

Understanding Micro-scale Individual Interaction Diversity and Discretionary Spending

Wei Pan,¹ Nadav Aharony,¹ Cory Ip,¹ Alex (Sandy) Pentland¹

¹MIT Media Laboratory, Cambridge, MA 02139, U.S.A.
{panwei, nadav, coryip, pentland}@media.mit.edu

Introduction

In this project, we are interested in the micro-scale relationship between an individual's financial status and his/her interaction diversity. Using Android-based smart phone sensing platforms and survey data, we demonstrate that there is significant positive correlation between discretionary spending and interaction diversity, including both the phone call interaction diversity and Bluetooth face-to-face interaction diversity. In addition, we investigate the connection between discretionary spending, interaction diversity and psychological personality measures, which are obtained from self-reported surveys. We here present the results as a pilot study, and a secondary larger scale study is currently ongoing.

Friends and Family Study

The data analyzed for these findings were collected in the ongoing *Friends and Family Study (1)*, which is the third in a series of mobile phone sensing studies run by the Human Dynamics Group at the MIT Media Lab. It builds on previous studies including the MIT Undergraduate Dormitory Study (2). The study's pilot phase started in March 2010, with a group of 26 couples living in the same MIT graduate residence hall selected to be experiment subjects. Each participant was given an Android-based mobile device that runs the Friends and Family software for passive sensing and data collection. In addition to data collected by the phone, participants fill out weekly and monthly surveys and run a companion Friends and Family Facebook application that logs Facebook activities. Monetary incentives are provided along with the free phones to encourage compliance of the participants with study requirements.

The central component of the study is the Android-based software sensing platform, which records users' call logs, contact information, Bluetooth face-to-face interaction information (by scanning for surrounding Bluetooth devices every five minutes), app usage information, and GPS location data, among others (1). When combined with the survey and Facebook data, we expect the broad spectrum of data collected will be fruitful for exploring many social science questions.

The pilot phase of the *Friends and Family Study* ended with more than four months of data collected. This phase was also used for discovering and fixing hardware and software issues and improving our mobile platform, and we are launching the expanded second phase of the study in the same graduate residence hall in the fall term, which will include a larger participant pool.

Data

For the findings in this abstract, we analyze the data collected automatically by the phones and from the surveys. For Bluetooth proximity data, we use the period from early March to mid-April, which has the most reliable and complete Bluetooth record. We use all call log data aggregated over four months.

To establish estimates for individual financial status, we asked the question, “As an *INDIVIDUAL*, how much do you spend per month on discretionary purchases?” on the initial enrollment survey. Discretionary items were defined explicitly in the survey as entertainment- and hobby-related items. $E(i)$ will be used to denote the discretionary spending for individual i . We use the discretionary spending to measure individual financial status because previous research suggests that the money teenagers spend on entertainment is highly correlated with family income and their satisfaction level with own spending (3). The histogram of the distribution of discretionary spendings of all FunF participants are shown below.

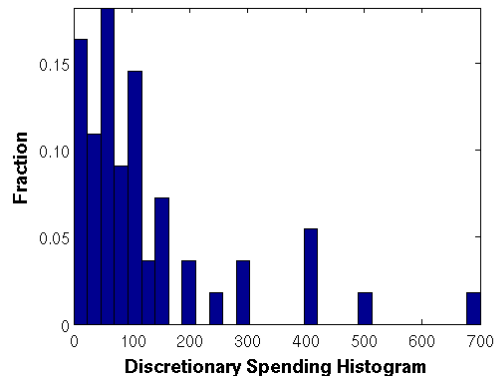


Figure 1: The histogram of the self-reported discretionary spending from all 55 FunF participants.

All participants also took the version of the Five Factor personality inventory on their surveys developed by John and Srivastava (4), used to gauge the Big Five personality traits of Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.

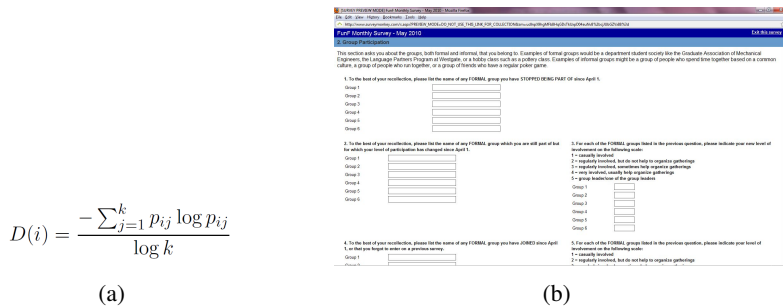


Figure 2: In this project, data are collected using both our passive sensing application running on participants’ Android phones (a) and multiple web-based surveys (b).

In the following section, data obtained from the 34 US and Canadian citizens in the study are considered. International students were not included in this analysis, in order to control for limited social

interaction because of barriers not associated with personality or economic situation (5). The 34 subjects consist of members of different social and ethnic groups, as well as of varied financial status.

Analysis

We use the same method as in Eagle et al. (6) to compute the diversity of interactions. The diversity $D(i)$ is defined as:

$$D(i) = \frac{-\sum_{j=1}^k p_{ij} \log p_{ij}}{\log k}, \quad (1)$$

where p_{ij} is the interaction volume between individual i and j divided by the total interaction volume of i , and k represents the total number of contacts. Volume is either the number of phone calls for call logs or the number of hits for Bluetooth proximity. The diversity score measures how evenly an individual's time is distributed among others. It is important to note that high diversity does not necessarily correspond to high call volumes or high Bluetooth interaction hits.

We compute $D_{\text{call}}(i)$ and $D_{\text{bluetooth}}(i)$ using call logs and Bluetooth hits respectively. We count all calls including contacts outside our focused community for $D_{\text{call}}(i)$. For Bluetooth diversity, we only count hits between participants in this study, because we are interested in the communication pattern within this MIT community.

We discover that the discretionary spending for individual i (denoted as $E(i)$) correlates weakly with the individual's call diversity $D_{\text{call}}(i)$ ($r^2 = 0.12$ and $p < 0.05$). However, the correlation between $E(i)$ and face-to-face interaction diversity $D_{\text{bluetooth}}(i)$ is significant ($r^2 = 0.25$ and $p < 0.005$). We observe no significant correlation between user call volumes, Bluetooth hits and discretionary spending. We conclude that people who spend more money are likely to have a more diversified social circle, but not necessarily more social activities.

We also explore the Big Five personality inventory to test if discretionary spending and interaction diversity are correlated with subjects' personalities. Extraversion, agreeableness, conscientiousness, neuroticism and openness scores for each participant are computed based on self-reported surveys. Intuitively, it is possible that discretionary spending can be largely effected by one's life style and personality, instead of financial status. However, we discover that there is no correlation between discretionary spending and any of the personality metrics, which further strengthens the hypothesis that discretionary spending is a reasonable indicator for financial status as in Alhabeeb (3).

Furthermore, there is no significant correlation between $D_{\text{bluetooth}}(i)$ any personality metrics except extraversion. There is, however, correlation between extraversion and the Bluetooth interaction diversity, but much weaker than the correlation between spending and interaction diversity ($r^2 = 0.16, p < 0.02$ vs. $r^2 = 0.25, p < 0.005$). This is reasonable as extraversion can be related to interaction diversity intuitively. In addition, extraversion is not correlated with call diversity at all. Combined with the fact that there is no correlation between personality metrics and discretionary spending, Our analysis tends to reject the hypothesis that correlation between interaction diversity and discretionary spending is due to one's extraversion level.

In conclusion, we argue that discretionary spending can reflect individuals' current financial status. We also observe that interaction diversity, in particular Bluetooth face-to-face interaction diversity, correlates positively and strongly with discretionary spending, which cannot be explained by personality variances. Therefore, our findings imply that people with good financial status exhibit different social

behaviors than ones with worse financial status, namely they are likely to spend their time more evenly distributed with different contacts.

Discussion

The results in this project match well with the large-scale data analysis in Eagle et al. (6), in which the authors discovered that the diversity of communities' connectivity correlates with the economic development of the community (with $r^2 = 0.59$). Instead of looking at macro-scale econometrics, in this work we discover the micro-scale correlation between individual interaction diversity and individual financial status as well.

The causality is unknown for both the results in Eagle et al. (6) and ours. One prevailing hypothesis is that people benefit and gain wealth from more heterogeneous social ties, which provide more opportunities such as jobs (7). We think this is a reasonable answer for the telecom data in Eagle et al. (6) However, interactions between participants living in this MIT residence hall are unlikely to improve each others' wealth, as they are all full-time graduate students, and have been in this community for only a short period. Therefore, our *Friends and Family* participants pool is naturally controlled so that individuals are unlikely to obtain new financial opportunities by exploiting different social ties within this community. As a result, the previous hypothesis may not explain the observed Bluetooth diversity correlation with discretionary spending in this study.

We suspect that the causality is the opposite inside our study: people come to the MIT community with greater financial resources keep their old habit of engaging both in a greater diversity of discretionary activities and with a greater diversity of social contacts.

Future Work

We are currently running the second phase of the *Friends and Family Study*. In this phase, we anticipate to add around 100 more participants to our study pool. We will also develop new surveys to better measure the financial situation of each individual in this phase. Bluetooth stability is improved to obtain a more complete face-to-face interaction dataset.

References and Notes

1. N. Aharony, C. Ip, W. Pan, A. Pentland, *NetMob 2010* (2010).
2. I. Chronis, A. Madan, A. Pentland, *Proceedings of the ICMI-MLMI'09 Workshop on Multimodal Sensor-Based Systems and Mobile Phones for Social Computing* (ACM, 2009), pp. 1–4.
3. M. Alhabeeb, *Financial Counseling and Planning* **7**, 123 (1996).
4. O. John, S. Srivastava (1999).
5. M. Summers, S. Volet, *Studies in Higher Education* **33**, 357 (2008).
6. N. Eagle, M. Macy, R. Claxton, *Science* **328** (2010).

7. M. Granovetter, *ajs* **78**, 1360 (1973).