A Comparative Study of Location-sharing Privacy Preferences in the U.S. and China

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ABSTRACT

While prior studies have provided us with an initial understanding of people's location-sharing privacy preferences, they have been limited to Western countries and have not investigated the impact of the granularity of location disclosures on people's privacy preferences. We report findings of a three-week comparative study collecting location traces and location-sharing preferences from two comparable groups in the U.S. and China. Results of the study shed further light on the complexity of people's location-sharing privacy preferences and key attributes influencing willingness to disclose locations to others and to advertisers. While our findings reveal many similarities between U.S. and Chinese participants, they also show interesting differences, such as differences in willingness to share location at 'home' and at 'work' and differences in the granularity of disclosures people feel comfortable with. We conclude with a discussion of implications for the design of location-sharing applications and location-based advertising.

1. INTRODUCTION

With the rapid adoption of location-enabled smartphones and the proliferation of mobile Internet services, we have seen the emergence of a large number of applications that can sense and share users' location information with others. Fueled by this trend, there has been a significant amount of research conducted to understand users' location-sharing privacy preferences in the context of such applications [1-8]. These studies have provided valuable findings and lessons for improving users' experiences; however, the participants in all of these studies were recruited exclusively in the U.S. or Europe. The extent to which these findings about location-sharing preferences generalize to other regions, such as Eastern Asia, is still largely an open question.

China is the world's second largest smartphone market with 35.4 million units shipped in 2010, representing 12% of all worldwide smartphone sales[9]. Smartphones have been forecast to be over 46% of all handset sales in China by 2013 [10]. It is reasonable to believe that, as part of this growth, location-sharing applications, though currently unfamiliar to most Chinese users, could soon see significant adoption in this country. As such, it makes sense to investigate location-sharing privacy preferences in China and compare them with those of people from other parts of the world.

Earlier studies in other contexts have suggested that East Asian users, in particular Chinese users, may be more conservative in information sharing and self-disclosure than Westerners [11,12]. Many of these studies predate the advent of social networking and smart phones. One objective of our study was to see to what extent this might be the case for location sharing. Our results are based on tracking users over three weeks and collecting detailed information about their willingness to share their locations with others. A second objective of our work is to understand to what extent differences in location-sharing preferences between the U.S. and China have effects on the design and likely adoption of location sharing and location-based advertising. For instance, to what extent do both populations require similar (or different) privacy settings?

Our study compares location-sharing preferences of two similar groups of participants in the U.S. and in China over the course of three weeks. Both groups were recruited on the campus of prominent universities. Participants of these two groups included both undergraduate and graduate students and were selected to be demographically similar. While these groups are certainly not representative of the broad population in each country, they capture a representative fraction of likely early adopters of mobile social networking applications. We analyze data collected about the willingness of these users to disclose their location under different conditions encountered as part of their daily lives and discuss both similarities and differences between the two groups. Where possible, we attempt to interpret differences based on cultural[1] factors, including life style differences.

Our analysis examines different aspects of participants' location-sharing preferences. This includes comparing their mobility patterns as well as their willingness to share locations with different types of recipients. It also includes examining how different conditions influence participants' willingness to share their locations, such as particular days, times of the day, and current location. Finally, we also look at differences in granularity at which people are willing to share their locations.

For both groups, we found that people's willingness to share depends significantly on with whom the location is shared. When it comes to a finer analysis of people's privacy preferences, there are, however, some interesting

[1] By "cultural factors", we mean to refer to a broad range of considerations, including beliefs, moral values, traditions, lifestyles, and related behavioral habits.

differences. For example, U.S. students were significantly less concerned about sharing their locations at 'work' (i.e. where they were studying or working on campus) relative to when they were at 'home' (i.e. where they lived. For undergraduate students, it could be dormitory on campus), whereas Chinese participants reported both locations as being equally private in most cases. In addition, we found that Chinese participants appeared to require more specific control over the times when their locations can be shared, such as the ability to differentiate between requests made during and outside work hours. When given the ability to control the resolution at which a location is disclosed (e.g. street address versus city), the two groups had substantially different privacy preferences. These and other findings have implications on the types of privacy settings one would want to offer to the two groups. They also suggest that early adopters of these applications could be different in the U.S. and China.

We acknowledge that fully understanding how culture influences location privacy will require a long-term research effort. What we offer here is a starting point, and we hope it can offer a useful perspective in the ongoing conversation in the HCI community regarding privacy.

2. Related Work

2.1. Location-sharing Studies

The past few years have seen the launch of many location sensing and sharing applications [13,1,14,15,3,16,17,8]. Many researchers have studied users' needs and concerns while using such applications. Some of this work has shown how lack of proper privacy controls could be a significant impediment to broad adoption of some of these applications [1-8].

For example, Sadeh et al. reported on the benefits of exposing location-based and time-based attributes to help users better control the conditions under which they are willing to disclose their location [8]. Tsai et al. showed that letting users know who has viewed their location information was important for improving comfort level and allaying privacy concerns [7]. Iachello et al. [5] argued that it is essential for applications to support plausible deniability when disclosing locations. Using hypothetical requests [6] and ESM [15], other researchers found that the primary factor mitigating users' location-sharing preferences was the relationship between the sharer and recipient. The purpose of sharing and the necessary level of detail needed by the recipient have also been shown to factor into users' decisions in sharing, albeit to a lesser degree. Benisch et al. quantitatively compared the effectiveness of different privacy-setting mechanisms used in location-sharing applications [2]. They compared the benefits of different combinations of privacy settings including whitelists, time-based settings, and location-based settings to determine the accuracy with which they could capture people's privacy preferences. Their results suggest that offering users richer privacy settings, such as those enabling them to control the disclosure of their location based on time of the day, day of week, or current location, could increase overall sharing and facilitate adoption. Others have also shown how these findings can in part be reconciled with user-burden considerations, by leveraging default privacy personas and user-oriented suggestions to refine one's privacy preferences [18,19] .

Toch et al. showed how different devices (i.e., mobile phones versus laptops) and the nature of locations visited (e.g., home versus work) impact the type and sophistication of users' privacy policies [20]. Tang et al. [21] suggested that using location abstractions can simplify privacy rules and encourage more sharing. Lin et al. studied how people modulate the disclosure of location information when it comes to sharing their whereabouts with different groups in different contexts. Using a taxonomy of location naming schemes, they further showed

they could often predict what kind of scheme people would want to use to disclose their location to others in different contexts [22].

These studies all provide valuable insights into people's location-sharing privacy preferences. However, they were all conducted in the U. S. and do not provide insight into potential differences in privacy preferences across multiple countries or cultures. To the best of our knowledge, our study is the first to consider similarities and differences in the location-sharing preferences of comparable user groups in a major Western country (the U.S.) and a major Asian country (China). In addition, it is also the first to systematically examine the impact of allowing people to disclose their locations at different levels of granularity on their sharing preferences – and compare this impact across two countries.

2.2. Cross-cultural Information Sharing and Privacy Studies

There is a lot of past research exploring the personalities, culture, and systems of thought of different countries and regions in the psychology and social science literature [23,24]. However, to the best of our knowledge, there has been no prior research on comparing privacy preferences in the context of location sharing.

The most relevant literature focuses on cross-cultural comparisons of self-disclosure and information sharing. Many researchers have found that East Asians are less likely than Westerners to disclose sensitive personal information [12,11]. Ardichvili et al. [25] investigated online information sharing behavior in Brazil, China, and Russia, and argued that high-level cultural characteristics, such as degree of collectivism [23], may explain some of the differences among the three countries. Schug et al. [26] surveyed Japanese and U.S. university students regarding self-disclosures with close friends. They found that cross-cultural differences in these self-disclosures were mediated by an individual's perception of relational mobility, which is the degree to which individuals in a society have opportunities to form new relationships. Chapman et al. [27] focused on usage patterns of Social Network Sites (SNS). They conducted cross-cultural interviews with SNS users in four countries including China and the U.S, and found that Chinese SNS users were generally more conservative about sharing personal information. He et al. [28] used scenario-based studies to examine how people shared positive and negative information online and offline with different types of relationships in the U.S. and China. Their results suggest that Chinese and Americans had different perspectives on how and when information should be shared.

Other relevant work has looked at cross-cultural aspects of information privacy. Bellman et al. [29] conducted a survey using a sample of Internet users from 38 countries. They found that "cultural values were associated with differences in privacy concerns" and "cultural differences are mediated by regulatory differences." Cho et al. [30] surveyed 1261 Internet users from India, Korea, Singapore, Australia and the U.S. regarding their perceptions and behavioral responses in the context of online privacy. They found that national culture influences people's online privacy concerns and privacy protection behaviors. Wang et al. [31] studied SNS users' privacy attitudes and practices in America, China and India by conducting an online survey. They reported that American users were more concerned with privacy than their Chinese and Indian counterparts.

As the first comparative study of location-sharing preferences between China and the U.S., we provide quantitative behavioral evidence suggesting interesting differences in the needs and concerns of these two groups. While our results in the context of location-sharing privacy are generally consistent with overall findings reported in the more generic studies identified above, they also identify finer differences. They offer insight relevant to the design of privacy settings for each of these countries and also suggest somewhat different paths to early adoption of location-sharing applications and location-based advertising in the U.S. and China.

3. Empirical Study

To gather data on people's location-sharing preferences under different situations, we conducted a three-week study in Dec 2010 at Beihang University in Beijing, Chinese university and repeated the same study in Feb 2011 at Carnegie Mellon University in Pittsburgh, the United States. Our research group consists of undergraduate and graduate students from both universities. A number of team members at each university are bi-lingual and have spent extensive time in both countries. All the materials (surveys, web applications, flyers, etc.) were originally written in English, then translated into Simplified Chinese for participants in China.

3.1. Participants

We recruited two demographically similar groups of participants with similar educational backgrounds at Beihang University in Beijing, China and Carnegie Mellon University in Pittsburgh, U.S.. Both universities are located in major metropolitan areas and are top universities covering extensive disciplines. Thirty students (undergraduate and graduate students) were recruited at each university using mailing lists and flyers posted around the campus. To avoid confounding factors, recruitment at each university was limited to nationals of the country where the university is located. One U.S. participant dropped out midway due to personal reasons. Among the 59 remaining participants, the average age was 22 years old (μ_{us}=21.8, σ_{us}=8.7, μ_{cn}=22.0, σ_{cn}=1.9); twenty-nine were female (15 Chinese females and 14 U.S. females). Participants were evenly split between those affiliated with technical (e.g., natural sciences, engineering) and non-technical fields (e.g., arts, sociology, and business). Participants received a $45 gift card (￥300 RMB) at the end of the study. The higher incentive paid to Chinese participants (relatively speaking, with respect to GDP per capita in China) was due to the adaptation we made in data collection, i.e. Chinese participants were asked to use the phone provided by us as their primary phone and upload data once a day manually. We will justify this adaptation in session 3.3 in detail.

3.2. Part 1: Entrance Survey

Participants completed a 10 minute online survey to collect demographic and social network information. As part of this survey, we collected participants' home and work addresses for further data analysis.

3.3. Part 2: Location-sharing Data Collection

In the U.S., we installed our location tracking application on participants' own smartphones (iPhones and Android phones) to collect their location traces. The software ran continuously in the background without user input, using both GPS and Wi-Fi positioning. Participants' best available location was sensed and uploaded to our server approximately every 5 minutes. Note that many smartphones sold in China before 2010 do not support Wi-Fi due to government regulations. To ensure accuracy, we provided our Chinese participants with Wi-Fi enabled Nokia N95 smartphones, in which they installed their own SIM cards – to ensure they would use them as their primary cell phones. The phones came equipped with our location sensing application pre-installed. This application had similar functionality and sensing frequency as the one used in the US. However, instead of uploading data in real-time, the sensed data was stored locally on the phone and uploaded by our participants using our web application once a day via their personal computers. We believe that this small adaptation just added a small step to the tasks our participants were requested to perform each day. Also since participants in both groups didn't need to interact

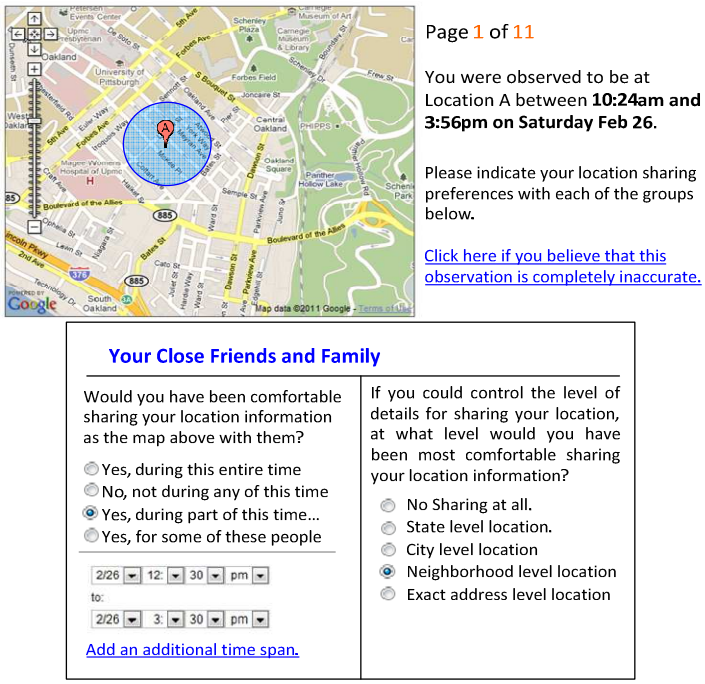

Figure 1: Screen shot of our web app. A map with timestamps was displayed to help participants remember the locations at which they had been. Questions about their willingness to share their location with members of four different groups (Close friends and Family, Friends on SNs, Members of the University Community, Advertisers) were displayed just under the map.

with the location sensing application, what type of phones they were using did not have significant effects on our participants' behavior nor influence the results we collected.

Once the data was on our server, the recorded Wi-Fi Access Point (AP) addresses were translated into geo-coordinates via Skyhook APIs [32]. We used a method similar to that described by Benisch et al. [2] to process the location readings sensed by our tracking application. Location readings were aggregated into either a *location observation* (if the participant stood still) or a *path observation* (if the user moved). A new location observation was created when a participant moved by more than 250 meters from his or her last known location and remained stationary again for at least 15 minutes.

We adopted the Day Reconstruction Method (DRM) [33] to collect participants' location sharing preferences. The location traces we captured by our mobile application provided participants with clues to recover their daily experiences. During the course of 3 weeks, participants were asked to log onto our web application once a day and answer questions about each place they had visited (location / path observation). These questions probed participants' preferences regarding sharing their location with four types of potential recipients – the same types identified by Benisch et al. [2] (close friends and family, friends on Social Networking Sites, university community, and advertisers[2]) in two cases. In the first case (referred to as the *all-or-none case*), subjects only had the option to share an exact location or not disclose any location at all. In the other case (referred to as the *granularity case*), participants could choose to manipulate the level of granularity at which their location would be disclosed. For example, in Figure 1, a participant was observed at location A between 10:24am to 3:56pm on Feb 26, 2011. She was asked to respond to both of the following:

[2] By advertisers, participants were specifically instructed to think of location-based advertisers.

1. How comfortable she would have been sharing her location with each recipient type at that time.[3]
2. At what level of granularity she would have liked to disclose her location (e.g., state, city, street, etc.).

For each place visited, the same questions were repeated for each of the four recipient types. We remind participants to complete tasks on time by emails. Note that no real location sharing took place in this study. Requiring participants to review their locations and answer these questions once a day was intended to ensure that they would remember the context at each location and would be able to provide accurate characterizations of the location sharing preferences. This same approach has been successfully used in other similar studies (e.g. [2]).

3.4. Part 3: Exit Survey

Participants completed a 10 minute online survey after the three-week period. In this survey, our participants were asked to reflect their location sharing preferences in general. Our participants were asked to rank the importance of four different factors on their willingness to share their location, namely type of recipient, time, type of place at which they are, and granularity of the location disclosure. They were also asked to evaluate their experiences in the study for us to possibly improve our methodology in the future.

3.5. Part 4: Optional Interview in China

We also gathered qualitative feedback from our Chinese participants to make sure there were no translation, misunderstanding or other unexpected issues that might compromise our comparisons. Furthermore, since it is the first time a location-sharing user study conducted in China, we would like obtain more direct evidence to study the rationale behind Chinese participants' sharing preferences. Our Chinese participants were given the option to sign up for a 15-minute phone interview in Mandarin Chinese. Ten participants (5 females) agreed to participate in the interview. In the interview, we asked participants to justify the reasons for sharing or not sharing certain locations in general. We also asked for their feedback on the overall design and conduct of the study.

4. Comparing Location-sharing Preferences between China and the U.S.

In this section, we examine data collected under part 2 of our study. Specifically, we present and compare data along several dimensions, including mobility patterns, willingness to share with different recipient types, as well as impact of one's location and time of day on willingness to share. We also look at gender differences and the impact of allowing people to modulate the granularity of their location disclosures.

4.1. Mobility Patterns

Our location tracking application collected location readings (i.e. geo-coordinates) during 82% of the study duration in the U.S., i.e., 147,238 location readings from our 29 U.S. participants. Due to lower coverage of Skyhook's Wi-Fi AP position data in China, we collected only 101,553 location readings from Chinese participants, or 55% of the study duration. The missing readings occurred either because participants turned off their cell phones at night (about a third of our Chinese participants did this) or because the participants were

[3] For the university community and advertisers, participants only had the first three options to choose.

Rank (Time Spent)	**China**	**U.S.**
(Home) 1	56.94%	51.91%
(Work) 2	31.38%	25.62%
3	6.17%	9.45%
4	2.58%	4.53%
5	1.01%	2.40%
Total	98.08%	93.91%

Table 1: Percentage of time participants spent at the Top 5 most visited locations, e.g., Chinese participants on average spent 56.94% of their time at home.

indoors (no GPS signal available) and the nearby AP addresses could not be resolved to geo-coordinates through the Skyhook API. We post-processed these location readings and interpolated the missing data using previous and subsequent available readings before they were shown to the users. This enabled us to accurately recover the location of those Chinese participants who had turned off their phones at night.

We then aggregated consecutive location readings into location or path observations as mentioned in Session 3.3. Based on participants' per-observation feedback, 89.3% of these identified places were marked as accurate by our U.S. participants. Among these accurate observations, each U.S. participant visited 17.87 distinct places[4] on average over a three-week period (median: 17, σ=8.78). In China, 91.5% of identified places were marked as accurate, and each Chinese participant, on average, visited 6.47 distinct places (median: 7, σ=3.21). The significant difference ($t(35)=6.57$, $p<.0001$ in two-sample t-test assuming unequal variances) in the number of distinct places visited by the two groups might be partially attributed to the lower tracking coverage in China. However, in the exit survey, Chinese participants indicated that most of the places they had visited had been captured. This leads us to believe that even with more comprehensive tracking coverage in China, the mobility differences between the two groups would still be statistically significant.

We further calculated the percentage of time participants spent at each of their top five most visited places (see Table 1). The top two places stood out, which corresponded to the place they lived and the place they were study or working on campus based on information provided in the entrance survey.[5] Throughout this paper, we would use 'home' and 'work' to refer to these two type of location for convenience. Table 1 also indicates that Chinese participants on average spent 11.68% of their time at places other than 'home' and 'work', whereas their U.S. counterparts spent 22.47% ($t(45)=2.79$, $p<.01$ in two-sample t-test with unequal variances) at such places. The top five places covered 98.08% of traces of our Chinese participants, and 93.91% of their U.S. counterparts.

In general, our results suggest that U.S. participants spent significantly more time at diverse places other than 'home' and 'work' compared with their Chinese counterparts.

4.2. Location Disclosure in Different Scenarios

In this subsection, we study participants' location disclosures in different contexts, including different recipients (with whom they share the location) and the semantic meaning of the place they were when the hypothetical

[4] A place was considered distinct only if it was 250 meters from all other distinct places and the subject spent at least 15 minutes there.

[5] The work address usually referred to a campus building where he spent the most time on weekdays. For participants who lived on campus, home addresses referred to their dormitories.

	China		U.S.		df	t (two-tailed)	p
	Mean	SD	Mean	SD			
Close Friends and Family (CF)	70.63%	11.03%	81.46%	13.86%	53	3.31	<.01
Friends on SNS (SN)	24.53%	8.47%	39.05%	18.66%	39	3.82	<.01
University Community (UC)	46.87%	6.31%	44.54%	8.25%	52	1.22	0.22
Advertisers (AD)	17.61%	3.22%	21.06%	7.11%	39	2.38	0.08

Table 2: Percentage of time participants would be willing to share location information with four types of recipients. Two-sample t-test assuming unequal variances was conducted to verify the significance of comparisons. On average, Chinese participants were willing to share their location with Close Friends and Family (CF) 70.63% of their time during the study.

sharing happened, since participants from both countries reported in the exit survey that these two factors were the top 2 most important factors affecting their comfort disclosing their location.

To investigate how these two factors influence people's location sharing and whether they have different levels of impact on the two study groups, we calculated the average percentage of time participants reported being comfortable sharing their location in each context and use it as the dependent variable. Note that, in this subsection we limit our analysis to disclosures in the all-or-none case (i.e. disclosure granularity cannot be modulated).

4.2.1 Location Sharing with Different Recipients

We consider four types of recipients with whom locations might be shared: *close friends and family* (CF), *friends on SNS*[6] (SN), *university community* (UC), and *advertisers* (AD), the same four types studied by Benisch et al. in [2]. These four recipient types are rather different both in terms of relationship with the participant as well as potential size and diversity. We pre-processed the raw data by averaging the percentage of time each participant would be willing to disclose their location with the four recipient types.

Table 2 shows Chinese and U.S. participants' sharing preferences with the four different types of recipients. A two-sample t-test assuming unequal variance was used to test the significance of the comparison[7]. For both groups, participants shared the most with close friends and family (CF), followed by university community (UC), friends on SNSs (SN), and then advertisers (AD). Chinese participants on average were significantly more conservative (sharing less) with CF ($t(53)=3.31$, $p<.01$) and SN ($t(39)=3.82$, $p<.01$), marginally with AD ($t(39)=2.38$, $p=.08$) and almost indifferent with UC ($t(52)=1.22$, $p=0.22$) comparing to their U.S. counterparts.

Although willingness to share with UC was close between Chinese and U.S. participants, comparatively, Chinese participants were more comfortable disclosing their location to their university peers than with friends on social networking sites (SN_{china}: 24.53%, UC_{china}: 46.87%, $t(29)=2.90$, $p<0.01$in two-tailed paired t-test). In contrast, there is no significant differences in U.S. participants when sharing with both types of recipients (SN_{us}: 39.05%, UC_{us}: 44.54%, $t(28)=1.66$, $p=0.11$). We confirmed these results by studying the interactive effects between country and recipient type by performing the Random Effects Generalized Least Square Regression on nationality, recipient types and the interaction between the two. The detailed resulting model could be found in Appendix 1.

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[6] This group usually consists of a diverse population. It might also include random people our participants don't know in person.

[7] All the p-values reported in the paper are two-tailed.

	China		U.S.		df	T (two-tailed)	p
	Mean	SD	Mean	SD			
Home	38.48%	12.98%	44.08%	14.27%	57	-1.5753	0.1203
Work	42.39%	11.87%	52.27%	13.03%	56	-3.0416	0.0035
Other	42.01%	15.29%	44.00%	14.67%	57	-0.5102	0.6118

Table 3: Percentage of time participants would be willing to share location information with four types of recipients. On average, Chinese participants were willing to share their location with CF 70.63% of their time during the study.

This difference might be attributable to utility reasons, e.g., the need to locate one another for coordinating a social activity. It might also suggest that Chinese participants feel closer to members of their university community than US participants. Based on the individualism index introduced by Hofstede (IDV_{china}=20, IDV_{us}=91) [23,34,35], collectivism has been identified as a notable cultural trait in China, whereas individualistic attitudes seem more prevalent in the U.S. Accordingly, the difference in comfort sharing one's location within the UC could be interpreted as a reflection of a more collectivist attitude among members of the university community in China.

Overall, our results show that the type of recipient is one of the significant factors in determining willingness to disclose one's location – both in the U.S. and in China. This is consistent with prior studies conducted in Western countries [22,15]. In general, it makes sense that people are more willing to share their location with those they feel closer to. The interesting difference here is that Chinese participants feel slightly different to certain social groups from U.S. participants. For example, Chinese participants would appear to feel closer to members of their university community than to friends on social networking sites, whereas US participants seem to view both groups as equally close and hence are equally willing to share their location with both groups.

4.2.2 Location Sharing at Different Types of Places

Some earlier work [22,20,2] reported that the semantic meaning of the places people are at can have an impact on whether or not they feel comfortable sharing their location. To see if this finding extended to our Chinese participants, we analyzed the sharing preferences of both groups of participants at different types of places.

We categorized all the observed places into three major categories: "home", "work", and "other", where "home" refers to the places our participants live and "work" refers to the places they were studying or working on campus. We present the sharing preferences of both Chinese and U.S. participants at these three types of places in Table 3, and verify the significant of the comparisons using two-sample t-test assuming unequal variance. This table suggests that, U.S. participants on average were significantly more open sharing their location at 'work' than their Chinese counterparts ($t(56)=3.04$, $p=.0035$), whereas at 'home' or other places, participants from both groups have similar level of sharing on average. When comparing location-sharing preferences within each group, we also notice that U. S. participants' willingness to location share at 'work' was 8% more than their willingness at 'home' or at 'other' places ($t_{home}(28)=2.283$, $p_{home}=.0321$; $t_{other}(28)=2.285$, $p_{home}=0.320$ in paired t-test). However, type of location didn't differentiate the level of sharing on Chinese participant on average. Their willingness to share location at "home", "work" and "other" places are generally close.

4.2.3 Interactions between Recipient and Type of Place

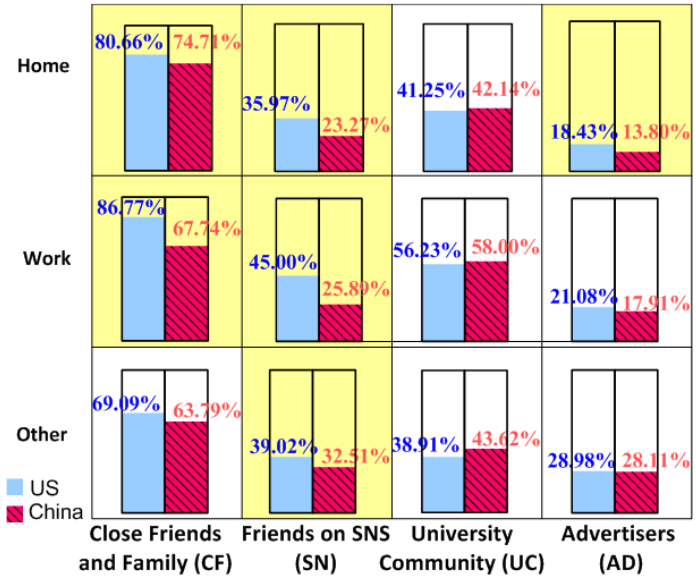

Figure 2: Average percentage of times shared at home, work and other places with different recipients. E.g., U.S. participants on average were willing to share 80.66% of the time with close friends and family when they were at 'home'. Highlighted grids mean significant differences (p<.05) in two-sample t-test assuming unequal variances.

In previous subsections, we studied the impact of two factors separately (i.e. recipient type and location type). We realize that, only looking into one factor at a time might over-simplify the problem. In fact, there were strong interactions between these two factors, i.e. the impact of these two factors might be canceled out or exacerbated in some cases. Therefore, in this subsection, we examine the interaction between these two independent variables. To help us more intuitively understand the data, we visualize the interactions between recipient and type of place in the 4 by 3 grids (see Figure 2). The highlighted grids indicate there exist statically significant differences ($p<.05$ two-tailed in two-sample t-test assuming unequal variances) between Chinese and U.S. participants.

When their locations were shared with close friends and family (CF), both groups shared the least when they were at 'other places'. U.S. participants were more willing to share their location at 'work' than at 'home', whereas Chinese participants on average did the opposite way. When the recipients were their friends on social network sites (SN), Chinese participants were particularly conservative when they were at 'home' and 'work'. In contrast, U. S. participants were quite open with their 'work' location but feel comparatively reluctant sharing 'home' and 'other places'. Prior research in psychology has suggested that people are less willing to share information that they view as being closely associated with their identity [12,11] especially with someone they don't know in person (e.g. advertisers and random people on social network sites). This would suggest that Chinese participants generally viewed both 'home' and 'work' locations as being particularly sensitive, whereas U.S. participants did not consider 'work' locations to be as personal as their 'home'. Our results also indicate that our US participants were more selective when it came to sharing information about other places they go to than their Chinese counterparts.

When sharing with UC, both groups of participants had similar level of sharing for all three types of places. When sharing with AD, they both had the highest percentage of sharing at 'other' locations. This is probably driven by utilitarian considerations: people are more interested in receiving location-based promotions when near restaurants, stores and other similar venues.

We also performed a Random Effects Generalized Least Square Regression on the complete set of variables including all possible interactions further verify these trends statistically. The detail of the resulting model can be

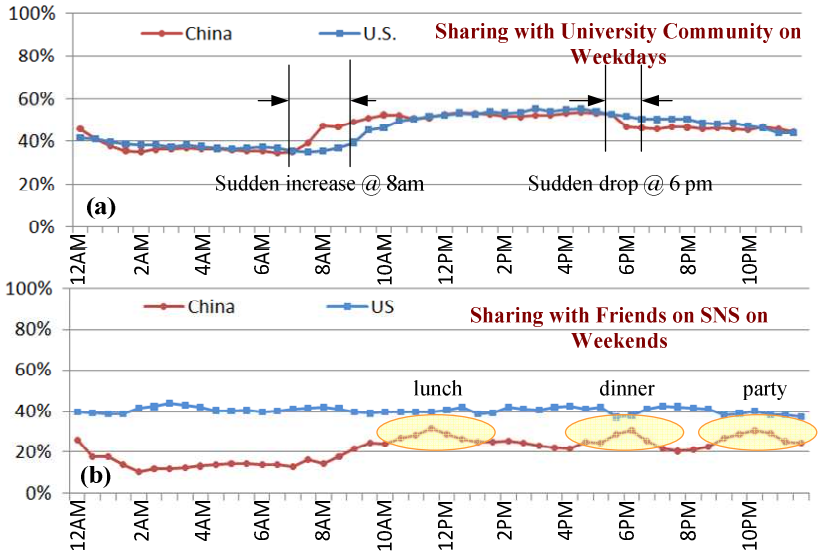

Figure 3: Sharing preferences breakdown by time: (a) sharing with University Community (UC) on weekdays (b) sharing with friends on SNS on weekends. In (a), on workdays, Chinese participants exhibit more sudden changes on their location-sharing preferences between working hours and personal time. In (b), on weekends among Chinese participants, we observed three peaks of sharing which could be corresponded to activities such as lunch, dinner and etc.

found in Appendix 3. By comparing the regression coefficients, we can also learn that recipient type have the greater impact than the location type on people's location sharing preferences for both participant groups.

4.3. Using Location Privacy Settings

In this subsection, we further analyze the privacy preferences of our U.S. and Chinese participants and discuss the benefits they would derive from different combinations of location-sharing privacy settings.

4.3.1 Time Control in Location Sharing

The first question we examine is whether or not participants' location-sharing preferences change with the time of day and day of week of the request, two important location-sharing settings identified by Benisch et al. [2]. We used the same procedure as in [2] to calculate the average percentage of sharing for every half-hour interval on weekdays and weekends in the all-or-none case (where participants only have the option of disclosing their location at the finest level of granularity or not disclosing it at all). In general, participants in both groups were more comfortable sharing their locations during the day – which is also closely correlated with not being at 'home'.

For example, Figure 3a shows the percentage of time participants were willing to share their locations with UC on weekdays during each 30-minute time interval (results for SN and AD were similar). The red dots represent the percentage of Chinese participants willing to share, and the blue squares represent the percentage of U.S. participants willing to share. In both groups, we observe that the amount of sharing from midnight to early morning is lower than during day time. Also, a sudden increase at around 8am and a sudden drop at around 6pm can be viewed on the red curve (China), whereas the changes on the blue curve (U.S.) are more gradual.

These sudden changes could be interpreted in two ways. One possible explanation is that Chinese participants have more differentiated location-sharing preferences for work and non-work hours. One piece of supporting evidence here was the choices participants made in the all-or-none sharing case where participants could choose to

share ‘during part of the time’ they were at a location and specify the time interval (see Figure 1). In our study, we found that the percentage of time that our U.S. participants selected this option was negligible (<0.5%), whereas Chinese participants selected this option occasionally when they shared their locations with CF, SN and AD (<6%), and quite often (14.62%) with UC. This observation suggests that U.S. participants made their sharing decisions primarily based on the type of place they were at and the target recipients, while Chinese participants considered time as an important factor as well. Several Chinese participants confirmed this in the optional interview after the study. For example, P3 said, “Although I’m still at school, it's my personal time. I don’t want to share (location) with my classmates or faculty after 6pm…” P5 also expressed a similar view: “I think (controlling) time is very important. I have different preferences for places I visited after working hours.”

Another possible explanation is that US participants also differentiate their location-sharing preferences based on time, however, their schedules were not as aligned as their Chinese counterparts. Therefore, after aggregating the data of individual participant, the changes between work and non-work hours were smoothed out. We didn’t have the chance to test this possible interpretation in either optional interview or exit survey, hence it remains an open issue that needs to be verified in the future work.

The second interesting pattern we observed is that U.S. participants have relatively stable sharing preferences during weekends, whereas Chinese participants had interesting peaks and valleys in the percentage of time they were willing to share their location. We plot the percentage of time that Chinese (red) and U.S. (blue) participants reported being willing to share their locations with SN during each 30-minute interval on weekends (see Figure 3b) as an example. As we mentioned before, Chinese participants were relatively more conservative in their sharing with friends on SNS. In addition, the blue curve (U.S.) is almost flat in different time slots, while the red one (China) exhibits significant changes based on time of day. We found that Chinese participants appeared to be very conservative during weekend nights but seem more willing to disclose their location over certain time intervals, e.g., around noon, 6pm, and 9-10pm. These time intervals seem to coincide with lunch, dinner, and social times. This would suggest that Chinese participants' location sharing is more event-driven – or again, perhaps, that their schedules are more predictable or both.

4.3.2 Granularity Control in Location Sharing

We also asked participants to specify the most appropriate level of detail at which they would want to share their location information (granularity case), ranging from no disclosure, state/province-level disclosure, to address-level disclosure. The objective is to learn how participants would change their behavior if they have more expressiveness to modulate their sharing preferences, and whether the two groups of participants would behave similarly or not. From this analysis, we can also imply whether adding expressiveness could help increasing the adoption of location-sharing services in both countries.

We visualize the percentage each granularity level was used with four types of recipients in Figure 4. We observe for both groups of participants, a significant portion of time participants' location is modulated between State level and Neighborhood level. This means in many cases people had to squeeze their real granularity preferences into a binary choice -- either sharing the finest location or no sharing at all. In other words, both U.S. and Chinese participants would significantly benefit from settings that enable them to modulate the granularity of their location disclosures.

As reported in an earlier section, Chinese participants were generally more conservative than their U.S. counterparts in the all-or-none case (i.e., no granularity control). However, when given the ability to modulate the

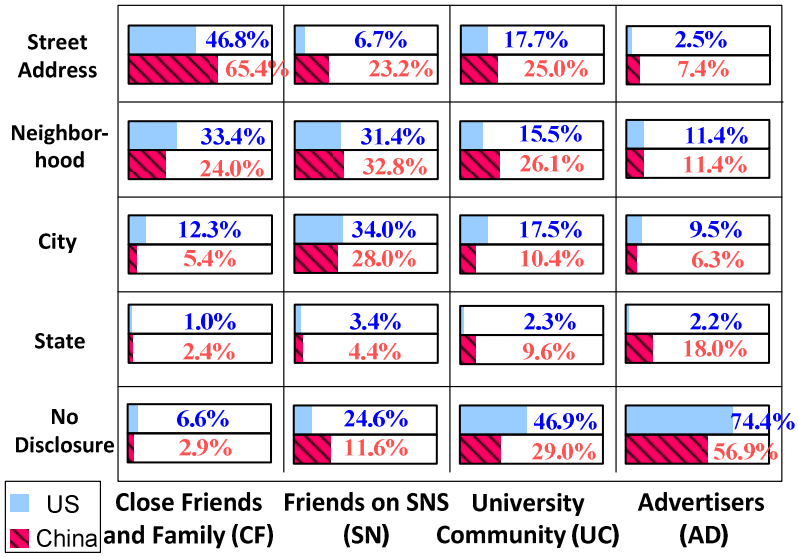

Figure 4: Granularity distribution with four recipient types by Chinese and U.S. participants. Chinese participants on average share more detailed location information with all four types of recipients. The numbers of same color add up to 100% in each column. In general, Chinese participants tended to share location with higher resolution than their US counterparts.

granularity of their location disclosures with each of the four recipient types, Chinese participants tended to share locations with higher resolution than their U.S. counterparts.

When sharing with close friends and family (CF), over 65% of the time Chinese participants reported being willing to disclose their address-level location, whereas U.S. participants only shared about 47% of the time at this granularity level. For sharing with friends on social network sites (SN), over 56% of the sharing was finer or equal to neighborhood level in the Chinese group, whereas only 38% was this fine in the U.S. group. Similar trends could also be found when sharing with the university community (UC) and advertisers (AD). Several Chinese participants confirmed this finding in the optional interview. For example, P1 said, "If I am willing to share (this location), I don't mind sharing with high resolution", P5 said, "Sharing location in neighborhood level is very vague and not useful at all. "

Furthermore, we studied the reasons why people chose different granularity levels by comparing their choices in both the "all-or-none" and "granularity" cases. We compared the average percentage of time participants chose NOT to disclose their location in these two cases (see Figures 5a, 5b). We found that for the Chinese participants, the majority of the no-disclosure cases in the all-or-none condition became sharable in the granularity case, especially when sharing with CF and SN recipient types (Figure 5a). The U.S. group also chose no-disclosure less often in the granularity case (Figure 5b), however this difference was not as significant as the one exhibited by their Chinese counterparts. In other words, the average percentage of time that Chinese participants reported being comfortable disclosing their locations increased more dramatically than that of U.S. participants when given granularity setting. This also implies that, in the absence of granularity setting, Chinese participants tended to strain their preferences towards the more conservative direction and chose to disclose nothing at all.

In Figures 5c and 5d, we compared the percentage of time participants chose to share their most detailed locations in the all-or-none case (best available location) and granularity case (street address-level location). For every recipient type, U.S. participants chose to share the finest location for a significantly smaller amount of time in the granularity case relative to the all-or-none case, whereas the reduction in sharing the finest location is very small among Chinese participants, especially when sharing with CF and SN. This suggests that, in the absence of

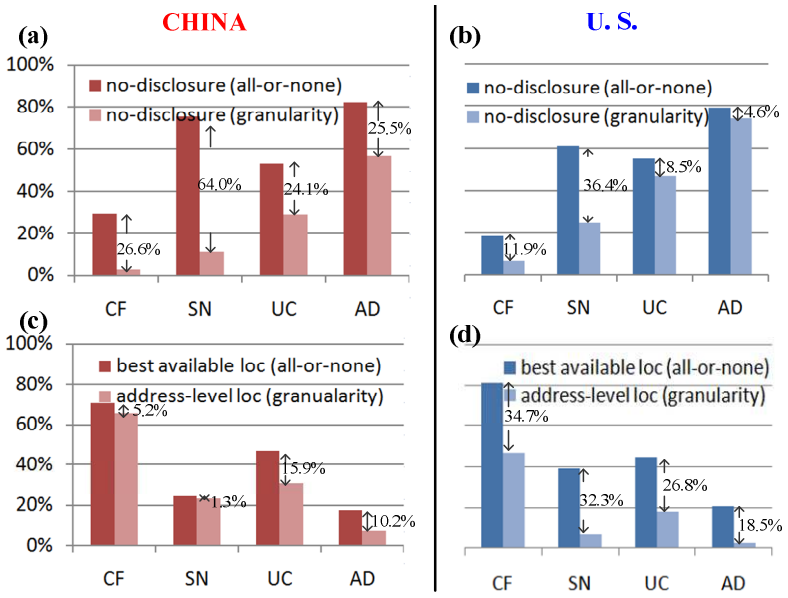

Figure 5: The average percentage of time participants share nothing and share the finest location in all-or-none and granularity cases. Red represents China and blue represents U.S.. In general, granularity control encouraged Chinese participants to share more location, whereas US participants used this additional control majorly for limiting the resolution of their sharing.

granularity settings, U.S. participants are more willing than Chinese participants to relax their preferences and share their finest locations even when doing so is not their optimal choice.

Thus, while it appears that in the "all-or-none" case Chinese participants are generally more conservative than U.S. participants, surprisingly, the opposite is actually true in the "granularity" case. A significant implication of this finding is that granularity settings are likely to be more important for adoption of location sharing in China than in the U.S.

4.4. Gender Differences in Location Sharing

Few location-sharing studies have attempted to quantify gender differences in location-sharing preferences, let alone compare these differences between different countries. Yet, significant gender differences have been reported in prior self-disclosure studies in the psychology literature [36,37,11,38]. Here, we attempt to see whether similar gender differences exist for location sharing preferences and to what extent they differed across the two participant groups.

We measured the average sharing time for female and male participants in the U.S. and China (see Table 4). Our data suggest that the participant's gender 1) matters, and 2) results in different attitudes in the U.S. and China. Overall speaking, Chinese female participants were significantly more conservative than Chinese males ($t(23)=-4.63$, $p<.0001$). In contrast, we didn't observe significant differences in sharing between US male and female participants when we average the results over all types of recipient ($t(27)=-0.86$, $p=0.396$).

When we break down the data into different recipient types, we observe several nuances within the general trend. While Chinese female exhibited conservative preferences consistently with all types of recipients, U.S. female participants show different attitudes with different recipients, i.e. a more open attitude towards sharing with CF and SN than U.S. males, but were more conservative when it came to sharing with UC and AD than males. This finding is consistent with several self-disclosure studies conducted in the U.S. and Europe [36,37,11]. These studies suggest that females generally have higher levels of self-disclosure with people close to them such as close

	Chinese Female	Chinese Male	df	t	US Female	US Male	df	t
Avg	28.78%	44.22%	23	-4.63 **	44.73%	47.95%	27	- 0.86
CF	63.59%	70.93%	24	-2.86 *	88.16%	75.29%	22	+5.05 **
SN	11.52%	33.35%	24	-7.90 **	44.06%	35.79%	27	+2.42 *
UC	26.91%	53.01%	21	-5.69 **	37.27%	49.43%	25	- 3.92 *
AD	13.10%	19.58%	28	-2.94 *	9.45%	31.29%	27	-13.11 **

Table4: Sharing preferences of different genders in two groups. Chinese female participants were strictly more conservative then Chinese males. U.S. females were more open when sharing with CF and SN but more conservative when sharing with UC and AD. * indicates that two-tailed p value is less than 0.05; ** indicates that p value is less than 0.0001

friends and family. Kolek et al. [38] also suggested that U.S. college women disclose personal information on Facebook at a greater level than men do across several areas, which is also consistent with our finding that U.S. female participants were more willing to share their location with the SN recipients than U.S. males.

Our finding could also infer that early adopters of location sharing services and location-based advertising in China are more likely to be males. In contrast, in the U.S., social network based location sharing might be better off targeting female users and location-based advertising businesses might want to first focus on males.

5. Discussion

Our main research objective was to study and compare the location-sharing preferences of participants in the U.S. and China. We believe different cultural backgrounds and life styles have great influences on people's sharing behaviors, particularly when it comes to sharing sensitive information like one's location.

5.1. Choice of Study Method

Many cross-cultural studies [25,12,11] have used surveys [26,31], interviews [25] or ethnography studies [27] as their primary methodology. Surveys can easily cover a larger sample size, but are generally restricted to simple self-reported facts. Prior research has shown that people's location-sharing preferences are highly context-sensitive, making such preferences less amenable to survey-based studies. While interviews and ethnographic studies could mitigate this limitation, they are resource intensive and difficult to scale. Many other location-sharing studies have used what is known as the Experience Sampling Method (ESM) [6,15], which requires interrupting users and can lead to large gaps in data if the prompts are ignored. We believe that capturing participants' whereabouts ground truth is essential to capture these diverse preferences, especially for places where participants stop by for only a short time. Hence, we opted for the Day Reconstruction Method (DRM) due to its better coverage and lower user burdens.

5.2. Study Limitations

We acknowledge that there were several limitations to our study. First of all, the participants were all university students, and some of the recipient groups, such as 'University Community' we probed might only be relevant to this specific population. As such they cannot be viewed as representative of the broader population. We believe that they are however a meaningful segment of the population to study, as they are likely early adopters of technologies such as location sharing. If anything, it could be argued that this segment of the population is also

more exposed to global cultural trends than the general population, and that cultural differences observed in this study might be further exacerbated if one were to look at the broader population of each country. Because this is just a conjecture, we feel more comfortable simply presenting our work as a first step towards understanding cross-country and cross-cultural differences in people's location sharing preferences, a domain where such studies had not yet been conducted.

Second, no real location sharing occurred in our study. One could argue that an actual deployment of a real location-sharing system might have yielded different results. We do not deny this possibility. However, actually sharing participants' location information would have led to challenges in recruiting participants along with people in their social networks. In addition, it would bring in extra variables that we have no control over in the study. As such, we believe that real location traces plus the per-location audit questions remain a reasonable method for estimating people's actual behaviors.

5.3. Design Implications

Our study is the first and only an initial exploration into the differences of location-sharing preferences between participants of two countries. Despite the limitations mentioned in the previous subsection, our findings suggest that there are significant differences between the two groups of participants regarding location-sharing preferences. These results have several design implications for future location-sharing applications (LSA). First, LSAs should consider providing different levels of privacy assurance to users with different cultural backgrounds. So far, location sharing is still a relatively unfamiliar service in China. Our findings suggest that in order for LSAs to be successful in China, these services will need to provide more privacy assurances to users.

Second, different cultures may have different control requirements for sharing their location data. For example, we observed that Chinese participants needed specific control over the time when their locations would be shared, while data from U.S. participants suggest that the type of place where they are might be enough. LSAs might consider providing different control mechanisms to cater to the diverse needs of users from different backgrounds or countries.

We also found that participants' sharing preferences were dramatically different when given additional control over how detailed their location information would be when shared. In our study, participants from both cultural backgrounds used many different granularities to accommodate their needs, which by itself is a significant finding and validates the availability of such controls in apps like Google Latitude[39]. However, Chinese participants used granularity settings primarily to maximize the amount of information they would be comfortable sharing, whereas U.S. participants used this control primarily to minimize their location disclosure. This finding suggests that introducing a more complex control mechanism could increase users' comfort levels, however, it might encourage or discourage users to share more information.

As the first work to demonstrate these differences, we also found that there is currently a lack of theory regarding design for cross-cultural differences. We believe this is an important area and strongly encourage communities to collaborate and contribute in this area.

6. Conclusion

Most existing location-sharing studies only involved participants from a single, Western cultural background. We conducted a three-week study collecting actual location traces and location-sharing preferences from two

comparable groups in the U.S. and in China to determine whether or not the two groups would significantly differ in their location-sharing behaviors. Our results revealed both similarities and differences between Chinese and American users. Chinese participants in general are more conservative in sharing their location comparing to their U.S. counterpart. The type of recipients and type of location both have significant but slightly different effect on the two groups of participants. In addition, Chinese and U.S. participants behave significantly different when given granularity control. Based on our findings, we offer design implications for future location-sharing applications that highlight tailoring privacy control mechanisms to accommodate users with different cultural backgrounds.

To the best of our knowledge, our work is the first research studying cultural differences regarding location sharing. Possible directions for future work include expanding the sample pools to more general populations from these two cultural backgrounds as well as investigating other factors of location sharing (e.g., the purpose of location sharing, plausible deniability, real-time feedback, etc). We acknowledge the challenge of generalizability of this kind of work, and hope that this paper can be viewed as a useful data point and a catalyst for more discussions about research on culture and privacy.

7. Acknowledgments

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Appendix

1. *Regression model predicting average percentage of sharing time on nationality and recipient type*

Sharing Time		Coef.	Std. Err.	z	p
	_cons	.6816	.0106	64.43	<.001
Country.	US	.1092	.0151	7.24	<.001
Recipient.	CF				
	SN	-.3975	.0150	-26.57	<.001
	UC	-.2230	.0150	-14.91	<.001
	AD	-.4890	.0150	-32.69	<.001
Country # recipient					
	US # SN	-.0051	.0213	-0.24	0.812
	US # UC	-.1195	.0213	-5.60	<.001
	US # AD	-.0597	.0213	-2.80	.005
Number of obs : 708 Group variable: userid Number of groups : 59					

2. *Regression model predicting average percentage of sharing time on nationality and location type*

Sharing Time		Coef.	Std. Err.	z	p
	_cons	.3752	.0198	18.92	<.001
Country.	US	.0601	.0282	2.12	.034
Location.	Home				
	Work	.0456	.0280	1.63	.104
	Other	.0415	.0280	1.48	0.139
Country # Location					
	US # Work	.0325	.0400	0.81	0.416
	US # Other	-.0232	.0400	-0.58	0.562
Number of obs : 708 Group variable: userid Number of groups : 59					

3. *Regression model predicting average percentage of sharing time on nationality , location type, recipient and all the possible interactions*

Sharing Time		Coef.	Std. Err.	z	p
	_cons	0.7350	0.0151	48.6600	<.0001
Country.	US	0.0570	0.0215	2.6400	0.0080
Recipient.	CF				
	SN	-0.4964	0.0210	23.6000	<.0001
	UC	-0.3285	0.0210	15.6200	<.0001
	AD	-0.6142	0.0210	29.2100	<.0001
Location.	Home				
	Work	-0.0575	0.0210	-2.7400	0.0060
	Other	-0.1026	0.0210	-4.8800	0.0000
Country # recipient					
	US # SN	0.0569	0.0300	1.9000	0.0580
	US # UC	-0.0639	0.0300	-2.1300	0.0330

US # AD	0.0193	0.0300	0.6400	0.5190
Country # Location				
US # Work	0.1370	0.0300	4.5700	<.0001
US # Other	0.0197	0.0300	0.6600	0.5110
Recipient # Location				
SN # Work	0.0710	0.0297	2.3900	0.0170
SN # Other	0.2257	0.0297	7.5900	<.0001
UC # Work	0.2177	0.0297	7.3200	<.0001
UC # Other	0.0988	0.0297	3.3200	0.0010
AD # Work	0.1239	0.0297	4.1700	<.0001
AD # Other	0.2517	0.0297	8.4600	<.0001
Country # Recipient # Location				
US # SN # Work	-0.0898	0.0424	-2.1200	0.0340
US # SN # Other	-0.0961	0.0424	-2.2600	0.0240
US # UC # Work	-0.1484	0.0424	-3.5000	<.0001
US # UC # Other	-0.0185	0.0424	-0.4400	0.6630
US # AD # Work	-0.1797	0.0424	-4.2400	<.0001
US # AD # Other	-0.0573	0.0424	-1.3500	0.1770
Number of obs : 708 Group variable: userid Number of groups : 59				