CIRCADIAN RHYTHMS OF FRIEND-MAKING BEHAVIOR: AN INVESTIGATION THROUGH ONLINE GAMING COMMUNITY

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Abstract

This research investigates the circadian rhythms of friend-making behavior using large-scale data from a social media platform, in particular a popular online gaming community. Enlightened by the notion of human biological clock and afforded by the massive yet fine-grained data, we longitudinally track the daily changes in actual friend-making activities of participants in the community and uncover regularities in this pertinent social behavior. We show that people are most likely to make friends at the night (e.g., 20:00, 0:00) and the least likely to do so in the morning (e.g., 8:00). This pattern was consistently observed after considering the number of available players, the players’ game levels, the effect of weekend, and time zones. The systematic variation unveiled in people’s friend-making behavior by hour of a day deepens our scientific understanding of this integral social behavior of human everyday life.

Keywords: Friend-making, Circadian rhythms, Biological clock, Online gaming community, Social media.
1 INTRODUCTION

Friend-making is undoubtedly a significant part of human life, and may serve many functions, including companionship and supportive role (Rook, 1990), as well as socialization and sustainment of identity and meaning (Hartup and Stevens, 1997). Compared to predetermined kinships, friendships are typically constructed through the actions of individuals on a voluntary basis (Adams and Allan 1998). Social media has in recent years emerged as a major platform for interpersonal relationship building and afford researchers with enormous yet fine-grained data for investigating human’s psychological states and behaviors including friend-making (Eagle et al. 2009; Dodds & Danforth 2010; Golder & Macy 2011). Users on these media are able to interact with and make friends with others sharing common interests and goals, and transcend geographical and temporal constraints in doing so as long as there is an Internet connection.

Although friend-making has a long tradition in sociology and psychology literatures, it still fascinates many scholars due to their unique nature and important sociological and psychological implications (Allan 1989; Fehr 1996). The extant research that investigates friend-making behavior has customarily focused on how friendships form, both in offline and online contexts, and identified such factors as individuals’ introversion-extraversion tendency, extent of self-disclosure, motive for social compensation, and frequency of online communication (Honeycutt & Bryan 2010; Parks & Floyd 1996). While these studies substantially add to our understanding of friend-making, there is a paucity of attention on the temporal dimension of this pertinent social behavior. As evidenced by large-scale social media data in recent literature, strong temporal regularities exist in human behaviors (Dodds & Danforth 2010; Golder & Macy 2011; O’Connor et al. 2010). Previous studies have also hinted possible links between time and friend-making behavior, such that moods vary by time of a day (Golder & Macy 2011), while positive moods could lead individuals to be more sociable (Whelan & Zelenski 2012). However, the direct link between time and friend-making behavior has not been directly tested. The research vacuum is also likely due to the lack of micro-level, large-scale temporal information of human behaviors including friend-making.

As human’s interactions leave microscopic traces on social media platforms so that digital lenses can reveal human’s friend-making patterns through information flow (Lazer et al 2009), we can now observe humans’ friend-making behaviors previously invisible and answer the following question, “Are people more likely to make friends during certain hours of a day, and refrain from doing so during the other hours?” Through investigating the daily waxes and wanes of friends; otherwise they may be irritated for their private time being disturbed.

2 CONCEPTUAL BACKGROUND

Our research is primarily informed by the notion of human biological clock that is closely related to time. Human biological clock is a self-sustained oscillator with an inherent frequency underlies human 24-hour periodicity (Aschoff 1965). The concept could be traced back to the discovery of rhythmic body temperature fluctuation by Gierse in 1842, which inspired a series of clinical and physiological studies that found other functions of human body to exhibit a similar circadian rhythm controlled by human biological clock (Aschoff 1965). Such physiological rhythmicity, which is found to persist even in temporal isolation (i.e., where a person is isolated in a closed room with no access to the 24-hour clock time) (Roenneberg et al. 2007), was later extended to inform various forms of
human behavior. For instance, it has been shown that accidents and errors in tending machines or in reading indicator boards are most likely to occur at 3:00 in the morning (Menzel 1962). Laboratory psychologists have also indicated that the circadian rhythm of body temperature is closely associated with the degree of a person being an introvert or extrovert, as well as his performance efficiency (Blake 1967; Colquhoun 1960).

More recently, researchers reveal a strong daily regularity of human communication patterns by observing messaging behavior of over four million Facebook members (Golder 2007). Twitter messages were analyzed to discover what scientists referred to as ‘pulse of the nation’ as it varies across the week and moves across time zones (Mislove et al. 2011). Human biological clock was also found to influence individual mood, such that people typically wake up in a good mood that deteriorates as the day progresses, while their negative moods reach the peaks at night and early morning (Golder & Macy 2011). Additionally, an association was indicated between a person’s mood and her sociability, such that positive moods may lead the person to be more sociable (Moturu et al. 2011; Whelan & Zelenski 2012).

Tying up the findings from these studies, one may infer that human biological clock could potentially influence people’s friend-making behavior as well. Specifically, there should be systematic variations in people’s tendency to make friends with others according to time of a day i.e., demonstrating clear circadian rhythms. This study seeks to test and uncover the patterns and dynamics of this behavior in a comprehensive, fine-grained manner using large-scale data from a popular online gaming community.

3 RESEARCH METHODOLOGY

Our study employs data from a popular Massive Multiplayer Online Role Playing Game (MMORPG) in China. Among all genres of online games, the popularity of MMORPG is especially prominent, and vibrant social communities typically form among players in these games (Chen et al. 2006). In the game world, each player performs various tasks and also meets other players. Similar to other online social network sites, the game provides strong functionality to enable players to interact socially. To add other player as a friend in the game, one can click on that player’s profile picture or through an “Add Friend” button in the menu under the picture. A player can unilaterally add another player as a friend, while the latter will be informed immediately when he is added as the former’s friend. Adding one as a friend allows the player to easily communicate and team up with that friend, to share news and to complete tasks together. Our data contain 8-million game players and their friend-making behavior during a three-month period from January 1 to March 31, 2011 (eighty days in total; ten days are missing due to game server maintenance). We have three sets of information: (a) each friendship made between two players during the period and when it was made (date and time of day), (b) each player’s “potential” friends, i.e., other players that she or he has met and thus has a chance to make a friend, and (c) each player’s personal characteristics (e.g., ability level in the game, IP address).

This data have two advantages which greatly facilitate our investigation. First, the detailed timestamps of friendship formations is rare in data from other online communities. This is because the servers in most social network sites (e.g., Facebook) usually do not record the time when users made friends with others. Unless researchers are able to track the daily evolution of network structure, the date (but usually not the time of day) of friendship may be obtained. Second, the information on “potential” friends is also rarely observed in other online communities. Typical social network sites do not provide users’ viewing history. Therefore, researchers do not know what users actually see and who they met at the moment when they decide to make new friends. This information is critical to measure one’s inclination of making friends; for example, a user has made more friends simply because she has met more people than others and not because she is more willing to make friends. This difficulty can be alleviated in our case. Because the major social activity of players is to team up with others to complete various tasks, we deem it reasonable to assume a player’s teammates as his or her potential friends. As our data contain all the team compositions and when these teams were formed, we are able to observe all the teammates of a player and when they met.
In contrast to the self-report methodology applied in offline studies, our measures are not prompted by an experimenter, or recollected after the event. Rather, they were directly recorded by the game server in real time, from players who were not interrupted in their usual course of behavior. Therefore, the data collected are less vulnerable to memory bias and experimenter demand effects. In addition, instead of relying on a small, homogenous sample, we analyze a large sample of individuals across the whole China with diverse backgrounds; players in this game come from different age groups, genders, income levels and geographical areas.

3.1 Friend-making Probability Measure

We computed the probability of making friends by individual players in the following way. For each player in a given hour, we counted the number of his or her ‘potential friends’ \((PFnd)\) and the number of friends she made \((Fnd)\) during this hour, then calculated the following probability:

\[
P(u, h) = \frac{[Fnd(u, h)]}{[PFnd(u, h)]}
\]

, where \(u \in U\) and \(U\) are all the players in our sample, \(h \in H\) and \(H = \{0…1919\}\) (assuming 0-23 for day 1, 24-46 for day 2, and so on). For example, in a given hour, if a player has teamed with three strangers to form a team, then he has three potential friends. Suppose that he has made friend with one of them, then \(P(u, h)\) is 0.33 for this given player-hour. Note that, if a player has not logged in the game in a certain hour or has logged in but met no potential friend, we coded the probability for that player-hour as missing. Because our focus is on circadian rhythm, we examine how the probability varies as a function of hour of day, and average \(P(u, h)\) for each given hour of day (0-23 hour) over the three months.

Conceptually, when \(P(u, h)\) in two hours are different, there can be two possibilities: individual players have different inclinations to make friends in these two hours (i.e., within-individual variations), and different players present in the two hours and they vary in their baseline probabilities (i.e., between-individual variations).

To measure within-individual variations, for each user, we first calculated his or her baseline probability \((BSP)\) (averaging \(P(u, h)\) across all the hours for this individual):

\[
BSP(u) = \frac{1}{|H|} \sum_{h \in H} P(u, h)
\]

Then the within-individual measure \((WP)\) is computed as follows:

\[
WP(u, h) = P(u, h) - BSP(u) + \frac{1}{|UH|} \sum_{h \in H, u \in U} P(u, h)
\]

That is, the within-individual measure represents the individual player’s deviation from her own baseline probability, allowing us to focus on her waxes and wanes of friend making behavior by hour of a day. The last term is the grand mean across all players over all the hours (in our case, it is 0.004733; all player-hours are equally weighted). Adding this term does not change the shape of the pattern, but only shifts up on the y-axis, producing easier interpretations.

The between-individual variation is computed as follows:

\[
BP(h) = \frac{1}{|U(h)|} \sum_{u \in U(h)} BSP(u)
\]

where \(U(h)\) refer to all the players who were playing the game during hour \(h\). A higher \(BP(h)\) indicates that the players in that hour are more active players in terms of their general inclinations of making friends.
Because our purpose is to uncover any circadian rhythms in individuals’ friend-making behavior, most of our analyses will be based on the within-individual measure, consistent with Gloder & Macy (2011). Nonetheless, we also checked against the effect of between-individual variations, since it is possible that players in the game in a certain hour could be more active than those in another hour, contributing to differences in the collective probabilities of making friends.

3.2 Results

We observed 120,142,105 friend pairs being established during the data period. To examine within-individual variations, we must ensure to observe a player’s friend-making behavior more than one time, so that we selected 732,426 players who have logged in the game at least three days during the three-month period. For 7% of these players, they logged in the game but did not participate in any team activity (i.e., zero potential friends), so that they were excluded in our analyses. This led to a sub-sample of 679,213 players.

In the sample, 19% of the players made at least a friend during the data period (i.e., $BSP(u)$ is non-zero). Figure 1 depicts the distribution of the baseline probabilities for these players; 99% of the players have a baseline probability of making friends lower than 0.20.

![Figure 1. Distribution of the Probability of Making Friends](image1)

![Figure 2. Probability of Making Friends by Hour of Day](image2)
Figure 2 depicts the collective probability of making friends by hour of a day. Interestingly, it shows a clear diurnal variation. The probability was lowest at 7:00 in the morning (M = 0.0020, SD = 0.0001); after that it increased sharply and then reached the peak at 20:00 at the night (M = 0.0067, SD = 0.0001; t(460,015)=55.61, P < 0.001).

We decompose the above collective pattern into the between-individual variation and within-individual variation. The between-individual pattern (Figure 3a) indicates that players at different times are indeed different in their inclinations of making friends. For example, people who played the game at 6:00 in the morning (BSP = 0.0023, SD = 0.0099) are least likely to make friends, whereas people who played the game at 13:00 in the afternoon are most active in making friends (BSP = 0.0063, SD = 0.0170; t(489,344) = 101.93, P < 0.001). Clearly, the changes in the composition of players have non-trivial effect on the collective probability pattern.

Separating from the between-individual variation, the within-individual pattern (Figure 3b) is flatter but still exhibits a statistically significant variation across hours of a day (F(23, 6,432,744) = 38.43, P < 0.001). The circadian rhythm has a trough at 8:00 (M = 0.0041) and peaks at 20:00, 21:00 and 0:00 (all Ms = 0.0053; P < 0.001), indicating that individual players have a higher inclination of making new friends at the night than in the morning.

To rule out alternative explanations other than individual biological clock, we examined a few factors below that can potentially contribute to the pattern that we observed.

3.2.1 Number of Available Players

One alternative explanation for the observed circadian pattern is that the number of available players varies by hour of a day. When there are more players in the game, each player may be able to form a more desirable team which can increase the probability of making friends with his or her teammates. To examine this, we plotted the graph of the within-individual probability against the number of players online and players in PVEs (team-play in the game) (see Figure 4). For ease of comparison, we rescaled the two numbers so that they can fit into the same graph. We examined the correlations among the measures. The within-individual probability is only weakly correlated with both the number of players online (r = 0.0060) and the number of players in PVE (r = 0.0047), indicating the relative independence of the patterns from the number of available players.

Further, we regressed WP on the number of players in PVE (as it is highly correlated with the number of players online, we skipped the latter). Figure 4 shows that the residual still exhibit the rhythmic changes over time in a day (F(23, 6,432,720) = 32.29, P < 0.001). For example, the peak (0:00) (M =
0.0006, $SD = 0.0311$) is still significantly higher than the trough (8:00) ($M = -0.0004, SD = 0.0248; t(448,067) = 12.44, p < 0.001$).

**Figure 4. Comparison between WP and Number of Available Players**

### 3.2.2 Player Ability Level

We also assessed if players’ level attained in the game influences the probability of making friends. As a player achieves more pre-specified goals, he or she will progress through the levels from 1 to 40. We classified all the players into the low-level group (levels 1-12) and the high-level group (levels 13-40), each accounting for 50% of the players. In terms of the baseline probability, the high-level group has a significantly higher probability than the low-level group ($M = 0.0055$ vs. $M = 0.0041; t(679,190) = 29.63, P < 0.001$), indicating the more senior players have a higher inclination of making new friends. We further examined if the two groups differ in their temporal pattern of making friends.

Figure 5 shows that the high-level group has a more fluctuated probability – it is significantly lower than that of the low-level group in the trough period (from 2:00 to 8:00; all $Ps < 0.05$) but significantly higher in peak hours (20:00 to 22:00; all $Ps < 0.05$). It indicates that senior players are more selective in the time of making friends, whereas junior players are making friends at a more even rate in a day. Nonetheless, clear diurnal rhythm in friend-making probabilities is observed for both groups (e.g., the probability of the low-level group varies significantly in hour of day, $F(23, 2,804,638) = 20.04, P < 0.001$), which is in line with the general pattern that we observed previously.

**Figure 5. Probability of Making Friends by Ability Level**
3.2.3 Effect of Weekend

We also plot the patterns for weekdays and weekends in Figure 6. Both the curves exhibit similar cycle and have significant variation by hour of a day ($P < 0.001$), but they have some slight differences. The probability in the weekends declined for a longer period, from 0:00 to 12:00 (vs. 0:00 to 8:00 in the weekdays), but reached a much higher peak than that in the weekdays (e.g., $M(20:00) = 0.0058$ vs. 0.0052; $P < 0.001$). This seems to suggest that the inclination of being social is affected by the biological clock and sleep. Because people usually get up late in the weekends, their inclination of making friends also take off late, but having a longer sleep makes them even more active during the peak hours.

![Figure 6. Probability of Making Friends by Weekend/Weekday](image)

3.3 Further Test: Time Zone Effects

Logically, if rhythmic changes of friend-making probabilities are rooted in some internal physiological regularity controlled by human biological clock, this circadian rhythm should demonstrate deviations geographically corresponding to time zone changes. That is, when measuring the average P within user groups from the western districts (whose areas of residence can be observed by IP address), we can expect that the peaks and troughs should come later than the average. Meanwhile, since China has adopted an official, unified time of Beijing (GMT+08:00) for a long time, it is expected that this official time reconciles with the natural local time, exhibiting some interestingly compromised results of user behaviors.

We longitudinally divided China into three major time zones, namely the eastern (GMT+08:00), central (GMT+07:00), and western regions (GMT+06:00). Each region consists of several provinces (see Table 1). This division could only be taken roughly, considering the complex structure of many districts in China. Even so, the results turn out to be interesting, as the percentages of players from the three regions approximate those of the Chinese population (Table 1).
Table 1. Provinces and Populations of Three Major Regions in China, and Corresponding Percentages

<table>
<thead>
<tr>
<th>Regions</th>
<th>Provinces &amp; Populations</th>
<th>Population Percentages</th>
<th>Game Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western</td>
<td>Tibet 2.67M</td>
<td>27.01M, 2.07%</td>
<td>0.4%</td>
</tr>
<tr>
<td></td>
<td>Xinjiang 19.05M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qinghai 5.29M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sichuan 86.73M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yunnan 43.33M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>Sichuan 86.73M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hunan 43.33M</td>
<td>241.96M, 18.61%</td>
<td>21.9%</td>
</tr>
<tr>
<td></td>
<td>Shaanxi 36.74M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chongqing 31.07M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ningxia 5.72M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern</td>
<td>Other Provinces 1032.99M</td>
<td>1032.99M, 79.32%</td>
<td>77.8%</td>
</tr>
</tbody>
</table>

Figure 7. A Comparison among Users from Different Time Zones across China

Figure 7 depicts the results of the segmented analyses. As the largest group with nearly 80% of the population, the pattern of the eastern region remains identical to the average of the whole China, while the curves of the central and western regions demonstrate some subtle differences. An examination of the locations of their peaks and troughs reveal interesting insights. The first afternoon peak of the central region comes at exactly the same position as the eastern, while the second small peak appears one hour later. More evidently, the trough of this curve has a one-hour bias, when the night peak remains consistent with the average. In the western region, obviously all the peaks and troughs come one hour later than the average.

Based on the observations, it seems that the reconciliations between the political, official time and local, natural time did take place. The western region should have a two-hour bias and turned out one, with the central region demonstrating a ‘half’ hour bias while it should be one. Such rhythm of social behavior, clearly associated with some internal and external factors, is discovered to vary with time zone changes.
3.4 Regularity of Diurnal Rhythm of Making Friends

The Social Rhythm Metric (SRM) is intended to capture an individual's 'social rhythm', or the frequency with which daily activities are performed and the level of regularity associated with these activities (Monk et al. 1990). In the original study, the measure was completed in the evening by subjects before going to bed and tracking the timing of their 15 specific activities performed over the day. The timing of these activities (e.g., waking up, taking meals) is thought to contribute to the stability of an individual's daily routine or constitute their social rhythm. If the time an activity occurs on a given day is within $\pm 45$ min of the average time, it is considered a 'hit' (Shen 2008, Grandin 2006). Social rhythm regularity is defined by the number of activities that had three or more hits in one week (possible range=0–17 activities). Average frequency of activities is typically calculated by averaging the frequencies of all items that had been endorsed as regular (possible range=3–7 times) (Monk et al. 1991). The SRM has been found to be consistent and valid in a group of 50 healthy controls (Monk et al. 1990; 1991). Other evidence for the conceptual validity of the SRM is derived from studies that found SRM scores are correlated positively with other indices of social rhythm stability (Brown et al. 1996; Monk et al. 1994; Szuba et al. 1992).

In our study, SRM was applied to provide a further assessment of the stability of our observations above. Thus, the ‘activity’ here is defined as the key point, i.e. peaks and troughs of the circadian curves (i.e., highest and lowest observed friend-making probabilities respectively). Again, we focused on the within-individual variation. As shown in Figure 6, the aggregate pattern has two peaks at 21:00 and 0:00 for weekdays (20:00 and 0:00 for weekends), and one trough at 8:00 for weekdays (12:00 for weekends). In the following, we examined the peaks and troughs in each day during the three-month period. If a peak or trough matches the general pattern, then it is considered a ‘hit’. By examining the frequency of hit, we are able to measure if the circadian rhythm that we showed above is consistent across days.

<table>
<thead>
<tr>
<th>Date</th>
<th>Trough</th>
<th>Peak</th>
<th>Date</th>
<th>Trough</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-10</td>
<td>5</td>
<td>9</td>
<td>Jan-18</td>
<td>8(hit)</td>
<td>21(hit)</td>
</tr>
<tr>
<td>Jan-11</td>
<td>8(hit)</td>
<td>21(hit)</td>
<td>Jan-19</td>
<td>8(hit)</td>
<td>22(hit)</td>
</tr>
<tr>
<td>Jan-12</td>
<td>9(hit)</td>
<td>2</td>
<td>Jan-20</td>
<td>7(hit)</td>
<td>0(hit)</td>
</tr>
<tr>
<td>Jan-13</td>
<td>9(hit)</td>
<td>2</td>
<td>Jan-21</td>
<td>8(hit)</td>
<td>21(hit)</td>
</tr>
<tr>
<td>Jan-14</td>
<td>7(hit)</td>
<td>1(hit)</td>
<td>Jan-22*</td>
<td>8(hit)</td>
<td>0(hit)</td>
</tr>
<tr>
<td>Jan-15*</td>
<td>4</td>
<td>23(hit)</td>
<td>Jan-23*</td>
<td>12(hit)</td>
<td>20(hit)</td>
</tr>
<tr>
<td>Jan-16*</td>
<td>9</td>
<td>20(hit)</td>
<td>Jan-24</td>
<td>11</td>
<td>22(hit)</td>
</tr>
<tr>
<td>Jan-17</td>
<td>3</td>
<td>0(hit)</td>
<td>Jan-25</td>
<td>8(hit)</td>
<td>20(hit)</td>
</tr>
</tbody>
</table>

Table 2. Sample of Peaks and Troughs (Jan 10 to 24)
Note: * indicates weekend.

A sample of the SRM results is presented in Table 2 above. We also tried a more tightened measure by defining hit as exactly matching the specific hours. The results (Table 3) show that the majority of the peaks (65%) hit within the range of one hour, although the hit rate for trough is lower than 50%. The results are generally better than those reported in literature, with hit rates ranging from 0.58 to 0.62 (Shen 2008, Frank 2005), so they demonstrate that the circadian rhythm is relatively stable over the three-month period.


The objective of this study has been to tap on the advantageous large-scale yet fine-grained data afforded by social media to investigate the regularities in human’s friend-making behavior, which is a pertinent social behavior and key to sustaining social media communities. Our results indicate some interesting diurnal rhythm in friend-making behavior. People are more likely to make new friends at the night while are least to do so in the morning, suggesting the possible tendency of people to engage in relationship building after finishing their whole day work and before sleeping. Evidently, this also shows that friend-making behavior may be less related to mood states, as has been indirectly hinted by some previous studies (Moturu et al. 2011; Whelan & Zelenski 2012). As shown by Golder and Macy (2011), people wake up in a good mood that deteriorates as the day progresses, while their negative moods reach the peaks at night and early morning. Our results on the diurnal rhythm of friend-making (that people are most likely to make friends at the night and the least likely to do so in the morning) indicate that the two may not be closely in line with each other.

To ensure the robustness of our results, we performed further tests to rule out the possibility that the observations are caused by some alternative factors, such as the number of players available, and players’ ability level in the game. The observations of the rhythmic changes of friend-making remain after controlling for these factors, suggesting that such observations may indeed be associated with human’s internal physiological rhythm. A stronger proof for the existence of such rhythm is provided by the time zone tests. An application of SRM to further quantify the observations offers consistent evidences for the circadian rhythms in friend-making behavior.

Still, the findings of this study need to be interpreted in light of its limitations. Unlike survey, interview, and laboratory studies, we have the advantage of big data to conduct group-level analysis, but lack knowledge of the underlying psychological conditions that may influence individual choice of making friends (Honecutt & Bryan 2010; Parks & Floyd 1996). Hence, while this research unveils the general patterns in people’s everyday friend-making behavior, it could not offer a definite explanation for the reasons behind this intricate social behavior. Future research may endeavor to delve into the temporal dynamics in the psychological states associated with friend making across different timings of a day. Also our use of the online gaming context implies that we may be less able to assess friend-making behaviors involving close relationships. The relationship formation in such online environments may mostly involve weak ties. Lastly, the online game under study is situated in China, and cultural factor could influence our observations. Future research may want to investigate other cultural contexts to see if our results remain valid.

Despite the limitations, this study has important implications for both research and practice. At a high level the findings deepen our scientific understanding about the social behavior of friend making. The explication of clear circadian rhythms in friend-making behavior may also imply that social researchers need to take additional care in conducting their study. Specifically, social researchers may need to be sensitive towards the timing of administering a survey or an experiment. Supposed the objective is to assess the social inclination of individuals and its impact on certain behavioral outcomes, such as message propagation. If the survey or experiment is conducted wholly within a certain timeframe during which the peak or trough occurs, the results could be biased since the subjects tend to provide more/less socially favorable responses. A more ideal approach is to spread

### Table 3. Summary of the SRM Results

<table>
<thead>
<tr>
<th></th>
<th>± 1 hour</th>
<th>± 0 hour (tightened)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hit/Miss</td>
<td>Hit Percentage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hit/Miss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hit Percentage</td>
</tr>
<tr>
<td>Peaks (21:00&amp;0:00 in weekdays; 20:00&amp;0:00 in weekends)</td>
<td>52/28</td>
<td>65%</td>
</tr>
<tr>
<td>Trough (8:00 in weekdays; 12:00 in weekends)</td>
<td>36/44</td>
<td>45%</td>
</tr>
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4 DISCUSSION AND IMPLICATIONS

The objective of this study has been to tap on the advantageous large-scale yet fine-grained data afforded by social media to investigate the regularities in human’s friend-making behavior, which is a pertinent social behavior and key to sustaining social media communities. Our results indicate some interesting diurnal rhythm in friend-making behavior. People are more likely to make new friends at the night while are least to do so in the morning, suggesting the possible tendency of people to engage in relationship building after finishing their whole day work and before sleeping. Evidently, this also shows that friend-making behavior may be less related to mood states, as has been indirectly hinted by some previous studies (Moturu et al. 2011; Whelan & Zelenski 2012). As shown by Golder and Macy (2011), people wake up in a good mood that deteriorates as the day progresses, while their negative moods reach the peaks at night and early morning. Our results on the diurnal rhythm of friend-making (that people are most likely to make friends at the night and the least likely to do so in the morning) indicate that the two may not be closely in line with each other.

To ensure the robustness of our results, we performed further tests to rule out the possibility that the observations are caused by some alternative factors, such as the number of players available, and players’ ability level in the game. The observations of the rhythmic changes of friend-making remain after controlling for these factors, suggesting that such observations may indeed be associated with human’s internal physiological rhythm. A stronger proof for the existence of such rhythm is provided by the time zone tests. An application of SRM to further quantify the observations offers consistent evidences for the circadian rhythms in friend-making behavior.

Still, the findings of this study need to be interpreted in light of its limitations. Unlike survey, interview, and laboratory studies, we have the advantage of big data to conduct group-level analysis, but lack knowledge of the underlying psychological conditions that may influence individual choice of making friends (Honecutt & Bryan 2010; Parks & Floyd 1996). Hence, while this research unveils the general patterns in people’s everyday friend-making behavior, it could not offer a definite explanation for the reasons behind this intricate social behavior. Future research may endeavor to delve into the temporal dynamics in the psychological states associated with friend making across different timings of a day. Also our use of the online gaming context implies that we may be less able to assess friend-making behaviors involving close relationships. The relationship formation in such online environments may mostly involve weak ties. Lastly, the online game under study is situated in China, and cultural factor could influence our observations. Future research may want to investigate other cultural contexts to see if our results remain valid.

Despite the limitations, this study has important implications for both research and practice. At a high level the findings deepen our scientific understanding about the social behavior of friend making. The explication of clear circadian rhythms in friend-making behavior may also imply that social researchers need to take additional care in conducting their study. Specifically, social researchers may need to be sensitive towards the timing of administering a survey or an experiment. Supposed the objective is to assess the social inclination of individuals and its impact on certain behavioral outcomes, such as message propagation. If the survey or experiment is conducted wholly within a certain timeframe during which the peak or trough occurs, the results could be biased since the subjects tend to provide more/less socially favorable responses. A more ideal approach is to spread
the study across different timings of a day to obtain a more comprehensive coverage of the possible states and to rule out the potential temporal influences.

References


