Making Social Matching Context-Aware - Design Concepts and Open Challenges

Julia M. Mayer
New Jersey Institute of Technology, USA
jam45@njit.edu

Starr Roxanne Hiltz
New Jersey Institute of Technology, USA
hiltz@adm.njit.edu

Quentin Jones
New Jersey Institute of Technology, USA
qgjones@acm.org

ABSTRACT
Social matching systems recommend people to people. In an ideal world, such systems could be *context-aware,* in that they would introduce users to each other in situations where they are mutually interested, available and open to meeting (i.e., facilitate a *valuable encounter*). Unfortunately, today's systems primarily match individuals based on simple similarity and proximity metrics. This paper explores how contextual information available on today's mobile phones could be used to identify opportunities for people to make valuable new connections. Three types of context that are relevant for this work are: *relational, social* and *personal*. We present insights gained from several iterations of semi-structured interviewing (N=58) exploring these three types of contexts and propose novel context-aware social matching concepts such as: *sociability of others* as an indicator of opportune social context; *activity involvement* as an indicator of opportune personal context; and *contextual rarity* as an indicator of opportune relational context.

Author Keywords
Context-aware social matching; introduction systems; chance encounters; social recommender systems

ACM Classification Keywords
H.1.2 [Information Systems]: User/Machine Systems.

INTRODUCTION
Chance encounters, the unintended meetings between people unfamiliar with each other, help people to create new social ties, such as making new friends, advancing one's career or finding an activity partner [2]. Every day we cross paths with numerous strangers, who might just be that tennis partner we have been looking for, the ideal partner for a political discussion, or the Spanish tutor we need so desperately. While we may not be aware of these nearby individuals, our smartphone could be. Social matching systems aim at supporting the creation of new social ties by recommending people to people [36]. While social matching is often considered to be synonymous with online dating (*Match.com, OKCupid, eHarmony*, etc.), it also supports a broader range of social needs, such as professional networking (e.g., *LinkedIn* people recommendations) or the formation of new friendships through mobile people discovery apps (e.g., *Highlight, MeetMe*).

The problem is that the matching supported by current mobile social applications is overly simplistic. Systems tend to assume that one's listed profile attributes and interests are always relevant which can lead to overwhelming amounts of irrelevant matches. For example, a user who sits in a coffee shop in New York is unlikely to be interested in a match notification informing him that someone nearby is also from New York and likes coffee. Unfortunately, beyond simple notions of similarity, proximity and social ties, we have limited knowledge about how systems could facilitate valuable chance encounters in socially intelligent ways. Therefore, this paper investigates what constitutes an opportune context for chance encounters, the impact of mobility on people's interest in meeting others, and how mobile systems could utilize contextual data to identify opportunities for valuable chance encounters. The contribution of this paper is a framework of contextual factors that should be taken into account when designing context-aware mobile social matching systems.

We begin with a review of the background literature, systems and theories of prior work and an examination of how they could inform the design of context-aware social matching systems. We then outline our theoretical framework that categorizes aspects that are relevant for this work into *social, personal, and relational context*. Our research questions further explore how these three types of context can be used to identify opportunities for valuable encounters. We present findings from a semi-structured interview study (N=58) and conclude by discussing the design implications of our findings as well as proposing novel context-aware social matching concepts that could enable systems to facilitate valuable mobile encounters.

CHI 2015, April 18 - 23 2015, Seoul, Republic of Korea
Copyright 2015 ACM 978-1-4503-3145-6/15/04...$15.00
http://dx.doi.org/10.1145/2702123.2702343

BACKGROUND

Below we present a summary of prior mobile systems that aim to introduce people to people. We then turn to context-aware computing research and its notion of 'context'. Finally, we review the notion of place and articulate our work through the lens of proxemics, which posits that the physical and social environment and distance between people have a strong impact on social interaction.

Prior Systems

People tend to seek out others who are just like them (*similarity-attraction effect*, i.e., "Birds of a feather flock together") [24]. Early research on mobile social matching aimed at building prototypes with a focus on proximity and similarity, rather than trying to get a more nuanced understanding of what users desire when being introduced on the go. One of the first systems, *Nokia Sensor* [30], relied on Bluetooth beacons to discover nearby people and to communicate with them. *Social Net* [35] used explicit social network information and RF-based devices to introduce people located in proximity to one another using a common friend. *Social Serendipity* [6] used Bluetooth and a database of user profiles to recommend face-to-face interactions between nearby users who share common preferences. *WhozThat?* [3] shared social networking IDs locally to help users find others with common interests.

Mobile social matching systems have gained wide popularity in the online dating space and a majority of online dating sites now offer mobile applications that help find dating partners in the users' vicinity (e.g., *OkCupid Mobile, eHarmony Mobile*). While some matchmaking algorithms are very complex in that they attempt to find *the perfect match* based on numerous personality traits and lengthy questionnaires, mobile apps like *Tinder* and *Grindr* have gained significant popularity by using a much simpler approach. In *Tinder*, the user is shown a series of photos of people who meet certain age, gender, and location criteria and users can simply indicate who they like (swipe right) and who they do not like (swipe left). Only if both users indicate interest in each other are they able to message each other. In this case, mutual interest and availability based on location is all the system uses for social matching.

Context-awareness

Context-aware computing is a computing paradigm that aims at understanding the user's current context and treating it as an input to allow computational systems to be sensitive to the situation in which the user is immersed [1,4,5]. Even though we intuitively understand what "context" is, it is hard to elucidate, and even harder to make a computer system understand it. Context has been defined as "*location, identities of nearby people and objects, and changes to those objects"* [32] and further specified as "*any information that can be used to characterize the situation of an entity where an entity could be a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves"* [1]. Of particular relevance to this work is Dourish's notion of context as a *relational property* between objects or activities that defines if something is contextually relevant to some particular activity [5]. Relational context requires constant in situ negotiation of meaning of place and action. The notion of relational context was also used when studying human interruptability, where relational context referred to who the interruption was from and what it was about [10].

While mobile phones are able to collect increasing amounts of information using various sensors, such as user location, user movement, environmental noise, temperature, and people nearby, its availability along with the lack of uniform methods to define, acquire and process contextual data has created new challenges in context-aware computing. Social matching can greatly benefit from contextual information, particularly the relational context between people. Prior work found that the rarer shared attributes of users in the current context are, the more desirable a social match based on these contextually rare shared attributes is (*contextual rarity* [22]). For example, being matched with somebody because they are a fellow HCI researcher at CHI is less desired than when the two individuals are both attending a large handball tournament (where the attribute "HCI researcher" is assumed to be rather rare). However, we need to gain a deeper understanding of what contextual aspects define an opportunity for a valuable encounter in order to design context-aware social matching systems.

The Notion of Place

From sociology and psychology research we know that people's current environment influences social interaction between strangers [5,14]. A place is "a space, which is *invested with understandings* of behavioral appropriateness, cultural expectations" [15] and places - just like individuals - have their own personalities and act as "social" filters; different types of places attract certain people. For example, social norms at places or events might prescribe certain behavior regardless of the fact that those present are strangers, e.g., dinner parties, work, summer camps and conferences [9,33]. Prior work found that individuals are interested in knowing about others nearby in places designed for socializing, such as pubs and diners, or in places where people have long waiting periods, such as airports and train stations [11,18].

Urban overload and population density might negatively impact interaction between strangers and increase social barriers [26]. Levine [20] explored local and environmental variations in people's willingness to help a stranger and found that the characteristics of the local environment are the main predictor. For example, people in more crowded cities were much less likely to take the time to help. This shows that an understanding of place - not only in terms of physical space but also its meaning, its activities, its

crowdedness, etc. - could potentially be used to infer how opportune the moment is for a social match.

Proxemics

Proxemics provides another perspective on how culture affects the way people understand the space around them and how proximity between people is interpreted and used to mediate interactions with others [14]. Perception of space is dynamic because it is related to action (i.e., what can be done here) rather than what is seen by passive viewing. Hall [14] distinguishes between *personal space* (immediate space surrounding a person) and *territory* (claimed area to defend against others). To assess and understand the effect of distance on communication, personal space can be divided into (1) *intimate distance* for embracing, touching or whispering, (2) *personal distance* for interactions among good friends or family members, (3) *social distance* for interactions among acquaintances, and (4) *public distance* used for public speaking [14]. In applying proxemics to ubiquitous computing, Greenberg et. al. [13] suggest that the dimensions of *distance, orientation* (e.g., facing toward or away from), *identity* (e.g., entity type), *movement,* and *location* (e.g., a particular room and its characteristics) be taken into account.

Research has shown that physical proximity and the resulting opportunity to interact increases attraction (*mere-exposure-effect*) [17] and that proximity further provides the occasion for the discovery of common attitudes [28]. The probability of face-to-face contact between two people decreases exponentially as the physical distance increases because distance increases effort [7,34]. Co-location traces have been used to identify groups and their associated places and predict the probability of contact between two users [21]. Further, it was found that people who have regularly seen each other before but never directly interacted (i.e. *familiar strangers* [26]) are more likely to introduce themselves in an unfamiliar setting, for example while travelling, than perfect strangers, as they have a background of shared experiences [29].

THEORETICAL FRAMING

Our review of background literature highlights some of the complex social dynamics of meeting new people in various contexts. The concept of *context-awareness* has not been explored deeply from a social-matching perspective. In order to build *context-aware* social matching systems, we need to understand how we could identify situations in which people want to meet new people, i.e., when are good opportunities for a system to introduce users to each other. We define *opportunities for valuable (mobile) encounters* as situations in which two or more people are mutually open to and interested in computer-mediated introductions. We believe such *opportunities* exist when two people are (1) interesting or relevant to each other in their current situation (*opportune relational context*), and/or (2) are in a situation where they are willing/able to act on the

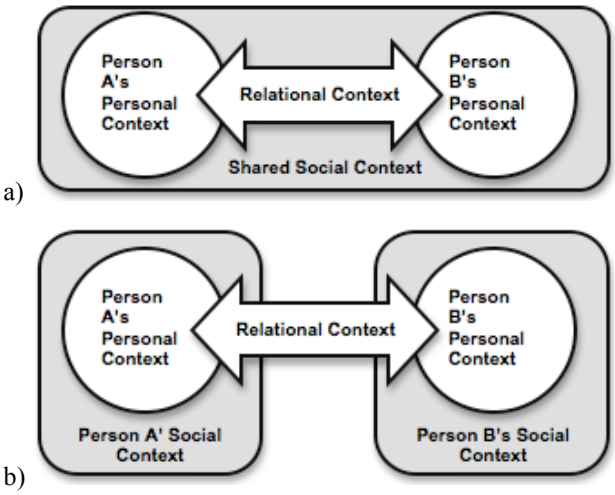

Figure 1. Relevant aspects of context for identifying opportunities for valuable encounters between people in a) the same social context or in b) distinct social context

introduction and start interacting (*opportune social context & personal context*). We propose a theoretical framework outlining *social, personal,* and *relational context* as relevant when identifying opportunities for valuable encounters:

Social Context: External factors of the place, such as the place type, activities offered, the people present within that place and their intentions, associated social norms, reputation, safety, etc.

Personal Context: Individual factors affecting people's state of mind, their attitude, ability and willingness to engage in a mobile encounter, e.g., based on current involvement in an activity.

Relational Context: Factors affecting the nature of the relationship between people (i.e., affinities, reason for match), including information about similarities, shared social ties, proximity, etc.

Figure 1a) and b) illustrate that while relational context depends on the relationship between person A and person B, personal context is an individual attribute. Person A and B could be either in the same social context, same place and time (Figure 1a) or they could be in different social contexts, e.g. different places or time (Figure 1b). Formalizing these constructs allows us to map out the design space of context-aware social matching systems.

This framework was informed by prior literature and further refined by insights from the iterative interview process presented later in this paper. Thus, while the framework was used to structure the interviews, our insights from the interviews also further refined the framework.

RESEARCH QUESTIONS

In order to gain a deeper understanding of these constructs, we need to answer the following research questions:

RQ1: *What external factors define situations where people are interested in meeting new people? (Opportune social context)*

RQ2: *What individual factors define situations where people are interested in meeting new people? (Opportune personal context)*

RQ3: *What relational factors define who people are interested in meeting? (Opportune relational context)*

RQ4: How do these factors - social, personal, and relational context - interrelate in defining who people are interested in meeting?

METHOD

We conducted short semi-structured interviews in various locations to investigate the proposed research questions. A total of 58 interviews were completed which lasted on average 15 minutes. The relatively short interviews were necessary because we stopped people in the midst of their daily activities, without an appointment, in order to take their current situation into account. All procedures were approved by an Institutional Review Board.

Participants and Places

The research involved several rounds of interviews, data analysis and refinement of our interview guide. The characteristics of the setting / "place" and the activities occurring there were observed and noted before beginning interviews. The initial interviews were conducted with students on an urban university campus with approximately 10,000 students during Fall 2013. These were complimented by two rounds of interviews with people in various public places in Manhattan, NYC (Spring 2014).

The focus of the early interviews with students was to get an initial understanding of the research space, to iterate quickly on findings and refine interview questions. College students are at a point in their lives where they are actively looking to build their social networks and an urban university campus in theory provides an environment that offers numerous opportunities for people to make new connections. Therefore, studying students within this larger urban environment provided a good starting point for learning about people's habits, patterns, and expectations in regards to meeting new people.

Students were randomly selected at different places around campus and asked to participate in a short interview (no incentive offered), similar to market research street intercepts. This approach allowed for the exploration of a variety of locations and quick necessary iterations in our interviews as the study progressed. Most students were willing to be interviewed, with only six out of 52 approached people declining participation in the study, resulting in 46 completed interviews. The average participant age was 21 years old with a range of 18-32. Females made up 28% of participants, consistent with the population of the predominantly male university. Participants had a variety of majors (business management, biology, mechanical engineering, computer science, digital design, etc.) and about one third of the participants lived on campus while the rest were commuters.

Interviews were conducted both indoors and outdoors, at locations with defined activities (15 at racquetball courts, soccer field, etc.), social settings (18 at student lounges), and non-social settings (13 at library/academic buildings). The soccer field was described as being used for games of pick-up soccer, but also for cricket, track practice, baseball, etc. Student lounges often provided us with students relaxing with other friends, groups working on assignments, or study sessions. At the library and academic buildings, we interviewed mostly solitary individuals studying or waiting for the next class to start, rather than groups of friends.

After five iterations of interviewing, initial analysis [16], and interview guide refining, we conducted in-depth open coding, employing emergent theme analysis of the data collected [8] from our campus based interviews. To reflect on emerged themes and patterns and see if they also held with a more general population and more diverse places we conducted a final round of interviews with 12 people in public places around Manhattan, NY, over two days (again, no incentive offered). Here the average participant age was 32.8, ranging from 22-48 with 50% being female. Interviewees had a diverse professional background (e.g., artist, medical doctor, office worker, film producer, software engineer, etc.). People were interviewed in six different public places around Manhattan, NY: Park (3), train station (3), Ground Zero (3), cafe (2), bar (1). All interviewees were alone except one man was with his wife.

Two slightly different sampling strategies were applied on the two days. The first day, the interviewer approached only people that appeared to be available and potentially open to be interviewed based on observed activity, being alone, and not glued to his/her phone. This resulted in all 6 approached people agreeing to be interviewed. On the second day, the sampling strategy was slightly modified and people were approached at random (i.e., no matter if they looked busy or available) and interrupted to ask if they would be willing to participate in a short interview. This resulted in 9 of 15 approached people declining to be interviewed. Most people who declined were walking somewhere, said they had to be somewhere or said they "didn't feel like it."

We acknowledge that differences between students and general public could have potentially biased our findings. However, we did not see strong differences between the two groups regarding their interest in meeting others. While strength of effects cannot be determined from qualitative studies, we did observe that people from the general public who were married and/or had a stable social circle seemed less interested in meeting new people when in their usual surrounding. Yet, when not in their usual surrounding (e.g.,

traveling, at a conference), their reasons and motivations for meeting new people were aligned with those of students.

Interview Process

Before we started the interviews, we recorded characteristics of the current situation of a potential interviewee from observation (location, place type, crowdedness, typical activity, etc.). After agreeing to be interviewed, we asked participants questions about their specific situation (what they were doing, how often they were here, who they were with, etc.). Then we delved deeper into their current as well as general interest in meeting new people. We encouraged storytelling by asking about specific past experiences of meeting new people at this or other places and specifically probed for situations where they liked/disliked meeting new people, where they found meeting new people particularly hard/easy and where they faced challenges and frustrations with finding interesting new people to talk to. We further asked them to elaborate on their motivations for interacting with new people and questioned them about their thoughts on being introduced to someone nearby by a mobile app. All interviews were recorded, with the permission of the participant, for later transcription and analysis.

FINDINGS

We recorded 926 minutes of semi-structured interviews, which we transcribed. For our analysis we followed a Grounded Theory approach [8] and used open-coding with two independent coders coding the transcripts to look for emerging themes around our three research questions. We discuss our findings below, which are illustrated through representative quotes with names changed to preserve participants' anonymity. The place of the interview is added to the quote when relevant.

Opportune Social Context

Participants generally identified places or situations where they felt it was "okay" to socialize as: bars, parties, conferences, organized trips, fraternities, and student clubs. While it may seem obvious to us that a bar is *more social* than a library, it is still difficult for systems to understand and identify opportune social contexts. From interviews we identified *sociability of people nearby, the familiarity with place and people, perceived safety,* and *jointly attended events/activities* as factors that influence how opportune the current social context for a mobile encounter is.

Sociability of People Nearby

A theme that emerged as important when meeting new people was a sense of other people's openness for socializing in the current context. Knowing if other people around them were open to meet new people influenced participants' openness, too. As Jenny put it, *"It's easy to strike up a conversation with someone when the other person seems open* Several participants expressed fear of rejection, e.g.: *"I'm always scared of bothering someone so that's like a reason why I wouldn't talk to someone in the park because people go there to read a book."* (Nicole at Union Square Park, NYC)

Participants illustrated how they assess not only their own but others' availability when thinking about meeting new people. Mark told us: *"At the beginning of the semester everyone is looking to meet new people with the influx of freshman…it sort of sets the expectation of meeting new people."* People seem to have a general idea of how open others around them are for socializing (which may not always be true, e.g., *pluralistic ignorance* [25]). Interestingly, openness to socializing seems to be 'contagious'. When people assume that others are not open to socialize then they will not socialize either. When people assume others are open to socialize, they are open, too.

Familiarity with Place and People

Familiarity with the people nearby as well as with the current place influenced people's interest in meeting others. Arnold told us, *"When my friends and I went snowboarding, I didn't really talk to anyone new because I was with a group of friends."* Participants were more motivated to meet new people when alone instead of with friends. Being in a new unknown place (e.g., while traveling) may also influence interest in meeting others. As John told us: *"I was at a bar in Hong Kong. I don't normally go up to others at bars but saw he was watching a soccer match and was traveling alone, so I started a conversation."*

Perceived Safety

We repeatedly heard that people are less open to meet new people when they feel unsafe in their environment. Maria told us *"I wouldn't want to meet someone in [an unsafe neighborhood] but on campus we're all students. I would be ok with other students coming up to me."* Here, the affiliation to a certain place (students on their campus in our case, or being a member of a church or gym) influences this feeling of safety towards meeting others. Other factors like time of the day, crime history, crowdedness, and reputation of a place also seemed to influence perception of safety.

Jointly Attended Events or Activities

Interview findings show how knowing about others who are at a place for the same reason (event or activity) helps people to connect with each other. Mark told us, *"It's easy to make new friends at certain organized hangouts, and things like different events. […] Most of the awkwardness of actually making new friends is taken care of by the structure of the club."* Shared experiences makes connecting to new people easier, as Norbert told us: "*I once went bungee jumping in Switzerland and met people on the way to do that. [...] We all kinda bonded, I think because in these moments of fear, these extreme situations make you bond."* This illustrates how opportune social context could

be derived from information about organized events or activities, such as conferences, concerts or clubs.

Opportune Personal Context

Exploring individuals' state of mind, their attitude, ability and willingness to engage in a mobile encounter, we found that involvement in an activity is the strongest predictor of how opportune current personal context is. For example, people in a hurry or busy with something else are rarely willing to meet new people. We talked to Angela in a train station and she said: "*I don't think you meet many people here, because everybody is hurrying somewhere, everyone is going somewhere, people don't have time to stop and chat with you.*" During interviews, people repeatedly told us that they would not want to be introduced to new people when they are busy with something else: "*Anytime that I'm really sort of busy and focusing on something I'm not up to meeting someone new. If I'm in studio, working on something and somebody comes in, my desires to keep on working won't allow my concentration to be broken, more so than to meet them, to get to know them.*"(Marcel)

Compared to that, it seems easier to meet new people while waiting somewhere. As Natasha said, *"Meeting people is easier, for example in a waiting room where there isn't so much outside distraction and it's just they waiting for someone, there is someone who has the same intention as you have, wait for something."*

We derived another strong indicator of people being less open when busy from our experience with finding participants to interview for this study. Students tended to be less likely agree to an interview at times between classes, as most students were focused on getting to their next class. Similarly, the majority of our declined interviews on campus (5 out of 6) occurred soon before the end of the semester with students citing the need to study as a reason for not participating in the interview. In Manhattan, people who declined an interview (9 out of 15) seemed to be in a hurry, or excused themselves with the reason that they had to be somewhere.

Opportune Relational Context

From our interviews, we found that people's reasons and motivations for meeting certain people vary strongly across contexts. In line with the similarity-attraction effect [24,27], *having something in common with another person* was one of the most mentioned reasons for connecting to a person. Delving deeper into what made these people interesting or relevant to participants, we found that *contextually rare shared attributes, contextually rare, but not shared attributes,* and *activity partnering* were the most prominent themes emerging around relational context.

Contextually Rare Shared Attributes

Prior research briefly explored the idea of contextually rare shared attributes used for matching [22]. We also repeatedly heard that people typically were interested in others with whom they share *something rare* in the current context. When delving deeper, we found that contextually rare shared attributes often are nationality, ethnic minority, religion or extraordinary hobbies. For example, Alyssa from Nigeria told us of the importance of meeting other Nigerians while on her current campus in the United States, *"I found out that [this other person] was also Nigerian, so I introduced myself with that […] and made friends with him because of that. I kind of know all the Nigerians on campus. So I was kind of interested that there was another Nigerian that I didn't know."* Because being Nigerian on an American campus was something unusual to Alyssa, she was interested in meeting any other Nigerian in this context.

Similarly, Scott, who is very religious, explained how his interest in meeting others from his religion varies based on where he is and how common his religion is in that place: "*In my town [my religion] is all over. But here [on campus] it's a lot rarer. Most of my friends from that religion go to [other colleges].*" When asked if he would like to meet others from his religion on campus, he said *"Yeah of course, there are always surprises around. That would be cool."*

We repeatedly heard from participants that they would be interested in meeting others that have a certain sought-after skill or interest; usually something that none of their current contacts does or have. Jenny, for example, told us: "*I would totally want to meet somebody right now who does 'international education'. I currently don't know anyone who does that, so I would make the time to have a conversation, definitely. It's what I wanna do next, it's a big career move for me.*"

Contextually Rare but Not Shared Attributes

We found that in some situations people are interested in others because they are both in some way different than the rest of the crowd at a place, i.e., have a contextually rare but not shared attribute. In other words, rather than being "birds of a feather" they are the "odd ducks". For example, Arnold, who was at a dinner party with his girlfriend where everybody was an artist, told us: *"I felt like an outsider because I was the only one there who wasn't an artist. But then I found this other guy who also wasn't an artist and we immediately bonded."* Similarly, another participant told of a recent internship she had in Wisconsin. She described the formation of a close friendship with the other external student based solely on the fact that neither of them was from Wisconsin. Pam said, "*When we found out we both weren't from Wisconsin, there was something for us to talk about. Eventually we got to know everyone else who was part of the internship but it was much easier for me to connect with [the other person who wasn't from Wisconsin].*" This illustrates that people do not necessarily have to have a specific attribute in common. Instead, interest in a match may result from both ***not*** possessing a common attribute that everyone else possesses (i.e.,

everyone was an artist except Arnold, everyone else was from Wisconsin except Pam).

Activity Partnering

People often were interested in meeting others with whom to do an activity of interest. Sue, who enjoys dancing salsa, told us: *"I have a friend who comes with me all the time but she's a girl and it doesn't work because you have to have a guy partner for salsa. We go together but we don't dance together. I would like to meet others who dance salsa, especially if they do it here [on campus]."* Currently, activity partners are generally sought at places where the activity can be done, e.g., finding tennis partners by the tennis courts. People mentioned how they intentionally go to certain places that imply a certain activity or interest to meet likeminded people there and/or do activities together: *"I go down to the game room whenever I have time, you know you play with others and that's how you make friends. […] Most of the people I know are from there"* (Scott). Participants identified locations where they went to meet others for specific activities: the soccer field, racquetball courts, church, game room, bars, and classrooms.

However, in many cases such attempts were problematic and unsuccessful due to lack of knowledge about who nearby might also be interested in doing a certain activity. Sue told us when talking about her interest in salsa: *"I'm sure there are a lot of people who do this around [this university] but I don't know, I don't know them. You can't ask someone, 'Oh, do you do salsa?' You can't just go up to somebody and ask. But if I knew someone was interested, I would talk to them about it."* This also illustrates the general challenge people have to discover and connect to interesting or relevant people nearby.

Interdependencies between Social, Personal, and Relational Context

We further examined how social, personal, and relational context may jointly define the extent to which an encounter represents a valuable opportunity.

Opportune Relational Context Trumps Inopportune Personal or Social Context

From the interviews we found that in some cases, even if people are busy they want to know about specific interesting people nearby. For example, in the rare case of another person from El Salvador nearby, Aaron would always want to be introduced, no matter how busy: *"I wouldn't consider it an interruption; I can choose to continue the introduction. I'd still like to know I had the chance of meeting another person from El Salvador."* This suggests that while opportune relational context provides the basis for a valuable encounter, social and personal context are mediators either improving or impairing the encounter opportunity.

Compatibility and Conflicts between Relational and Social Context

We further found that in a situation where the reason for the match (relational context) and their current situation or activity (social context) would be compatible, participants were more open to introductions, even when busy. Initially, Eugene said, *"I [wouldn't want to meet new people at] the library. Because I'm there to study and I'm usually there by myself trying to keep focus and I wouldn't want people, even like my friends, disturbing me."* But later he admitted, *"It all comes down to what I'm doing. If I'm studying for an exam, [I wouldn't want to be interrupted], unless that person wants to study the same thing that I'm studying, then I would take the time to talk to that person."*

In a different case, a participant told us of not wanting to meet new people when the reason for the match (relational context) conflicts with the current activity (social context). Scott, who is religious and generally interested in meeting others from his religion, said *"I mean I don't want to meet people from my religion if I'm at a party, when I'm doing something I'm not supposed to be doing … You know, I mean I'm human. I do stuff."* This suggests that the compatibility or conflict between relational context and users' current social context influences whether a mobile encounter is considered valuable and wanted.

DISCUSSION & DESIGN IMPLICATIONS

While some of our findings reflect what can be found in sociology and psychology literature, no prior work has explored how context-aware social matching systems could be designed accordingly. In order to map out the design space for context-aware social matching systems, we discuss our findings in the light of what they mean for system design. In particular we outline how opportune social, personal, and relational contexts could be identified based on contextual user information that currently is, or soon will be available on mobile devices (Table 1). Several open challenges regarding how systems could obtain an understanding of how opportune a user's current context is, are pointed out along the way.

Social Context	Personal Context	Relational Context
Contextual Sociability - Place type - Crowdedness - Typical activity at place - Time / season - No. of people new to place - No. of new connections made at the place - Self-reported openness *Contextual Familiarity* - No. of friends in close proximity - No. of prior visits to place	*Contextual Engagement* - Current Activity - Scheduled upcoming events - Speed of moving - Self-reported busyness	*Contextual Rarity* *Contextual Oddity* *Contextual Activity Partnering*

Table 1. Potential Indicators of Opportune Social, Personal and Relational Context

Identifying Opportune Social Context

Interview findings suggest that *sociability of others nearby* influences whether people are interested in meeting others. For systems to get an understanding how sociable people at a certain place are, several factors could be considered, such as place type, crowdedness, and typical activity. In some situations, the time (e.g., beginning of the semester) and the amount of people new to a place (e.g., lots of freshmen) can be indicators of how open people generally are. A direct measure of *sociability of others* could also be collected directly from users through unobtrusive user interfaces allowing users to input their openness to meeting others in a quick and easy way in various settings. Another more indirect measure of sociability of people at a place may be the *number of new connections between people* made at a place. This could be computed based on total connections over an extended time period, seasonally adjusted (e.g. start of each fall semester), or relative to a given point in time (e.g. tonight).

The interviews also showed that *familiarity with place and people* influence how opportune the social context is. This could be inferred by systems based on the number of friends (or otherwise known people) in close proximity, as well as a measure of how often a user has been to a place before, to decide if the social context is opportune.

Identifying Opportune Personal Context

We learned from interviews that *involvement in an activity* defines how opportune an individual's personal context is. Contextual cues informing us about a users' busyness could be derived from scheduled upcoming events in the user's calendar or at a place (e.g., a class or a meeting) and/or the speed at which people move (hurrying somewhere). Furthermore, the current place (library) and current activity (study) can provide hints about a users' busyness.

Identifying Opportune Relational Context

As pointed out earlier, an opportune relational context is the basis of all valuable encounters between people. We propose three concepts that could be used to infer opportune relational context: *shared contextual rarity, contextual oddity* and *contextual activity partnering*.

Our findings dictate that the rarity of a user's attribute in the current relational context is a powerful predictor of how opportune the relational context is. The underlying logic of *shared contextual rarity* is: the rarer a shared user attribute is in the current context, the more interested the user is in meeting another person who shares this contextually rare attribute [22]. Systems can calculate the prevalence P_a of an attribute *a* by dividing the number of occurrences of the attribute n_a by the size of the population N. While this concept has been previously explored through a survey study [22,23], there are still many open challenges related to the size of the population to take into account (a room, a building, a neighborhood, a town, etc.) and the granularity of the user attributes to be considered.

Contextual oddity could be used in the specific case of not shared contextually common attributes to match outsiders. Our findings illustrate how people who do not necessarily have anything in common but are different than the general crowd in the current situation tend to bond more easily. Systems could identify such outsiders in situations where a very high proportion of people share a certain attribute by identifying people who do not possess this common attribute. To achieve this computationally, further research into the dynamics of outsiders in mostly homogenous groups and how systems can identify them is needed. This approach presents new opportunities to connect people who are not alike, which is valuable for learning from different people, being exposed to different opinions and mindsets [12], and building "bridging" social capital [31].

Furthermore, the concept *contextual activity partnering* could be used to match people for activities that are relevant, interesting and available to them in the moment or in the near future. Contextual information regarding the typical activity at the current place as well as users' current activity in addition to users' activity interests could be used to identify and match activity partners near a location where the activity is offered.

Identifying Interdependencies

Study findings also suggest that there are interdependencies between social, personal and relational context. When there is a very strong relational motivation for a match, social and personal context seems to play a less significant role. However, when the relational motivators are lower, opportune social and personal contexts are required. This should be considered by system design.

Furthermore, *contextual compatibility or conflict* could be considered by systems to infer opportune and inopportune social context to introduce people. While a social match might be possible in one situation it may not be acceptable or appropriate. Reducing the likelihood of matches on religion in a wild party environment, or romantic introductions in a workplace setting, may seem obvious but is not addressed by existing matching systems. Similarly, if the reason for the match (taking the same class) and the current activity (studying for that class) are compatible, an encounter opportunity is even more valuable.

Mediating the Introduction Once an Opportunity is Identified

While this paper mostly focuses on identifying opportunities for valuable encounters, we also want to briefly discuss how context-aware social matching systems could mediate an introduction between two people. Once an opportunity is identified as being valuable enough to inform the user about it, an introduction is triggered. The matched parties get informed about the opportunity and get provided with tools to connect with each other (e.g., messaging, profile exchange). The most crucial part of the introduction is the amount and kind of information that comes with the initial match notification. Enough information to make the

value of the encounter obvious has to be revealed but at the same time user privacy has to be ensured. This means that the reason for the match (relational context) should ideally be revealed to the parties concerned to help the introduction process. Furthermore, specific information about the social and personal context that contributes to the encounter opportunity being valuable should be conveyed. For example, our interview findings showed how important it is for people to know that others, and in particular the matched person, is currently open to meeting new people. We believe that conveying this information through the app can increase successful introductions.

We understand that computer-mediated mobile encounters are changing the nature of the interaction and are not exactly the same as chance encounters between people without a system mediating. Future work testing an instantiation of a mobile social matching application will explore how such a system itself influences people's perception of the value of encounter opportunities in varying contexts.

LIMITATIONS

This qualitative research was exploratory, aimed at developing an initial understanding of the problem of developing a system to identify potentially valuable mobile encounter opportunities. We used semi-structured interviews to uncover underlying motivations that influence people's interest in meeting new people across different situations. Our contribution is to better understand the interaction of a number of factors that influence mobile encounter opportunities. At this stage, we do not present computational aspects of the proposed concepts but instead aim at theory construction and raising important issues.

Only a limited number of subjects were interviewed, in two locations, a college campus in the Northeast USA and in Manhattan public places. Openness to meeting new people may vary in different geographic locales, such as small towns, different regions of the USA, and other countries.

We are aware of a certain self-selection bias since we only talked to people who currently were open to be interviewed. We did note where, when and why people declined to interview with us, if a reason for refusal was volunteered.

CONCLUSION

This paper explored the nature of situations in which opportunities exist for valuable mobile encounters. We present a theoretical framework of social, personal, and relational context as important aspects for identifying such opportunities. Insights gained from an interview study suggest that opportune social context relates to sociability of people nearby, familiarity with place and people, perceived safety of the location and jointly attended events and activities. Moreover, opportune personal context is mostly reliant on people's current activity and how busy they are. Finally and most importantly, opportune relational context can be identified based on contextually rare shared and not shared attributes, as well as activity partnering. From these findings we derive novel design concepts to identify valuable mobile encounter opportunities based on social, personal, and relational context. These are instrumental in the implementation of context-aware social matching applications.

Moreover, social matching systems rely on the fact that users are willing to share personal information with others. The collection of personal and contextual information requires a thorough understanding of users' privacy concerns. While this study did not directly examine privacy concerns, we do recognize that it is an important issue. Privacy safeguards to protect users will be considered as part of future work.

As a next step, we are planning to conduct a quantitative Experience Sampling Method (ESM) [19] study with a larger sample of random participants to explore how social, personal and relational context could be operationalized to identify valuable mobile encounter opportunities. Expanding our understanding of these concepts will produce entirely new possibilities for social navigation enabling people to create new, valuable, unexpected relationships on the go.

ACKNOWLEDGMENTS

This research is partially supported by a grant from the National Science Foundation 1422696.

REFERENCES

1. Abowd, G.D., Dey, A.K., Brown, P.J., Davies, N., Smith, M., and Steggles, P. Towards a Better Understanding of Context and Context-Awareness. In H.-W. Gellersen, ed., *Handheld and Ubiquitous Computing*. Springer Berlin Heidelberg, 1999, 304–307.

2. Bandura, A. The psychology of chance encounters and life paths. *American Psychologist 37*, 7 (1982), 747–755.

3. Beach, A., Gartrell, M., Akkala, S., et al. WhozThat? evolving an ecosystem for context-aware mobile social networks. *IEEE Network 22*, 4 (2008), 50–55.

4. Dey, A.K. Understanding and Using Context. *Personal Ubiquitous Comput. 5*, 1 (2001), 4–7.

5. Dourish, P. What We Talk About when We Talk About Context. *Personal Ubiquitous Comput. 8*, 1 (2004), 19–30.

6. Eagle, N. and Pentland, A. Social serendipity: mobilizing social software. *IEEE Pervasive Computing 4*, 2 (2005), 28 – 34.

7. Festinger, L., Back, K.W., and Schachter, S. *Social Pressures in Informal Groups: A Study of Human Factors in Housing*. Stanford University Press, 1950.

8. Glaser, B. and Strauss, A. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Aldine Transaction, 1967.

9. Goffman, E. *Behavior in Public Places*. Simon and Schuster, 1966.

10. Grandhi, S. and Jones, Q. Technology-mediated interruption management. *International Journal of Human-Computer Studies 68*, 5 (2010), 288–306.

11. Grandhi, S.A., Jones, Q., and Karam, S. Sharing the big apple: a survey study of people, place and locatability. *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, ACM (2005), 1407–1410.

12. Granovetter, M.S. The Strength of Weak Ties. *American Journal of Sociology 78*, 6 (1973), 1360–1380.

13. Greenberg, S., Marquardt, N., Ballendat, T., Diaz-Marino, R., and Wang, M. Proxemic Interactions: The New Ubicomp? *interactions 18*, 1 (2011), 42–50.

14. Hall, E.T. *The Hidden Dimension*. Anchor, New York, 1990.

15. Harrison, S. and Dourish, P. Re-place-ing space: the roles of place and space in collaborative systems. *Proceedings of the 1996 ACM conference on Computer supported cooperative work*, ACM (1996), 67–76.

16. Hughes, J., King, V., Rodden, T., and Andersen, H. Moving out from the control room: ethnography in system design. *Proceedings of the 1994 ACM conference on Computer supported cooperative work*, ACM (1994), 429–439.

17. Insko, C.A. and Wilson, M. Interpersonal attraction as a function of social interaction. *Journal of Personality and Social Psychology 35*, 12 (1977), 903–911.

18. Jones, Q., Grandhi, S.A., Whittaker, S., Chivakula, K., and Terveen, L. Putting systems into place: a qualitative study of design requirements for location-aware community systems. ACM (2004), 202–211.

19. Larson, R. and Csikszentmihalyi, M. The Experience Sampling Method. *New Directions for Methodology of Social & Behavioral Science 15*, (1983), 41–56.

20. Levine, R.V. The Kindness of Strangers: People's Willingness to help somone during a chance encounter on a city street varies considerably around the world. *American Scientist 91*, 3 (2003), 226–233.

21. Mardenfeld, S., Boston, D., Pan, S.J., Jones, Q., Iamntichi, A., and Borcea, C. GDC: Group Discovery Using Co-location Traces. *2010 IEEE Second International Conference on Social Computing (SocialCom)*, (2010), 641–648.

22. Mayer, J.M., Motahari, S., Schuler, R.P., and Jones, Q. Common attributes in an unusual context: predicting the desirability of a social match. *Proceedings of the 4th ACM Conference on Recommender Systems*, ACM (2010), 337–340.

23. Mayer, J.M., Schuler, R.P., and Jones, Q. Towards an understanding of social inference opportunities in social computing. *Proceedings of the 17th ACM intl. Conference on Supporting Group Work*, ACM (2012), 239–248.

24. McPherson, M., Smith-Lovin, L., and Cook, J.M. Birds of a Feather: Homophily in Social Networks. *Annual Review of Sociology 27*, (2001), 415–444.

25. Merton, R.K. *Social Theory and Social Structure*. Simon and Schuster, 1968.

26. Milgram, S. The Familiar Stranger: An Aspect of Urban Anonymity. In *The Individual in a Social World: Essays and Experiments*. MA: Addison-Wesley, 1977, 51–53.

27. Morry, M.M., Kito, M., and Ortiz, L. The attraction–similarity model and dating couples: Projection, perceived similarity, and psychological benefits. *Personal Relationships 18*, 1 (2011), 125–143.

28. Newcomb, T.M. The Prediction of Interpersonal Attraction. *American Psychologist 11*, 11 (1956), 575–586.

29. Paulos, E. and Goodman, E. The familiar stranger: anxiety, comfort, and play in public places. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM (2004), 223–230.

30. Persson, P. and Jung, Y. Nokia sensor: from research to product. *Proceedings of the 2005 conference on Designing for User eXperience*, AIGA: American Institute of Graphic Arts (2005).

31. Putnam, R.D. *Bowling Alone: The Collapse and Revival of American Community*. Simon and Schuster, 2000.

32. Schilit, B.N. and Theimer, M.M. Disseminating active map information to mobile hosts. *IEEE Network 8*, 5 (1994), 22–32.

33. Shimanoff, S.B. *Communication rules: Theory and research*. Sage Publications, Beverly Hills, CA, 1980.

34. Sykes, R.E. Initial Interaction between Strangers and Acquaintances: A Multivariate Analysis of Factors Affecting Choice of Communication Partners. *Human Communication Research 10*, 1 (1983), 27–53.

35. Terry, M. and Mynatt, E.D. Social Net: Using Patterns of Physical Proximity Over Time to Infer Shared Interests. *In Proceedings of Human Factors in Computing Systems (CHI 2002*, ACM Press (2002), 816–817.

36. Terveen, L. and McDonald, D.W. Social matching: A framework and research agenda. *ACM Transactions on Computer-Human Interactions 12*, 3 (2005), 401–434.