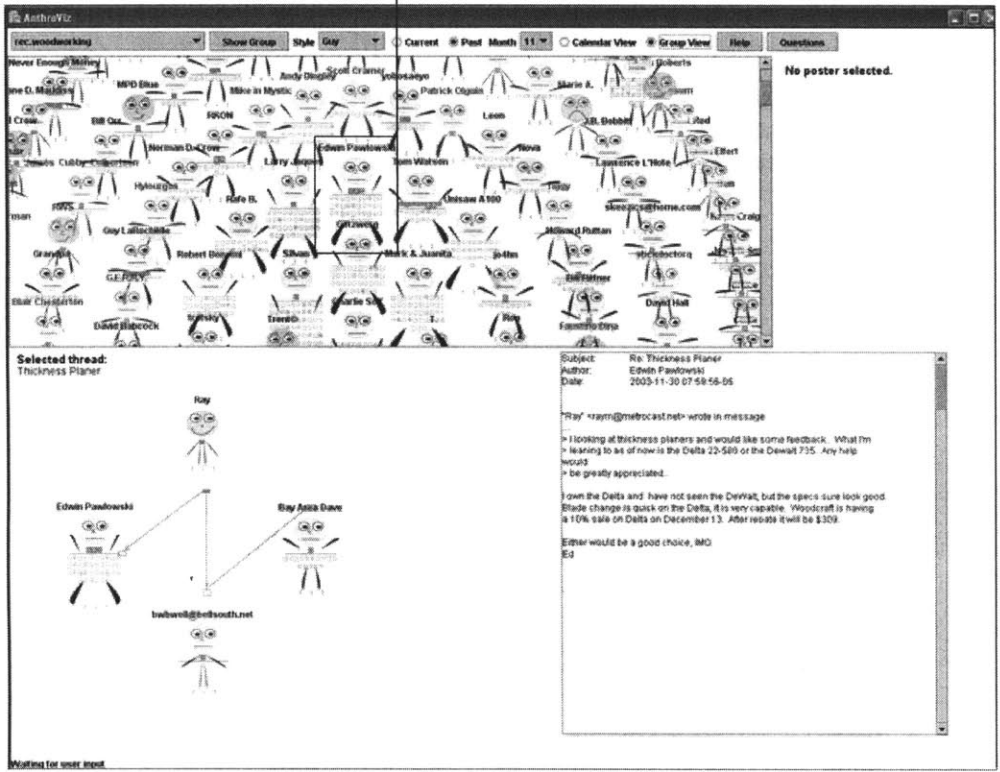
Figure 22: The Anthropomorph is loaded into the Poster View panel.
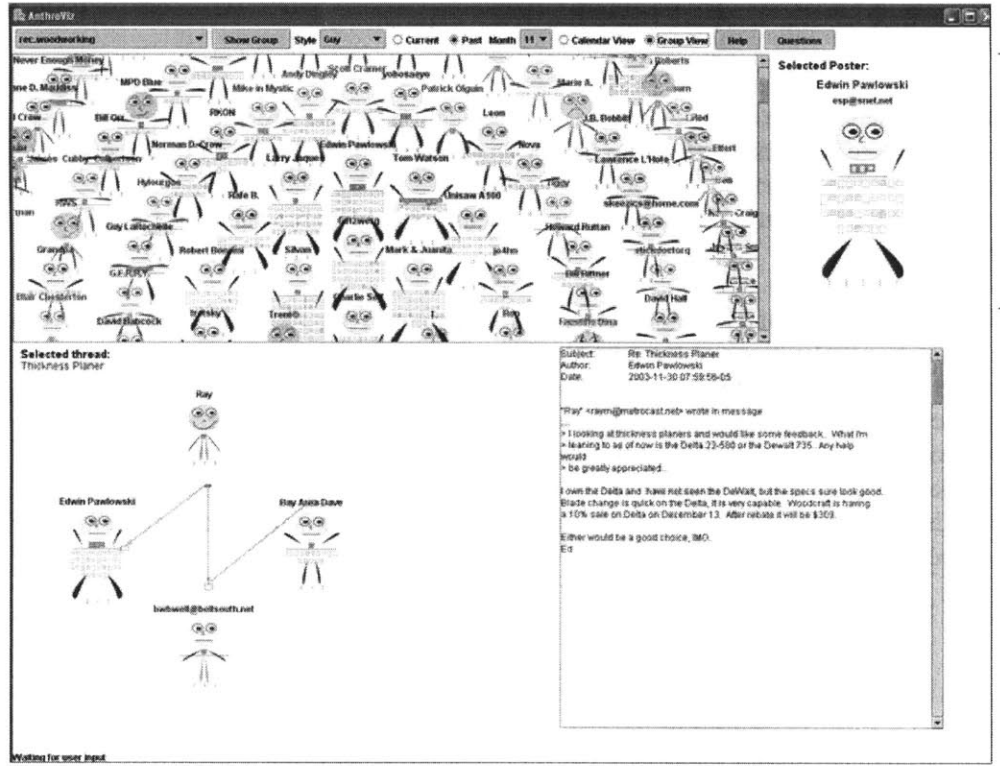
4.2 System Architecture and Data Model
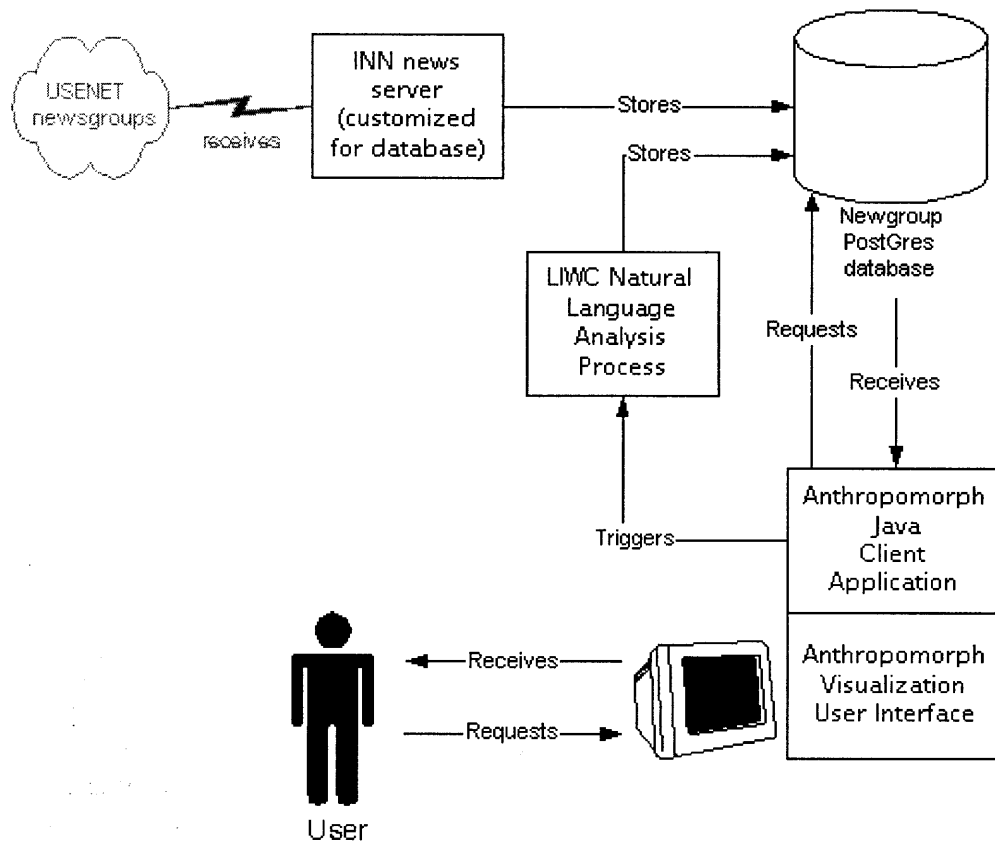
Figure 23. System architecture diagram

The system relies on an open-source newsgroup server application that has been customized to write messages to a PostgreSQL database set up to store newsgroup data. The INN open source implementation of NNTP news server functionality was customized by Andrew Fiore and Scott Golder in the Sociable Media Group. The newsgroup database is used as the backend for the Anthropomorph client.

The client is a Java application that I developed to read in the newsgroup messages and allow users to browse through visualizations of the participants and threads. It reads in the messages from the newsgroup database with SQL commands transmitted via the JDBC connection protocol. In order to minimize interruptions once a user is browsing through a group, all messages are read in when the newsgroup is initially selected so that the calendar view for the group can be displayed as a whole. Additional information about each of the messages is subsequently added in the background so that by the time a thread is selected, or the group view is shown, the emotional tone data are incorporated into the visualization.

The group data that are read in are contained within the following object model:
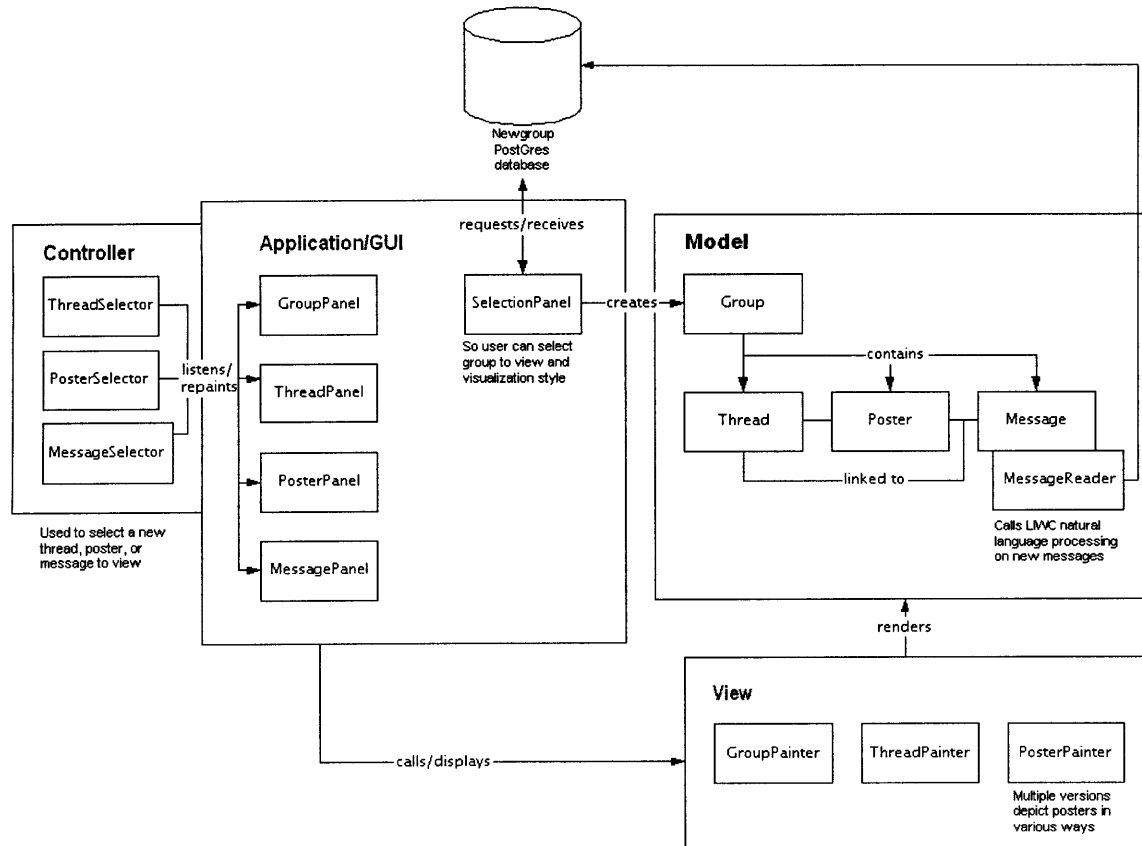
Figure 24. Anthropomorph object model

The Application uses the Model/View/Controller object-oriented design pattern in which the newsgroup message data are organized into the "Model" classes, is displayed using the "View" classes, and is controlled by the user with the "Controller" classes. When the application is loaded, pulldown menu GUI elements in a SelectionPanel enable the user to select the group to load in as well as the visualization style to view the participants in the group. Once a group is selected, the application reads in the message data from the external database and creates a data model for the group:

- **Message objects** contain message text, subject title, length, date, and emotional tone values for the message. They also contain ID numbers that link the message to its group, author, thread, parent message (message to which it is a response) and child messages (responses to the message).
- **Poster objects** contain the poster's name, email address, the list of message IDs he or she has written, the list of thread IDs the messages are part of, the number of responses the poster has received, the total emotional tone values for the author and the group ID number.
- **Thread objects** contain the list of message IDs in the thread, the list of poster IDs in the thread, the title of the subject of the initial post, the date of the most recent message and the group ID.
- **The Group object** contains the group name, the group ID, the hashmap of author IDs and links to the author objects, the hashmap of thread IDs and links to the thread objects, and the hashmap of message IDs and links to the message objects. By using the ID as the

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hashmap entry key, message, poster and thread objects can be easily retrieved from the group object. The group object also has a Boolean value that keeps track of whether all of the messages have been collected into the group.

When a message is read in for the first time, the LIWC natural language processing routines are called in the database to analyze the message text and generate emotional tone values for the message.

4.3 Java Client and Visualization Algorithms

The application contains Java GUI Panels that display the group view, poster view, thread view and message view using the GroupPainter, PosterPainter, ThreadPainter and MessagePainter "View" classes to render the appropriate visualization and content elements.

Listener objects watch for user mouse clicks that indicate that a new thread, poster or message has been selected to view. These are referred to as the ThreadSelector, PosterSelector, and MessageSelector "Controller" classes:

- The ThreadSelector refreshes the ThreadPanel display by loading in a new thread diagram whenever the user clicks on an image of a thread in the Calendar view of the GroupPanel or on a message box in the PosterPanel view of the poster.
- The PosterSelector refreshes the PosterPanel display whenever the user clicks on the image of a poster in a thread diagram in the ThreadPanel display or in the Group View of the GroupPanel display.
- The MessageSelector refreshes the MessagePanel display with a new message when the user clicks on a message box in the PosterPanel view of the poster or on a message box in thread diagram in the ThreadPanel display.

4.3.1 Rendering Posters

As described in the Design chapter, several different versions of the Poster visualization were developed. All of the anthropomorphic visualizations use the same general structure to render the posters:

- Author name and/or email address are drawn above the poster.

- The head either depicts the facial expression that represents the average emotional tone of the poster's messages of is a silhouette. In an earlier version, eye size was based on the responsiveness of the poster and mouth curve was based on the valence of the emotional tone (i.e. happier messages resulted in a larger smile), but these dynamically rendered facial elements were harder for users to interpret, so later versions select from a pre-rendered image for the appropriate facial expression.

- The body contains representations of the messages depicted as boxes. Boxes are drawn in rows of ten, with each box representing a message.

- Arms and legs are drawn with their radial position and width based on activity level and centrality and positioned according to the size of the body.
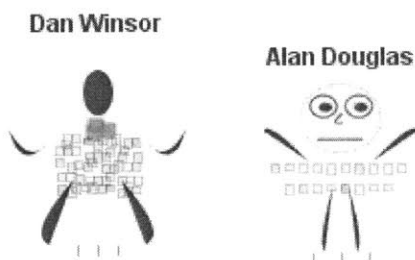
Figure 25. Example posters

4.3.2 Rendering Threads

When a new thread is loaded into the Thread view panel, several elements are drawn to depict the thread:

- The subject of the thread is written in the upper left corner.

- The posters are drawn at regular intervals along the edges of a circle. The author of the first message is positioned at the top of the circle, with each subsequent author arranged clockwise around the circle. The posters' distance from each other is based on the number of authors participating in the thread. Whatever visualization style is selected in the control panel is used to depict the posters. If a new style is selected, the thread is redrawn.

- Each message a poster writes is positioned in a straight line next to the author.

- An arrow line is drawn between each message and its response.

The position of each Anthropomorph and message is stored so that when the user clicks in the Thread view panel, the PosterSelector and MessageSelector listener routines can check whether a poster or message has been selected.
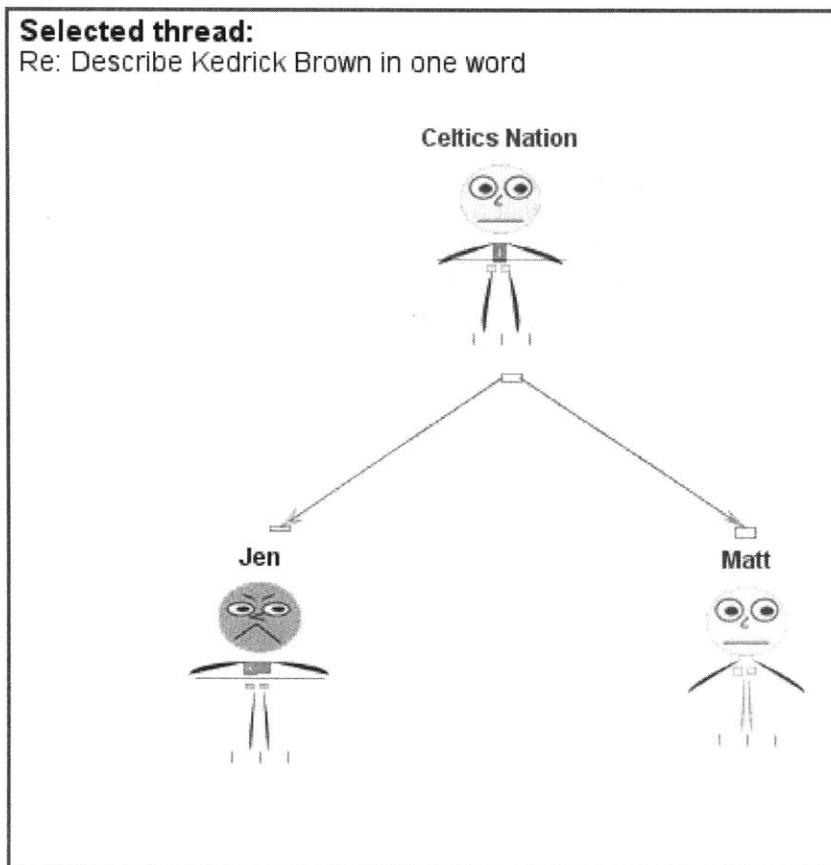
Figure 26. Example thread

4.3.3 Rendering the Group

In the Calendar view, the threads are drawn in rows. Each of the last 30 days gets a row across the group panel. The name of the day and date is drawn on the left hand side of the panel. Each thread is placed sequentially in the row corresponding to the day on which it was most recently active. If necessary, days with many threads expand to contain multiple rows. The panel scrolls so that users can browse through active groups with many rows of threads in the last month.

The subject of each thread is drawn below a small diagram of the thread. For each thread, the participants are depicted using small silhouettes in a small spiral. Each silhouette contains a circle for the head and two legs positioned below the circle. The circle's size is based on the number of messages the poster has written, and the width of the legs is based on the number of responses the author has received. This creates a general sense of the size of the conversation as well as some basic information about the posters participating.

Figure 27. Chronological Calendar view of the group
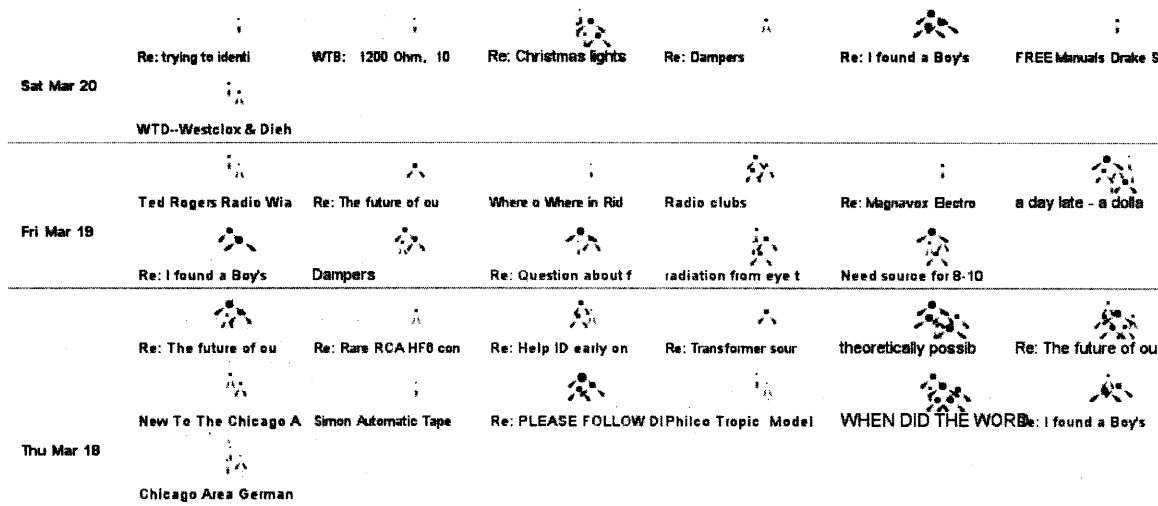
In the group view, the posters are rendered using the currently selected visualization style. They are drawn in a series of concentric circular rings. The more responses a poster has received, the closer to the center he or she is positioned, allowing the user to easily view the most central members of the group in the center of the display. See Figure 16 for an example group view visualization.

Chapter 5: Evaluation of Anthropomorphic Visualization

There are several perspectives that are relevant for evaluating the anthropomorphic visualization approach that I developed. Critiquing the visual appearance and style of the visualization from a visual design perspective is important. Since the design approach is unfamiliar, it was also important to see how well users could interpret the information in the visualization. I conducted a comprehension study that tested users' ability to interpret each piece of data represented in the visualization.

Anthropomorphic visualizations were conceived to play a social role as well. In order to test users' social reactions to other individuals who were depicted as Anthropomorphs, I had members of a newsgroup respond to visualizations of information about actual participants in their group. The study compared users' perceptions of authors and messages that were shown with visualizations to users' perceptions of authors and messages that were shown without visualizations.

The following section describes the assessment of the visual approach. Then the results of the comprehension studies and social impact study I conducted are described in detail, with a discussion of these results.

5.1 Visual critique

In the course of developing the Anthropomorphs, I conducted several design reviews with colleagues from the MIT Media Laboratory. Initial sketches were drawn in Adobe Illustrator and were not limited by the constraints of the Java graphics library. The sketches had a relatively abstract feel composed of shapes that appeared as if they were depicting data instead of simply appearing to be an illustration. Several key themes came up during the critiques of the design:

- The Anthropomorphs' novel appearance, combining abstract shapes into a representational form, was different than prior representations of humans such as avatars. Reviewers said this visual approach seemed fresh and valued the unusual nature of the design.

- Users would need to understand each of the individual visual elements. Therefore, each element in the body needed to be clearly identifiable and ideally have some logical connection to the data it represented.

- People with significantly different past behavior need to have Anthropomorphs with visually distinct appearances that were pronounced enough to show the differences among the population.

After I created a Java implementation that generated the Anthropomorphs automatically, some other visual issues emerged.

- It became critical that the algorithms for generating anthropomorphic visualizations create Anthropomoporphs that looked relatively natural. The population of authors we generated visualizations for had a wide range of data values. The visualizations resulting from this wide range of data needed to have facial features and elements in the body that looked humanoid and undistorted. If Anthropomorphs had distorted faces or limbs, critics felt them to be visually confusing and inappropriate.

- It was also necessary to insure that users could understand the meaning of the facial features and body element positions. If the appearance of the Anthropomorphs was too novel, they would be more unfamiliar, resulting in a design approach that was less understandable. So despite the fact that reviewers liked the visual novelty of the approach, I moved to a slightly more familiar visual appearance for the design, making them look more like cartoon characters or silhouettes seen in other contexts.

When we see images of people, we make assumptions about them based on how they look. For instance, if someone has an angry facial expression and is waving their arm, we assume they are agitated. The Anthropomorphs also create similar expectations even though they are not depicting a person's literal physical appearance. When data are depicted in a way that is consistent with the physical world, it is usually easier to interpret. The facial expressions, for instance, are perhaps the easiest pieces of information to interpret because they mean the same thing on the Anthropomorphs as they do in a face-to-face situation. More abstract information that is simple to interpret visually can also be relatively easy to learn. For instance, users can learn that the number of messages someone has written is represented by the number of boxes in the torso of the Anthropomorph. However, more abstract information such as the responses someone has received or the degree of subjectivity a person's messages contain can be more difficult for users to interpret.

5.1.1 Visual Styles

A number of styles would be possible for creating an anthropomorphic form that resembles a human. My interest was to test the impact of the human form as a visualization format, but the

visualizations I created had a relatively narrow set of visual styles. The style of the Anthropomorphs with faces has been called "cute" and "campy." The Anthropomorphs with the silhouette form have been described by critics as "interesting" and "cool". Some users did not find the visual appearance of the Anthropomorphs to be appealing as they referred to them as "childish" and "too cute." Clearly different social groups have different cultures and tastes and the particular style I have developed has a playful feel. It is quite possible that some of the responses users had to these visualizations were a result of the particular visual decisions I made in creating the styles that were used for the testbed system. Since people react to relatively subtle differences in the visual appearance of the human form, it would be worthwhile to investigate a wider set of visual approaches.

Explorations of different visual styles of anthropomorphic visualizations could take several directions. It would be worthwhile to explore more and less photorealistic styles, ranging from images similar to photographs to simple line compositions. It would also be appropriate to explore different aesthetic styles inspired by different artistic traditions. More impressionistic styles might be appropriate for situations where the data represented are vaguer, while more detailed line drawings based on traditions of etching and shading might be used to represent anthropomorphic visualization with more detailed data. Alternatively, different media such as water colors, acrylics, and pen and ink might provide inspiration for a broader range of visual styles that might be used for groups with varying tastes in aesthetics.

Overall, the Anthropomorphs I created are successful in their ability to communicate variations in information about individuals in a human form. The current designs look relatively natural for the ranges of data they were applied to and are sufficiently familiar that users can understand the approximate values of the data represented. The style appeals to some users more than others. Additional styles should be created for users who are not comfortable with the playful visual approach that is currently implemented. Each group using the system might agree on a particular style that they feel reflects an appropriate tone for their group. However, it may also be case that different individuals might choose different styles to view the group with. This raises a larger question that is out of the scope of this thesis about what happens when participants in an online space view different depictions of the same space.

5.2 Comprehension Studies

In order for users to get a sense of the population of an online discussion group using anthropomorphic visualization, they must be able to interpret the information contained in the Anthropomorphs. To see how accurately users could interpret the Anthropomoporphs, I created an online survey. The survey first presented users with a short tutorial explaining the meaning of each element in the visualization. It then asked users to answer multiple choice questions about the format to see whether they understood and remembered the mappings between visual elements and data.

To test how well users interpreted the data in the visualizations, they were shown five example visualizations and asked to identify the number of messages an author had written, how many of those messages were replies or initial posts, how much other group members responded to the author, the average emotional tone of the author's messages, and how recently the author had written. These values were displayed in the various body parts of the Anthropomorphs. While I wanted to insure that users could at least get a general sense of the information represented in the visualization, I chose to ask subjects to estimate precise values for each of these questions. Rather than have subjects choose whether someone had written "A small amount", "A medium amount", or "A large amount" of messages, I had them estimate a specific number. That way I was able to determine exactly how accurate subjects were in their interpretation of the visualizations.

After conducting the online survey to test users' comprehension of the Anthropomorphs with two initial designs, I refined the approach and ran a second survey with two additional designs. In the first comprehension study, respondents were contacted via email messages to the following mailing lists: MIT Media Lab messages list, Mapping Cyberspace mailing list, alt.usenet.surveys newsgroup, alt.current-events.usa newsgroup. 24 respondents completed the survey. 2 different versions of the visualization were tested, with 12 respondents receiving each one. Version 1 was more cartoonish and Version 2 was more abstract.

The visualizations in all studies depicted newsgroup authors with a range of characteristics. Authors had written between 1 and 125 messages, and had written their most recent message between 0 and 29 days ago. They had received between 0 and 40 responses, and had written between 0 and 20 initial posts. They had facial expressions ranging from happy to angry.

5.2.1 Results of the Studies

People were generally able to estimate message quantity/size represented by the number of boxes or bubbles in the Anthropomorph's body with the average estimate less than the actual number represented, a discrepancy of 3.8 messages which was significant at $p < 0.02$. People also accurately estimated recentness (represented by the darkness of the Anthropomorph) with the average estimate 3.7 days less than the actual number represented ($p < 0.01$). People had trouble with the specific values of replies and responses represented by the openness of the eyes, the position of the legs, and the differing outlines of the message boxes. Many people identified the facial expression based their own interpretation of its appearance (especially for the less abstract visualization), regardless of the instructions I had provided at the beginning about what each expression signified.

Based on the results of this first study, I made several changes to the Anthropomorphs:

- Eye shape remained constant rather than being dynamically generated based on responsiveness.

- Facial expressions were more pronounced to improve user accuracy in interpreting the expression.

- Initial post messages and reply messages separated into groups in the Anthropomorph's torso to increase the user's ability to get a sense of the quantity of initial posts vs. replies written by the author.

- I reduced the number of visual elements I explained to subjects in the tutorial portion of the survey to 4 or 5.

In the second comprehension study, conducted after the design changes were made, respondents were contacted via email messages to the AIR-L Internet Researchers mailing list. While subjects who responded from this list and from the lists in the previous study were likely to have some interest in Usenet, respondents from AIR-L might not have been as likely as some of the respondents in the previous study to be interested in information visualization as it is rarely discussed in that group. Nonetheless, correct answers on the meaning of the different visual elements increased substantially with subjects getting 96% of the answers correct. Also, fewer people abandoned the survey midway. This is likely because I reduced how many elements I included in the visualization and explained in the tutorial.

I asked users whether they had used avatars in graphical environments and how much they liked using avatars. Users who had used them ranked the difficulty of the visualization an average 1.88 lower on a scale of 1 to 7 than those who had not used them ($p < 0.004$). However, this did not correlate with how appealing they found the visualization or how much they wanted to use it.

Recognition of the facial expression in the cartoon version improved over the prior versions with subjects correctly interpreting 82% of the facial expressions. The majority of the errors were misinterpretations of the expression I had created to represent "thoughtful" authors, so I altered that expression in later versions of the application. Estimates of the quantity of messages, quantity of responses received and recentness of messages posted were similar to the previous study. Subjects' estimates were improved but somewhat less accurate for quantity of responses received with the average estimate higher than the actual number represented, a discrepancy of 9.7 responses on average which was significant at $p < 0.001$. Estimates of the number of initial posts written by a poster were relatively accurate with the average estimate 0.8 messages less than the actual number represented ($p < 0.001$).

Summary

Overall, subjects were able to remember the meanings of the visual elements in the anthropomorphic visualizations when there were 4 or 5 elements representing different pieces of data. Earlier versions with 7 or 8 pieces of data were harder for subjects to remember completely correctly and they often were unable to remember the meanings for one or two of the elements. Within an approximate range, subjects could estimate the values represented by the visualization for the number of messages an author had written, how many of those messages were initial posts vs. replies, and how recently the author had written. Subjects were less accurate interpreting the values represented by the width and position of the legs that indicated how many responses an author had received.

Subjects seemed to interpret facial expressions based on their own assumptions about the expression of the face regardless of the example expressions explained in the tutorial. In the revised design with more pronounced expressions, subjects more accurately interpreted them in the way that they were intended to.

5.2.2 Discussion

To make anthropomorphic visualizations that have a social impact, the elements of the visualization need to be understandable to users. A question I considered while designing the Anthropomorphs was how accurate a representation of data was necessary to help users distinguish among each other and get some sense of the population of the group. In order to form a social picture of a group, the user needs to be able to categorize participants according to how they behaved: who are most and least active, who are most and least responsive, who are angry or sad, and who are most central. In order to get a sense of these types of participants, users do not need to know precisely how many messages someone has written or how exactly how many responses he or she has received. Instead, users need to be able to compare members of the population and get a general sense of the ranges of activity. If the user perceived participants based on this information, the visualization could be said to have a social impact. In addition, if the presence of an anthropomorphic figure made the user more likely to respond to participants or to be more polite, the visualization could also be said to have a social impact.

While accuracy of data is a high priority, if users could get a relatively accurate sense of the population but perhaps not a completely precise one, the visualization might still be considered a success. For instance, identifying the most active participants or the participants who were significantly less responsive might be sufficiently useful without insuring that users were able to accurately interpret the precise values of the activity level or responses received. Since I also needed to insure that the visual form appeared humanoid, there were certain limitations on the visual formats I could use, and the number of data elements that I could convey. Presenting an approximate sense of several pieces of data rather than a precise set of values seemed to be an acceptable tradeoff to explore the social impact of this type of visualization on a group. Therefore, the Anthropomorphs can be considered a type of "approximate" visualization as opposed to a precise one.

While the current designs are understandable enough for me to study their use with actual discussion groups, it would be desirable to create anthropomorphic visualizations that users interpret even more accurately. It would be worthwhile to pursue additional design formats that users can more easily interpret by further exploring visual elements that can be used as a body element in a humanoid form.

5.3 Social Impact Study

To test users' reactions to messages shown with an anthropomorphic visualization of the author, I created an online survey. Subjects were recruited through messages sent to a small set of newsgroups. Participants were first asked to provide some personal information about themselves, their participation in the newsgroup, and their reasons for coming to the group.

To test whether the visualizations had a social impact on users, I compared subjects' perceptions of authors and messages shown *with* visualizations to subjects' perceptions of authors and messages *without* visualizations. If users had different expectations about authors' characteristics because of the presence of visualizations, this might influence their social responses to those authors (by making them more or less likely to respond to a particular author or more or less trusting of the author's messages) and the visualization might be said to have a social impact. They first viewed an explanation of the visualization format (if appropriate), and then read six messages from two threads from a particular newsgroup. In order to make sure the messages and authors were relevant to their interests, I solicited subjects from the newsgroup they were already familiar with. Each subject read messages with only one of the following three conditions:

- Data about posters are displayed in an anthropomorphic visualization
- Data about the posters are displayed in a bar chart format
- Messages are displayed with no additional data about posters

To test users' perceptions of the authors, subjects were asked to rank their perception of the posters who wrote each message that they read. On a scale of 1 to 7, they ranked the poster's social characteristics such as friendliness, helpfulness, etc. I analyzed these assessments to see if subjects were influenced by the visualization type. For some of the messages, they were also asked to write a short statement justifying their decision. These statements were then analyzed to test how much users based their answers on the appearance of the visualization of the author.

After subjects finished reading messages, they were asked whether they felt it was appropriate for this information to be shown to the group. Despite the fact that in a sense these data are public since the messages themselves are in a public forum, users' feelings about synthesizing this information into a more explicit presentation are unknown.

5.3.1 Results of the Study

Subjects responded to our survey from three different newsgroups. One group was composed of fans of a rock group, one group was composed of hobbyists working on construction projects, and the third group was composed of collectors of antique objects. I received 51 subjects from the rock group fans, 42 subjects from the hobbyists, and 27 subjects from the antique collectors. The reasons they had for coming to the group were very different. While 88% of the rock fans who responded said they came to find out the latest news, only 22% of the antique collectors came for that reason. While 47% of the rock fans came to get advice or help, 83% of the hobbyists came for that reason. While only 26% of the hobbyists came to socialize with friends and acquaintances, 52% of the antique collectors and 43% of the rock fans came for that reason [see Fig. 28].

The majority of the subjects who completed the survey were very familiar with the newsgroup they participated in, having spent an average of 37 months in the group, 10 years on the Internet, and over 7 years in online discussion groups [see Figures 32, 30, 31]. They also were familiar with many of the authors in the survey's visualizations, frequently mentioning their knowledge of the author's past messages as justification for their ranking of the author's characteristics.

Unfortunately, because the subjects were so familiar with the authors whose messages they read, I was not able to fully examine how much of an impact the visualization might have on users unfamiliar with the people being represented with Anthropomorphs.

Figure 28: Reasons for Coming to Newsgroup Varied for Three Different Groups
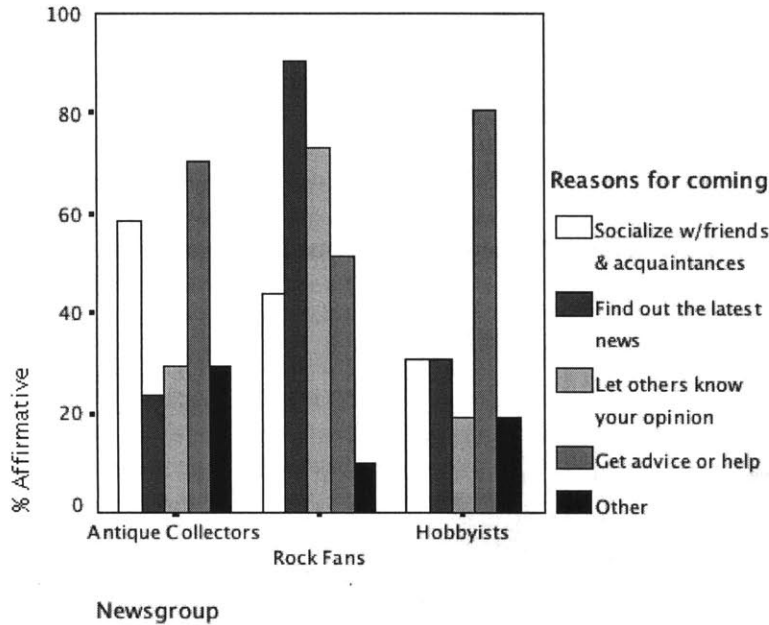
Figure 29: Histogram of Ages of Respondents
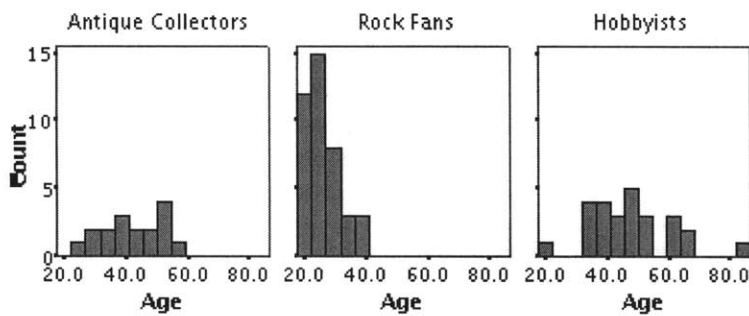
Figure 30: Histogram of Time Respondents had been on Internet
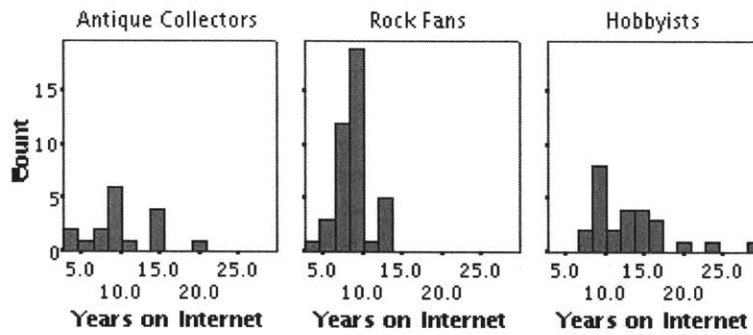
Figure 31: Histogram of Time Respondents had Participated in Discussion Groups
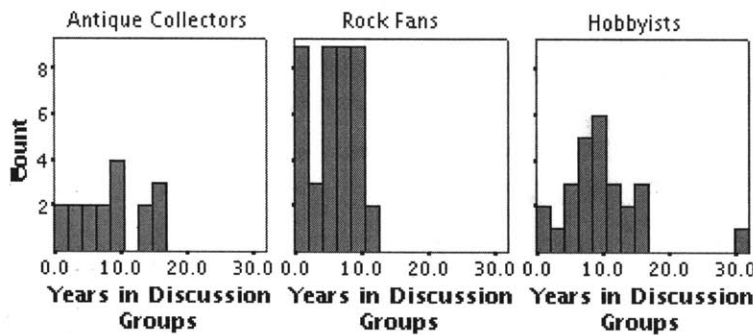
Figure 32: Histogram of Time Respondents had Participated in Selected Newsgroup
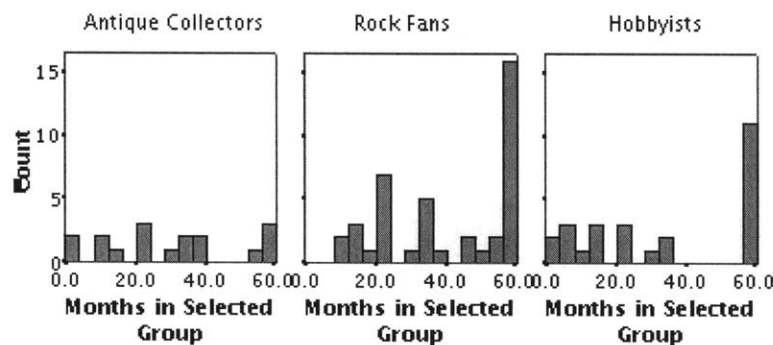
NOTE: Subjects could select values between 0 and 60, so some subjects may have participated in a group for more than 60 months.

I found no meaningful correlations between the presence of a visualization that was shown to subjects and their impressions of the author. Instead I found that there were many correlations between their familiarity with the author and their ranking of that author, with more familiar authors receiving more positive rankings. For instance, there was a moderate correlation between how familiar they were with the author and how likable they said the author was ($r = 0.49$, $p < 0.01$). There was also a moderate correlation between how familiar they were with the author and how intelligent they said the author was ($r = 0.49$, $p < 0.01$) [see Appendix C, Table 1]. For

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subjects who rated their familiarity with the author at 4 or more on a scale of 1 to 7, the mean value of their ranking of authors' likeability was 5.42 as opposed to 4.24 for authors who ranked their familiarity with the author at 3 or less. A t-test showed this difference to be significant ($p < 0.001$) [see Appendix C, Table 2].

When asked to explain their rankings of the participants, many subjects said they based the ranking on knowledge of the individual gained from reading previous posts. No subjects mentioned the visual appearance or the data represented in the visualization as an explanation.

Subjects were also asked how likely they would be to respond each message they read. Here the results are less conclusive. While two of the groups had no correlation between the type or presence of the visualization and the likelihood that the subject would respond, the antique collector group did have a slight correlation between the visualization type and the likelihood they said they would respond ($r = 0.27$, $p < 0.01$) [see Appendix C, Table 3]. When respondents in that group who were presented with an anthropomorphic visualization were shown messages, they said they might respond to the message 60% of the time. Those who were shown messages without a visualization said they might respond 45% of the time. Subjects who were presented with messages with a bar chart visualization in that group said that they might respond 83% of the time. We used two different anthropomorphic visualization styles (one with facial expressions and one with silhouettes), and gave subjects a choice of indicating that they "definitely wouldn't respond", "might respond" or "definitely would respond". The breakdown of each of the responses for each visualization condition is shown in Figure 33.

It is unclear exactly why the subjects in the different visualization conditions responded the way they did. Several different factors influence a subjects' likelihood to respond to a message including their perception of the author, their motivation for participating in the group, and their sense of what behavior is acceptable or expected in the group. For instance, it is possible that the subjects viewing anthropomorphic visualizations with faces more frequently said that they "might respond" because of their desire to be polite in response to viewing a face on screen, even if they were not as motivated to respond. Additional research is necessary to clarify which factors are influencing user behavior in conjunction with the presence of the different visualization styles.

Figure 33: How subjects in the Antique Collectors group viewing different visualization types said they would respond to messages
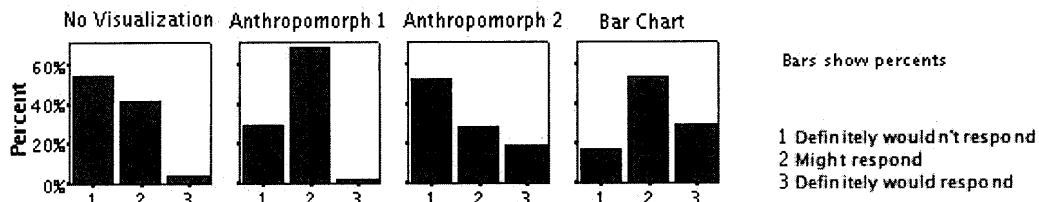
When asked how appropriate it was to share the information shown in the visualizations with the group, subjects had a variety of reactions. On a scale of 1 to 7 from very inappropriate to very appropriate, viewers of the anthropomorphic visualizations selected a mean response of 4.25 (s.d. = 2.09). Viewers of the bar graph visualization selected a mean response of 4.15 (s.d. = 1.88) [see Appendix C, Table 4]. Subjects gave a variety of explanations. Some expressed concerns that the participants who looked less active might be ignored inappropriately. Some said that the information about the author was irrelevant to the conversation and did not make a difference as

to whether their message would be worthwhile. Others said they thought it might be useful for learning about the author.

When asked about how appropriate it was to analyze messages to estimate emotional tone, viewers of the anthropomorphic visualizations with facial expressions and the bar graph visualizations selected a mean response of 3.63 (s.d. $\approx$ 2.0 in both cases) [see Appendix C, Table 4]. Subjects expressed concerns about the accuracy of the measure and feelings that it was not relevant to the conversation. A few said it might help them filter out the negative authors.

Summary

Subjects from three different newsgroups responded to the survey and each read six messages from the group they participate in. I found moderate correlations between how familiar the subject was with the author of the message and how they rated the authors they viewed. The population of subjects we received had spent several years on average in Usenet newsgroups, and was relatively familiar with many of the authors whose visualizations we displayed. Unfortunately, I was not able to fully investigate the social impact of the visualizations on users unfamiliar with the individuals represented.

Perhaps because of the authors' familiarity with each other, there were few correlations between the visualization type that was shown and the subjects' impressions of the author. Within the Antique Collectors group, there was a slight correlation between the visualization type and how likely the subject said they would be to respond to the message they viewed.

Subjects had mixed responses to whether it was appropriate to depict the information about authors' past behavior in the group. Some subjects had concerns that this information might be emphasized too much by participants when responding to each other but others thought it might be useful for getting an understanding of the authors.

5.3.2 Discussion

The population of users who responded to the survey from the newsgroups I contacted turned out to have spent more time in their group and be more familiar with the other authors than I anticipated. It seems to be the case that when visualizations are shown in conjunction with messages, veteran users of discussion groups who are used to relying on text to get a sense of other participants may not be influenced much by the visualization. Anthropomorphic visualization is more likely to be useful to people who are not as familiar with the population of the group they are interested in learning about. This approach may be more appealing to users of online environments that are already visual. It also may be most appropriate for users wanting to get an overview of a group or conversation, rather than reading detailed text messages.

For users who do focus primarily on the visualizations rather than on the messages, there are a number of social issues to consider. In face-to-face situations, individuals present themselves to others in a way that they believe is appropriate for the situation and that often anticipates the others' social responses to their behavior. People also make assumptions about others' social standing and personality by drawing inferences from the others' appearances (Goffman, 1967). Automatically generating a depiction of an individual without taking these factors into account is potentially problematic. Individuals have several types of concerns about the depictions:
- Does the information represent them fairly? Is it sufficiently accurate?
- Will the information represented emphasize the values of the group? If, for instance, the group values occasional contributions from peripheral members of the group, will the

representations enable those members to be recognized appropriately? If high levels of activity are encouraged, will the representations highlight high levels of activity appropriately?

- Is the style of the depiction acceptable? Are cartoon representations considered appropriate within the social context of the group? Are abstract information graphics more reasonable?

The visual representations may also encourage certain types of stereotyping. Participants with Anthropomorphs that appear similar might be assumed to have similar behavior. This tendency could be detrimental to group interactions if users overly simplify their expectations of others, assuming for instance that occasional participants are not contributing valuable information to the group as much as frequent participants. However, in our study, there was no evidence of users making overly simplistic assumptions.

While subjects in the evaluation of the social impact of the visualizations expressed the concerns mentioned above, their ranking of their fellow authors did not present any evidence that they made inappropriate assumptions because of the visualizations. A number of factors play a role in people's perception of each other online. Introducing a visualization next to the text of the messages may not influence users who have already formed an opinion of the author depicted. While some of the active participants said that the metrics such as number of messages written and number of replies were irrelevant to them, others acknowledged that the active members already know this information. In fact users probably do have some knowledge of these statistics but do not think about them explicitly. So the attributes depicted in the Anthropomorphs are perhaps most likely to be helpful to newcomers to the group since they are able to more quickly get a sense of the history someone has in the group even if they have not read past messages.

Among the respondents to the survey, less than 5% had spent less than 6 months in the group they were asked about. So there was not enough of a population of respondents who were unfamiliar with the people represented in the visualization to see whether the anthropomorphic visualization types had a stronger influence on these users. Nonetheless, informal testing with users at the Media Lab indicated that they were able to quickly get a sense of an unfamiliar group and differentiated among users with different characteristics. Additional research is appropriate for investigating the social impact of the Anthropomorphs on a population that is unfamiliar with the individuals represented in the visualizations.

Chapter 6: Conclusion and Future Work

This thesis introduced a new technique for visualizing information about individuals in online spaces. These anthropomorphic visualizations, or "Anthropomorphs," can be used to provide an overview of a group engaged in discussions, incorporating several pieces of data that describe each individual's past behavior. The thesis also introduced the idea that by presenting information about people in a humanoid visual form, an information visualization could play a social role in influencing users' behavior.

6.1 Contributions

Describing an iterative design process and several user studies, the thesis demonstrated an approach to representing data about individuals in online spaces using a humanoid visualization format. I presented several potential pieces of data that would be relevant for depicting users' past behavior, and discussed their appropriateness:

- Depicting data about activity level and responsiveness are useful to individuals unfamiliar with the person depicted. An initial study indicated they are less so for a longtime member of the group.
- Depicting a user's centrality in the group can enable users to quickly identify the core members.
- Depicting estimates of an author's average emotional tone is problematic in that the estimates are sometimes inaccurate and yet the depiction of the emotion is instantly recognizable. If natural language processing technology improves so that accuracy is less of an issue, it would be more appropriate to depict emotional values.

The thesis described how to make anthropomorphic visualizations legible. Several comprehension studies demonstrated that users could interpret approximate values in the visualizations, allowing them to easily differentiate between depictions of individuals with varying characteristics.

The thesis also suggested some guidelines for using the human form:

- Anthropomorphs' with significantly different past behavior need to have visually distinct appearances that are pronounced enough to show the differences among the population.

- Individual visual elements needed to be easily understood, so each element in the body needed to be clearly identifiable and ideally have some logical connection to the data it represented.

- Faces and limbs should look natural for all potential data values that are represented in the visualization. If the human form looks distorted in an unnatural way, users have trouble making sense of them.

The evaluation included an approach for measuring the social impact of the visualizations. Measuring users' social reactions to visualizations instead of simply testing their effectiveness for completing certain tasks is a new way to evaluate visualizations. Archives of individuals' social data are becoming more prevalent. Designers creating visual representations of this data should consider how its depiction impacts users' perceptions.

The results of the social impact study indicated that the user's reactions to the person represented are often influenced by factors such as familiarity more than they are by the visual representation of the user. Further research is necessary to examine how and under what conditions the visuals

play a significant role in influencing user perceptions. Nonetheless, informal testing showed that anthropomorphic visualizations provide an overview of the characteristics of individuals in a group, leading to certain conclusions about particular people within the group. The visualizations could be used to identify the links between certain types of behavior and certain roles within a group. Thus, the visualization approach should be useful for investigating group dynamics that are present in an existing online space or in some other population.

Finally, the technical design for the object model of the visualization system may have some value to other researchers and designers in its approach to the integration of users, documents (in this case messages), and groups.

6.2 Future Work

In this thesis, I developed a test-bed prototype system that generated anthropomorphic visualizations for the populations of several USENET newsgroups. Some lessons about the design and use of these visualizations resulted from this work and are discussed in the Evaluation chapter. However, I have not fully identified the conditions when anthropomorphic visualization is appropriate and desirable. Several interrelated research areas are relevant to investigate this question:

- The type of data that is used to generate the Anthropomorphs may be more or less relevant to particular groups or populations of online users. Therefore we should investigate using different types of data to generate the Anthropomorphs.

- Certain visual styles of Anthropomorphs are more appealing and acceptable to some users than others. Additional styles should be created to conduct further study of the impact of different visual styles of Anthropomorphs on different populations of users.

- Additional features of the Anthropomorphs could make them more effective at providing certain types of information. Extensions to the visual display of the Anthropomorphs such as animation should be investigated.

- It is unclear to what extent the visualizations impact users' social perceptions. Users have some concerns about the negative effects that Anthropomorphs will have upon others' perceptions of the individuals in their group. However, these effects have not been observed in our initial studies. Further studies of the various factors that influence social perceptions of visual representations of individuals online should be conducted to gain a more detailed understanding of what effects anthropomorphic visualizations will have on user perceptions.

- The Anthropomorphs have been informally shown to be useful for retrieving particular types of information about the participants in an online group. It would be worthwhile to conduct formal task-based evaluations of the Anthropomorphs for their effectiveness in communicating specific information about the population of a group as compared to other displays of online groups. This type of task might occur when users are looking for groups to take part in and are interested in finding groups with high levels of participation or when someone within an organization is comparing different groups' responsiveness to understand how much particular communities share with one another.

The following sections describe these future research areas in more detail.

6.2.1 Different types of data

Groups that are very information-based have different needs than groups that are purely social in nature. If the data that we depict in the visualization were especially relevant to the users' goals, they might be more likely to be influenced by it. Reputation-based metrics such as the usefulness of the author's past posts (evaluated by the other members of the group) should be incorporated into anthropomorphic visualizations. Authors' self-assessment of their own expertise would also be valuable for users looking to judge how knowledgeable an author is. Incorporating other types of natural language processing beyond emotional tone, such as which topics an author discusses, would also be desirable.

The addition of these other types of data into the Anthropomorphs might make them more valuable to users who are more familiar with the participants in the group. After additional types of data have been incorporated into Anthropomorphs, user studies should be conducted to determine whether this data makes the visualization more useful to the "insiders" in a group.

6.2.2 Different visual styles

Some users are more comfortable with the cartoon style and human form of the visualizations than others. Before such styles are introduced to a population of users, it may be appropriate to investigate user perceptions of these visual approaches. A wider range of visual styles including more "serious" styles could be created and tested with users to understand their responses to different designs. Visual directions could be based on a variety of artistic traditions. Designs could incorporate more abstract modernist styles, impressionistic styles, or more realistic painterly renditions of individuals.

Identifying factors that determine which visual styles are acceptable to which users might be accomplished by getting feedback about several different styles from a variety of types of users.

6.2.3 Visual extensions to the Anthropomorphs

As mentioned in the Design chapter, the humanoid form of the Anthropomorphs suggests various possibilities for animation. Having an Anthropomorph change appearance quickly through animation could be useful for communicating how the person's behavior changed over time. It also might be appropriate to make certain elements in an Anthropomorph's body move to communicate other types of information. For instance, an Anthropomorph might move its eyes in the direction of another Anthropomorph to indicate who the author pays most attention to.

Another visual issue to address further is the role of the face. The presence of the face seems to make the visualization more engaging, but it is problematic if it is communicating information about emotional tone that is inaccurate. Having the face represent emotional tone information that is more specifically related to particular sections of messages may be more appropriate. In addition, research into generating more detailed and subtle facial expressions should be applied to see whether more precise facial expressions provide a more accurate sense of author tone (Perlin, 1997). Developing some kind of representation of a face that does not communicate emotional tone should also be investigated further.

6.2.4 Social impact of visual representations of individuals

In order to identify how users are influenced by the visual representation of individuals in different situations, a broader study of the use of anthropomorphic visualizations is necessary. It is desirable to assess users' social perceptions of individuals who they are initially unfamiliar

with. We should also study users' changing perceptions of other individuals in an online space over a longer duration. A longitudinal study of use of online environments with varying types of representations of participants would be desirable. This might enable us to see whether users begin to change their message writing behavior to influence the way they are visually depicted.

In the social impact study, many users expressed concerns about stereotyping and worried that the Anthropomorphs encouraged too much emphasis on metrics such as activity level. However, no evidence of users making inappropriate assumptions was found. This suggests that many users may view the visualizations as data about the participants rather than as representations of them. More research is necessary to identify whether users will draw inappropriate conclusions from the visualizations.

6.2.5 Task-based evaluations

Conducting a formal evaluation of users' abilities to quickly discern information about the population of the group would help to prove whether the Anthropomorphs are more effective as an information visualization technique than other forms of data reporting. The study would involve asking subjects to conduct a set of tasks to find out information about the population of a group such as who were the most active or responsive members. We could compare their performance with users viewing the same information on Marc Smith's Netscan site and with users viewing a more abstract representation of the data

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Appendix A: User Study Questionnaire

Social Impact Study
Email to participants

Dear [newsgroup] participants-

I am a graduate student researcher at MIT and have been investigating new ways to display information from Usenet newsgroups. I have noticed that your group has an active community of participants and was hoping that you would help me to evaluate some new ways to view information about the other participants. I would really appreciate your help in determining whether my approach is useful to you.

I've developed an online survey that shows 2 threaded discussions from your newsgroup. It takes approximately 30 minutes to read the material and answer the questions.

We are offering a prize of a $50 gift certificate to Amazon.com to one randomly selected person from the group who completes the survey.

To participate, please take the survey at:
[URL]

If you have any questions about this research, feel free to contact me at anthroviz@media.mit.edu.

Thank you-

Ethan Perry

Ethan Perry
Sociable Media Group, MIT Media Laboratory
Email: anthroviz@media.mit.edu

Survey

Newsgroup Participants Survey

Thank you for your interest in this survey. This is your opportunity to give us feedback about a visualization we have created to present information about authors of newsgroup messages.

When you begin, you will learn about the visualization. We will then ask you some questions about the visualization, and then show you several threaded discussions from [selected newsgroup].with each of the participants displayed using the visualization. You will be asked to respond to some questions about the messages and authors displayed.

The survey should take approximately 30-40 minutes. If you have already taken the survey, you may not take it again.

All data gathered in this study will be anonymous. We will not keep your name anywhere in our files and nothing that you write in this survey will be connected back to you. Your participation in this study is completely voluntary and you are free to choose whether to be in it or not. If you choose to participate in this survey, you may subsequently withdraw from it at any time.

We are also offering a prize of a $50 gift certificate to Amazon.com to one randomly selected person from the group who completes the survey.

For more information about the study, you can contact us at anthroviz@media.mit.edu.

DISCLAIMER: The images you will see have been generated automatically from the messages in [selected newsgroup].. You may or may not find them appealing. This survey is your opportunity to provide feedback about whether you feel they are appropriate for your group.

Continue>>

Please note: this survey requires the Macromedia Flash Player.

Newsgroup Participants Survey

This survey contains the following sections:

1. Some questions requesting information about you and your use of newsgroups.

2. An explanation of a new visualization used to present historical information about individuals who write messages in Usenet newsgroups.

3. Some questions about the visualization.

4. A chance to review the visualization.

5. A set of messages from two threaded discussions with questions about the messages and their authors.

6. Some questions about your opinion of the visualization

Note: Please do not use the back button during the course of the survey.

Continue>>

[Note: Some participants who do not view any visualizations will only see items 1 and 5

Three different groups of test subjects were used with different versions of the survey:

- One group will see messages without any visualizations and will only see items 1 and 5 listed above
- One group will see messages with bar-graph based visualizations and will only see items 1,2,5, and 6 listed above.
- One group will see messages with anthropomorphic visualizations and will see all items listed above.

]

Newsgroup Participants Survey
Section 1: General Information About You

Please provide the following information about yourself:

Gender ☐ Male ☐ Female

Age [18 ▼]

Education Completed ☐ High School ☐ Undergraduate ☐ Graduate

Internet
Number of years you have been using the Internet [0 ▼]

Discussion Groups
Have you used online discussion groups and are you familiar with the concept of a discussion thread?
☐ Yes ☐ No

Number of years since you started using online discussion groups
(Usenet newsgroups or other online forums) [0 ▼]

Have you used graphical online environments with avatars such as the Palace or the Sims Online?
☐ Yes ☐ No

If yes, how much do you like using avatars? Please answer on a scale from 1 to 7.

Dislike Very Much.......................................Like Very Much
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☒ Not Applicable

Please explain your choice.
[   ]

Questions About Your Participation in
How many months have you participated in this group? [0 ▼]

How often do you read messages from this group? (Choose the answer that best applies to you.)

☐ Once a month or less ☐ Once a week ☐ Several times a week ☐ Daily
☐ Multiple times a day

How often do you write messages to this group? (Choose the answer that best applies to you.)
☐ Once a month or less ☐ Once a week ☐ Several times a week ☐ Daily
☐ Multiple times a day

Why do you come to this group?
☐ To socialize with friends and acquaintances
☐ To find out the latest news
☐ To debate the latest issues and let others know your opinion
☐ To get advice or help
☐ Other (please specify):

How would you describe the participants in this group?

Continue>>

Newsgroup Participants Survey

Email address

Please submit your email address so that in the event you are the person selected to win the prize of the $50 Amazon.com gift certificate we can send it to you.

We will not use your email address for any other purpose and will remove it from our records when it is no longer needed.

Enter email address:

Continue>>

Newsgroup Participants Survey [shown only to subjects viewing anthropomorphic visualizations]

Section 2: Explanation of the Visualization

Here is an overview of the visualization that will be used to present information about the participants in [newsgroup]. The visualization looks like a picture of a person, but has been generated from the messages an individual has written in the group. Each part of the body shown in the visualization indicates a particular piece of information about the person's history in the group. When you read through the messages in this survey, you will see a visualization of each message's author.

Click on the words below to find out what each part of the body represents.

[Flash tutorial of visualization format]

<u>Please study this page until you feel you are familiar with what each part of the body signifies. Your responses to some of our questions will be based on the details explained on this page.</u>

Continue>>

Newsgroup Participants Survey [shown only to subjects viewing visualizations]

Section 2: Explanation of the Visualization

Here are two example visualizations that have been generated from authors in a Usenet newsgroup. We explain what piece of information each part of their body represents.

[image of 2 example visualizations]

Continue>>

Newsgroup Participants Survey [shown only to subjects viewing anthropomorphic visualizations]

Section 3: Questions About the Visualization

To make sure you are familiar with the meaning of each body part in the visualization, please answer the questions below.

What do the message boxes represent?

☐ how many messages they've written

☐ average emotional tone of their messages

☐ how many responses they've received from others

☐ how recently they've written

What do the legs represent?

☐ how many messages they've written

☐ average emotional tone of their messages

☐ how many responses they've received from others

☐ how recently they've written

What does the darkness of the figure represent?

☐ how many messages they've written

☐ average emotional tone of their messages

☐ how many responses they've received from others

☐ how recently they've written

What do the thick message boxes represent?

☐ how many replies they've written

☐ average emotional tone of their messages

☐ how many responses they've received from others

☐ how many initial posts they've written

Submit | Reset

Newsgroup Participants Survey [shown only to subjects viewing anthropomorphic visualizations]

Section 3: Questions About the Visualization

Here are your responses accompanied by the correct answers when you submitted an incorrect answer. Please keep the correct answers in mind when answering the rest of the survey.

[include responses and correct answers]

Continue

Newsgroup Participant Survey [shown only to subjects viewing anthropomorphic visualizations]

Section 4: Review of the Visualization

Here is a review of the visualization again. Refresh your memory one last time before you move on.

Click on the words below to review what each part of the body represents.

[Flash tutorial of visualization format]

Please study this page until you feel you are familiar with what each part of the body signifies.
Your responses to some of our questions will be based on the details explained on this page.

Continue>>

Newsgroup Participants Survey [varies depending on whether subjects view visualizations or not]

Section 5: Reading Messages

You will now see a series of messages taken from two threads in [newsgroup].

The messages will be shown in sequence, with a diagram of the thread on the left, and the text of the message on the right. The visualization of the author of the current message will be highlighted with a box around it.

For each message, you will be asked to indicate whether you are the author of the message. You will also be asked to indicate how likely it is you'd write a response to this message and to provide your impressions of the author of the message.

After reading all the messages, you will be asked to try to remember some information about two of the authors.

Continue>>

Example diagram of thread:

Section 5: Reading Messages

Message 1 of 6, Step 1

Look at the diagram of the thread, read the message, and then answer the questions below.

tootal2

Donald Kerns

Subject: how much gravel do i need?
Author: tootal2
Date: 2003-12-14 00:23:46-05

how much gravel do i need in my goldfish
tank? i have about 1 inch of gravel
in it now.
thanks

--

----
http://www.tootal2.com

.

Are you the author of this message? ☐ Yes ☒ No

How likely would you be to respond to this message? ☐ Definitely wouldn't respond
☐ Might respond ☐ Definitely would respond
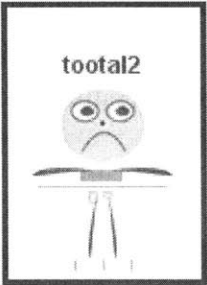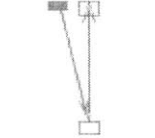
Continue >>

Newsgroup Participants Survey [repeated 6 times]

Section 5: Reading Messages

Message 1 of 6, Step 2
Answer the questions below about the message you just read.

Subject: how much gravel do i need?
Author: tootal2
Date: 2003-12-14 00:23:46-05

how much gravel do i need in my goldfish
tank? i have about 1 inch of gravel
in it now.
thanks

--

----
http://www.tootal2.com

.

Response to the message
What is your impression of this message?
Negative..Positive

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Your Impressions of tootal2

How familiar with this author were you before reading this message?
Very unfamiliar...Very familiar

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

How likable is this author?
Least likable..Most likable

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

How friendly is this author?

Very unfriendly...Very friendly

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

How intelligent is this author?

Very unintelligent..Very intelligent

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

How happy is this author?

Very unhappy...Very happy

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

How cooperative is this author?

Very uncooperative..Very cooperative

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Submit

Newsgroup Participants Survey [shown only to subjects viewing visualizations]

Section 5: Reading Messages

Here are two authors of the messages you've just read. When you continue to the next screen you will be asked to remember some information about them.

tootal2

Shane D. Maudiss

Continue >>

Newsgroup Participants Survey [shown twice, only to subjects viewing visualizations]

Section 5: Reading Messages

Please answer the following questions about the author of a message you just read.

Approximately how many messages has tootal2 written in the last month?

| 1 ▼ |

What is the average emotional tone of tootal2's messages?

☐ Happy ☐ Sad ☐ Angry ☐ Anxious ☐ Thoughtful ☐ Neutral

Approximately how many days has it been since tootal2 wrote a message?

| 0 ▼ |

Approximately how many of tootal2's messages are initial posts (as opposed to replies)?

| 0 ▼ |

Approximately how many responses has tootal2 received from other participants in the group?

| 0 ▼ |

| Submit |

Newsgroup Participant Survey [shown only to subjects viewing visualizations]

Section 6: Your Feedback

Provide your feedback about the visualization.
How easy or hard was it to interpret the information in the visualization?
Easy...Hard

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Please explain your choice.

```
┌─────────────────────────────┬──┐
│                             │▲ │
│                             ├──┤
│                             │▼ │
├──┬──────────────────────┬──┬┴──┤
│◄ │                      │► │   │
└──┴──────────────────────┴──┴───┘
```

How easy or hard was it to remember the information in the visualization?
Easy...Hard

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Please explain your choice.

```
┌─────────────────────────────┬──┐
│                             │▲ │
│                             ├──┤
│                             │▼ │
├──┬──────────────────────┬──┬┴──┤
│◄ │                      │► │   │
└──┴──────────────────────┴──┴───┘
```

How appealing or unappealing did you find the visualization?
Unappealing......................................Appealing

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Please explain your choice.

```
┌─────────────────────────────┬──┐
│                             │▲ │
│                             ├──┤
│                             │▼ │
├──┬──────────────────────┬──┬┴──┤
│◄ │                      │► │   │
└──┴──────────────────────┴──┴───┘
```

How likely or unlikely is it that you would want to use the visualization when reading messages from a group mailing list or Usenet newsgroup?
Unlikely..Likely

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Please explain your choice.

```
┌─────────────────────────────┬──┐
│                             │▲ │
│                             ├──┤
│                             │▼ │
├──┬──────────────────────┬──┬┴──┤
│◄ │                      │► │   │
└──┴──────────────────────┴──┴───┘
```

How appropriate do you think it is to show information about authors' past messages to the group?

Very inappropriate.......................................Very appropriate

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Please explain your choice.

How appropriate do you think it is analyze authors' past messages to estimate the average emotional tone of the messages?

Very inappropriate.......................................Very appropriate

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Please explain your choice.

Is there information about the authors that is not currently shown in the visualization but which you think should be?

Do you have any other suggestions about the visualizations?

Submit | Reset

Newsgroup Participant Survey

This completes the study. Thank you very much for participating.

If you have any further questions about the study, feel free to contact us at anthroviz@media.mit.edu.

In the event that you are randomly selected to win the prize of the $50 gift certificate from Amazon.com, we will email it to you within 2 weeks.

Close Window

Appendix B: Application of Information Visualization Guidelines to Anthropomorphic Visualization

This table shows how the design of the Anthropomorphs takes into account these principles. It will be moved to the Design chapter but is relevant to the overview of information visualization guidelines.

Guideline	Feature	Response	Source
Show data without distortion	Message boxes	Much of our data are actually distorted to achieve a social effect in addition to clearly reporting statistical data since our motivations are different from Tufte's	Tufte
Focus on substance	All	""	""
Present many numbers in small space	Message boxes, legs, darkness, faces	The Anthropomorphs do present many numbers in a small space	""
Make large data sets coherent	Sets of Anthropomorphs	Viewing a landscape of Anthropomorphs allows viewers to get an overall sense of the population in the way that Chernoff faces do	""
Encourage comparison	Sets of Anthropomorphs	Size, color and position are easily comparable with the Anthropomorphs functioning as small multiples	""
Be closely integrated with descriptions	Integration of Anthropomorphs in message thread and group displays	The use of the Anthropomorphs in the context of reading the messages or comparing multiple participants provides better information	""
Impart as much data as possible [paraphrase]	Message boxes, faces, legs, darkness	Much of our data are oriented towards achieving a social effect in addition to clearly reporting statistical data since our motivations are different from Tufte's	""
Use graphic elements that are most appropriate for particular data type	• Position is used to locate most central Anthropomorphs in group • Color is used for the ordinal representation of emotional expressions • Length represents length of message • Angle/length represents number of responses received	These properties are used in various features in Anthropomorphs.	MacKinlay, Cleveland and McGill

	• Density of border is used to represent the different ordinal values of initial post vs. reply		
Under different conditions, certain visual elements can be distinguished with pre-attentive processing	Message boxes, legs, face, darkness	Pre-attentive qualities are incorporated into many features such as colored faces, darkness, and size of Anthropomorphs.	Hearst tutorial, Healey
Density (greyscale) -> darker = more	Darkness of figure = more recent	Not using purely greyscale; using metaphor of fading where value is time so quantity does not map to guideline	Hearst tutorial, Senay & Ignatius
Size/Length/Area -> larger = more	Message boxes, legs	Used according to guideline	""
Position leftmost = first, topmost = first	Position of group members and thread members arranged in circle	First post is at the top of the circle	""
Hue, slope have no intrinsic meaning	Face color	Hue used for emotional categories	""
Law of simplicity (figure and ground, law of good continuation), Law of familiarity	All parts of the body read as a single unit	Since we are used to seeing anthromoporphic figures as single elements, the simplest most familiar interpretation is view them as representing a person	Gestalt/ Kaufman
Law of proximity	Boxes, head and legs are arranged as single unit	Anthropomorphs read as one entity as opposed to multiple since they are placed close to each other	""
Law of similarity	Coloring and size of Anthropomorphs	Larger and similarly colored Anthropomorphs read as being part of the same subgroup when shown in a group	""
Take into account emotional impact of communication	Facial expressions signify the emotion they express, not some other value	Facial features have to be treated as component of overall expression, not as individual elements	Critique of Chernoff faces

Appendix C: Social Impact Study Data

Table 1: Correlations between visualization type, response to message, familiarity with author, impressions of authors, and likelihood to respond.

Descriptive Statistics

	Mean	Std. Deviation	N
Positive Response to Message	4.82	1.705	811
Familiar with Author	3.13	2.204	811
Author is Likable	4.74	1.545	811
Author is Friendly	4.86	1.543	811
Author is intelligent	4.80	1.559	811
Author is Happy	4.60	1.492	811
Likely to Respond to Message	1.58	.616	811

Correlations

		Visualiza-tion Type	Positive Response to Message	Familiar with Author	Author is Likable	Author is Friendly	Author is Intelligent	Author is Happy	Likely to Respond to Message
Visualiza-tion Type	Pearson Correlation	1	-.006	.118$^{(**)}$	.036	.030	.055	.023	.053
	Sig. (2-tailed)	.	.869	.001	.311	.389	.118	.519	.134
	N	811	811	811	811	811	811	811	811
Positive Response to Message	Pearson Correlation	-.006	1	.267$^{(**)}$	.724$^{(**)}$	.715$^{(**)}$	.680$^{(**)}$	.665$^{(**)}$	.046
	Sig. (2-tailed)	.869	.	.000	.000	.000	.000	.000	.186
	N	811	811	811	811	811	811	811	811
Familiar with Author	Pearson Correlation	.118$^{(**)}$	.267$^{(**)}$	1	.492$^{(**)}$	.417$^{(**)}$	.524$^{(**)}$	.366$^{(**)}$	.114$^{(**)}$
	Sig. (2-tailed)	.001	.000	.	.000	.000	.000	.000	.001
	N	811	811	811	811	811	811	811	811

Correlations, continued

		Visualiza-tion Type	Positive Response to Message	Familiar with Author	Author is Likable	Author is Friendly	Author is Intelligent	Author is Happy	Likely to Respond to Message
Author is Likable	**Pearson Correlation**	.036	.724$^{(**)}$	.492$^{(**)}$	1	.884$^{(**)}$	.839$^{(**)}$	.756$^{(**)}$	.062
	Sig. (2-tailed)	.311	.000	.000	.	.000	.000	.000	.078
	N	811	811	811	811	811	811	811	811
Author is Intelligent	**Pearson Correlation**	.055	.680$^{(**)}$	.524$^{(**)}$	.839$^{(**)}$	.811$^{(**)}$	1	.716$^{(**)}$	.042
	Sig. (2-tailed)	.118	.000	.000	.000	.000	.	.000	.236
	N	811	811	811	811	811	811	811	811
Author is Happy	**Pearson Correlation**	.023	.665$^{(**)}$	.366$^{(**)}$	.756$^{(**)}$	.790$^{(**)}$	.716$^{(**)}$	1	.010
	Sig. (2-tailed)	.519	.000	.000	.000	.000	.000	.	.777
	N	811	811	811	811	811	811	811	811
Likely to Respond to Message	**Pearson Correlation**	.053	.046	.114$^{(**)}$	.062	.059	.042	.010	1
	Sig. (2-tailed)	.134	.186	.001	.078	.091	.236	.777	.
	N	811	811	811	811	811	811	811	811

** Correlation is significant at the 0.01 level (2-tailed).

Table 2: Differences between user perceptions of authors they are more familiar with vs. those they are less familiar with

Group Statistics					
	FAMILIAR	N	Mean	Std. Deviation	Std. Error Mean
Positive Response to Message	>= 4	345	5.20	1.380	.074
	< 4	466	4.53	1.861	.086
Author is Likable	>= 4	345	5.42	1.174	.063
	< 4	466	4.24	1.594	.074
Author is Friendly	>= 4	345	5.42	1.172	.063
	< 4	466	4.44	1.649	.076
Author is Intelligent	>= 4	345	5.53	1.141	.061
	< 4	466	4.25	1.605	.074
Author is Happy	>= 4	345	5.08	1.228	.066
	< 4	466	4.25	1.573	.073
Likely to Respond to Message	>= 4	345	1.65	.634	.034
	< 4	466	1.53	.598	.028

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Positive Response to Message	Equal variances assumed	30.070	.000	5.619	809	.000	.67	.119	.435	.901
	Equal variances not assumed			5.868	808.996	.000	.67	.114	.444	.891
Author is Likable	Equal variances assumed	9.548	.002	11.643	809	.000	1.18	.102	.983	1.382
	Equal variances not assumed			12.170	808.984	.000	1.18	.097	.992	1.374
Author is Friendly	Equal variances assumed	15.168	.000	9.448	809	.000	.98	.104	.779	1.188
	Equal variances not assumed			9.925	807.696	.000	.98	.099	.789	1.178

Independent Samples Test , continued

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference		
Author is Intelligent	Equal variances assumed	13.101	.000	12.578	809	.000	1.27	.101	1.075	1.473
	Equal variances not assumed			13.211	807.743	.000	1.27	.096	1.085	1.464
Author is Happy	Equal variances assumed	4.666	.031	8.087	809	.000	.83	.102	.625	1.025
	Equal variances not assumed			8.386	806.689	.000	.83	.098	.632	1.018
Likely to Respond to Message	Equal variances assumed	.465	.496	2.853	809	.004	.12	.044	.039	.210
	Equal variances not assumed			2.828	716.275	.005	.12	.044	.038	.211

Table 3: Antique Collectors group – Correlations between visualization type, response to message, familiarity with author, impressions of authors, and likelihood to respond.

Correlations

		Visualization Type	Positive Response to Message	Familiar with Author	Author is Likable	Author is Friendly	Author is Intelligent	Author is Happy	Likely to Respond to Message
Visualization Type	Pearson Correlation	1	-.018	.163[*]	.020	.024	.056	.014	.270[**]
	Sig. (2-tailed)	.	.810	.028	.792	.748	.454	.849	.000
	N	180	180	180	180	180	180	180	180
Positive Response to Message	Pearson Correlation	-.018	1	.363[**]	.787[**]	.736[**]	.692[**]	.683[**]	-.073
	Sig. (2-tailed)	.810	.	.000	.000	.000	.000	.000	.328
	N	180	180	180	180	180	180	180	180
Familiar with Author	Pearson Correlation	.163[*]	.363[**]	1	.494[**]	.389[**]	.564[**]	.349[**]	.030
	Sig. (2-tailed)	.028	.000	.	.000	.000	.000	.000	.687
	N	180	180	180	180	180	180	180	180
Author is Likable	Pearson Correlation	.020	.787[**]	.494[**]	1	.880[**]	.769[**]	.815[**]	-.097
	Sig. (2-tailed)	.792	.000	.000	.	.000	.000	.000	.197
	N	180	180	180	180	180	180	180	180
Author is Friendly	Pearson Correlation	.024	.736[**]	.389[**]	.880[**]	1	.727[**]	.876[**]	-.104
	Sig. (2-tailed)	.748	.000	.000	.000	.	.000	.000	.164
	N	180	180	180	180	180	180	180	180
Author is Intelligent	Pearson Correlation	.056	.692[**]	.564[**]	.769[**]	.727[**]	1	.697[**]	-.173[*]
	Sig. (2-tailed)	.454	.000	.000	.000	.000	.	.000	.020
	N	180	180	180	180	180	180	180	180
Author is Happy	Pearson Correlation	.014	.683[**]	.349[**]	.815[**]	.876[**]	.697[**]	1	-.116
	Sig. (2-tailed)	.849	.000	.000	.000	.000	.000	.	.121
	N	180	180	180	180	180	180	180	180
Likely to Respond to Message	Pearson Correlation	.270[**]	-.073	.030	-.097	-.104	-.173[*]	-.116	1
	Sig. (2-tailed)	.000	.328	.687	.197	.164	.020	.121	.
	N	180	180	180	180	180	180	180	180

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 4: How appropriate subjects felt it was to share information about past messages and to estimate emotional tone

			How appropriate is it to share information about authors' past messages to the group?	How appropriate is it to analyze authors' past messages to estimate the average emotional tone?
Visualization Type				
Anthropomorph 1 (with face)	Mean		4.55	3.636
	N		33	33
	Std. Deviation		1.622	1.8844
Anthropomorph 2 (silhouette)	Mean		3.69	NA
	N		29	NA
	Std. Deviation		2.072	NA
Bar Chart	Mean		4.25	3.625
	N		24	24
	Std. Deviation		2.090	2.0176
Total	Mean		4.17	2.070
	N		86	86
	Std. Deviation		1.929	2.6999

The table header "Report" spans the two data columns.