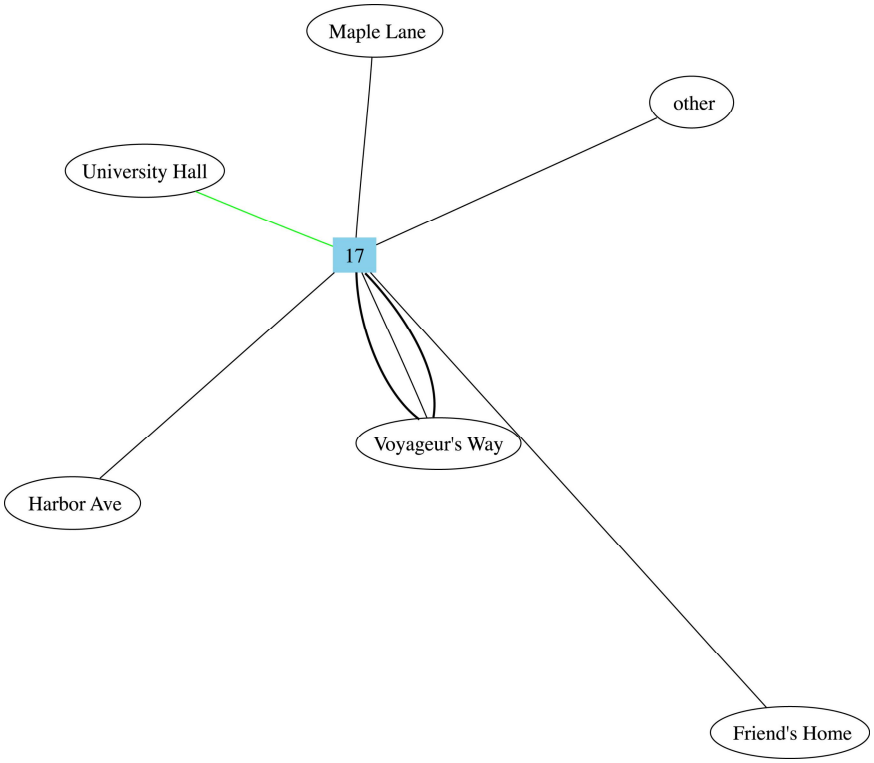

Social Networks and Travel Behavior: Report from an Integrated Travel Diary

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Abstract

This paper reports preliminary results of a survey designed to quantify how social networks influence travel behavior. Using a three-day activity diary, we simultaneously measured social interactions and travel behavior. Respondents were asked to record all trips, as well as all social interactions with friends and family for three days. We use a novel survey method—iterative recruitment—to uncover networks of social interactions. Respondents were asked to distribute postcards to individuals with whom they interacted, which gave each recipient the opportunity to volunteer to participate in the study. This method yielded strong response rates and had low overhead. Our survey provides a means of directly relating the characteristics of social trips to characteristics of the social interactions they enable, rather than being limited to relating general information on social networks to an individual diary of travel behavior. We hypothesized that respondents would travel longer times for greater social benefits, i.e., that people would be willing to travel further to see more people, or to see people whom they have known for a longer period of time. However, we found that only the number of non-immediate kin at the destination affected respondents' trip duration. Additionally, we found that both the total number of trips a respondent made *and* the number of different locations that a respondent visited were closely correlated both with size of his or her social network and with the number of repeated contacts. A repetitive social network actually resulted in a larger activity space. These effects were not uniform: we saw that a higher number of repeated interactions led to greater number of trips, while a larger social network size led to visiting more locations.

Keywords

Social networks, travel behavior, iterative recruitment

Preferred Citation

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1. Introduction

People travel to see other people. Whether it is to watch a ball game, visit family, or to attend a wedding, physical presence is at the heart of many social interactions (Urry, 2002). Social and recreational trips comprise 25% of the total trips made in the U.S. (Liss et al., 2003). Because social and recreational trips can and do occur at any time of the day or week, and between diffuse origins and destinations that cannot easily be predicted, they are the most difficult to model (Bhat, 1998, Schlich et al., 2004). Furthermore, recent gas price spikes suggest that this type of travel may be more discretionary than other types (Hakin and Peters, 2005), making it both harder to understand and an ideal subject of study since it should be more responsive to experimental 'treatments' than other types of relatively inelastic trips.

Social networks have been the subject of intense scrutiny recently, but the processes by which these networks are created and maintained have been little studied (Watts, 2004, Newman et al., 2002). Newman et al. (2002) define a social network as "a set of people or groups of people…with some pattern of interactions or 'ties' between them." Three examples of commonly studied networks are that of business executives who share common board memberships, that of actors who have co-starred in a movie together, and that of scientists who have co-authored papers together (Watts, 2004, Newman, 2003, Newman et al., 2002).

This research focuses on ego-centered networks, which are defined by a few crucial characteristics; this analysis focuses on network size, or number of unique nodes, as well as the number of interactions each center has with each node, limiting the scope of our analysis to social interactions. We also measure the nature of the link between the center of each network and each node: e.g. whether the two are family and how long they have known each other. We use these structural network components as our independent variables; our dependent variables are dynamics on the network, such as the frequency and duration of trips. In short, we are attempting to correlate structure and dynamics of social networks to improve our understanding of social trip-making behavior.

2. Background

Several mechanisms and conceptual frameworks have been advanced to explain the possible relationships between social networks and travel (Gotz, 2003, Axhausen, 2002). One approach employs the concept of an activity space—a 'prism' of time and space carved out by distance from home (Haggerstand, 1970). Time-space theory posits that a person's travel increases as their potential activity space increases (Timmermans et al., 2002). Social contacts, then, both in-person and virtual, may represent an increase in this potential activity space (Black, 2001). Axhausen (2002) points out that social ties have establishment and maintenance costs associated with them, costs which may be paid in either in face-to-face interactions, or through other means such as telecommunication. Both travel and telecommunication have become 'cheaper' over the past 50 years, which seems to have lead to larger and more dispersed social networks, although people's travel time budgets have held relatively constant at roughly an hour of travel per day (Thulin and Vilhelmson, 2005). However, there is little consensus or empirical evidence supporting a single, consistent theoretical relationship between travel and social networks; even the direction of such a relationship is ambiguous.

Thus far, such relationships have only been explored at the aggregate level. For instance, Willmott (1988) found that the geographic size of a network was strongly correlated with

number of network members, and that car ownership (a gross indicator of travel) was associated with larger social networks. In a study of an online friendship site, where users listed contacts with whom they were 'friends', Liben-Nowell et al. (2005) found that two-thirds of these online friendships were actually geographically-based, and relied on some in-person interactions—which require travel—to perpetuate. In sum, higher mobility is associated with larger social networks.

The reverse is also true: studies from the public health field have shown that limited mobility is associated with smaller social networks (Banister and Bowling, 2004, Golob et al., 1995). In a survey of the quality of life of elderly, Banister and Bowling (2004) found a correlation between mobility and social involvement: people with higher levels of social involvement expressed greater satisfaction with their local public transit facilities. Access to a vehicle was a strong indicator of social involvement: "[t]hose with access to [a] car were consistently more likely to make more social activities" (p. 110). Finally, the interactions between social networks and travel may also be affected by sociodemographic characteristics. For instance, people who have recently moved or people who have higher education or incomes may have larger social networks (Rogerson, 1997). In fact, Willmott (1988) found that "on every index, social status and affluence went with bigger social networks" (p. 16). These variables may affect both social networks and travel behavior simultaneously: people with higher incomes have higher levels of mobility and larger, more geographically dispersed social networks (Willmott, 1988), complicating our efforts to separate out the effect of income from the effect of social network size on mobility.

This evidence suggests there is a positive feedback loop between travel and social contacts, whereby travel enables social contacts, and social contacts stimulate travel, but the aggregate studies conducted thus far cannot advance a mechanism underlying the basic relationship between an individual's social networks and his or her travel patterns. In contrast, we take a disaggregate approach, examining each social trip. By examining how the number and kind of social contacts at a destination affected the trip to that destination, we are able to investigate mechanisms linking travel to social contacts, direction of causation, and whether such travel is habitual. We conducted a pilot survey to assess the value of a disaggregate approach. As a pilot, our sample size is small, and the results should be considered exploratory.

We hypothesized that people will be willing to make higher cost trips (in terms of time) for a greater social payoff. More specifically, individuals would be willing to travel further (1) to see more people, or (2) to see people whom they have known for a longer period of time, or (3) to see family members. We asked respondents two questions about each social interaction designed to proxy social payoff: whether they were related to the person and how long they had known the person. We also asked how many people were present at each location, and thus could use that number present as a metric for social payoff as well. The dependent variables were the number and duration of one-way trips, as reported by respondents.

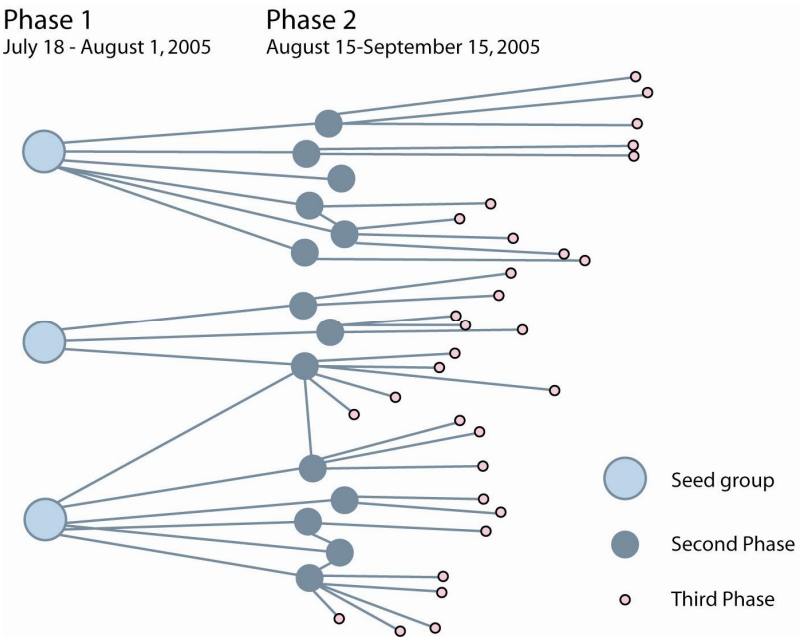
Our results suggest that people are indeed more willing to travel longer distances for social purposes, but at the disaggregate level of individual trips, our putative measures of social payoff proved to have only weak correlations with trip characteristics, suggesting that the survey and measurement approach needs refinement. However, at an aggregate level, we verified that people with larger social networks made more social trips, and visited more unique locations than those with smaller networks.

3. Methodology: Survey design

Respondents were asked to record all trips and social interactions—such as visits, phone calls, and emails—for three days in a survey booklet.[1] We did not ask respondents to list everyone in their social network; the tendency to underreport members of social networks is well-accepted (Feld and Carter, 2002, Newman, 2001, Rogerson, 1997). Our prospective method relies on reported actions rather than recall, and thus should be more accurate. First round respondents were given the booklet in person, and guided through how to fill it out. Later respondents, recruited by postcard, were contacted via mail and telephoned before they started the survey to explain the process and provide them an opportunity to ask questions.

Respondents were recruited using a new methodology. We began the survey with three seed respondents, who did not know one another. They were all women living in Davis, California, two had children at home and one did not. These three seed, and all subsequent, respondents were asked to give postcards to people with whom they interacted socially over three days. The postcards asked general questions about the recipients' interactions with the respondent, and the cards also gave the recipient a means to volunteer to participate in the study. The study design yielded a three-phase grouping of respondents (see Figure 1). The postcards handed to respondents in phase three were slightly different; they asked the same general questions about the recipients' interactions with the respondents, but did not give recipients an opportunity to participate in the survey.

Figure 1: Schematic of the iterative recruitment method



The survey was in the form of an activity diary where respondents reported each activity undertaken. Respondents also reported the type of location at which they did the activity, whether they had traveled to get there, how long that trip was, what mode they took, and

[1] Survey materials available upon request.

whether they traveled with others. For social interactions,[2] they were asked whether they saw the person, emailed him, or spoke to her on the phone. Finally, respondents indicated whether that person with whom the social interaction occurred was kin, and that person's age, gender, how long they had known the person, and whether they gave him or her a postcard.

We had 24 respondents reporting a total of 505 trips (441 non-work trips), and 972 social interactions spanning two months. We found the iterative recruitment to work better than expected, but there was notable non-response and under-reporting of certain kinds of data. We had a response rate of just under 50% for those individuals who received a postcard and subsequently returned a survey. A more holistic estimate of our response rate would be that 12% of eligible interactions yielded useable surveys.[3] The step-by-step response rates suggest that the two easiest ways to increase the overall response rate would be to further emphasize to respondents the need to give postcards to *everyone* with whom they interacted and to make the postcards more compelling, so that the people who received them would be more likely to participate.

This iterative recruitment essentially relies on respondents to recruit other respondents, lowering the overhead required by researchers. One disadvantage of this iterative recruitment is its potential for multi-layered selection bias. Several respondents reported that they felt uncomfortable handing out the postcards. Therefore, the survey would be likely to miss people with whom respondents were not as comfortable. In addition, there is a general selection bias that the people who respond to a postcard may be systematically different from the general population, and a specific selection bias related to how the recipient felt towards the participant handing him or her the postcard. However, this bias likely would yield data on more established and strong social relationships, which are most likely to generate trips. These selection biases pose a fairly intractable threat to the ability to make generalizations from our findings, because they are impossible to quantify or address with caveats, given our data. Furthermore, it would be difficult to construct a representative sample using this iterative method, since the researcher essentially abdicates control of the sample selection process. Newman (2001) argues that a network radiating from a single person may be influenced by the characteristics of that person at nodes two degrees removed. Nevertheless, the value of an iterative approach to yield a rich and descriptive dataset could make it appealing to researchers interested in examining the relationship of other network measures, such as 'betweenness' or 'centrality',[4] to travel behavior.

[2] We relied on respondents to report interactions they considered to be social, which we explained as interactions with people they knew by name, and would consider a social acquaintance.
[3] Respondents reported giving postcards to 47% of eligible contacts, 75% of those people contacted by another respondent returned postcards, 44% who had the option to participate agreed to do so, and 76% of those returned completed surveys, for an overall response rate of 12%.
[4] Betweenness is defined as the number of shortest paths that run through a node, while centrality is defined as the node's proximity to some statistically identified central hub.

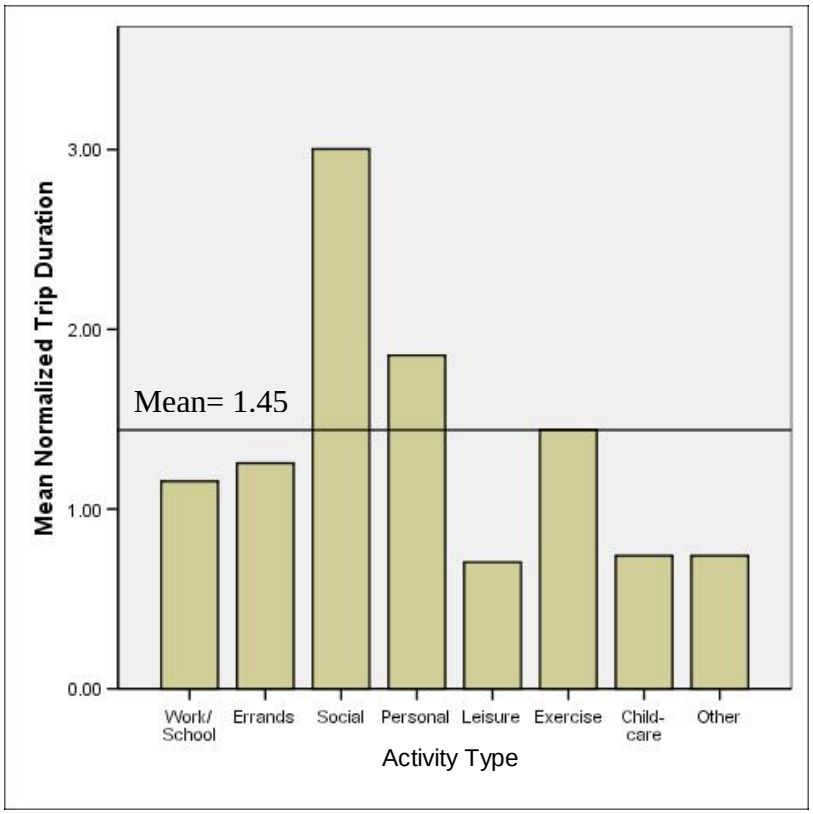
4. Results

Our preliminary results show that respondents were willing to make longer trips for social purposes. However, results were mixed for our various measures of social 'payoff.' Results also indicate that the both the number of trips a respondent made and the scope of a respondent's activity space—the number of locations visited during the survey period—were closely correlated with the size of his or her social network, but even more closely correlated with the number of social interactions reported.

4.1. Social trips are longer

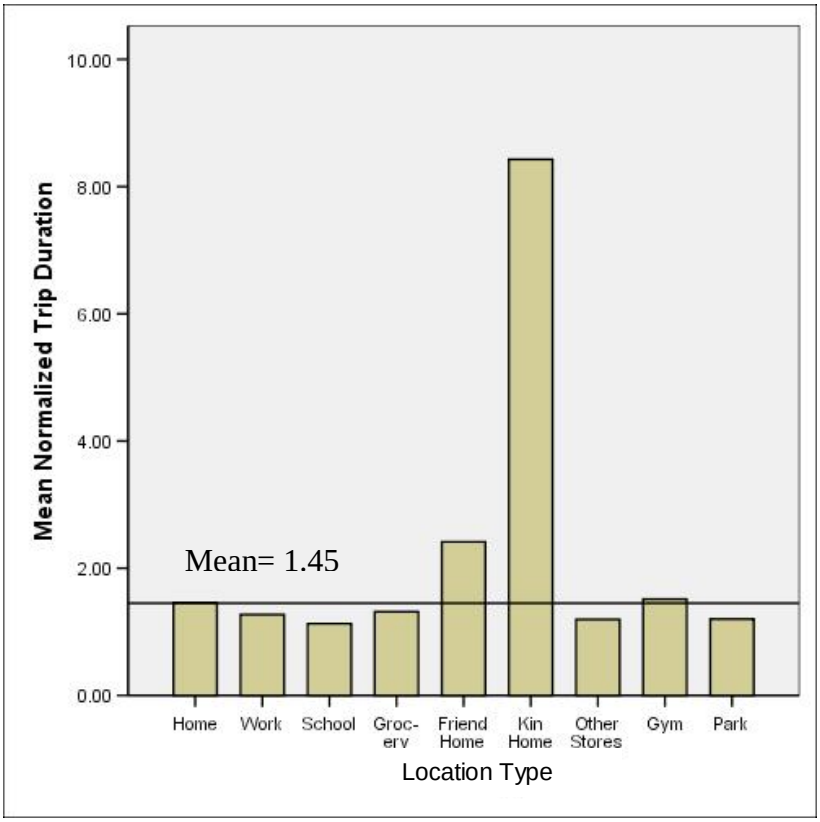
We found that respondents were willing to travel notably longer distances for the purpose of socializing (See Figures 2 and 3). In both figures, trip durations have been normalized by the respondent's average commute duration.[5] Our results indicate that people are willing to make much longer than average trips to socialize. In Figure 2, the second and third highest bars—titled 'personal' and 'exercise'—were activities that had notable overlap with social activities as well.

Figure 2: Mean trip durations by activity type.
Respondents made the longest trips for social activities. Note that normalized trip duration equals trip duration (minutes) ÷ respondents average commute (minutes), and thus the y-axis has no units itself.



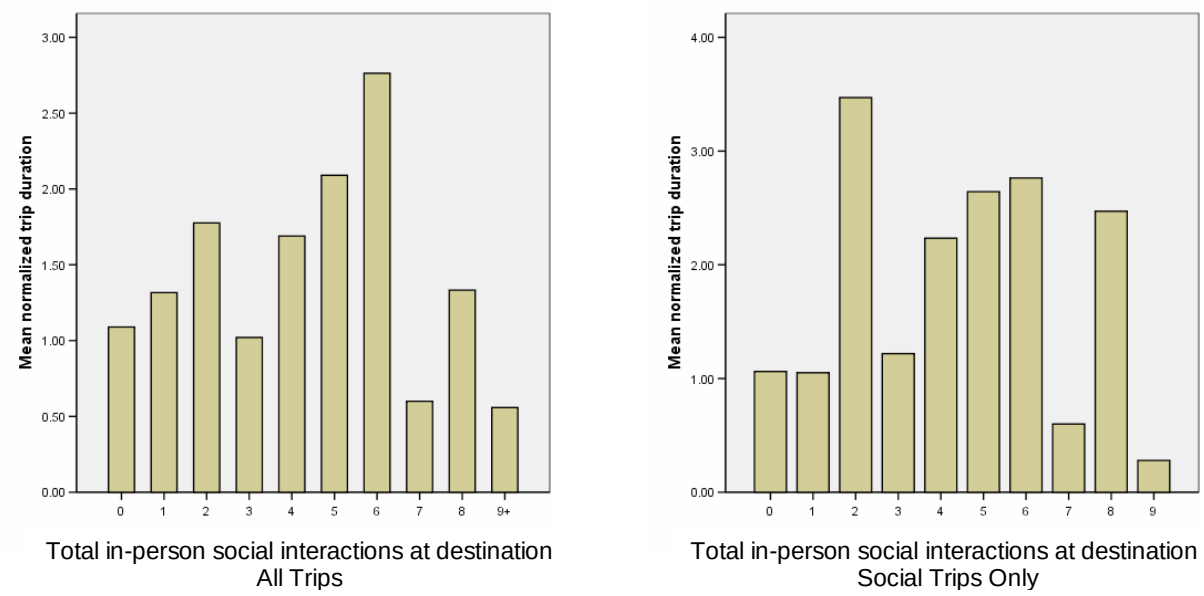
[5] The work/school bar is not of exactly length one because it contains both work and school trips, which included people dropping of children at school.

Figure 3: Mean trip durations to location types.
Respondents made the longest trips to visit the homes of family members—represented by the bar titled 'kin home.'



This trend however, was not strongly apparent at finer grained measures of social payoff. The number of people at the destination was not correlated with longer trip durations, either for social trips, or for all trips. Our hypothesis would have predicted steadily increasing mean trip duration in Figure 4. We do see somewhat of an increasing trend when looking at the total interactions graph (on the left), but this relationship disappears when restricted to social interactions (on the right). It may be that there are diminishing marginal returns related to number of people at a location (i.e. people might be most willing to make trips for one-on-one interactions, rather than to attend a large gathering where interactions may have less meaning). Indeed, organizational theorists have clearly identified that human groups can become too big for members to navigate successfully when they grow larger than 150 members (Aiello and Dunbar, 1993) but with social interactions, presumably that (much lower) threshold is determined by individual taste.

Figure 4: Effect of number of social interactions at the destination on trip duration



Respondents made longer trips to see family members, as evidenced by the high mean trip duration to family members' homes (Figure 3). They also traveled longer to see more family members; the correlation coefficient between trip duration and 'number of kin at the destination' was weak (0.11), but suggests that kin may be subject to a different mental cost-benefit analysis—seeing a large family group may have greater value than seeing a large group of friends. The third hypothesized measure of social payoff, 'number of years known', was not a significant predictor of trip duration. When fitting a linear regression to social trips with the three hypothesized variables, the variable 'number of in-person interactions' and 'proportion of non-immediate kin' at the destination were significant, but with predictive power likely limited by our small sample size (Table 1).

Table 1: Summary for three variable model (Dependent variable = Trip duration)

R	R-square	Adjusted R square	Std. Error of the Estimate	F	Significance
.228	.052	.042	11.43	5.27	.001
Coefficients					
		B	Std. Error	t	Significance
(Constant)		5.805	1.615	3.594	.000
Number of people		.924	.417	2.217	.027
Years known (mean)		.082	.071	1.160	.247
Proportion non-immediate kin		2.6701	.845	3.162	.002

We found that the variable '*number* of non-immediate kin', rather than '*proportion* of non-immediate kin', yielded a better model. We also removed the variable 'number of people at destination' since it was highly correlated with 'number of non-immediate kin' (Table 2).

Table 2: Summary for two variable model (Dependent variable = Trip duration)					
R	R-square	Adjusted R square	Std. Error of the Estimate	F	Significance
.340	.116	.085	13.87	3.73	.030
Coefficients					
		B	Std. Error	t	Significance
(Constant)		7.872	3.124	2.250	.015
Number non-immediate kin		2.810	1.046	2.686	.009
Years known (mean)		.118	.165	.714	.478

4.2. Number of social network interactions are correlated with number of social trips

For our aggregate analysis, we used the number of social trips, totaled for each respondent. The total number of in-person social interactions a respondent had was the strongest predictor of that respondent's total number of social trips, stronger than the number of people in of their social network.[6] We also explored how useful this number was in predicting a respondents total number of trips. We found that the total number of in-person social interactions a respondent reported was a strong predictor of total trips. Our sample size was small, but this variable was a stronger predictor of total trips than household size or income, two traditional variables used in to predict the total number of an individual's trips.[7]

Table 3: R-square Correlations with 'Number of Trips' by Trip Type		
Variable	Social Trips	All Trips
Total number in-person social interactions	.477	.363
Social network size	.329	.229
Household size	.041	.060
Income	.035	.019

4.3. Repetition leads to more trips, and more locations visited

Finally, we examined the degree to which people made repeated contacts by creating a 'repetition' variable by dividing the number of unique interactions by the number of total interactions. Our results were counter-intuitive: the more repetitive respondents were in their social network, the more trips they made. We had originally thought that a more repetitive social pattern would indicate a smaller network size, and in turn, that this 'curtailed' network size would lead to curtailed trip-making behavior, especially since network size was correlated with trip-making. However, this was not the case (Table 4). Repetitiveness was

[6] Here, we distinguish between size of a network—number of individuals with whom the respondent reported interacting—and number of interactions, a number which may include repeated interactions.

[7] The small size of our sample meant that there was less variation in income than would be found in the general population, with 11 respondents falling into the highest income category, where annual household income exceeds $95,000.

weakly correlated with network size (R^2 = 0.11), but in a positive direction, opposite our expectations. Repetition was uncorrelated with social trip-making (R^2 = 0.01). However, the *number* of repeated social interactions was strongly correlated with number of social trips (R^2 = .508)[8], more strongly than simple number of interactions (R^2 = .477) or network size (R^2 = .329). This result suggests that variation in the number of social interactions is more a function of number of repeated contacts rather than network size. That is, in our sample, greater sociability manifests as repeating interactions with a set group of friends rather than as interacting with many different people.

Table 4: R-square Correlations with Total Social Trips and Total Locations Visited

Variable	Social Trips	Locations Visited
Repetition ratio	.01	.06
Number of repeated social interactions	.508	.249
Total number of social interactions	.477	.248
Social network size	.329	.490

Furthermore, repetitiveness in interactions (meaning that the respondent saw the same person multiple times) did *not* translate into repetitiveness in locations visited (meaning the respondent went to the same place multiple times). There was not a strong correlation (R^2 = .06) between repetitiveness and scope of activity space, but the direction was positive—that is, more habitual interactions lead to more locations visited. Thus, the behavior was simultaneously more repetitive and less repetitive. In terms of predicting the number of unique locations visited, the number of repeated interactions and the total number of social interactions were predictors of equivalent strength (R^2 = .249 for repeats vs. R^2 = .248 for total social interactions). However, the best predictor of the scope of a respondent's activity space was social network size, with an R^2 of 0.490. In summary, we saw that a higher number of repeated interactions led to greater number of trips, while a larger social network size led to visiting more locations.

5. Discussion

In addition to our basic analysis, we also mapped the networks of social interactions and trips. This allowed us to compare trips, which constitute a geographically-based network, with social interactions, a network independent of geography. Similar to Gotz (2003), we found two different socio-mobility styles stood out: one group (Style 1) made many shorter trips to see a large number of people individually, while the other (Style 2) made fewer longer trips to see many people simultaneously at each destination. We present typical respondents from each group to highlight the differences between the two (Figure 5).

[8] And with total number of trips (R^2 = .432 compared with 0.363).

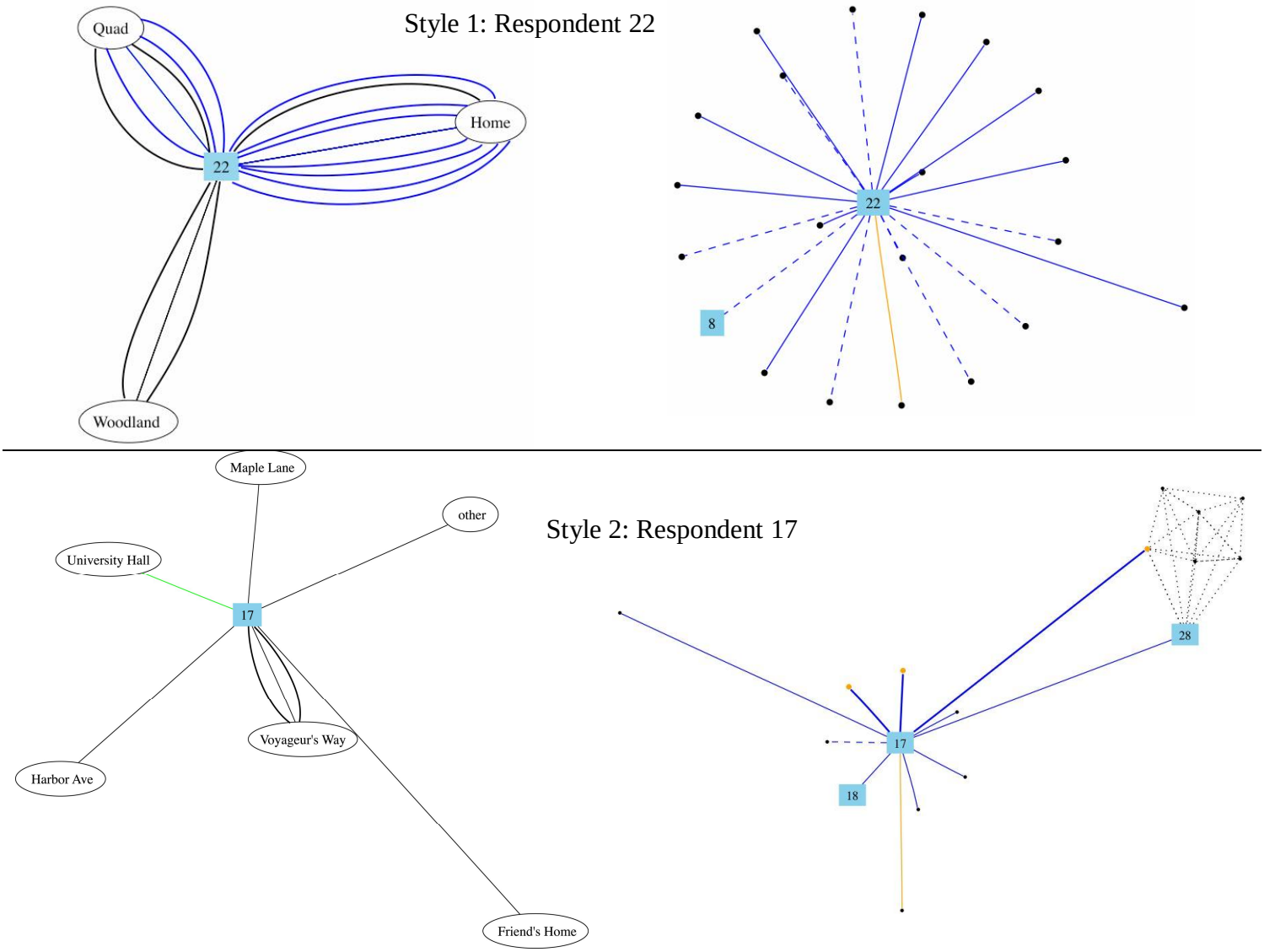


Figure 5: Comparison of the two sociomobility styles.
The networks of respondents' trips are shown on the left side of the figure; the network of social interaction on the right. Respondent 22, on the top, typifies the first sociomobility style. Respondent 17, shown on the bottom, typifies the second style.

In our sample, the activity styles of 14 respondents fit into Style 1, while 5 respondents could be categorized by Style 2, with the remaining 5 respondents falling between the two. Since our survey was small, we cannot comment on the prevalence of these types in the population at large; other socio-mobility styles might also emerge from a larger sample. We found no statistically significant differences on sociodemographic variables between groups, suggesting that social patterns may be fairly universal within this sample, which was more homogenous on a sociodemographic level than the population at large would be.

6. Conclusion

Our results suggest that social trips, while complicated, could be modeled using social network theory. Current census practices collect data on household size and income, but these variables nearly always prove to be poor predictors of social trips. Instead, data measuring social network size and perhaps number of kin living locally should be included in such surveys because these variables have been shown to be accurate correlates of travel behavior. Although social scientists dispute the validity of self-estimates of social network size, our data show that adding some uniform metric of the amount of social interactions to the census could give us more power to holistically understand trip-making.

A fruitful extension of this research would be to investigate the murky relationship between information and communication technology (ICT) on social travel. We designed the survey with hopes that we would be able to gather reliable information on the use of email to develop and maintain social networks, but reporting on email and phone conversations proved too burdensome for respondents. Restricting the investigation of the impact of ICT on travel to social travel may allow its effect in that sphere to become clear. Additionally, the figures developed in the exploration of sociomobility styles suggests that finding a way to *quantify* the correlation between social interactions and social trips would be fruitful. Finally, our new survey methodology was developed to specifically establish social interaction networks. Additional research needs to be conducted on issues of selectivity bias in terms of the generalizability of the propagated networks. However, we believe this method could be very useful for understanding how social networks are developed and maintained.

Acknowledgements

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References

Aiello, L. & Dunbar, R. I. M. (1993) Neocortex Size, Group Size, and the Evolution of Language. *Current Anthropology,* 34**,** 184-193.

Axhausen, K. (2002) A dynamic understanding of travel: A sketch. Institut fur Verkehrplanung.

Banister, D. & Bowling, A. (2004) Quality of life for the elderly: the transport dimension. *Transport Policy,* 11**,** 105-115.

Bhat, C. R. (1998) Analysis of travel mode and departure time choice for urban shopping trips. *Transportation Research Part B-Methodological,* 32**,** 361-371.

Black, W. R. (2001) An unpopular essay on transportation. *Journal of Transport Geography,* 9**,** 1-11.

Feld, S. & Carter, W. C. (2002) Detecting measurement bias in respondent reports of personal networks. *Social Networks,* 24**,** 365-383.

Golob, T. F., Bradley, M. A. & Polak, J. W. (1995) *Travel and Activity Participation as Influenced by Car Availability and Use,* University of California Transportation Center, University of California at Berkeley.

Gotz, K. (2003) A research concept for mobility styles. *Moving through nets: The physical and social dimensions of travel.* Lucerne, Switzerland, 10th International Converence on Travel Behavior Research.

Haggerstand, T. (1970) What about people in regional science? *Papers of the Regional Science Association,* 24**,** 7-21.

Hakin, D. & Peters, J. (2005) Go Ahead and Drive Less, if you Can. *New York Times.* New York.

Liben-Nowell, Novak, J., Kumar, R., Raghavan, P. & Tomkins, A. (2005) Geographic routing in social networks. *Proceedings of the National Academy of Sciences,* 102**,** 11623-11628.

Liss, S., Mcguckin, N. & Gross, B. (2003) Changes in the Purpose of Travel Over Time: A snapshot analysis of the National Household Travel Survey 2001. *Highway Information Quarterly Newsletter.* Office of Highway Policy Information-Federal Highway Administration.

Newman, M. E. J. (2001) Ego-centered networks and the ripple effect, or, Why all your friends are weird.

Newman, M. E. J. (2003) The Structure and Function of Complex Networks. *Society for Industrial and Applied Mathematics Review,* 45**,** 167-256.

Newman, M. E. J., Watts, D. & Strogatz, S. H. (2002) Random graph models of social networks. *Proceedings of the National Academy of Sciences,* 99**,** 2566-2572.

Rogerson, P. A. (1997) Estimating the Size of Social Networks. *Geographical Analysis,* 29**,** 50-63.

Schlich, R., Schonfelder, S., Hanson, S. & Axhausen, K. W. (2004) Structures of Leisure Travel: Temporal and Spatial Variability. *Transport Reviews,* 24**,** 219-237.

Thulin, E. & Vilhelmson, B. (2005) Virtual Mobility of Urban Youth: ICT-Based Communication in Sweden. *Tijdschrift voor Economische en Sociale Geografie,* 96**,** 477-487.

Timmermans, H., Arentze, T. & Joh, C. H. (2002) Analysing space-time behaviour: new approaches to old problems. *Progress In Human Geography,* 26**,** 175-190.

Urry, J. (2002) Mobility and proximity. *Sociology-The Journal Of The British Sociological Association,* 36**,** 255-274.

Watts, D. (2004) The 'New' Science of Networks. *Annual Review of Sociology,* 30**,** 243-270.

Willmott, P. (1988) *Friendship Networks and Social Support,* London, Policy Studies Institute.