

**DHB: Large-Scale Analysis of
Computer-Mediated Intimate Relationship Formation and Development
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We propose to study intimate relationship formation and development on a massive scale, making use of a very large online personals website. The sheer quantity of people and interactions in a large online dating system allow for studies with great statistical and ecological validity, since such a system is the real environment in which millions of people are searching for long-term romantic partners.

For decades, psychologists have studied interpersonal attraction and intimate relationships. Yet relationship formation – the intervening process between attraction and a stable relationship – has been understudied. This is due in large part to the difficulty of recruiting study participants at this delicate stage; a dyad (pair) on a second date will not respond to a recruitment call for a couples' study because, at that point, the people themselves do not know if they will become a couple. Understanding what leads to successful formation is a critical step in understanding successful relationships generally.

The proposed research will allow us to capture relationship formation at its early stages. By tracking communicating dyads before they meet in person, through their face-to-face meeting, and on to the establishment of a relationship, we will have access to their perceptions of each other throughout the crucial but ambiguous process of relationship formation. At each step, some dyads will dissolve – that is, some will never meet in person, and of those that do, only a fraction will form a relationship – but by taking an initial sample in the hundreds of thousands, we will be assured of a large set of participants who do progress to a full-fledged relationship. Psychologists have long sought longitudinal data of this scale and scope but until now have had no practical way to obtain it.

The proposed work is an interdisciplinary combination of methods from the fields of social psychology, human-computer interaction, and quantitative sociology. We will use questionnaire techniques from personality studies, the results of which we will analyze with statistical methods including structural equation models and event-history analysis, and then develop alternative user interfaces based on the results of the statistical analysis. This will be followed by a new round of questionnaires and analysis to determine the effects of the intervention.

Intellectual Merit: The proposed research will advance scientific knowledge by deepening our understanding of relationship formation processes in general, on a scale large enough to be broadly generalizable and statistically powerful. The data will also allow for studies that take into account diversity considerations, including socio-economic factors, location (urban / suburban / rural), race, and age, that have been lacking in previous research which has depended on limited cross-sectional data. The results should shed new light on several important questions in social psychology, including the role of personality and attitudinal similarity in long-term relationship satisfaction and success, and the balance between positive and authentic self-presentation for relationship formation. This research will also contribute further to our understanding of the effects of computer-mediated communication on interpersonal relationship formation.

Broader Impacts: This research has the potential to positively affect individuals and society in both the online and the offline world. A better understanding of what makes for compatible romantic matches should improve individuals' well-being and happiness, leading to a more stable and positive society. An understanding of interpersonal compatibility over computer-mediated communication should help improve collaborative processes in many spheres, including for partnering students to work together in distance education, and facilitating geographically dispersed team formation for businesses, government, and other organizations.

1 Introduction

The NSF HSD program seeks to provide new insights into socio-technical structures that create change in the human experience, and to help understand how individuals make important decisions in an increasingly technology-dominated world. Online dating systems are changing how millions of Americans find their life partners. These systems are worthy of study both because they provide an unprecedented opportunity to learn about relationship formation at a massive scale, and because they are having an enormous impact on one of the most important decisions that people make in their lifetimes.

By collecting data from an online personals (dating) website used by millions of people, we propose to study questions surrounding intimate relationship formation that are of great importance to both social psychology and computer-mediated communication.

1.1 Motivation and Research Questions

In this research, we will be able to tackle questions from the literatures on mate selection and relationship satisfaction that to date psychologists have not been able to adequately address. A major advantage of the proposed study is the ability to draw a large, diverse sample. The size of the sample alone is a significant improvement over the studies that are typically conducted, and has the added benefit of being able to directly compare how people choose dating partners as a function of different demographic characteristics. Moreover, by sampling from a population of online dating users at the time they are actively seeking mates, our study has ecological and external validity beyond that which psychologists are usually able to establish in their research.

Personality psychologists have long been interested in understanding what draws two people together, essentially pitting the belief that “birds of a feather flock together” against “opposites attract.” Recently there has been a new surge of interest in how people select romantic partners (Klohn & Mendelsohn 1998; Luo & Klohn 2005), perhaps spurred by the influx of new dating options available to people looking for mates. Although theories and hypotheses abound, the biggest problems facing this literature right now are sampling issues. Psychologists usually recruit participants from undergraduate populations or, less frequently, from the community. Samples tend to be small ($n = 300$ would be considered large) and homogeneous with respect to age, ethnicity, and socioeconomic status. Perhaps not surprisingly, results from these studies can be inconsistent and difficult to integrate.

Importantly, we will be sampling participants at the time they are actually in the process of selecting romantic partners. Past psychological research has by necessity studied people who are in established romantic relationships; for instance, one recent study of partner selection included couples who had been together for a minimum of six months (Klohn & Mendelsohn 1998). Thus, there are always lingering questions about the interpretation of the data, since, for example, it is possible that happy couples become more similar over the course of a relationship, while unhappy couples do not (Morry 2005). Until now, psychologists have not had a good answer to this problem, since it is nearly impossible to recruit newly formed couples for laboratory-based studies.

For the same reason, there is also a significant gap in the psychological literature on relationship satisfaction. As with partner selection, relationship satisfaction is a topic that is receiving a lot of attention from social and personality psychologists (Neyer & Voigt 2004; Schmitt 2005; Spotts *et al.* 2004). Due to the difficulty of getting new couples into the laboratory, little is known about satisfaction in the beginning stages of romantic relationships. Psychologists do not know, for example, what factors predict whether couples will dissolve

early in relationships because only the initially successful couples participate in studies. Again, sampling online dating users allows us to access participants early enough in the dating process to study couples during the crucial first few weeks of their relationships.

By studying relationship formation and development online, we can also reexamine hypotheses about how relationship satisfaction is affected by perceptions about one's relationship alternatives. Rusbult and colleagues (Rusbult & Farrell 1983; Rusbult *et al.* 1998) have shown that people are more satisfied with their relationships when they feel like they do not have better alternatives available to them if they leave those relationships. In the context of online dating, it is likely that people feel that alternative relationship partners are particularly salient and numerous, which could adversely affect their satisfaction with the people they meet online. In short, we can expand on past research by looking at how the perceived quality of alternatives at initial stages of partner selection affect later relationship satisfaction, and also how its effects are similar to or different from perceived quality of alternatives once the relationship has been established.

Accessing people who are in the process of attracting and selecting romantic partners also allows us to test traditional theories about self-presentation in new and exciting ways. Social psychologists debate whether it is better to be seen positively by others (i.e., to self-enhance (Sedikides 1993)) or to be seen as one sees oneself (i.e., to self-verify (Swann 1990)). In general, the theories agree that it is best to be seen positively early in relationships (Swann *et al.* 1994), but it is unclear whether there are limits to how positively people should portray themselves when they are trying to attract mates. Psychologists who study self-presentation point out that eventually people have to live up to their early self-presentations, and inauthenticity is frowned upon (Baumeister 1992; Schlenker 2003). On the other hand, there is an abundance of research showing that idealizing one's partner can benefit romantic relationships (Drigotas *et al.* 1999; Klohnen & Mendelsohn 1998).

Online personals differ from traditional face-to-face initiation of dating in that people get a chance to present themselves in great detail before ever actually meeting potential mates. Users must perform a delicate balancing act between making themselves attractive to others browsing the site while still being truthful (Ellison *et al.* 2006). We will have access to participants' personals profiles, so we can have them independently rated on dimensions such as attractiveness, positivity, and conceitedness. Then we can use these dimensions to predict whether participants will be contacted by other users and, more importantly, whether face-to-face meetings with other users are successful (i.e., result in future dates and/or relationships). These results will be particularly informative with regard to how much positivity is too much. Psychological theory would suggest that it is best to present oneself positively but with enough "wiggle room" to allow partners to project aspects of their ideal partners onto oneself.

This research will also help further our understanding of the questions surrounding the social effects of computer-mediated communication (CMC). Many theories of computer-mediated communication describe the medium as impoverished compared to face-to-face communication; for example, e-mail is text-only and does not allow for nonverbal cues such as facial expressions to be transmitted. How does this affect the user's experience of communicating through such a channel? Walther (1996) proposed a theory of *hyper-personal* communication that might explain what happens: when the channel is impoverished, users cannot get as much information as quickly as they would face-to-face, so they fill in the blanks optimistically about their conversational partner. That is, in some sense they idealize them in light of incomplete information. Walther's later work established that this effect is most powerful – generating the greatest interpersonal affinity – in long-term online interactions in which participants never see photos of each other (Walther *et al.* 2001). By contrast, Walther *et al.* (2001) found the least social affinity occurred in short-term online interactions without photographs, a finding particularly germane to online dating, where many users remain unwilling or unable to post photos of themselves with their profiles.

Walther's findings suggest that users of online personals systems are likely to systematically misperceive the people with whom they communicate on the site. If so, this may help explain a particularly vexing problem experienced by many users of online dating systems – that of disappointment arising from unmet expectations when a communicating dyad first meets in person (Ellison *et al.* 2006). Users often assume that the other person was misleading in their self-presentation, when in fact the main source of the divergence may be inflated expectations caused in part by the communications medium. Thus, studying expectations before and after a face-to-face meeting can help shed light on the effects of CMC more generally.

1.2 Proposal Roadmap

Having described and motivated the research questions, the next sections of this proposal describe online personals systems and the related research, then describe our proposed method of study. This is followed by our plan of work and the potential broader impacts of this research.

2 About Online Dating

According to a recent Pew Research report, there are approximately 65 million adults in the US (about 33% of the adult population) who are neither married nor in a committed relationship (Rainie & Madden 2006). In this sample, about 3% of those who are married or in long-term relationships found their partner online; a recent industry press release claims that of 12% of *recently* married or engaged couples met one another online (Ellis 2005).

Online personals sites play a prominent role in the social lives of millions of users. The use of online personals has lost most of its stigma, and has become an easy, socially acceptable way to meet partners for dates or relationships. (For the purposes of our research, we are focusing on those users who are seeking long-term relationships.) At its height in August 2003, personals Web sites in the United States drew 40 million unique visitors (Mulrine 2003), although many of these people were not serious users. Recent reports suggest that the number of paying subscription holders is currently about 8 million (Elliott 2006), although a substantially larger number of people use such websites without paying for a subscription.

2.1 Types of systems

Underlying most online dating systems is the notion that users can search for a potential partner according to certain criteria that they find appealing. Alternatively, some online dating systems do not allow users to do the searching, but instead exercise control over who sees information about whom (purporting to find matches with well-suited others via online personality assessments and related mechanisms).

Online personals systems usually include what are commonly referred to as personal *profiles*, which are written and edited by the user seeking a relationship. Profiles allow users to indicate their location, gender, age, physical attributes, race, religion, smoking and drinking habits, and other personal attributes. They also usually contain a free-text essay in which the user is meant to describe themselves and what they are looking for in a match. This is often followed by a list of the user's preferences for characteristics in a potential mate. Users are encouraged to upload one or more photographs of themselves onto the profiles. (See Figure 1.)

Online personals systems invariably provide a private channel through which members communicate without revealing their names or regular email addresses. Typically, it functions like a Web-based email client,

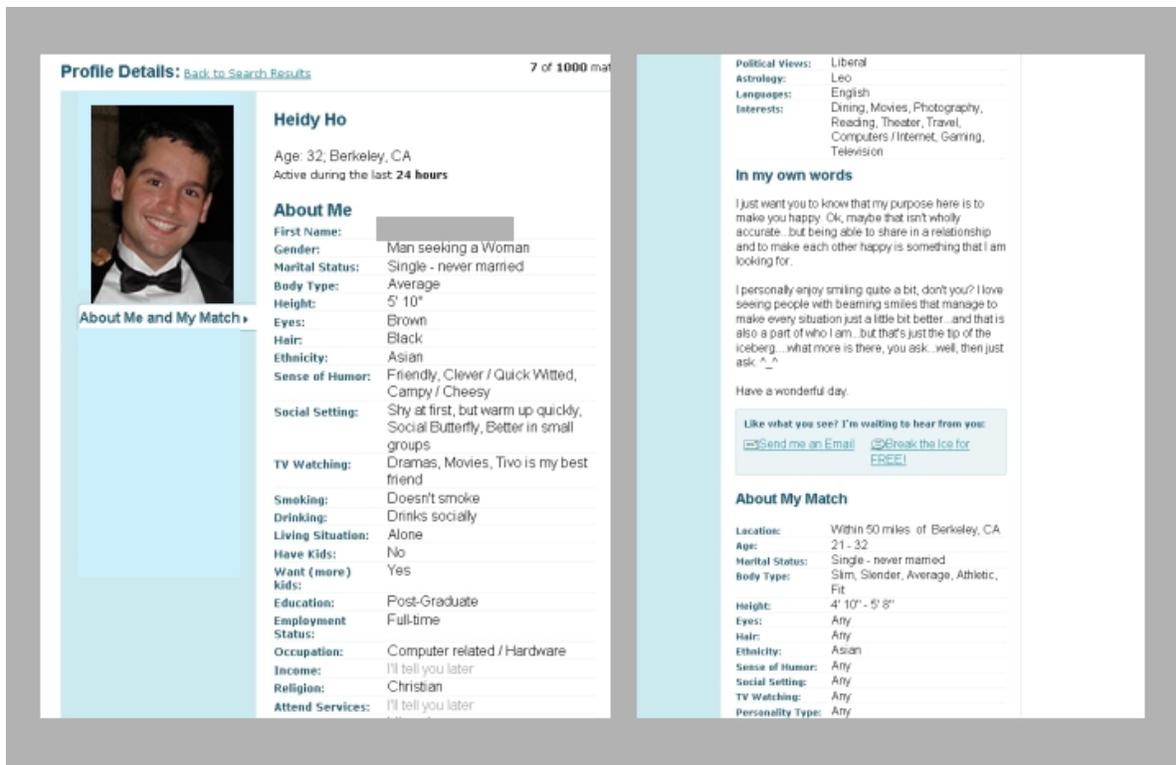


Figure 1: Sample Online Personals Profile (partial, anonymized, with substituted photo).

except that users can write only to others on the same site. Users write each other with the private messaging system to find out whether they want to proceed to contact via email, phone, or face-to-face interaction. This provides privacy and safety until the users are comfortable with each other.

In most systems, users search for potential matches according to constraints specified on the attributes listed in the profiles. Below we differentiate among the different types of systems based primarily on the mechanism that enables users to find one another.

- *Search/sort/match systems.* By far the most common kind of personals system, they provide the profile, search-and- match, and private messaging capabilities.
 - *Mainstream systems.* Web sites like Match.com and Yahoo Personals draw a broad base of users from a variety of racial, ethnic, and socioeconomic backgrounds. These sites function as a baseline both demographically and in terms of their design.
 - *Subpopulation systems.* Sites like JDate.com for Jewish singles and Manhunt.net for gay men attempt to serve a specific subpopulation. These sites add population-specific details to their profiles. Some mainstream sites also run smaller sub-sites for subpopulations.
- *Personality-matching systems.* Sites like eHarmony.com and Tickle.com give personality tests to their users and match them based on research into compatibility of personality features. The recent success of eHarmony has prompted more mainstream sites such as Match.com and Yahoo Personals to add an option for users to take personality tests in order to obtain better matches.

- *Social network systems.* These sites, best represented by Friendster.com, are the most recent type of personals system. They encourage users to bring their friends onto the system and then suggest matches between members of their social networks. According to JupiterResearch, these sites do not have much of the market for online dating (Elliott 2006).

Most systems provide both searching and matching functionality. In searching, users specify exactly what characteristics they are looking for. They can search the set of profiles based on constrained descriptors such as age, eye color, and religion, and sometimes by keywords in the free-response descriptors. In matching, which is slightly less direct, systems pair users by comparing their profile descriptors to the descriptors of others – usually the constrained descriptors, because contemporary techniques for clustering or otherwise identifying similarity work better with clearly defined features than with free text. Different systems apply different weightings to the features of the profiles.

Although sites often allow free browsing and searching in order to attract customers, most require users to pay for the ability to send private messages. Some sites allow non-paying users to reply to messages from paying users but not to initiate conversations on their own. One system, eHarmony, restricts whom even paying customers can contact. In this system, users can contact a potential partner only after the system has matched them with the person based on the results of their personality tests. That is, eHarmony provides only matching, not searching, and prevents communication between people who are not matched by the system.

Quite recently, online dating sites have branched far beyond an “online classified ads” approach. eHarmony was the first to have nationwide success as an online matchmaker. Their approach is to match users based on a “compatibility test” and then to structure the getting-to-know-you stage of relationships through a series of prearranged interactions. Users must pass through the structured phase before they can meet face-to-face. The advent of sites such as eHarmony, combined with the sheer number of online dating options available, has forced dating sites to search for new and innovative approaches and niches. Many sites have added personality questionnaires and matching services to their sites. Match.com has been particularly novel, recently launching Mindfindbind.com, a sort of self-help site for daters that features a television personality. Match.com also introduced Chemistry.com, which, with the help of respected anthropologist Helen Fisher of Rutgers University, hopes to match people based on personality types rooted in brain chemistry. Chemistry.com has used evolutionary principles of mate compatibility based on neurochemistry to produce an online questionnaire that purports to match people to their chemical complements.

2.2 Our Prior Research on Online Dating

Homophily is the tendency for people to associate with and develop relationships with people with characteristics (such as demographics, attitudes, values) similar to themselves. Psychologists have found that actual and perceived similarity between potential romantic partners correlate positively with attraction and, later, relationship satisfaction (Luo & Klohnen 2005).

Our earlier work (Fiore & Donath 2005; Fiore 2004) sought to determine if the new computer-mediated method of partner selection offered by online dating sites would alter the effects of homophily, since the information provided by online sites differs dramatically from what a person might glean from face-to-face interaction. Importantly, we treated dyads (pairs) as the fundamental unit of analysis in our research. Dyadic analyses have gained favor over the past decade among social psychologists studying intimate relationships. They make clear that the interaction of a pair of people, not just the separate characteristics of two individuals, is vital to our understanding of attraction and relationship formation.

The next subsections briefly summarize the data collection, analysis methods, and results found in this earlier work.

2.2.1 Data Collection

We performed an analysis of dyadic interactions of approximately 30,000 heterosexual users of an online dating system in the U.S (Fiore & Donath 2005; Fiore 2004). The data available consisted of a snapshot of activity on the site over an eight-month period, including an anonymized list of email communications between the users of the sites (who sent email to whom, but the content of the messages was not analyzed), as well as the anonymized profiles, including the self-reported preferences for a partner, as expressed in the profiles. Anonymous ID numbers were used to distinguish the individuals.

2.2.2 Analysis Method

When assessing similarity based on shared characteristics, it is important to take into account the fact that some characteristics are more *bounding* than others – that is, people are more likely to seek someone like themselves on that dimension. For example, smokers might want to find other smokers more so than people with blue eyes want to find other people with blue eyes. We would say that smoking is more strongly bounding than eye color because people with a given smoking status are less likely to cross the boundary to choose someone with a different smoking status than someone with brown eyes would be to choose a partner with blue eyes.

To determine the bounding strength of descriptors in the data set, we compared the percentage of contacts between two users who shared the same value for a characteristic (e.g., athletic for the characteristic "physical build") with the percentage of contacts we would expect to share the value if one male user and one female user from the active population were paired randomly.

For example, on the site, 32.6 percent of male users and 9.2 percent of female users report their build as "athletic". If users were contacting each other randomly but in heterosexual pairs, we would expect $0.326 * 0.092$, or 3.0 percent, of contacts to involve two users of athletic build. However, if users of athletic build sought other such users more often, the percentage of contacts involving two of these users would exceed 3.0 percent; if these users avoided each other, the percentage would be lower. By summing the probability of sameness across all possible values of a characteristic, we find an overall probability that a random pair of one male and one female user will share the same value for that characteristic.

Having calculated the expected sameness, we computed the actual percentage of dyads with the same value for each categorical characteristic, both for all pairwise exchanges and separately for the subset of reciprocated exchanges. The absolute value of the difference between the actual percentage of sameness and the expected percentage of sameness indicates how much users were deliberately seeking someone with the same values as themselves. We calculated the proportion of the actual to the expected percentage sameness for each characteristic.

2.2.3 Findings

The study found that users of the system sought people like them much more often than chance would predict, just as in the offline world. Figure 2 shows the bounding strength of categorical characteristics found. *Expected percent same* indicates the statistically expected percentage of dyadic pairs who share the

Characteristic	Expected percent same (x)	Actual percent same (all contacts, a_1)	Actual percent same (recip. con. only, a_2)	t ($a_2 \neq x$)
Marital status	31.6	51.7 (1.64x)	56.0 (1.77x)	76.001†
Wants children	25.1	38.7 (1.54x)	40.5 (1.61x)	48.553†
Num. of children	27.8	38.7 (1.39x)	38.6 (1.39x)	34.352†
Physical build	19.2	24.5 (1.28x)	25.6 (1.33x)	22.435†
Smoking	40.5	50.6 (1.25x)	54.0 (1.33x)	41.979†
Phys. appearance	37.6	46.1 (1.23x)	49.2 (1.31x)	35.886†
Educational level	23.6	28.0 (1.19x)	29.3 (1.24x)	19.360†
Religion	42.4	49.7 (1.17x)	52.6 (1.24x)	31.589†
Race	71.1	81.2 (1.14x)	85.9 (1.21x)	65.808†
Drinking habits	61.2	68.7 (1.12x)	73.4 (1.20x)	42.692†
Pet preferences	34.7	38.5 (1.11x)	39.9 (1.15x)	16.425‡
Pets owned	21.8	23.6 (1.08x)	24.0 (1.10x)	8.038‡

† d.f. = 23,940; $p < 0.001$ ‡ d.f. = 23,855; $p < 0.001$

Figure 2: Bounding strengths of categorical characteristics in study of dyadic interchanges (see text for details).

same value for the listed characteristic. The expected probability is based on random selection from the male and female population distributions for the characteristic. *Actual percent same* indicates the empirical percentage of dyadic pairs who shared the same value for the listed characteristic, across all contacts and just the reciprocated subset, in which the initial recipient replied.

The users' preferences were most strongly same-seeking for attributes related to the life course, like marital history and whether one wants children, but they also demonstrated significant homophily in self-reported physical build, physical attractiveness, and smoking habits. This concurs with the overwhelming evidence gathered by relationship researchers (summarized in (Brehm *et al.* 2002; Fisher 1992)) that actual and perceived similarity in demographics, attitudes, values, and attractiveness correlate with attraction (and, later, relationship satisfaction). However, users demonstrate this homophily to differing degrees for different characteristics.

2.3 Other Online Dating Research

To date, only a small amount of research has been published on the use of online personals sites. We summarize this research below.

Hitsch *et al.* (2004) conducted a post hoc quantitative analysis of the behavior on one online dating system of 23,000 users in Boston and San Diego. They found that these users did not differ notably from the Internet-using population generally in those cities, lending credence to the notion that online dating users are not an idiosyncratic subset of population. Next, like Fiore (2004), which examined the behavior of approximately 30,000 users in the United States and Canada, Hitsch *et al.* (2004) built quantitative models to examine what characteristics influence who communicates with whom on the online dating system. They found that less attractive users were two to four times more likely to initiate communication than less attractive users. In general, men were more likely than women to initiate communication, and they were more likely to include their outside email addresses and phone numbers in an initial contact, findings which mirror those of Fiore

(2004). Women more so than men stated a preference for dating someone of the same ethnicity.

Many of these findings coincide with the psychological research into offline attraction (Buss 2003): women prefer tall men, but men prefer shorter women. Men with higher incomes, educational levels, and job attainment receive more initial communications, but these effects are marginal for women. Having a photograph in the profile boosts the number of initial communications received by women to a greater degree than it does for men.

Norton *et al.* (2004) argue that ambiguous characterization in online dating profiles allows others to project the attributes they prefer onto a person, leading to a more favorable perception of them. Consider common statements in personals advertisements, such as: “really enjoy good music,” “I like going to movies,” or “I enjoy spending time with my friends.” These statements are true about so many people that they provide little or no information, yet they allow the reader to imagine that the movies and music that the writer enjoys match the reader’s preferences in those domains. Norton *et al.* (2004) argue that this optimistic interpretation of others relates to the human tendencies to assume that in-group others are like oneself (social projection (Clement & Krueger 2002) and generally to like people (person-positivity (Sears 1983)).

As evidence for their hypothesis, Norton *et al.* (2004) conducted a series of studies in which they showed participants online dating profiles with varying amounts of information about a hypothetical partner. First, they found that participants thought they would like a hypothetical person better given more information about them. Second, they showed that, contrary to the intuition demonstrated in the first study, in fact participants liked the hypothetical people less when they had more information about them. Third, they found that with repeated trials, the trend reversed, and in the final of four trials, participants liked people better given more information about them. Frost (2005) suggests that this counterintuitive finding could lead to disappointed online dating users, who expect that learning more about a potential partner will increase their mutual liking but instead find that liking decreases as they share information about each other.

A few ethnographic studies have examined the individual experiences of online dating users. (These involve on the order of dozens of participants in qualitative interviews.) Yum & Hara (2005) compared the styles of self-disclosure among users in Japan, Korea, and the United States. They found that Westerners tended to place a greater emphasis on intimate self-disclosure as the online relationships developed. Ellison *et al.* (2006) studied how users present themselves and perceive the social cues of others to gain a sense of the “actual self” behind the online dating profile. They note some users may deliberately lie or exaggerate about their personal characteristics, such as weight or age, but that for others, distortions in the profile descriptions may simply reflect an optimistic self-perception rather than an attempt to deceive.

Baker (2005) took a broader look at online relationship formation – via chat rooms and message boards as well as online dating systems – in interviews with 87 couples who met over more than a decade. She found substantial variation in their satisfaction with the experience, and their relationship outcomes, based on where and when they met, how long their online courtship proceeded, and how they related at a distance when they were not in the same area. Similarly, Nice & Katzev (1999) surveyed university students about their experiences in online relationships. From a 1,000-person sample taken in 1996, 88 reported forming friendships via computer-mediated channels, and 12 reported romantic involvements that began online.

Finally, some companies in the online dating industry tout their own research as evidence that online dating works. eHarmony researchers compared couples who met and married through their Web site with a sample of married couples who met offline (Snow & Carter 2004). They found that eHarmony-initiated couples scored significantly higher than the offline sample on the Dyadic Adjustment Scale, which measures aspects of relationship satisfaction, cohesion, and emotional expression. However, the authors failed to account for important differences in the samples that could negate their findings: the offline couples dated for an average

of three years before marriage and had been married for an average of two years at the time of the study, whereas the eHarmony couples had dated for an average of three months and had been married for an average of six months at the time of the study. Even if the authors attempted to control statistically for the duration of the relationship in the pre-married and married phases, they cannot control for the differences between people who wish to get married after three months of dating vs. three years of dating. Methodologically questionable research like this highlights the need for independent, academic investigation of the processes and outcomes of online dating.

3 Method

Much of the limited prior work on online dating has relied on the post hoc quantitative analysis of behavior. (This has been true of our own work (Fiore 2004; Fiore & Donath 2005) and that of others, such as (Hitsch *et al.* 2004).) Analyzing a static snapshot of user characteristics and communication behavior allows for the discovery, for example, that for men, being tall and well-educated is associated with receiving more messages, whereas for women, being young and thin receives more attention (Fiore 2004).

As much as we have learned from post hoc analysis of online behavior, even with the dyadic paradigm, we also encountered fundamental limitations in this approach. First, in the post hoc analysis, we cannot ask the users about their experiences directly, thus forcing us to make inferences about their internal states – how attracted is Person A to Person B – via imperfect proxies. Fiore & Donath (2005) used the number of messages a user received as a proxy for the user’s attractiveness. This is plausible, and likely correlated with the attractiveness of his or her personal profile, yet it remains only an approximation of how attractive others find the user in question. Second, with only a limited online slice of users’ behavior, we cannot tell what happens when they take their online relationships offline. What are the outcomes when users meet face to face? How often do successful online dating email exchanges lead to real-world relationships? These questions we cannot answer with post hoc analysis of online behavior.

Thus, we have designed a new, long-ranging study to overcome these limitations. We will follow participants from their first online contact with a potential partner, through their first face-to-face meeting, and, for a longitudinal subsample, far into relationship formation and development. To the best of our knowledge, no dataset of this kind currently exists.

This study consists of three main phases:

- Phase 1: Short-term Dyadic Interaction
- Phase 2: Longitudinal Relationship Development Study
- Phase 3: Design Interventions

Each is described in detail immediately below. Section 5.1 discusses the arrangements we have made with a very large online personals website, which below we refer to as the Site or the Personals Site.

3.1 Phase 1: Short-term Dyadic Interaction

In this first phase, we will take measurements of interacting pairs, via questionnaire, just before they meet face-to-face for the first time. We will then issue a follow-up questionnaire intended to be answered immediately after the pair has met in person.

We will write software (in conjunction with the Personals Site's engineers) that can identify pairs of users who have recently begun communicating with each other. We will use this software to take a random sample of the communicating dyads who have agreed to be contacted for such purposes. Our initial sample will comprise approximately 50,000 dyads.

After we obtain informed consent from these potential participants, we will send them (via email) a link to the first questionnaire (Initial Questionnaire), which comprises three sections:

1. Participant's expectations of the effectiveness of online dating in general,
2. Participant's personality (Ten-Item Personality Inventory [TIPI (Gosling *et al.* 2003)]),
3. Participant's attachment style (Experiences in Close Relationships Revised [ECR-R (Fraley *et al.* 2000)]).

Justification for Item 1: The first set of questions will be useful for gaining an understanding of how users' preconceptions about online dating affect their experiences in subsequent relationships initiated through online dating.

Justification for Item 2: We are including a standard personality inventory – i.e., a measure of the “Big Five” personality traits – of the type used in past psychological research, such as Luo & Klohnen (2005), in part so that we can duplicate their methods for testing hypotheses about whether similarity (or dissimilarity) is important for successful romantic pairing. The Big Five personality traits are widely used among personality researchers and act as an organizing framework for personality assessment. Located at the top of the taxonomy of personality traits, the five main categories are: Extraversion, Agreeableness, Conscientiousness, Neuroticism (or inversely, Emotional Stability) and Openness to Experience. More specific subtraits fall within the more general ones; for example, a Conscientious person is also organized, punctual, neat, etc.

The most common measure of the Five Factor Model is the NEO-PI-R (Neuroticism Extraversion Openness Personality Inventory, Revised), containing 240 items. Gosling *et al.* (2003) developed a ten item personality inventory (TIPI) as “an extremely brief measure of the Big Five personality dimensions,” useful when researchers want information about participants' personalities but do not wish to burden them with the dozens of items on a typical instrument. TIPI has been shown to have reasonable test-retest reliability and convergence with longer Big Five measures. We choose TIPI as a compromise between assessing personality dimensions reliably and alienating our participants with a long, intimidating instrument.

Justification for Item 3: Adult attachment theory is a widely used construct in social and developmental psychology. It is based on infant attachment theory, which provides a framework for understanding how infants' relationships with their primary caregivers affect how they perceive and approach the world (Bowlby 1982). In contrast, adult attachment focuses on how people approach romantic relationships (Hazan & Shaver 1987), and adult attachment styles reflect individual differences in how avoidant or anxious people are in those relationships.

Adult attachment styles are described by categorical typologies and dimensional measures. To assess adult attachment style, we employ the standard Experiences in Close Relationships Revised scale (ECR-R; (Fraley *et al.* 2000)). This 36-item scale yields two continuous dimensions, Anxiety and Avoidance, which can also be used to group participants into four adult attachment styles: Secure, Preoccupied, Fearful-Avoidant, and Dismissing-Avoidant.

After participants have completed the Initial Questionnaire, we will send them another questionnaire asking about another user “with whom you have recently begun communicating.” This questionnaire (Dyadic

Perception Questionnaire 1) will assess how each participant in a dyad views his or her communicating partner. This will include questions eliciting responses about:

- The participant's attraction to the partner
- The participant's expectations of a future relationship with the partner
- How well the participant knows the partner
- To what degree the participant idealizes the partner
- The participant's perception of the partner's personality
- How much the participant thinks he/she has in common with the partner
- How much the participant thinks he/she appeals to the partner
- Whether the participant thinks he/she will meet the partner in person

Assuming both parties in a dyad agree to participate, each will be asked to complete this questionnaire shortly after they start communicating via the Site's private messaging system. Within a short timeframe (approximately one week), we will contact the participants in the dyad again to ask whether they have met face-to-face. If they have, we send them each another questionnaire (Dyadic Perception Questionnaire 2) that corresponds closely to Dyadic Perception Questionnaire 1, but with the addition of a few questions about the face-to-face experience specifically. We want Dyadic Perception Questionnaire 2 to be very similar to Questionnaire 1 so that we may see how the responses change following a face-to-face meeting. Of course, many fewer dyads will receive Questionnaire 2 because only some who have communicated online will meet face to face. We are starting with a very large sample to mitigate this problem, though we will have to examine our set of respondents for sampling bias.

We will examine the changes in response over the two Dyadic Perception Questionnaires with mean difference tests and build regression models to predict the responses on Questionnaire 2 with the responses on Questionnaire 1. Furthermore, we will use the participants' profiles, which include demographics and other descriptive variables, to predict the changes in response from Questionnaire 1 to Questionnaire 2.

To facilitate this analysis, we will devise computer algorithms to classify the text of users' profiles according to subject matter (Sebastiani 2002), language usage (Karlgrén & Cutting 1994; Biber 1993), and emotional content (Kramer *et al.* 2004; Sugimoto *et al.* 2004). These techniques require human-coded training sets, which we will train coders to label. We will also train coders to rate the profile photographs according to attractiveness, content, and technical quality.

We anticipate thousands of responses to the Dyadic Perception Questionnaires. If the response rate is lower than we anticipate, we will simply add another random sample of Personals users to the participant pool.

3.2 Phase 2: Longitudinal Relationship Development Study

Some subset of dyads will not only meet in person but also form a relationship following their meeting. To examine the development of relationships formed through online dating, we will follow a subset of those dyads who meet in person for 24 months or until their relationships end.

We will repeatedly employ two instruments for the longitudinal phase, the Relationship Satisfaction Questionnaire and the Longitudinal Dyadic Perception Questionnaire. The Relationship Satisfaction Questionnaire first asks participants whether they are still in a relationship with their initial dyadic partner. If the relationship persists, we will give participants the 7-item Relationship Assessment Scale (Hendrick 1988), a brief instrument that assesses satisfaction with a romantic relationship (not necessarily marriage, which some other scales presume). If the relationship has ended, the system diverts the two participants to the Dissolution Questionnaire, which queries them about their perceptions of the dissolution process, including their attribution of blame and their level of distress.

We will send both participants in the dyad questionnaires periodically over the two-year study period unless they report that the relationship has ended. Specifically, we will send them the Longitudinal Dyadic Perception Questionnaire and the Relationship Satisfaction Questionnaire at the following intervals from their initial face-to-face meeting: 2 weeks, 4 weeks, 3 months, 6 months, 9 months, 12 months, 18 months, and 24 months. Repeating data collection with the same instruments over time will facilitate our analysis of the magnitude and direction of specific effects over time.

Using data gathered during Phase 1 and information from the users' profiles, we will build regression models that predict relationship satisfaction through the two-year period covered by Phase 2. We will also use Structural Equation Models to evaluate the competing factors that influence relationship satisfaction and Event History Analysis to examine how the role of these factors changes over time (see below). Regression models will allow us to use data gathered during Phase 1 and information from the users' profiles to predict relationship satisfaction in the short- and medium-term. We will also employ Event History Analysis to predict relationship dissolution and Structural Equation Modeling to infer its causation (see below).

3.3 Phase 3: Design Interventions

Online dating systems provide an unprecedented opportunity for the study of intimate relationships in a real-world context, but users of these systems will not benefit from this work unless the findings facilitate concrete improvements in the way online dating works. To this end, we will use the results of the analysis of Phase 1 and (preliminarily) Phase 2 to identify weaknesses in the online dating process – either in terms of self-presentation in profiles or the way users communicate with each other – and implement new self-presentation and interaction modalities that address these weaknesses. Designers and engineers from the Personals Site will help us develop these interventions so that they work properly with the existing system.

Although the specific improvements to the Site under study will depend on our findings in Phases 1 and 2, we expect them to fall into several broad classes:

- *Adding, removing, emphasizing, or de-emphasizing certain characteristics in user profiles.* If certain characteristics are found to be more likely to lead to disappointment or other negative responses in the first face-to-face meeting, we would remove those characteristics, or potentially re-word them. Similarly, our analysis may suggest descriptors to add to the profiles.
- *Adding richness to the communication process.* If the analysis indicates that interacting via email gives insufficient grounds to evaluate their date's self-presentation, voice and video channels could replace text-only interaction. Some theorists suggest that "sparse" media (those with relatively few channels for transmitting social cues) like text can inhibit the sense of a communication partner's social presence (e.g., (Walther 1992), though the evidence for this contention is ambiguous (Nowak *et al.* 2005; Walther 1996; Walther *et al.* 2001))

- *Adding structure to the communication process.* Progressive self-disclosure is vital to the process of relationship formation (Rubin *et al.* 1980; Yum & Hara 2005). If the analysis shows that, prior to meeting in person, participants are self-disclosing too quickly or too slowly, or failing to disclose helpful information, we would add structure to the online communication process. This structure could consist of guided questions (an approach eHarmony.com sometimes employs) that help users elicit information relevant to an incipient relationship from each other. Frost (2005) suggests structured games as a venue for self-disclosure that permits users to disclose information about themselves by demonstrating who they are rather than stating it explicitly.

In the field of Human-Computer Interaction, the standard practice for creating user interfaces is to utilize a design cycle consisting of (a) assessing user needs, (b) creating an initial design, (c) testing the design with representative users, and (d) assessing the results of the test and redesigning based on these results, and looping back to (c) until a satisfactory design has been obtained or deadline pressures force the cycle to halt.

Following this pseudo-experimental tradition, we will expose a small fraction of the Site's users to these interventions and repeat the procedure of Phase 1: Short-term Dyadic Interaction to see whether our changes lead to more accurate perception of others in the online dating system prior to meeting face-to-face, as compared to the results from Phase 1 with the original design components. That is, we intend for our design interventions to reduce the discrepancy between how users perceive each other when they have interacted only online and when they have met in person.

With the large number of users on the Personals Site, we will be able to expose distinct random subsamples of users to each design change or set of changes, so that we can compare the efficacy of these interventions on demographically equivalent groups of users.

3.4 Statistical Methods and Data Considerations

As we describe in the methods descriptions above, our three-phase data collection model will allow us to collect large amounts of information on relationship dyads over time. In addition to the personality and attachment instruments, we will also collect individual demographic information which includes gender, racial differences, location (urban/suburban/rural), and other socio-economic factors. By collecting such information, we will be able to address many important diversity considerations that are an essential part of understanding the complicated process of dyadic, romantic relationship development. In our view, the lack of such diversity information has been one of the key failings of previous research which has depended on limited cross-sectional data.

For a project of this size and scope, it is crucial not only to collect large quantities of data but also to collect data that will be suitable for the most informative and powerful statistical methods. The quantity of data in this project will not only be significantly larger than previous studies in this area of research, it will also be collected in light of the requirements for more advanced causal models. The longitudinal dataset that we outline in Phase II is ideally suited for both structural equation models (SEM) and event-history analysis (EHA).

As a new and sophisticated multivariate technique, structural equation modeling is superior for confirmatory analysis and efficient hypothesis testing compared to other more common associational or causal methods (Bollen 1989; Kline 2004). Since structural equation models allow for the detection of both direct and indirect relations (rather than just simple one-way predictive relations), we can gain a much more thorough understanding of the competing effects of various characteristics which influence dyadic dating relationship construction and maintenance over time. In fact, many of the existing studies of online dating (Fiore 2004;

Fiore & Donath 2005; Hitsch *et al.* 2004) necessarily depend on simple causal models that cannot account for the more complicated relationships between multiple causes, correlated direct effects, and indirect effects. We do not view this so much as a failing of previous studies, but rather as an indicator that this research area needs data of sufficient size and scope over time. The proposed data collection in this research proposal provides such an opportunity.

In addition to direct-effect and indirect-effect causal structural equation models, the full picture of romantic relationship development is, by definition, dependent on time. As a result, the longitudinal data collected in Phase II of this proposal will also be well-suited for Event History Analysis (EHA). EHA models allow us to determine the magnitude and direction of specific effects, while simultaneously controlling for time-dependence. For the entire sample and for key subgroups, we can examine the rate at which individuals form relationships and potentially leave them. Since we are collecting data using the same instruments over multiple time points, we expect the responses on these instruments to change over time. By using EHA techniques on our longitudinal data, we can examine the effects of time-dependent covariates which would otherwise be impossible with standard regression or associational statistical tests (Allison 1984). That is, we can examine the rate of relationship formation and dissolution as various explanatory factors change over time.

4 Broader Impacts of the Proposal

The proposed research has the potential not only to contribute to scientific knowledge across a variety of disciplines, but also, ultimately, to improve the quality of people's dating experiences. While our research focus is online relationship formation and development, most of our findings will be applicable to "real-world" relationships as well. For example, by studying online dating, we are able to examine early stages of relationship formation and development. What we learn about the impact of people's expectations for and idealizations of their partners in the initial stages of dating will be applicable to dating relationships that are initiated both on- and offline.

This is important because an abundance of research demonstrates that being in a committed romantic relationship improves people's subjective and objective well-being. We seek to uncover some of the barriers to successful relationship formation, as well as to develop interventions that help people improve their online dating experiences. Since millions of people use online dating sites to try to meet their mates, the findings from research have the potential to have a major impact.

Many studies have demonstrated that being in romantic relationships is positively associated with subjective well-being, which refers to how satisfied people are with their lives and how happy they are, e.g., Keyes *et al.* (2002). For example, people in romantic relationships, particularly marriage, tend to have lower levels of stress and higher levels of happiness than their unattached counterparts, e.g. Coombs (1991); Umberson *et al.* (1996). This is usually attributed to the social support that people get from their partners (Dush & Amato 2005). For example, women in happy relationships have a lower risk of heart disease (Gallo *et al.* 2003), and married women have fewer alcohol-related problems (Horwitz *et al.* 1996). Notably, longitudinal analyses suggest that marriage actually does positively affect well-being, and it is not simply the case the happier, healthier people are more likely to get married (Dush & Amato 2005; Horwitz *et al.* 1996).

In sum, close relationships are vital for well-being, and the more committed the relationships, the greater the positive effects (Dush & Amato 2005). The sheer number of people using online dating ensures that faulty approaches (in terms of technology or the underlying psychology) could leave the mistakes of online dating systems writ large on millions of relationships. Conversely, successful approaches have the potential

to promote successful relationships, resulting in companionship, social support, and well-being. In short, it is not unreasonable to think that CMC systems that promote the formation of satisfying relationships have the power to improve the quality of life for millions of users.

Tools that facilitate online relationship formation represent a way to facilitate relationship formation in general. Moreover, the way these systems mediate interactions between potential mates is likely to affect the way users choose partners for marriage and child-rearing, a process with broad social implications. As the sociologist Wellman (2001) asserts, "People do not neatly divide their worlds into two discrete sets ... The cyberspace- physical space comparison is often a false dichotomy." Using online dating sites to find mates represents the merging of age-old desires with modern technology. Understanding how relationship processes play out online is necessary for anyone hoping to understand the processes underlying happy, healthy relationships in the 21st century.

5 Research Plan

5.1 Establishing Access to The System Under Study

Our research team has been able to form a partnership with one of the world's largest online dating web sites. We have provided a letter of collaboration to prove to the reviewers that we have established this relationship. The Personals Company has not yet decided whether or not it would like to expose its identity in our published results; for that reason, we would like to request that all reviewers and NSF staff retain the confidentiality of the identity of the company with which we are working.

This collaboration was made possible in part by the PI's pre-existing relationship with the company as a member of their Science Advisory Board (which is a separate unit from the Personals part of the company), and in part by a presentation on social science research results that the team made to the Personals portion of the company. The Personals management and staff were quite excited about the insights that can be gained by such research and decided to make it possible for our team to perform studies of the kind described here using their site.

The arrangements with the Personals site are deeply in place; the Personals company has provided our research team with a dedicated server machine located within their facilities, as well as a computer account that allows our program to access the appropriate databases. We have also completed human subjects approval procedures within our university in which the staff approved our mechanisms for ensuring confidentiality of the study participants.

Thus we have completed the process of establishing the relationship, receiving approval for the work from high levels of management as well as earning the cooperation of programmers and other staff whose help is crucial to implementing the questionnaires and database access. This stage took nearly a year to complete, and the access we have obtained would probably be difficult for others to duplicate.

We see this work as primarily scientific in nature; however, some of what we are studying could lead to better online experience for personals users of the collaborating company as well as other personals sites. Given that we will be publishing results, this will have a wide impact on potentially millions of people who are seriously searching for a life partner.

5.2 Plan of Work

The following plan of work assumes the grant is awarded and funding begins in July 2006.

In the months leading up to this date we will have completed the coding of the tool for conducting the online questionnaires and will have pilot tested the Initial Questionnaire, Dyadic Questionnaire 1, and Dyadic Questionnaire 2. It may be necessary to reduce or rework the questionnaires if response rate is lower than expected. If necessary, we will offer incentives in the form of raffle prizes as well. By May 2006, data collection for Phase I should be up and running.

5.2.1 Year 1

By the start of the first year, we will already have Phase 1 of our research project underway, in which we will send questionnaires about interpersonal perceptions and expectations to dyads from the Personals Site who have recently begun communicating with each other. We will begin the analysis with regression and structural equation models to predict outcomes following the dyads' face-to-face meetings, as reported on our post-meeting questionnaires, based on their mutual profile characteristics, their communication histories, and their responses to our pre-meeting questionnaires. Graduate student researchers will code participants' profile photos to facilitate this analysis. From a set of initial codings of the self-descriptive text, computer algorithms will be devised that automatically classify the text along various dimensions (see Section 3.1).

Halfway through Year 1, we will begin the longitudinal Phase 2 of the project, selecting a random subsample of participants to receive period questionnaires about their perceptions of their partner and their satisfaction with the relationship over a two-year period or as long as the relationship persists.

5.2.2 Year 2

In the second year, we will begin Phase 3 of our research. Using the results of the analysis of Phase 1, we will design and implement changes in the profile and communication systems, as described above (see Section 3.3). In the last quarter of Year 2, we will deploy these interventions to a subset of the Site's users and repeat the procedure of Phase 1 with these users to evaluate the efficacy of the interventions in improving interpersonal perception and communication. Phase 1 (short-term dyadic questionnaires) will conclude during Year 2, and Phase 2 (longitudinal dyadic questionnaires) will continue.

5.2.3 Year 3

In the final year, we will conclude data collection for Phase 2 (longitudinal questionnaires) and Phase 3 (design interventions and evaluation). We will analyze the data from these phases in the second half of Year 3 using regression models, structural equation models, and event history analysis to determine what factors at the beginning of a relationship begun via online dating predict future relationship satisfaction or dissolution.

In addition to publishing the results of our analyses in journals of social psychology and computer-mediated communication, we will also create a white paper for online dating industry designers and developers that explains the implications of our findings for the improvement of online dating systems in the future. This document will describe the most acute failings in the present online dating experience and indicate which design interventions proved most helpful in mitigating these problems.

5.3 Qualifications of the Research Team

Dr. Gerald (Jerry) Mendelsohn has 40 years of experience as a professor in the Psychology Department at UC Berkeley studying personality psychology. His research includes studying the effects of communication medium on interpersonal perception, studying partner selection in terms of personality characteristics, and studying behavior ratings and their causal attributions. He will lead the experiment and questionnaire design portion of the research. Dr. Mendelsohn is advising psychology PhD student Lindsay Shaw (described below).

Dr. Coye Cheshire is a newly-hired professor at the UC Berkeley School of Information, having received his PhD in 2005 from the Stanford Department of Sociology. While at Stanford, he was the Research and Technology Coordinator for the Institute for Research in the Social Sciences (IRiSS), where he assisted with the development of IRiSS as a cross-disciplinary center for collaborative research, workshops, and conferences. He also was a senior Software and Research Consultant at the Social Science Data and Software Service at Stanford, where he conducted in-person consultations for faculty, students, and staff in the use of statistical and qualitative software for academic research. As part of this work, he developed and conducted workshops on selected topics in quantitative and qualitative research software. Dr. Cheshire will lead the statistical data analysis portion of the research project.

Dr. Marti Hearst is an Associate Professor in the School of Information at UC Berkeley. She received her PhD in Computer Science at UC Berkeley, and worked as a Member of the Research Staff at Xerox PARC (Palo Alto Research Lab) for three years before returning to Berkeley as a professor. Her core expertise lies in the fields of human-computer interaction (and user interface design), computational linguistics, and search engine interfaces. Dr. Hearst is advising School of Information PhD student Andrew Fiore (described below), who initiated this research project. Dr. Hearst is managing the research project and will lead the user interface and language analysis portions of the research project.

The prior work described in section 2.2 was conducted by UC Berkeley PhD student Andrew Fiore while he was a masters student at the MIT Media Lab, using a dataset obtained by faculty at the Media Lab. Fiore's bachelor's degree at Cornell was an interdisciplinary mix of computer science, sociology, human-computer interaction, and psychology. Fiore has the technical expertise to write programs that access the Personals Site's databases, build and conduct the online questionnaires, and allow data analysis using methods not present in common statistical packages. He is also skilled in statistical and quantitative methods.

Lindsay Shaw is a UC Berkeley PhD student with a social psychology background. She has wide-ranging experience designing measures and questionnaires. In addition to proficiency in regression- and correlation-based statistics, she is currently receiving training in structural equation modeling, which we will use extensively in the proposed project. She also utilizes recently-developed dyadic data analytic techniques that are recommended for data derived from pairs of participants, as our data will be.

The UC Berkeley School of Information is an interdisciplinary program whose mission is to study the interface between technology, society, and information, and whose faculty hail from computer science, economics, sociology, law, and political science. Through our Master's program we train students for careers as information professionals and entrepreneurs. Through our Ph.D. program and faculty research, we explore and develop solutions and shape policies that influence how people seek, use, and share information to create knowledge. We will involve a series of I-school masters students in this research in various capacities, including data coding, data analysis, and interface design.

5.4 Management Plan

Since all members of the research team work on the UC Berkeley campus, coordination for the project is relatively simple. We will have biweekly research meetings with the entire team, and weekly meetings with relevant subteams.

PhD student Andrew Fiore will visit the Personals Site headquarters about twice a month (it is located approximately 50 miles from the UC Berkeley campus). Communications channels are already in place for working with this team.

5.5 Dissemination of Results

The products of this research will be disseminated in several ways:

- Research results will be published in appropriate conferences and as journal articles.
- The research team will present the result in talks to academic audiences.
- The research team will also write articles suitable for practitioners where appropriate.

5.6 Educational Plan

We are planning a graduate course on computer-mediated communication for the Spring 2007 semester. This course, like the proposed research, will draw on theoretical perspectives from social psychology (self-presentation, idealization), communication (media richness, Walther's hyperpersonal interaction), and sociology (social networks) to give students a framework for understanding CMC as it affects the lives of individuals and society as a whole. For the term project, students will choose among writing a theoretical term paper about a CMC topic, conducting an empirical analysis of a particular CMC environment, or designing and building a new CMC software tool. The proposed research will give us a platform on which to demonstrate how to apply social science research techniques to CMC. Interested students will also have the chance to build their research projects on analyses of the data we collect from our study.

6 Prior Results from NSF Funding

6.1 CAREER: Incorporation of Categorical Metadata into Information Access User Interfaces

NSF IIS-9984741, PI Marti Hearst, \$303,000, June 2000 - December 2004

For our prior NSF-supported research we developed a user interface paradigm for large collections of images, citations, text, and product listings that allows users to navigate explicitly along conceptual dimensions that describe the items (Hearst *et al.* 2002; Yee *et al.* 2003; Stoica & Hearst 2004). The interface uses hierarchical faceted metadata and dynamically generated query previews seamlessly integrating category browsing with keyword searching. Over the course of the grant, we developed and tested different interface ideas in a series of usability studies, and succeeded in finding a design that was strongly well-received by participants.

This research has had wide and significant impact on practitioners, especially in the field of information architecture. Although the notion of faceted metadata existed in information science before we began this research, it was rarely mentioned before we began to popularize it. Furthermore, there was little understanding of how to incorporate hierarchical faceted metadata into user interfaces before we began this work. We provided a theoretical framework, a design methodology, usability results to both instruct the community about how to design systems and to convince supervisors and others in decision making capacities to adopt the approach. By personal communication the PI has been told that this work significantly influenced two of the main commercial vendors of systems that successfully sell software which implements the ideas developed in this proposal and has influenced e-commerce and other sites to adopt the approach. We disseminated the results widely, through academic publications in high-visibility and highly-selective venues, and through public presentations, tutorials, and through the web-accessible demonstrations. An open source version of the code is being released in March 2006.

6.2 Biotext: Improving Search Over Bioscience Literature Via Language Analysis and User Interface Design

NSF DBI-0317510, PI Marti Hearst, \$840,000, August 2003 - July 2007

(Ongoing research.) The overarching goal of the BioText project is to help bioscience researchers find the information they need from the published scientific literature. We are developing computational techniques to extract entities and relations between them from the bioscience literature. We plan to apply the results to improving search interfaces and to semi-automated curation of information from text. In the first two years of this grant, we have made progress on the database infrastructure software and on three pieces of work in the area of automated text analysis (Nakov & Hearst 2005; Nakov *et al.* 2005; Rosario & Hearst 2005). We have developed several software tools and have already shared some of them with others in the community. A software tool we released (for abbreviation definition recognition) has gained wide usage within the community (Schwartz & Hearst 2003).

6.3 The Emergence of Generalized Information Exchange

NSF-0402614, PI: Coye Cheshire, National Science Foundation Dissertation Improvement Grant (\$7,500), 2004

This project examined how generalized exchange systems emerge when information, as the object of exchange, produces a collective good. In the generalized information exchange systems that were studied in this project, individuals contributed to a collective good (pool of information), and the rewards that individuals received came from this collective good. Several experiments were conducted in which subjects participated in a computer-based exchange system that manipulated either the popularity of a subject's contributions or the observed cooperation in the system. The results of these experiments demonstrated that social psychological selective incentives such as observational cooperation and social approval significantly encourage cooperation in generalized information exchange systems.

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