The Evolution of Social Relationships and Strategies Across the Lifespan

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Abstract. In this work, we unveil the evolution of social relationships across the lifespan. This evolution reflects the dynamic social strategies that people use to fulfill their social needs. For this work we utilize a large mobile network complete with user demographic information. We find that while younger individuals are active in broadening their social relationships, seniors tend to keep small but closed social circles. We further demonstrate that opposite-gender interactions between two young individuals are much more frequent than those between young same-gender people, while the situation is reversed after around 35 years old. We also discover that while same-gender triadic social relationships are persistently maintained over a lifetime, the opposite-gender triadic circles are unstable upon entering into middle-age. Finally we demonstrate a greater than 80% potential predictability for inferring users' gender and a 73% predictability for age from mobile communication behaviors.

Our study [1] is based on a real-world large mobile network of more than 7 million users and over 1 billion communication records, including phone calls and text messages (CALL and SMS). Previous work shows that human social strategies used by people to meet their social needs indicate complex, dynamic, and crucial social theories [2]. This work unveils the significant social strategies and social relationship evolution across one's lifespan in human communication. Specifically, we investigate the interplay of demographic characteristics and three types of social relationships, including social ego, social tie, and social triad.

The social strategies that people use to build their ego social networks are observed from Figure 1. The X-axis represents central users' age from 18 to 80 years old and the Y-axis represents the demographic distribution of users' friends, in which positive numbers denote female friends' age and negative numbers denote male friends'. The spectrum color, which extends from dark blue

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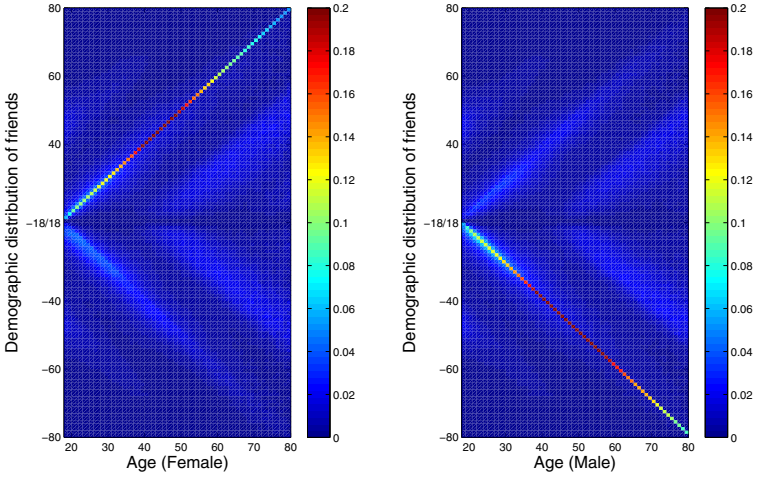
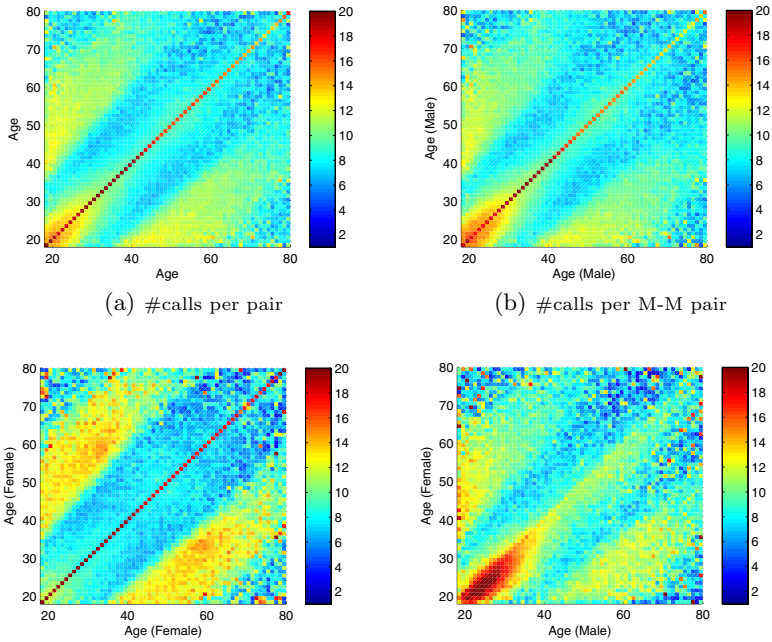


(a) Demog. dist. of Female's friends (b) Demog. dist. of Male's friends

Fig. 1. Friends' demographic distribution in ego social networks. X-axis: (a) female age; (b) male age. Y-axis: age of friends (positive: female friends, negative: male friends). The spectrum color represents the friends' demographic distribution.

(low) to red (high), represents the probability of one's friends belonging to the corresponding age (Y-axis) and gender (positive or negative). First, the highlighted diagonal lines indicate that people tend to communicate with others of both similar age and gender, i.e., age homophily and gender homophily. Furthermore, we can see that young and middle-age people put increasing focus on the same generation and decreasing focus on the older generation, while the seniors devote more attention on the younger generation even along with the sacrifice of age homophily. Third, we observe that young people are active in broadening social circles (high degree and low clustering coefficient centralities), while seniors tend to keep small but stable connections (low degree and high clustering coefficient centralities).

We further study the social strategies by which people maintain their social tie relationships. The heat maps in Figure 2 visualize the communication frequencies—the number of calls per month between two people with different demographic profiles. Four sub-figures detail the average numbers of calls between two individuals, two males, two females, and one male and one female, respectively. We can see that the interactions between two young males are more frequent than those between two young females (Cf. Figures 2(b) and 2(c)), and moreover, opposite-gender interactions between one young female and male are much more frequent than those between same-gender individuals (Cf. Figure 2(d)). However, reversely, same-gender interactions between two middle-age individuals are more frequent than those between opposite-gender



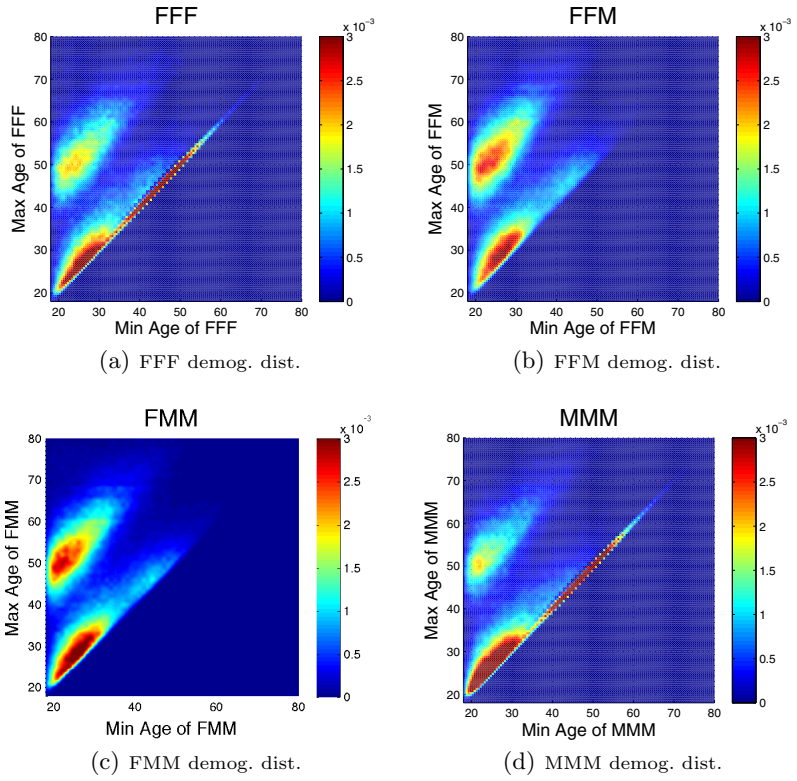
(a) #calls per pair (b) #calls per M-M pair

(c) #calls per F-F pair (d) #calls per M-F pair

Fig. 2. Strength of social tie. XY-axis: age of users with specific gender. The spectrum color represents the number of calls per month. (a), (b), and (c) are symmetric.

individuals. In addition to the diagonal lines in each sub-figure, the cross-generation areas that extend from green to yellow indicate that on average 13 calls per month have been made between people aged 20–30 years old and those aged 40–50 years old. The frequent cross-generation interactions are maintained to bridge the age gaps between different generations, such as parents and children, managers and subordinates, and advisors and advisees, etc.

More interestingly, we highlight the social strategies on triadic relationships unveiled from Figure 3, wherein the X-axis and Y-axis denote the minimal and maximal age of three users within a closed social triad. Sub-figures 3(a) and 3(d) show the distributions of same-gender triads: 'FFF' (Female-Female-Female) and 'MMM' (Male-Male-Male), and sub-figures 3(b) and 3(c) present distributions for users' age in opposite-gender triads: 'FFM' and 'FMM'. From heat-map visualization, we observe that people expand both the same-gender and opposite-gender triadic relationships during the dating active period. However, people's attention to opposite-gender circles quickly disappears after entering into middle-age (Cf. Figures 3(b) and 3(c)) and the same-gender triadic relationships are persistent over a lifetime (Cf. Figures 3(a) and 3(d)). To the best of our knowledge, we are the first to discover the instability of opposite-gender triadic relationships and the persistence of same-gender triadic relationships over a lifetime in a large



(a) FFF demog. dist. (b) FFM demog. dist.

(c) FMM demog. dist. (d) MMM demog. dist.

Fig. 3. Demographic distribution in social triadic relationships. X-axis: minimum age of three users in a triad. Y-axis: maximum age of three users. The spectrum color represents the distributions.

population, which demonstrates the evolution of social strategies that are used by people to meet their social needs in different life stages.

Based on these discovered social strategies, we further study to what extent users' demographic information can be inferred from mobile communication behaviors. The objective is to infer users' gender and age simultaneously by leveraging their interrelations. We present the WhoAmI framework—a Multiple Dependent-Variable Factor Graph model, whereby the social interrelations between users with different demographic profiles can be modeled. On both CALL and SMS networks, the *WhoAmI* method can achieve an accuracy of 80% for predicting users' gender and 73% for users' age according to their daily mobile communication patterns, significantly outperforming several alternative data mining methods.

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