AGENCY IN SOCIAL ACTIVITY INTERACTIONS: THE ROLE OF SOCIAL NETWORKS IN TIME AND SPACE

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Juan Antonio Carrasco (corresponding author)
Department of Civil Engineering, Universidad de Concepción
P.O. Box 160-C, Concepción, Chile
j.carrasco@udec.cl

Bernie Hogan and Barry Wellman
Centre for Urban and Community Studies
455 Spadina Avenue, Toronto, ON, M5S2G8, Canada
bernie.hogan@utoronto.ca, wellman@chass.utoronto.ca

Eric J. Miller
Department of Civil Engineering, University of Toronto
35 St. George St, Toronto, ON, M5S1A4, Canada
miller@ecf.utoronto.ca

ABSTRACT

This paper explores the relationship between travel behaviour, ICT use, and social networks. Specifically, we outline a theory of social action that can inform how ICTs relates to social activity travel and explore the efficacy of this theory in an empirical setting. We begin by outlining two factors that influence the propensity to travel: an individual's will to initiate events with members of one's social network, referred to as ***agency***, and the ***social accessibility*** of network members themselves. Social accessibility defines a series of practical constraints for social-activity travel and agency defines the extent to which an individual will *actively* work within these constraints to maintain their social network. The theoretical section first unpacks these concepts while embedding them in the research literature, finishing with an operationalisation of agency and social accessibility. Using this theory, the empirical section investigates the relationship between agency, social accessibility, and factors associated with both the respondents and their personal networks. More specifically, we examine how agency levels of interaction are related to differences in demographics, global measures of network structure and composition, and measures of media use, particularly of Internet and telephone. We conclude that individuals who are proximate or more active are more likely to maintain reciprocal relationships, and that more distant or infrequent ties require greater maintenance on the individual's part. We believe that studies of activity-travel and ICTs will benefit from a theoretical lens that articulates some of the transformative effects of ICTs on travel vis-à-vis its effects on social life. Social accessibility and agency can help focus that lens thereby enabling researchers to make potentially more elaborate and realistic models that move beyond the spatial and temporal dimensions into social dimensions.

1. INTRODUCTION

1.1. Motivation and Objectives

A substantial portion of activity travel behaviour concerns social activity travel. In such contexts it is especially important to incorporate the notion that travel is oriented towards specific preferred individuals and specific activities. The traditional individualistic perspective is insufficient to account for this social dimension as it does not take into account differences in both the number of individuals with whom this activity takes place and ways in which these individuals are related to each other. We propose an alternative framework that locates travel behaviour within an individual's social context. This context includes an individual's social network, and the tools (email, telephone) used to maintain awareness of that network in between events. By focusing on a person's interactions with a concrete set of preferred individuals, the social network approach is a promising theory to incorporate interactions in agent-based travel demand models as well as to understand the decision processes embedded in travel.

A key reason for an interest in the specific relationships between actors is because the decision-making process leading to travel is not equally shared among activity participants. Individuals have differing levels of responsibility for both past social engagements and the organization of future engagements. Some actors are almost always successful at getting the ball rolling, while others are lucky if they even show up. Generally speaking, some actors are more active in seeking interactions with their network, whereas others can be more passive. This difference in the actor's engagement with her / his social network can be termed the actor's ***agency***. Agency is conceptualized as the extent to which an actor can vary the spatial location, temporal coordinates, and social participation of others. Thus, an actor who does not negotiate time, place, or participant, has little agency, and one who sets all three has a great degree of agency.

One necessary precondition for agency is that actors can access each other before an event and negotiate time-space coordinates. This capacity is referred to as ***social accessibility***. While social accessibility defines a series of practical constraints for social-activity travel, agency defines the extent to which individuals actively work within these constraints to maintain their social networks. This framework also enables us to assess the role of information and communication technologies (ICTs) in social activity travel, as these tools enable individuals to initiate and organize future events. The unique properties of various ICTs can also change the level of social accessibility between individuals, potentially altering their travel demands and transforming social life in general.

An agency perspective also considers individuals' decision making as embedded in their constraints, such as particular spatial locations, temporally constraining sets of obligations (e.g., young children or demanding jobs), individual characteristics (e.g., income and age), and social structural attributes (e.g., network size and fragmentation). In addition, the social network approach conceptualizes one's structure as a product of the residual trends of past social engagement and the set of resulting future expectations rather than a static object exerting a constant weight on travel decisions. In this regard, the key research question of the paper is whether agency constitutes a fundamental

attribute to understand social network dynamics, and consequently, social activity, and ICT interaction dynamics.

After reviewing key concepts about social networks, social activity-travel, and the role of ICTs, our paper offers a conceptual background of social networks and agency, discussing and contextualizing their importance for the study of activity-travel behaviour and the influence of ICTs. With that theory as a background, the paper then presents an operationalisation of the concept of agency in social interaction, performing an empirical analysis of the relationship between agency and the characteristics of the individuals who interact, the social structure in which they are embedded, and such other relevant aspects as distance and the role of ICTs.

1.2. ICTs and Social Activity-Travel

The link between the people's social activity-travel and their ICT use has been discussed in the recent past (Senbil & Kitamura 2003; Mokhtarian *et al.* 2006). Telephones play an important role of support and companionship (Wellman & Tindall 1993), with mobile phones involving the possibility of partial independence with respect to the spatial context (e.g., Ling 2004; Geser 2004). However, research that links face-to-face, telephone, and the social dimension is very limited (a partial exception is Schnorf 2005) and does not explicitly incorporate travel behaviour. Overall, studies have found that for social activity, the telephone complements or is neutral with respect to face-to-face interaction (e.g., Claisse & Rowe 1993; Senbil & Kitamura 2003), with different levels of affective and physically proximate relations leading to different levels of telephone use (Dimmick & Patterson 1996; Larsen *et al.* 2006).

Similarly, the Internet has received attention in the travel behaviour literature, but there rarely has been an explicit interest in linking the Internet to travel behaviour and social activities. For example, Hjorthol (2002) does not find any substantial substitution effect or significant impact on travel activities, contrary to Srinivasan & Athuru (2004), who find room for substitution in recreational activities. Using a mix of qualitative and quantitative techniques, Brown *et al*. (2005) found a dominant neutral effect – in some cases substituting other media, such as telephone – with very low expected substitution between the Internet and travel.

Another perspective is given by a number of studies in social sciences, which in general have tried to assess the impact of the Internet on face-to-face activities, seeking to understand if dispersed communications diminishes local community activities (see the review in Wellman & Gulia 1999). Findings suggest that the relationship between communications (the Internet, the telephone), distance, and local communities is not necessary negative but also can foster local interaction (Hampton & Wellman 2001) and social support (Wellman 1979; Wellman & Wortley 1990; Boase *et al.* 2006). From a social interaction perspective, the Internet seems to be crucial to maintaining dispersed and large social networks, connecting both close and distant alters, as a tool of *glocalization* (global + local; Hampton & Wellman 2001). Furthermore, Haythornthwaite (1998) argues that the Internet – and more precisely email – is part of a media multiplexity phenomenon, which involves a complementary relationship with face-to-face and phone interaction, with people using multiple media to interact. A different

perspective is offered by Larsen *et al.* (2006) suggesting that email substitutes face-to-face for very long distances, when time and costs are very high.

1.3. Social Activity-Travel and Social Networks

Recently, the study of social activities has gained more attention, recognizing its increasing number, kilometrage, and complex associated travel patterns (Miller & Shalaby 2003; Bhat & Gossen 2004; Schlich *et al*. 2004; Larsen *et al*. 2006; Srinivasan & Bhat, 2006). From a policy viewpoint, social activities have an increasing relevance due to an aging population (Banister & Bowling 2004; Newbold *et al.* 2005), a steady increase in leisure time budgets, a weaker separation of work and leisure time (Larsen *et al*. 2006), and the spreading of social networks (Wellman 2001). Social activity-travel is also relevant since it directly touches upon the people's overall quality of life, representing an important type of travel. Such travel does not merely connect people to friends and family, but also facilitates the emotional and material benefits from these networks, namely the *social capital* that networks can provide (Lin 2001; 2006; Larsen *et al*. 2006).

From a behavioural perspective, social activity-travel is different with respect to other purposes, such as working and shopping. This aspect was recognized long ago by authors such as Stutz, who argued that social trips were concerned by person to person connections, which makes them more personalized (…) because the trip maker becomes socially involved at the trip destination, thereby differing from pure leisure or shopping trips that are concerned with person-to-activity connections (1973, p. 7). In other words, since the main motivation of social activities is precisely interpersonal interaction, the associated travel generation has an intrinsic social dimension. Although this is intuitively obvious, explicit attempts to incorporate the social dimension in social activity-travel models are scarce in the literature. Yet, a social network approach can explicitly capture the person-to-person link of these trips and elaborate on how activities and travel emerge from maintaining a social network (Carrasco *et al.* 2008a).

These ideas become even more relevant when studying the relationship between ICTs and social activities. With the partial exception of Larsen *et al.* (2006), the literature rarely includes nuanced discussion of the social relationships that motivate both social face-to-face and ICT interactions. In this context, the social network approach is useful to study ICTs and social activity-travel not only from the theoretical perspective, but also to gain empirical insights about that issue, especially considering the very few attempts that have been made to link ICTs, social networks, and social activity-travel behaviour.

The social network approach can be defined in the following way: Social network analysis is the study of social structure and its effects. It conceives social structure as a social network, that is, a set of actors (nodes) and a set of relationships connecting pairs of these actors (Tindall & Wellman 2001, p. 265-6). Social networks are thus composed by two key components: *actors***,** who represent different entities (e.g., groups, organizations, as well as persons); and *relationships***,** which represent flows of resources between them (e.g., control, dependence, cooperation, information interchange, and competition). The core concern of the social network approach is to understand how social structures facilitate and constrain opportunities, behaviours, and cognitions (Tindall & Wellman 2001, p. 256). A key link with travel behaviour is that ties among

people do not merely represent a relationship but also the *potential activity and travel between them*. Therefore, the social dimension defined by the individuals' structural characteristics – and the underlying actor attributes – constitute promising sources of explanation of activity and travel.

2. THEORISING THE ROLE OF AGENCY IN SOCIAL ACTIVITY-TRAVEL

2.1. Introduction - Framing the debate

Although the relationship between ICTs and travel demand is complex and indirect, this makes it no less real and no less significant. Our theoretical framework seeks to move the discussion beyond another debate about substitution versus additive effects by illustrating how ICTs *facilitate* social interaction, and by implication, the activity-travel demand associated with such social interaction. To articulate this relationship, this framework integrated a series of concepts in the sociological and social geographic literature about ICT use and travel.

The following section argues that ICTs transform social relations by decoupling the time-space paths associated with corporeality. People are not merely accessible through a path in a physical time-space prism but through a swath of communication media (e.g., Miller 2005). What is altered is not necessarily the volume or frequency of activity, but the processes by which it is organized and implemented. ICTs make it easier for people to act on their impulses to organize social activities and also enable people to negotiate optimal times and places for activities. The theory presented in this paper characterizes an individual's drive to organize social activity as ***agency***, and the differences in their capacity to do so as ***social accessibility***. Both agency and social accessibility are not evenly distributed throughout a population.

We place the theory of agency and social accessibility in the context of work on ICTs and travel (e.g., Salomon 1986; Mokhtarian 1990), focusing particularly on the activities that trigger travel (e.g., Timmermans 2005). The theoretical approach also draws from the time-space constraints that people face in their daily life (Hägerstrand, 1970) and the work on ICT use within a theory of time-geography (Kwan 2002; Dijst 2004; Miller 2005). A relevant example in this context is the work by Raubel *et al.* (2004), which extends the concept of time-geography to incorporate emerging technologies through the use of the concept of affordances. All that said, we also believe there are important links to be made between these ideas and the sociological literature on time use, social affordances, and social accessibility. We believe that our focus on the *social* dimension of travel can facilitate useful insights about the social geographic concepts of telepresence, time-space prisms, and time-space coupling.

2.2. Theorizing Agency

2.2.1. The decoupling of time and space through ICT

Time geography offers a very specific understanding of coupling whereby there is an inherent relationship between a particular place and a particular time for a specific individual. People travel to be at the same place at the same time. However, since information and messages may be asynchronous (through mail, email and voicemail; see for example Mokhtarian *et al.* 2006) and not tethered to a place (through mobile phones and webmail), this suggests that social contact does not need to be at the same place at the same time, and hence social contact can, to some extent, be decoupled.

An early example of ICT punditry was the assertion that the Internet would lead to a death of distance. This is an example of taking decoupling to its extreme. This has not happened, and it is not likely to happen in the near future, if ever. We agree with Dijst (2006, p. 3) that the decoupling processes will not, however, lead to the often-discussed 'death of distance' (Cairncross 1997), but rather to the continuous reconfiguration of the locations where physical and electronic encounters take place. This has been assessed in a number of studies in the context of social activities (e.g., Senbil & Kitamura 2003; Carrasco & Miller 2006; Carrasco *et al.* 2008b). ICTs do not make a good substitute for in-person contact any more than telephones. No one has suggested that a Thanksgiving dinner can be experienced on a conference call, why would it be spent with a webcam? The converse is also true and sorely neglected. ICTs enable types of information retrieval unavailable through corporeality. Mapping services for individuals are robust and rapid. Some traffic systems also give real-time information about flows across a city. In practical terms this has led to a particularly *facilitative* relationship between ICTs and in-person contact. That is to say, ICTs facilitate flexible in-person contact and help sustain groups between fixed periods of contact.

What has emerged in this decoupling is a new emphasis on who is doing the communicating. Wellman's schema of *door-to-door*, *place-to-place* and *person-to-person* networking is instructive in this regard (Wellman 2001). In the absence of media (say 200 years ago), all contact is necessarily corporeal, or literally door-to-door. With the emergence of the telephone and the telegraph, interaction could take place across distances, but the tools were still tethered to place, hence place-to-place networking. The emergence of personal technologies such as the mobile phone and email see a new form of networking that is tethered to the person rather than a fixed place, hence person-to-person. This latter form of networking means that ICTs cut through group boundaries. Instead of a phone call being to the household (whereby someone else might answer, or leave a message) it would be directly to the person. Hence, differences in the structure of social relations play an increasing crucial role. Whereas before one individual might be part of a web of mutually-shared places, times and information, now everyone is their own personal switchboards, selectively reorienting themselves to new information from separate areas of the network in real time.

Email use has also led to differences in networking. The specific ways in which these technologies affect behaviour are represented by the social affordances approach (Bradner *et al.* 1999; Wellman 2001; Boase 2006). One of these affordances is personal broadcasting: an individual can send the same message to many persons. Another

affordance is asynchronicity, whereby email enables people to send information when it is convenient for the sender, while the others will receive it when it is convenient for them. Asynchronicity has facilitated the blurring of the home-work boundary (Kennedy 2007).

Considering these technologies in concert has also led to insights about the nature of social interaction. In a study of distance learners, Haythornthwaite (1998) noticed that individuals who were closer tended to use more media to interact. They termed this phenomenon media multiplexity. Media multiplexity has been subsequently found in cases with in-person interaction (Wellman & Hogan 2004; Boase 2006).

2.2.2. ICTs and travel: Affordances and social accessibility

The influx of changes to person-to-person networking has prompted us to consider a broad framework that can successfully encompass these changes in meaningful ways. In this context, the concept of ***social accessibility*** from the work of sociologist Eviatar Zerubavel is particularly useful. For Zerubavel, social accessibility is a means for interpreting differences in the organization of time (1979). Certain times and places are coupled, thereby leading to distinctions between public and private lives. Crudely speaking, the evening is private time, for family duties and personal restoration, while the daytime is public time for work, volunteering, and shopping. The evening is considered private time because only certain particularly close ties are given unproblematic access to an individual – spouse, children, immediate family and close friends. Anyone outside of a close circle who calls an individual late in the evening should have a good reason.

In the age of ICTs, social accessibility has become a complicated affair. It can no longer operate under the simple axis of work time-space and home time-space. Individuals do not need to be coupled to a particular place to be contacted, nor does a message have to be sent and received at a particular time. Thus, one can email their boss at 3 in the morning, whereas in email's absence such a message might have to wait until morning.

Hence, social accessibility has also become a more personalized affair. If contact between individuals is not entirely coupled with particular places and times, then media access rather than broad social norms determine social accessibility. In other words, since people must be considered to be normatively accessible before one person is going to seek out another— and people neither drop in on strangers nor call up their friends in the middle of the night (without good reason)—social accessibility is a *precondition* for social activity travel. All else being equal, people who take advantage of new media possess more social accessibility over greater spans of space and time. At the same time, ICTs widen the scope for social accessibility. Using ICTs, people will not necessarily have more face-to-face contact, but will be more able to leverage their accessibility, contacting a larger number of people and especially those more difficult to contact. This may lead them to spend less time with a small number of network members and more time with a greater variety of network members.

Changed social accessibility has both positive and negative impacts. The good news is that increased social accessibility can reasonably be linked to greater social capital: resources embedded in one's social networks, resources that can be accessed or mobilized through ties in networks (Lin 2006, p. 2). Social accessibility comes into play

since, the intriguing question is why, given the same level of accessible embedded resources, some individuals *mobilize* better resources than others (Lin 2001, p. 22; emphasis added). Individuals can access weak ties through ICTs even when co-presence is difficult to achieve. They can inform their ties more rapidly and efficiently, dynamically arranging interactions (and possibly support) that might not otherwise be feasible.

The bad news is that the emergence of new ICTs creates new inequalities (Lenhart *et al*., 2003; Servon, 2002). First, media are not universally affordable. Always-on email requires a broadband Internet connection, which is often not prevalent because of cost or poor infrastructure (Chen & Wellman 2005; Dijst 2006). Second, people who do not see the value in this technology are cut-off from potential channels for social organization. They will need others to work with non-preferred media, such as letter writing, or to work through transitive ties, such as hearing of news through mutual friends or other family members. Third, there are inequalities of competence. While the operation of a telephone is a reasonably simple affair, mobile phones and email require a number of skills. Power emailers can use a variety of hot keys and tricks to optimize their email usage, while others may never figure out how to send a photo.

2.2.3. From affordance to action: Agency

Social accessibility offers a powerful framework for thinking about differences in contact between individuals and how ICTs can play unique roles within social contexts. But all of this is provisional. Individuals actually have to do the contacting: they have to make the plans, send invitations, initiate trips, or otherwise take steps towards communication within the expanding constraints afforded by new technologies. If social accessibility offers a lens to observe the *constraints* that people face in making contact with others, then ***agency*** directs that lens to the ways in which people *work within these constraints* to achieve the goals of human contact and social interaction.

Agency describes the tendency of people to capitalize on their circumstances and create / reproduce social order (Emirbayer & Mische 1998). Such social order means a shared understanding between individuals about the specific time-space coordinates of future interactions. For example, planning a party is an agentic act: individuals set the time, the place and the invitation list. The attendees also exert agency by deciding whether to show up and whether to bring a guest. However, the attendees exhibit less agency insofar as they do not hold the same sway over the time, the place and who else is invited. There are obvious links between social activity-travel and agency. Agency indicates the propensity of an individual to set in motion plans that will require travel. The individual may not be the one traveling, but the individual's agency was the necessary condition for travel in the first place.

To diagnose the causes of agency we look to the social attributes of people, such as their levels of income, gender, and lifecycle. But we also look at the social contexts of the individual, both regarding who are their social network members and what are the structures of their networks (e.g., density, subgroups).

We can make certain deductions about people's agency based on their structural location. First, we assert that people who exist in a dense network of mutually reinforcing relations are likely to exhibit less active agency. This is because the duties of planning

can be diffused throughout a group. This assertion is based on findings that dense networks lead to norms of reciprocity and information sharing (Uehara 1990; Wellman & Wortley 1990), while sparse networks indicate personal control of information (Freeman 1979; Burt 2005).

The second is that network size is associated with relative levels of agency. Individuals with larger networks are likely to maintain these networks through active planning and engagement. The fact that their networks are larger should be seen as products of their ability to actively maintain a large number of connections and preserve these connections across time-space (Boase *et al.* 2006).

Agency should not to be equated with novelty in people's actions. People can be both agentic and habitual (Giddens 1984; Emirbayer & Mische 1998). They might organize events in the exact same way for months, thereby ensuring a great deal of time and space fixity. What emerges then is a habitual coupling of expectations between individuals. Agency, then, indicates that both parties mutually maintain these events and work towards that goal.

As stated above, we believe ICTs play an essentially *facilitative* role in this process. ICTs do not necessarily mean more travel directly, but they enable people to be accessible over larger stretches of time-space. Since people are only agentic when they can access others; the fact that ICTs enable greater social accessibility means that they can facilitate greater agency. People can plan more frequently, make more optimal negotiations, and replace time-space fixity with time-space optimality.

3. RESEARCHING AGENCY

3.1. Data and Methods

3.1.1. The Connected Lives study

The data used to perform the empirical analysis come from the *Connected Lives* study of communication patterns, conducted in the East York area in Toronto by the NetLab at the Centre for Urban and Community Studies, University of Toronto, between May 2004 and April 2005 (Wellman *et al.* 2006). East York is located east of downtown Toronto, and is representative of the overall central city socio-demographics and general transportation characteristics. The data were collected in a survey of 350 randomly-sampled adults (18+) and a long follow-up interview with 84 people, which elicited information about their personal network members (a total of 2,045), as well as about the social face-to-face, telephone, and email interactions between the respondents and a representative sample of around half of those network members (Hogan *et al.* 2007; Carrasco *et al.* 2008a).

A personal network is my network for any given individual. The respondent is referred to as ego and all of the people mentioned by the respondent are referred to as alters. Measures of the size of a personal network vary. Boissevain's extensive year-long study of two persons in Malta, found that egos had meaningful interactions with almost 1800 alters (1973). By contrast, McCarty *et al.* estimated networks of about 250 ties in a larger American sample (2000). However, as scope conditions get more specific, the

number of network members decreases. In this study, we asked people to elicit the names of alters who are very close (those in frequent contact, those who one discusses important matters with or those who can be called on for help) and those who are somewhat close (others who are more than casual acquaintances, but not 'very close'). For further details about the collection procedure and main data characteristics, see Hogan *et al.* (2007) and Carrasco *et al*. (2008a). This collection procedure elicited a mean of 23 ties. A mean of 12.13 of these ties were sampled for an intensive social activity profile. Prior analysis has found that these sampled ties are representative of the ties in network as a whole (Hogan *et al.* 2007).

The resulting dataset is inherently hierarchical. The first level refers to the alters, including their relationship to egos plus the alters' personal characteristics. The second level covers measurements about the networks as a whole and descriptive data about the egos. Analyzing differences between alters cannot be done using standard regression because such data violates the assumption of independence between cases. Hence, we use multilevel hierarchical linear modeling as it controls for the variation between networks and between alters (see also van Duijin *et al*. 1999; Wellman & Frank 2001; Snijders 2003).

3.1.2. Measuring agency and its influencing factors

One of the core benefits of a personal network approach is that one can measure variations within a given individual depending on who the individual is interacting with. In this case, we measure agency at the level of the ego-alter pair. That is to say, for every network member studied, who is more active in initiating contact, ego or alter? We define three ordered categories of agency between any pair of individuals:

1. Active – the ego almost always initiates contact.
2. Mutual – either ego or alter initiates contact.
3. Passive – the alter almost always initiates contact.

Table 1 shows the wording of the questions on agency for socializing, telephone, and email contact and indicates how the responses were coded into the ordinal scheme above.

To explain variation in agency, we examined variables at both the alter relationship level and at the ego/network level.

Alter level:

- *Alter's personal characteristics*: This includes alters' *gender*, *age*, and *spatial distance* to ego.
- *Relationship characteristics*: This includes whether alter is *very close* or *somewhat close*, *frequency of interaction* through ICTs, and the alter's *role* (family member, workmate, friend, neighbour, etc…).
- *Network characteristics:* These measures take into account connections within a network. Alter's *degree* is the number of connections an alter has to others in a network. Alter's *betweenness* indicates the number of shortest paths that include that alter. It is interpreted as a measure of control: high betweenness means information should typically flow through that alter (Freeman 1979).

***Ego/Network Level*:**

- *Personal characteristics*: This includes ego's gender, age, stage in the life course (living with a stable partner and having children at home), household income, working at home, having internet at home, immigration status, and years of residence in the city and in the same household.
- *Aggregate network characteristics*: This includes all measures of the network as a whole. It includes the structural measures such as *number of alters* in the network, two measures of how *unequally distributed* connections are in the network (*betweenness centralization* and *degree centralization*), the *density* of the network (the number of connections relative to the maximum possible number of connections), how *fragmented* the network is (*number of components* including and excluding isolates),[1] and how many *isolates* are in the network. It also includes compositional measures such as the *percentage of alters* who are family and the percentage who are workmates.

The two measures of centralization are particularly noteworthy as they indicate the extent to which overall network connectivity falls on the shoulders of disproportionately few individuals. High degree centralization indicates that links are connected to disproportionately few central individuals suggesting that these individuals are particularly active in the network (McCarty 2002). High betweenness centralization indicates that a few individuals are prominently placed on the shortest paths between many network members (Wasserman & Faust 1994) and probably are important in coordinating social activities and making plans. We assert that where centralization is high, these individuals are especially agentic.

3.2. Hypotheses

The empirical analysis explores six hypotheses, grouped into four aspects that relate agency in socializing to social activity-travel behaviour and ICT:

1. *Agency and network characteristics*
    - H1. Ascribed ties (primarily family) will be more agentic (either passive or active), whereas acquired ties such as friends will be more mutual.
    - H2. Densely knit networks enable individuals to be more neutral, since the work of coordinating is more likely to be shared.
    - H3. Larger networks and more fragmented networks are associated with more agency.
2. *Media specific effects*
    - H4. Media accessibility leads to increased mutually-reinforcing communication. People who are more accessible (by virtue of being in contact by more media) require less active work on the part of either ego or alter. Therefore spatially closer individuals who interact by multiple media will exhibit more neutral agency, while those further away will be more polarized.
3. *Distance*

[1] A component is a maximally connected subgraph. A network may have several components including a group of co-workers and one's family. A network with many components indicates that egos keeps their ties separate. A network with one large component indicates that egos are embedded in a well-connected web of relationships. An isolate is a single individual who is unconnected to anyone else. It is a trivial component and generally not counted.

- H5. Spatial accessibility leads to increased social activity. Individuals who are more accessible (by virtue of being spatially closer) require less active work on the part of either ego or alter. Therefore closer individuals will exhibit more neutral agency, while individuals further away will be more polarized.

4. *Frequency of interaction*
   - H6. Dyads that frequently socialize face-to-face will be neutral, as they are accessible and embedded in a web of socializing expectations. Those who socialize less frequency will exhibit more polarized agency.

In general, the hypotheses suggest a situation whereby individuals who are either *socially close* (by virtue of mutual ties or frequent interactions) or *spatially close* are more likely to be embedded in webs of mutually reinforcing communication and travel. For those individuals who are further away (either socially or spatially), relationships are more prone to interpersonal asymmetries: one party will be more likely than the other to invite or initiate an email or a phone call.

We primarily employ two techniques to explore these hypotheses – comparison of column proportions and multilevel analysis. The appendix at the end of the paper provides an in-depth description of the comparison of the column proportion method and multilevel models.

3.3. Empirical Analysis

Overall agency levels. Tables 2 and 3 show the overall distributions of agency per media at the ego-alter level, that is, for the interactions of egos with each of their alters. Neutral agency is by far the majority in all media. Note also the symmetrical distribution in all cases, with a similar number of active ego-alter agency compared with passive ego-alter agency in socializing; similar tendencies occur for telephone and email.

At the ego-network level, the ego's overall agency level was calculated by taking the mean value of the individual agency scores, defining these scores as *1* for active, *2* for neutral, and *3* for passive, and excluding ego-alter interactions where no socializing occurs. The resulting ego-network mean values of socializing agency were further classified as active / somewhat active if the mean value was lower than *2*, neutral if it was *2*, and passive / somewhat passive if it was greater than *2*. Using these definitions, 37.3% of the egos are active / somewhat active, 32.5% are neutral, and 30.2% are passive / somewhat passive.

3.3.1. Agency, and personal and network characteristics

Socio-demographics. We first explore the relationship between individual characteristics and agency as a way of setting the background in the study of the hypothesis formulated in the previous section. Social agency and the socio-demographic characteristics of ego and alter were analysed using both comparisons of column proportions (Table 4) as well as a multilevel model that integrates ego-alter and ego-network levels (Table 11). The comparison of column proportions highlights that friends are more likely than family members to have mutual levels of agency, but it does not reveal many other details. However, the multilevel analysis does indicate significant relationships between alter's

role and agency. As shown in the multilevel model in Table 11, if alters are immediate family members or extended family members, there is a higher probability that egos will be more active in their social interaction, all else equal. On the contrary, if alters are neighbours or coworkers, egos are less likely to be agentic.

Age has a relationship with agency. The multilevel model shows that older egos are more likely to be passive all else equal. At the same time, the older the alter, the more likely the ego is to be agentic. Thus, the intuitive idea of young people being more agentic in social activities is supported by these two results. These results are also supported by the bivariate analysis at the ego-alter level (Table 5), which shows that egos are proportionally more neutral with alters aged between 30-59 years old, and proportionally more passive with alters with 60 or more years old. Note, however, that in absolute numbers, most of the ego-alter relationships are neutral.

Immigration, measured through the ego's *language spoken at home*, shows weak results. Although there is no multilevel evidence about a relationship of immigration to social agency, the boxplot of the egos' social agency level with respect to immigration shows a slightly higher dispersion of non-immigrants towards more agentic levels (see Figure 1). A second related variable that shows a much stronger effect according to the multilevel model is *years at the same home*: the results suggest that the more years living at the same home involves a more active socializing agency. A possible interpretation of this result is that egos who have more established networks (i.e., the ties are longer in duration) are more able to capitalize on their social relationships and thus more able to plan instances of social interaction.

An initial examination indicates that high *Internet* users tend to be more active (see Figure 2). However, both the multilevel model and the bivariate analysis do not show that Internet use significantly affects socializing agency. This finding is consistent with the previous discussions about the Internet as a facilitative medium for social interaction. Finally, other socio-demographic variables that are important to define the frequency of social activities (Carrasco & Miller 2007) do not have the same relevance with respect to the socializing agency: *income* and the *presence of children at home*.

One novel aspect of multilevel analysis presented in Table 11 is that it can take into account not only alter's role, but also the proportion of people in the network who share that role. When there is a high proportion of family members, the effects noted above are muted. That is to say, if most of the network is not family, ego is very *active* in contacting family members, but when most of the network is family, ego is more likely to be mutual or passive. This is shown by the fact that 'alter is immediate family' has a positive coefficient, while proportion of family members has a negative coefficient. The same type of phenomenon occurs among coworkers, except in the case of coworkers, ego is generally *passive*, but as the proportion of coworkers in the network increases, ego tends towards mutual agency. This result directly tackles hypothesis H1, suggesting that ascribed ties (especially family) will be more agentic than those who are not.

Network structure. Both the number of ties and the ways these ties are organized can inform social activity and communication agency. In particular, individuals with larger networks are more likely to initiate contact actively with network members (Table 11), as stated in research question H2. This result helps explain Boase's findings that people with

larger networks are in contact with a disproportionate number of them (Boase 2006; Boase *et al.* 2006): it is because they actively seek out this contact.

We also find evidence that the ways in which ties are organized makes a difference (research question H3). A more fragmented network (more components) is associated with more passivity. However, group size makes a difference. Some components only include one individual who is not connected to anyone else in the network (an isolate). When we removed isolates from the count of components, the effect is reversed meaning that people who have a lot of larger groups are more active but people who have a lot of small groups are more passive (supplementary model not shown).

When alters are connected, betweenness appears to have a substantial effect. When alters have a *high betweenness* (connecting separate groups), egos are less active. When the entire personal network has a high overall betweenness score (meaning a few individuals are particularly important in linking the network together), again ego is less active. Second, the positive relationship between *degree centralization* and ego being more active in socializing is consistent with McCarty's (2002) interpretation of this measure, where a higher degree of centralization involves a potential higher level of activity (socializing in our case) in the network.

As there is no relationship between network density and levels of agency, we can say that it is not the number of connections in an individual's network as much as how these connections are organized. When ego bridges many groups, ego is active. When specific alters connect different groups (i.e., high betweenness), these alters are more active and ego is more passive. Thus it is possible to say that social activity is often organized around certain focal individuals, be they ego or someone in ego's network. These individuals are relevant not only because they link groups, but because their linking is associated with their being active individuals and actively initiating contact.

Telephone and email agency. A similar analysis was done for telephone and email agency. None of the socio-demographic variables analyzed show a clear relationship with either telephone or email agency, at least on the levels that were observed with socializing. Regarding network structure variables, *network size* and *number of components excluding isolates* show the same tendency as in the case of socializing frequency, with a positive relationship with email and especially telephone agency (Figure 3).

3.3.2. Agency and media of interaction

The second set of research questions (H4) explores the relationship between the different agency levels defined by face-to-face socializing, telephone, and email for each ego-alter interaction. Concerning the telephone, those individuals who are mutual in initiating telephone are particularly likely to be mutual when socializing, Table 6. Meanwhile, those who are active [or passive] in initiating telephone calls are *disproportionately* likely to be active [or passive] when initiating social activity. This suggests that media do not merely reflect one's overall level of agency. The telephone, in particular, *amplifies* it. Such a finding reinforces the overall argument about social accessibility. The telephone amplifies a pre-existing tendency to be either mutual or active/passive.

Email does not show quite the same relationship. While most people are neutral in both media (as is the case with the telephone), it seems that many emailers passively receive emails from their network: they are the ones being invited rather than doing the inviting. We believe this is a consequence of email's broadcasting affordance in which a person can send invitations to many others at one time.

Table 7 shows the three-way combination of agencies. There is an amplification effect again, although it is only observed in the neutral socializing category, most likely because of the small sample sizes in the other categories. Among those who are neutral in terms of inviting, one's agency level with one medium is often linked to one's medium agency level in other media. That is to say, people who are active/passive/neutral in initiating telephone calls are more likely to behave similarly when initiating email conversations.

3.3.3. Agency and distance

The third research question (H5) explores the relationship between agency and the distance between egos and alters. Distance is a categorical variable that divides three scales, *local* (lower or equal than 35 km), *regional* (elsewhere in Ontario and Quebec: greater than 35 km, and a plane is not required to reach the destination), and *long-distance.* Although the results from the multilevel model are weak, they suggest that distance is positively related to agency: more distance make it likely egos that have active social agency with their alters. Similar results were obtained when distance is defined as the logarithm of the kilometres separating egos and alters, thereby de-emphasizing small differences in long-distances.

Complementing the multilevel model results, Table 8 shows the relationship between spatial scale and levels of agency. Local ties tend to have a statistically higher proportion of neutral social agency than regional or long-distance ties. Regional and long-distance ties tend to have a statistically higher proportion of active telephone agency than local, and at the same time, local ties tend to have a much higher proportion of neutral telephone agency than regional ties. Finally, regional ties have a much higher proportion of active email agency than do local ties.

Again, these findings reinforce an argument about social accessibility and agency. Those who are closer are more accessible in terms of distance and are more likely to consider social activity initiation a mutual affair. Those alters who are further away from ego have a more defined level of agency – either they invite or are invited. They are less accessible so one person is going to have to be more agentic than the other.

3.3.4. Agency and frequency of interaction

Finally, we turn our attention to the frequency of social interaction (research question H6). As with the three previous sections we hypothesize that increased frequency or ease of contact will be associated with more mutuality, while less contact will be associated with more active or passive behaviour. The results partially reinforce this expectation. Those who socialize at least weekly are disproportionately neutral when considering who does the inviting (Table 9). The results for telephone are not as pronounced. Comparing of telephone agency and frequency of telephone interaction shows that the majority of

ties are neutral. The one disproportionate case is in keeping with our assumptions: egos who talk by telephone monthly tend to have more agency than those who interact by phone weekly or more frequently (Table 10).

The results from email are perhaps the most pronounced. Those who email at least weekly are more likely to consider the relationship neutral, much like a long email thread where individuals reply frequently to the senders (Table 10). When interaction is less frequent, egos are more active in initiating email with alters, consistent with our hypothesis that ICTs expand the social accessibility of individuals, thus enabling more agency. While people telephone others with more neutral agency regardless of frequency, they are more apt to initiate email contact with others whom they have not emailed recently.

Although the majority of agency is neutral for all media regardless of the frequency of interaction, there is a high likelihood that if egos have more frequent interaction with alters, they will have more neutral (mutually reinforcing) relationships. Thus, as hypothesized, those who are socially more accessible tend towards more reinforcing relationships, while those who are less accessible tend towards more active or passive engagement.

4. DISCUSSION AND CONCLUSIONS

This paper uses a novel perspective in the travel behaviour literature to present a theoretical statement and an empirical offering about the relationship between ICTs, social networks, and activity-travel behaviour, In addition to incorporating concepts from time-geography, we have introduced two concepts from the sociological literature: social accessibility and agency. We argue that these two concepts are relevant for understanding the dynamics and characteristics of the social interactions that lead to activity and travel, as well as to ICT-mediated interaction that is embedded in real life. Social accessibility provides on the one hand, a framework to understand variations in contact between different network members, especially the constraints imposed by the way individuals organize time and provide (or restrict) access to others. Individuals' agency comes into play to capitalize on the opportunities for interaction that these constraints define, providing a framework to understand the facilitative process of ICTs in social interaction.

Using this theoretical framework as a background, the paper empirically explores how agency – operationalised in the context of social activities – is related to key aspects of social networks, and the use of ICTs. Although more experience on measuring and understanding the overall importance of agency is needed, one value of this paper is in opening a different theoretical perspective to study the effects of ICTs in social activity-travel, by explicitly considering the social context in which these interactions occur.

More specifically, most close relationships seem to be mutually reinforcing, with one person as likely as the other to initiate contact. This makes sense, given a concept of agency that suggests most interaction is habitual and done with those who are accessible. More interesting are the conditions under which agency tends away from neutrality towards being more active or passive. In general, more passivity is associated with older individuals and those who have bridges in their network. In general, more activity is associated with having a large network and a more fragmented network – both kinds of networks need much work to be maintained. The finding about older individuals coupled

with the increased agency of email suggests that the elderly may miss out on social interaction opportunities afforded by ICTs.

Regarding specific dyadic relationships in particular, those who are physically more distant or have less contact are associated with more asymmetric initiation patterns. That is to say, far away friends and kin need to be sought out actively or else contact may drift.

Media can facilitate agency, which is to say it can enable people to actively seek out and contact their ties. With most friends and relatives living far away and unannounced visits and phone calls seen as intrusive, email is probably the best contemporary medium to support active agency. Telephoning seems to have a polarizing effect, whereby those who are more active (or passive) in calling are even more active (or passive) when socializing. Unlike AT&T's legendary commercial, email is more strongly associated than the telephone with actively trying to reach out and touch someone.

In conclusion, we have shown that the study of activity-travel and ICTs will benefit from a theoretical lens that articulates some of the transformative effects of ICTs on travel and on social activities. The concepts of social accessibility and agency can help focus that lens, by enabling researchers to have new understandings of the activity-travel behaviour processes and to develop more elaborate and more realistic models that add social dimensions to spatial and temporal dimensions.

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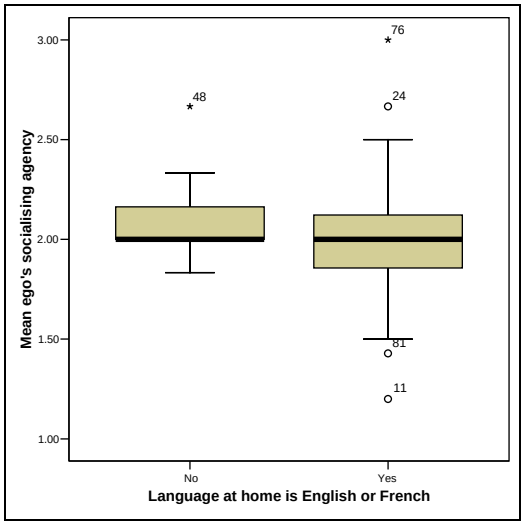
TABLES AND FIGURES



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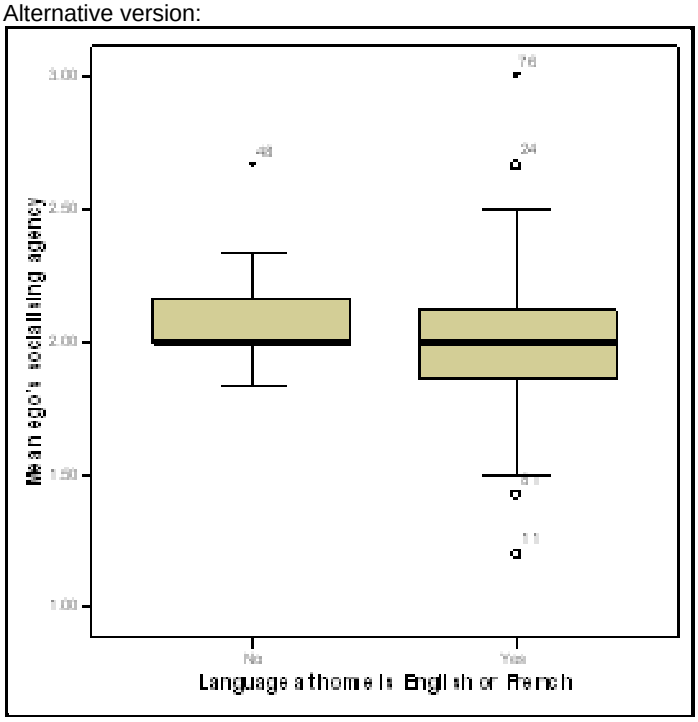
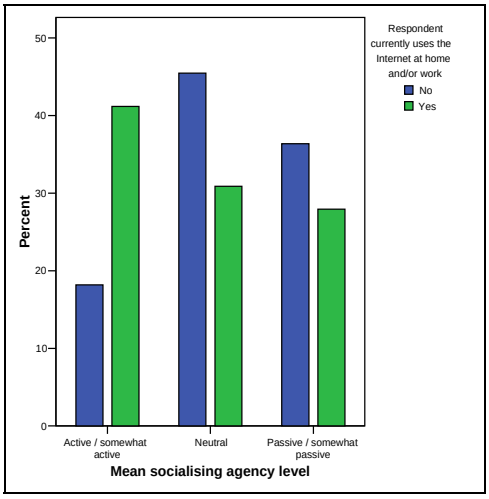


Figure 1: Mean ego's socializing agency BY ego's immigration (per ego)

Note: In these graphs, the *black line* corresponds to the median, the box length corresponds to the interquartile range (defined by the 25th and 75th percentiles), *extremes lines* correspond to maximum and minimum cases that are not statistically outliers (respectively defined as the 25th and 75th percentiles minus 1.5 times the interquartile range), *dots* correspond to outliers (cases with values between 1.5 and 3 times the interquartile range), and *asterisks* correspond to extreme cases (cases with values greater than 3 times than the interquartile range); outliers and extreme cases are individualized by the number of the specific network.



Alternative version: (blue means does not use internet at home or work, green means use at either location). The three columns represent 'active' / 'mutual-neutral' / 'passive' levels of overall socializing agency for ego.

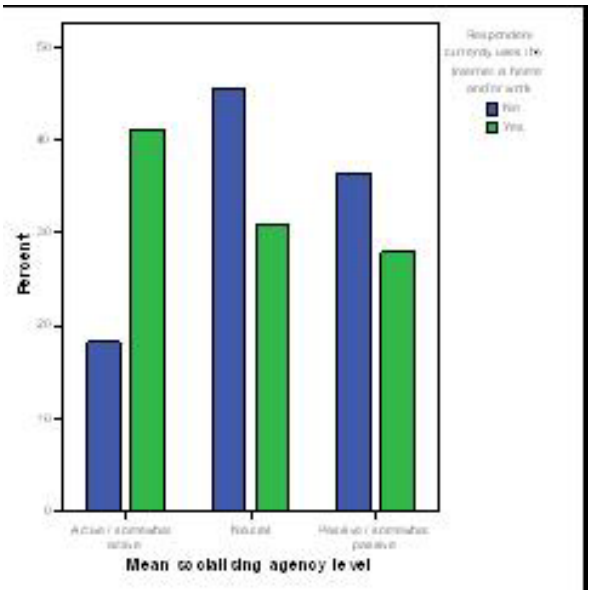
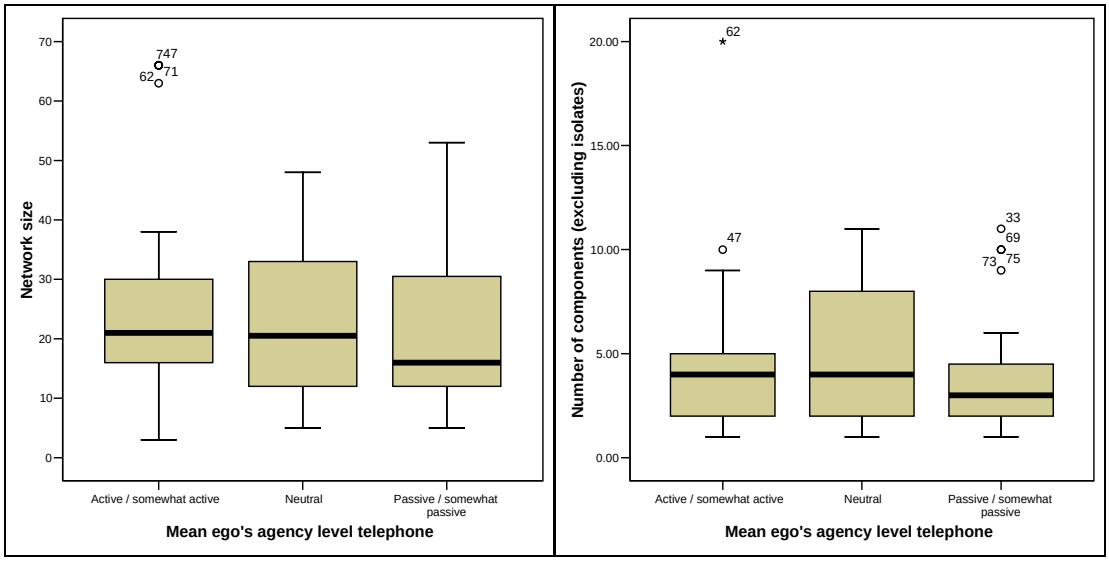


Figure 2: Frequency of socializing agency BY ego's Internet use



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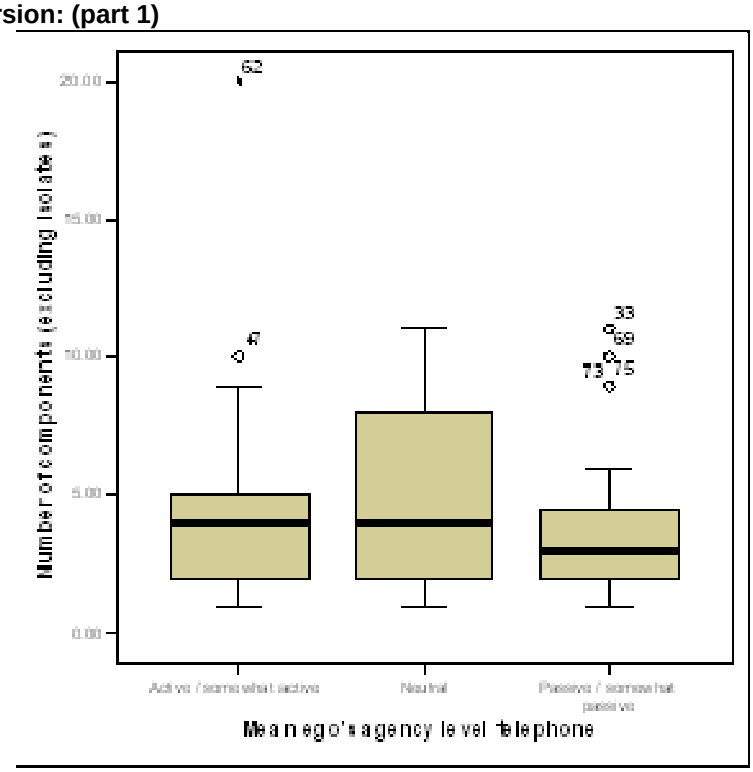

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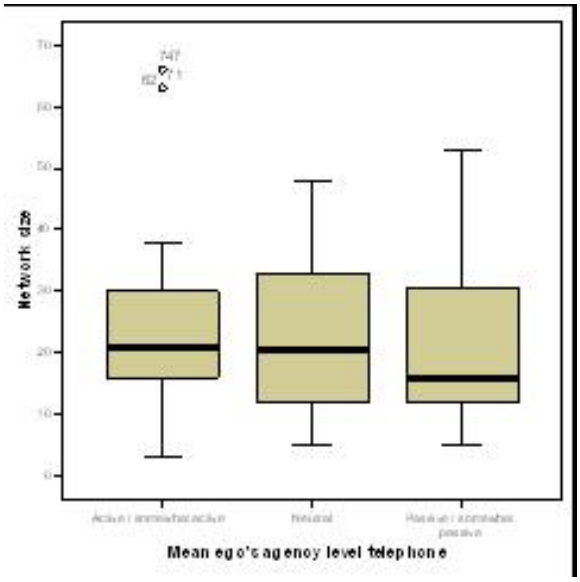

Figure 3: Mean ego's telephone agency BY network size and BY number of components (excluding isolates)

Table 1: Definitions of agency levels using the Connected Lives Study

Social agency: who invites who?				
	Active = I usually invite him/her [active] Passive = S/he usually invites me [passive] Neutral = We go to see each other equally [neutral] Someone else invites both of us [neutral] We socialize at a regular meeting [neutral]			
Telephone agency: usually calls who?				
I call her [active]	[somewhat active]	We call equally [neutral]	[somewhat passive]	S/he always calls me [passive]
1	2	3	4	5
Email agency: who usually starts the email conversation?				
Me [active]	[somewhat active]	Both [neutral]	[somewhat passive]	Him / Her [passive]
1	2	3	4	5

Table 2: Overall frequencies of socializing agency

		Frequency	Percent	Valid Percent
Valid	Active	101	9.9	16.1
	Neutral	432	42.4	68.7
	Passive	96	9.4	15.3
	Total	629	61.7	100.0
Other	Never socializes	211	20.7	
	Missing cases	179	17.6	
Total		1019	100.0	

Table 3: Overall frequencies of telephone and email agency

		Telephone agency		
		Frequency	Percent	Valid Percent
Valid	Active	137	13.4	16.3
	Somewhat active	62	6.1	7.4
	Neutral	483	47.4	57.3
	Somewhat passive	62	6.1	7.4
	Passive	99	9.7	11.7
	Total	843	82.8	100.0
Other	Never telephones	139	13.6	
	Missing cases	37	3.6	
	Total	176	17.2	
Total		1019	100.0	
		Email agency		
		Frequency	Percent	Valid Percent
Valid	Active	80	7.9	18.7
	Somewhat active	28	2.8	6.5
	Neutral	227	22.3	53.0
	Somewhat passive	23	2.3	5.4
	Passive	70	6.9	16.4
	Total	428	42.0	100.0
Other	Never emails	588	57.7	
	Missing cases	3	0.3	
	Total	591	58.0	
Total		1019	100.0	

Table 4: Agency social BY Role

		Role					
		Immediate family	Extended family	Neighbour	Coworker	From organiz	Friends
		(A)	(B)	(C)	(D)	(E)	(F)
Agency social	Active	33	14	4	10	5	32
	Neutral	75	36	44	59	29	**(A)** 167
	Passive	24	14	9	16	6	25

Note: In all cross tables, the results are based on two-sided tests with significance level 0.10. For each significant pair, the key of the category with the smaller column proportion appears under the category with the larger column proportion. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

Table 5: Ego's socializing agency BY alter's age

		Alter's age		
		< 30	30 – 59	>= 60
		(A)	(B)	(C)
Agency social	Active	12	63	26
	Neutral	40	**(C)** 307	72
	Passive	11	56	**(B)** 27

Table 6: Socializing agency BY Telephone agency and BY Email agency

		Agency telephone		
		Active / somewhat active	Neutral	Passive / somewhat passive
		(A)	(B)	(C)
Agency social	Active	**(B)** 24	39	**(B)** 21
	Neutral	50	**(AC)** 252	55
	Passive	**(B)** 22	46	**(B)** 25
		Agency email		
		Active / somewhat active	Neutral	Passive / somewhat passive
		(A)	(B)	(C)
Agency social	Active	11	23	8
	Neutral	51	**(C)** 115	33
	Passive	8	17	**(AB)** 15

Table 7: Socializing agency BY Telephone agency BY Email agency email

				Agency email		
				Active / somewhat active	Neutral	Passive / somewhat passive
				(A)	(B)	(C)
Agency social	Active	Agency telephone	Active / somewhat active	2	7	2
			Neutral	4	9	1
			Passive / somewhat passive	2	3	3
	Neutral	Agency telephone	Active / somewhat active	**(BC)** 17	12	2
			Neutral	23	**(AC)** 78	17
			Passive / somewhat passive	5	6	**(AB)** 9
	Passive	Agency telephone	Active / somewhat active	1	4	1
			Neutral	5	8	7
			Passive / somewhat passive	1	5	7

Table 8: Socializing, Telephone, and Email agency BY spatial scale

		Spatial scale		
		Local	Regional	Long-distance
		(A)	(B)	(C)
Agency social	Active / somewhat active	64	21	9
	Neutral	**(C)** 311	78	26
	Passive / somewhat passive	61	22	12
Agency telephone	Active / somewhat active	89	**(A)** 56	**(A)** 46
	Neutral	**(B)** 305	86	79
	Passive / somewhat passive	106	25	23
Agency email	Active / somewhat active	49	**(A)** 33	21
	Neutral	119	52	51
	Passive / somewhat passive	**(B)** 57	13	19

Table 9: Socializing agency BY Frequency of socializing

		Frequency of socializing		
		rarely (A)	monthly (B)	weekly or more frequent (C)
Agency social	Active	44	38	19
	Neutral	178	147	**(A)** 107
	Passive	49	32	15

Table 10: Telephone and Email agency BY Frequency of telephone

		Frequency of telephone		
		rarely	monthly	weekly or more frequent
		(A)	(B)	(C)
Agency telephone	Active / somewhat active	46	**(C)** 86	67
	Neutral	102	174	207
	Passive / somewhat passive	26	58	77
		Frequency of email		
		rarely	monthly	weekly or more frequent
		(A)	(B)	(C)
Agency telephone	Active / somewhat active	**(C)** 27	**(C)** 50	31
	Neutral	37	88	**(A)** 102
	Passive / somewhat passive	22	37	34

Table 11: Multilevel model of socializing agency

	Model 1: Intercept and ordinal threshold		Model 2: Ego-alter level added		Model 3: Ego-network level added		Model 4: Cross-level interactions added	
Intercept Level 1	coeff.	t-stat	coeff.	t-stat	coeff.	t-stat	coeff.	t-stat
Intercept Level 2	-1.747	(-13.39)	-2.565	(-6.25)	-2.380	(-3.59)	-2.112	(-3.05)
Ego's age					-0.429	(-2.64)	-0.443	(-2.70)
Ego has children at home					0.168	(0.76)		
Household Income					-0.036	(-0.65)		
Years at the same home					0.028	(3.03)	0.030	(3.14)
Network size					0.029	(2.28)	0.024	(1.91)
Proportion of females in the network					0.391	(0.72)	0.469	(0.84)
Proportion of extended family in the network					-0.484	(-0.64)		
Proportion of neighbours in the network					-0.779	(-0.92)		
Proportion of coworkers in the network					1.626	(2.41)		
Number of components (includes isolates)					-0.067	(-2.11)	-0.059	(-1.88)
Degree of centralization					2.355	(1.65)	2.130	(1.48)
Degree of betweenness					-3.312	(-2.29)	-2.703	(-1.82)
Betweenness slope								
Intercept			-0.011	(-1.44)	-0.012	(-1.50)	-0.013	(-1.48)
Alter is immediate family member slope								
Intercept			0.661	(2.76)	0.720	(3.00)	0.450	(1.50)
Alter is extended family slope								
Intercept			0.727	(2.45)	0.781	(2.59)	1.936	(3.06)
Proportion of extended family members in the network							-5.992	(-2.58)
Alter is neighbour slope								
Intercept							-0.478	(-1.25)
Alter is co-worker slope								
Intercept							-1.356	(-2.28)
Proportion of co-workers in the network							3.819	(2.61)
Alter is friend slope								
Proportion of friends in the network							-0.435	(-1.04)
Alter's age slope								
Intercept			0.108	(1.60)	0.131	(1.79)	0.117	(1.58)
Alter is very close slope								
Intercept			0.086	(0.43)				
Alter has the same gender as ego slope								
Intercept			-0.21	(-1.05)	-0.189	(-0.93)	-0.141	(-0.69)
Distance between alter and ego slope (categorical)								
Intercept			0.164	(1.10)	0.163	(1.08)	0.114	(0.75)
Threshold 2	0.914	(10.46)	0.983	(10.28)	0.990	(10.17)	1.009	(10.2)

Appendix: Statistical techniques employed in the analysis

Comparisons of Column Proportions

Comparisons of column proportions using Bonferroni correction is a technique used in bivariate tables (or 'crosstabs'). One can think of the columns as independent variables and the rows as dependent variables. In these analyses, the rows are the three agency values (active, passive and mutual). The columns are the independent variables (labelled as A,B,C, etc…). For every row, the technique tests whether there are proportionately more cases in a given column. If there is a letter in the cell, it indicates that in this row, this particular column has a disproportionate number of cases compared to the columns denoted by the letter. Using Table 4 as an example, we can see that 'friends' are more likely to be mutual than 'immediate family'.

The formal definition is based on (Milton and Arnold, 2003). Consider a set of k population means. There are $\binom{k}{2} = \frac{k(k-1)}{2}$ possible pairs of means. Thus, there are $k(k-1)/2$ possible individual t tests that can be performed. The Bonferroni T test is a generalization of the individual tests, where the statistic is

$$T_{N-k} = \frac{\bar{Y}_{i\cdot} - \bar{Y}_{j\cdot}}{\sqrt{MS_E\left(\frac{1}{n_i} + \frac{1}{n_j}\right)}} \qquad [1]$$

where i and j represent each sample, $\bar{Y}_{i\cdot}$ and $\bar{Y}_{j\cdot}$ are the corresponding mean values in each pair, MSE is the mean square error of the overall sample; and n_i, n_j and N are the sample size for i, j and the overall sample, respectively. Finally, the Bonferroni critical point of this test is defined by

$$cp = t_{N-k,1-\alpha/2}\sqrt{MS_E\left(\frac{1}{n_i} + \frac{1}{n_j}\right)} \qquad [2]$$

Multilevel Models

Multilevel models were used to explore the relationship between the ego-alter agency level and characteristics at both the ego-network and the ego-alter levels. The main objective of multilevel models is to capture phenomena where the data have a hierarchically clustered structure that cannot be assumed to consist of independent observations (Van Duijn *et al*., 1999: 187). Personal network data have a hierarchical structure: the *ego-network* and *ego-alter* levels. These levels can also be conceived as two units of analysis that are related, since several alters belong to the same ego and must be treated in clusters (Snijders, 2003; Snijders and Bosker 1999; Raudenbush and Bryk 2002; Goldstein 2003). The most basic model consists of two levels modeled by two sets of equations. The specification in this paper uses ordinal values where 1 is active, 2 is neutral, and 3 is passive.

The functional form can be derived as follows (adapted from Raudenbush and Bryk, 2002). Let M be the number of ordered categories, $m = 1\ldots M$. Then, the dependent ordered variable can be defined as:

$$Y_{mij} = \begin{cases} 1 & \text{if } R_{ij} \le m \\ 0 & \text{otherwise} \end{cases} \qquad [3]$$

where Y_{mij} is the dependent variable for level *ij* and R_{ij} is the corresponding response variable for that level. Each dependent and response variable has a cumulative probability function:

$$\Pr(Y_{mij} = 1) = \Pr(R_{ij} \le m) \equiv \varphi_{mij} \qquad [4]$$

The cumulative probabilities in [4] can be defined as logit functions:

$$\eta_{mij} = \log\left(\frac{\varphi_{mij}}{1-\varphi_{mij}}\right) = \log\left(\frac{\Pr(R_{ij} \le m)}{\Pr(R_{ij} > m)}\right) \qquad m = 1...M \qquad [5]$$

In this way, the *level 1* structural model (*ij*) can be defined as:

$$\eta_{mij} = \beta_{j0} + \sum_{k=1}^{K} \beta_{jk} x_{ijk} + \sum_{m=2}^{M-1} D_{mij} \delta_m \qquad [6]$$

where D_{mij} is a dummy variable indicating category *m* and δ_m is the *threshold* value of category *m*. Note that each of these threshold values δ_m separate categories *m* – 1 and *m*, defined from 2 → *M*. In personal networks, this level is the *ego-tie or ego-alter level* represented by alter *i* and ego *j* or simply the tie *ij*.

Level 2 is given by:

$$\beta_{jk} = \gamma_{k0} + \sum_{l=1}^{L} \gamma_{kl} z_{jkl} + \nu_{jk} \qquad \nu_{jk} \sim N(\mathbf{0}, \Omega) \qquad \forall k = 0 \to K \qquad [7]$$

where *l* are the attributes, z_{jl} is the *l-th* attribute (*L* in total), and λ_{kl} are the corresponding coefficients. In social networks, this is the *ego-network level*, represented by the ego and its corresponding network *j*.

Combining [6] and [7], the multilevel model obtained is:

$$Y_{ij} = \left[\gamma_{00} + \sum_{l=1}^{L} \gamma_{0l} z_{j0l} + \sum_{k=0}^{K} \gamma_{k0} x_{ijk}\right] + \left[\sum_{k=1}^{K}\sum_{l=1}^{L} \gamma_{kl} z_{jkl} x_{ijk}\right] + \left[\nu_{j0} + \sum_{k=1}^{K} \nu_{jk} x_{ijk} + \sum_{m=2}^{M-1} D_{mij} \delta_m\right] \qquad [8]$$

Equation [8] shows the *three effects* in the response variable (each in parenthesis, respectively): the effect of each level, the cross-level interaction, and the variance effects of both levels. These three effects are the *raison d'être* of multilevel models: taking into account each level and simultaneously, the interaction or dependence between them. From a statistical perspective, multilevel models account for the correlation induced by the nested structure of the two levels. From a social networks perspective, multilevel models account for the fact that alters are not independent, but instead belong to the same personal network. More generally, multilevel models capture how context (macro-level) affects relations among individual-level variables (micro-level) (DiPrete and Forristal, 1994). This aspect contrasts with approaches that assume independence between the different response variables, without considering the impact of macro context on the micro level and ignoring the clustering characteristics of personal networks (Van Duijn, *et al.*, 1999).

From the functional form shown in [5], coefficients have to be interpreted with care, since the sign of the coefficient refers to alter. A *positive* coefficient means alter (not ego) is more agentic, and a *negative* coefficient means alter is more passive. More technically, a *negative* coefficient in a multilevel ordinal model such as [6] and [7] implies that *increasing* values of the related independent variable are associated with

increasing probabilities with increasing values of *m*. In other words, negative coefficients imply a *positive* effect in the ordered response value from ego's point of view, and vice versa.

The model is estimated using the Penalized Quasi-Likelihood (PQL) method, which is one of the easiest and most reliable available methods to estimate these kinds of models (Raudenbush *et al.,* 2006). The basic idea of PQL is estimating using the joint posterior modes of both level coefficients, given variance-covariance estimates. Since PQL does not use full information likelihood, tests for overall models are not available (McCullagh and Nelder, 1989; McCulloch and Searle, 2001). For this reason, the main goodness of fit measures in the fixed coefficients are *t*-statistics. In addition, no random errors in the coefficients were estimated due to sample size limitations. The models in Table 11 were specified using a sequential procedure inspired by Hox (1995) and Van Duijn, *et al.* (1999), consisting of four progressive specifications:

1: Base model, includes intercepts from both levels and threshold coefficients
2: Add fixed ego-alter explanatory variables
3: Add fixed ego-network explanatory variables
4: Using the previous model as base, add cross-level explanatory variables

The last model is the most interesting from a theoretical viewpoint since it incorporates the cross-effects between both levels, that is, the *combined* effect that alters (and ties) and egos (and networks) have on the frequency of performing social activities. Note that some explanatory variables that were statistically significant in ego-network or ego-alter levels independently become significant only as cross-level variables in more complex models. Also, key variables that were non-significant in earlier models were again tested in posterior specifications to prevent the intrinsic bias of this type of forward specification.