

Co-evolving social networks and activity-travel patterns

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Co-Evolving Social Networks and Activity-Travel Patterns

Fariya Sharmeen, Theo Arentze and Harry J.P. Timmermans

Eindhoven University of Technology

Vertigo 8.09

P O Box 513, Eindhoven

The Netherlands

E-mail f.sharmeen@tue.nl

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Abstract: This paper explains the contribution of a project on social networks to the u4IA research program. To understand long-term behaviour and decision changes, it is imperative to understand social networks in a dynamic setting. Based on a review of the state of the art in travel behaviour research related to social networks and put forward our research concept for a project that is part of a larger research program which aims at developing dynamic activity-based models.

1. INTRODUCTION

The U4IA research program is concerned with the dynamics of activity-travel program. Different time horizons are distinguished: long-term, mid-term and short-term. Short-term dynamics concern the rescheduling of activity-travel program when faced with unexpected events. Mid-terms dynamics relate to how individuals and households adapt their context-dependent activity-travel patterns as they learn. Long-term dynamics are related to major events in one's lifecycle such as birth, marriage, residential move and job change.

The project reported in this paper is concerned with social networks. Social networks need maintenance and therefore social travel makes up a significant part of daily travel. Moreover, it also offers some challenges in modelling. Social gatherings may involve joint activity scheduling and rescheduling. It can be viewed as an extension of household level decisions (e.g. Borgers, Hofman and Timmermans, 2002, Ettema, Schwanen and Timmermans, 2004, Zhang, Timmermans and Borgers, 2005). Joint activities do not only involve household members, but may also include members of our social network. Each individual is part of a social network and individual behaviour may be influenced by the attitudes and behaviour of peer groups. To better understand people's activity-travel patterns we need to understand how they organize their social space, widening a whole new dimension of transport behaviour modelling research. Consequently, the relationship between social networks and travel has been subject of an increasing number of studies in recent years (e.g., Carrasco and Miller, 2005; Hackney and Axhausen, 2006; Silvis, Niemeier and D'souza, 2006, Páez, Scott and Volz 2008; Van den Berg, Arentze and Timmermans, 2009).

Most of these studies have examined the cross-sectional relationships between characteristics of social networks and facets of physical and virtual travel. However, the scope of the U4IA program is to move from single-day approaches to more dynamic activity model analysis, focusing on behavioural adaptability with response to demographic, social and policy changes. Thus, the focus on the project is to understand and model how social networks emerge, evolve and fade away. In turn, these evolving social networks provide the condition to simulate activity-travel patterns. Social networks induce, alter and even constrain travel. As social networks evolve, so do related activity-travel decisions.. As Hackney and Axhausen (2006), Páez and Scott (2007) and Arentze and Timmermans (2008) have showed, participation in social networks may lead to adaptation of aspirations and diffusion of knowledge, which in turn may trigger changes in activity-travel choice behaviour. The importance of dynamic personal networks has been long pronounced in the field of sociology and demographic research (e.g., Watts, 1999; Hummon, 2000), but it is not readily evident how such research can be elaborated to fit the agenda in transportation research.

In this paper, we review the literature on social networks and discuss the conceptual underpinnings of this study. .

2. LITERATURE REVIEW

A social network consist of ‘the individuals with whom one has an interpersonal relationship and the linkages between these individuals. The structure has two dimensions: the formal relations and the informal social relations, i.e. the social network. Formal relations are social relations due to one’s position and roles in society. A social network consists of individuals and linkages between individuals with whom one has a close family relation and/or affection (Due et al., 1999). In the research project, we adopt a so-called ego-centric approach, where each individual (called ego) has a social network, defined as a set of actors or alters who have relationships or ties with the ego, and who may or may not have ties with each other (Carrasco and Miller, 2006).

Personal social networks are important in travel behaviour research as they can induce, alter or reduce mobility in a number of ways. The spatial arrangement of social contacts generates and determines travel and communication behaviour (Ohnmacht, 2009). For short and mid-term mobilities, we depend on our social networks as they form our social support system (spatial aspect) and a reliable information source (a-spatial aspect). As far as long-term mobility is concerned (such as, residential mobility) social networks can influence through local social capital the creation of neighbourhood attachment (spatial aspect). Thus, social networks might be considered to have two broad dimensions (or aspects): spatial and a-spatial, by means of which they influence mobility decisions (Figure 1). The spatial dimension refers to those aspects that have a spatial component attached, whereas the a-spatial dimension relates to those that operate through virtual means and are not necessarily local in nature.

2.1 Spatial dimension of social networks

The spatial dimension is related to the arrangement of support systems (physical and emotional), place attachment and physical social interactions. Social support systems work through social networks, and are particularly crucial for families with children and for elderly residents. Social networks could have a significant influence on short-term mobility decisions, for example, by taking care of children, pets, by watching the house, car, plants. Wellman and Frank (2000) report that the probability of giving and

receiving support (and consequently travel behaviour) depend on the characteristics of social networks. Karsten (2007) found that Migrant households in the cities (Rotterdam) have intensive relationships with their relatives, who live nearby. They engage in a variety of mutual-support activities. Grandparents care for the children when parents go to work.

Various studies in the social support literature show that kinship is not in decline in complex societies; for daily life problems and crises management people turn to family and kin. Ethnic affiliation has also been considered in social support studies. A study of Hispanic Americans, for instance, showed that kin and local ties are more important than neighbours and friends are for socializing only (Schweizer, Schnegg and Berzborn, 1998). To this end, social support systems affect long-term (residential) mobility decisions along with short-term mobility scheduling decisions. Neighbourhood-level social ties may be conceived as either a 'push' or 'pull' factor, depending on whether such ties influence the decision to leave a given neighbourhood or choose a particular destination (Dawkins, 2000). Myers (2000) employed measures of the presence of friends and relatives within an hour's drive and found that the presence of relatives is associated with lower rates of residential mobility. The effect of friends, on the other hand, is not significant. For some households, the friendly contacts in the neighbourhood apparently function as a form of self-selected kinship.

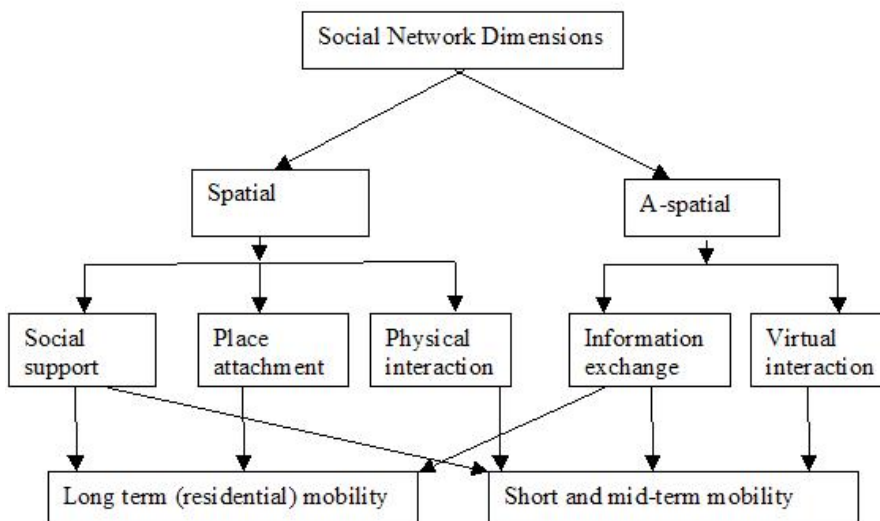


Figure 1: Dimensions of Social Network

The third component of spatial dimension of social network is local physical social interactions. In most cases, social activities are conducted with someone else. Conducting joint activities means that the accompanying person's agenda influences the timing, location and travel modes of the activities concerned, hence affecting short term mobility decisions.

2.2 A-spatial dimension of social networks

The a-spatial dimension refers to those components of social networks that are not necessarily local but could affect our local short and mid-term mobility decisions, by means of exchange of information and virtual interactions (through popular social network websites, such as, facebook, skype, myspace, msn, yahoo etc). Social networks act as a valuable information source. People can learn about various travel alternatives through information exchange in social networks, which might help them in short term mobility decisions (Ettema, Arentze and Timmermans, 2007). The information exchange also assists long-term decisions. For instance, studies show that social networks are the most important source in finding a home (Roper, Volker and Flap, 2008). Likewise, greater social diversity could assist in finding a job (Stoloff, Glanville and Bienenstock, 1999). Information dissemination could also change people's attitudes and perceptions leading to changes in travel behaviour decisions (Han et al. , 2007; Molin, Arentze and Timmermans, 2008,). Research shows that information and communication technologies (ICT) does not replace physical interaction with family and friends but provides emotional support and helps to cope in difficult situations (e.g.; Shklovski and Mainwaring, 2005; Shklovski, Kraut and Cummings, 2006; Axhausen and Frei, 2008). On the other hand, it has also been found that with increasing physical and relational distances, both telephone and electronic communication frequencies tend to decline among social network members (Tillema and Dijst, 2007).

3. SOCIAL NETWORK AND TRAVEL BEHAVIOUR

One of the most interesting projects in this context is the Canadian "Connected Lives" study (Carrasco and Miller (2005), Carrasco et al., 2008,

Carrasco, Miller and Wellman, 2008). They focused on social activity generation explicitly incorporating social networks - characteristics of each network member as well as the characteristics of the overall social structure. In a recent study (Carrasco and Habib, 2009), the social embeddedness of activity-travel participation has been examined as a function of alters' characteristics and network degree apart from socio-economic attributes. The results show that egos tend to maintain an intense relation with a very close-circle of contacts and tend to keep in touch with those with a wider connection. Carrasco, Miller and Wellman (2008) discussed social activity generation through multi-level analysis of ego and social network structure.

Axhausen (2008) argued that social network membership influences person's mental map and thus logically network geography should have an impact on travel behaviour. Axhausen and Frei (2008) found that face to face contact frequency decreases with increasing distance whereas email frequency increases. Similarly, van den Berg, Arentze and Timmermans (2009, 2010) using social interaction diary and social network data collected in Eindhoven in 2008 examined the impact of ICT on social travel behaviour and reported that the results differ significantly from a previous study conducted by Molin, Arentze and Timmermans (2007), who used data about social networks collected in the 1980s also in the Dutch context, implying that the inter-relations of social network and travel demand have changed in last two decades.

Silvis et al. (2006) used a similar social interaction diary in Davis. They concluded that individuals do not mind making longer trips for socializing and visiting family. Ettema and Kwan (2010) analysed the company of social activities among ethnic groups in the Netherlands. They tested a number of hypotheses contextual to social and recreational travel and found that individuals have multiple networks (such as family, friends, associational and professional) which potentially perform multiple roles. They also concluded that contact frequency with social network members is positively correlated with the frequency of social and recreational activities, which often is not domain specific.

In addition to these empirical studies, several authors have examined the relationship between social networks and travel by (numerical) simulation and model development. Dugundji and Gulyás (2008) developed a multi-agent simulation model of household interactions looking at how they decide on transportation mode alternatives by carefully distinguishing social and

spatial network interdependencies. In particular, they considered the interdependencies between individual's choice and the aggregate decision of his/her socio-economic networks in close proximity. Using pseudo-panel microdata collected by the Amsterdam Agency for Traffic, Transport and Infrastructure they extended standard discrete choice models to account for the social influence on choice decisions. Finally, they compared the results for different assumed social and spatial networks based on similar residential location and socio-economic profile of agents.

Páez, Scott and Volz (2008) described a discrete-choice model to account for social influence on decision making as advancement over auto-correlation analysis. Simulated data were used to compare models with social influence and without social influence in making residential location decisions. Social network simulation was developed on the basis of the structure-analysis tradition of sociology by developing an informal support network. In an earlier research (Páez and Scott 2007), a similar methodology was applied for decision in terms of telecommuting to consider social influence on travel behaviour.

Han et al. (2007) presented a dynamic model that simulates habitual behaviour versus exploitation and exploration as a function of discrepancies between dynamic, context-dependent aspiration levels and expected utilities. Principles of social learning and knowledge transfer were used in modelling the impact of social networks, and related information exchange, adaptations of mutual choice sets and formation of common aspiration levels. Dynamics on the level of evaluation of choice is drawn from the activation level and the inclination to explore depends on an individual's satisfaction with available alternatives in his/her choice set. Satisfaction depends on the individual's aspiration level, where aspiration level serves as a subjective reference point, which determines what qualifies as a satisfactory outcome for that attribute. Dynamics of aspiration level on the other hand depend on social comparison, among many others. The outcome of a comparison between aspiration and expected outcome given current beliefs marks a switch of choice mode from habitual behaviour to a conscious choice.

Hackney and Axhausen (2006, see also Hackney, 2007) developed a multi-agent representation, incorporating dynamics of social network, by addition, deletion of links, based on feedback through activity choice set. Arentze and Timmermans (2008) developed a more comprehensive

theoretical and modelling framework to capture the essence of social networks, social interactions and activity travel behaviour. The model is consistent with the traditional social network theories (like homophily and transitivity) developed in the social science literature. Ronald, Arentze and Timmermans (2009) report a partial extension of this work. Illenburger et al. (2010) conducted a similar simulation with a different approach. They tested network indicators (edge-length distribution, network degree distribution, etc) but did not account for properties like homophily.

4. CONCEPTUAL FRAMEWORK

This discussion of the existing literature demonstrates that the vast majority of these studies have not examined the dynamics of social networks. However, social networks are dynamic. People do not have the same circle of friends and neighbours all their life. With age, education, job, marriage and other lifecycle events, social networks keep changing. When someone first enters college or university s/he meets a whole new circle of friends, when s/he gets married, the spouse's social network adds up and maybe some old relations fall apart, when the children come, the social network changes again and so on.

In the field of sociology, demography and anthropology the need for constructing a dynamic social network has been realized a number of times (Stoloff et al. 2008, Hummon, 2000). The attempts made so far are fragmented and focused on specific groups or parts of the lifecycle. It is plausible that with age and lifecycle events the size and diversity of social networks change. However, there are contradictions about the pattern of these changes. Empirical studies contradict whether it is somewhat U shaped or the changing pattern of social networks with lifecycle can be explained by an inverted-U shaped curve (Kan, 2007).

Nevertheless, networks do evolve with socio-demographic status and life-cycle events. And these changes in social networks are most likely to affect long-term mobility and short-term activity-travel decisions. These arguments can be conceptualized in Figure 2. We hypothesize that with changing socio-demographics and life-cycle events, social networks (and corresponding social support systems) change, having an impact on activity-

travel behaviour, both directly (frequency and duration of contact, use of ICT) and indirectly (exchange of information).

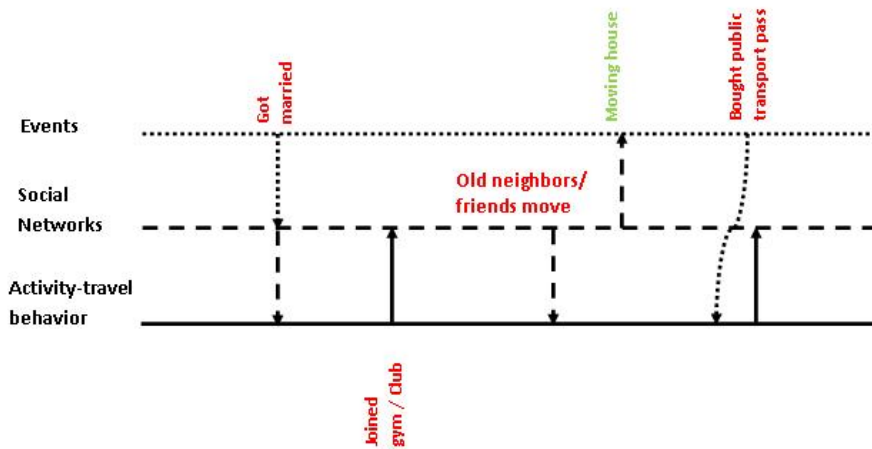


Figure 2: Conceptual framework

Hence, we conceptualize three parallel phenomena, events (including socio-demographics and lifecycle events), social networks and activity-travel behaviour. All three of them are interdependent. Any change in one could result in change in the other two or any one of them. For instance, we hypothesize that the event of ‘getting married’ could mean that the spouse’s (partial) social network is now included, resulting in a change in social network and could eventually lead to changed activity-travel behaviour. On the other hand, new activity-travel behaviour, such as joining a new gym or club may possibly result in a change in social networks and so on.

5. ISSUES IN DATA COLLECTION

Ideally, data on these dynamics should be collected using a panel. However, it goes without saying that in terms of costs, such data collection may be prohibitive. Moreover, it will be hard to keep panel members sufficiently interested in such a data collection effort in the long run. Therefore, in the current project, we plan to use a retrospective survey instrument. This means that respondents are invited to recall changes in life

trajectory events, their social network and travel. The reliability of recall data in general depends a lot on the importance and uniqueness of the event. Although not perfect, we contend that major lifecycle events and social network dynamics can be remembered relatively well.

Nevertheless, respondents may need help to trigger their memory. Based on the conceptual framework, the recollection of social network change will be prompted by asking systematically about lifecycle events that we assumed may likely cause such social network change. They will also be asked about the nature of the change (frequency, medium, etc.)

6. CONCLUDING REMARKS

As part of a larger U4IA research program on developing dynamic activity based models, this paper has argued for the need to expand the recent studies on social networks in the transportation research community to include the dynamics of social networks. The results of a literature review on the current state of the art have shown that the vast majority of current studies have examined cross-sectional relationships between social network characteristics and travel demand. However, social networks, especially the network of friends, are not static but changes with particular lifecycle events. As a consequence, individuals and household will need to adapt to these changing social networks and perhaps reconsider how to organize their social activities in time and space. The extent of such behavioural change will depend on the nature of the change in the social network. On the other hand, more substantial changes in the social network may trigger more dramatic changes in activity-travel patterns. Our contention therefore is that the study of the dynamics of social networks should be seriously undertaken to better understand and model the dynamics of activity-travel patterns.

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References

- Arentze, T. and Timmermans, H. 2008, "Social networks, social interactions, and activity-travel behavior: a framework for microsimulation", *Environment and Planning B*, 35(6), p. 1012-1027.
- Axhausen, K. 2008, "Social networks, mobility biographies, and travel: survey challenges", *Environment and Planning B*, 35, p. 981-997.
- Axhausen, K. W. and Frei, A. 2008, "Contacts in a shrunken world", Paper presented at *Transportation Research Board*, Washington D.C.
- Borgers, A.W.J., Hofman, F., and Timmermans, H.J.P. 2002, "Conditional choice modelling of time allocation among spouses in transport settings", *European Journal of Transportation and Infrastructure Research*, 2, p. 5-17.
- Carrasco, J. A. and Miller, E. 2005, "Socializing with people and not places: modelling social activities explicitly incorporation social networks", Paper presented in *CUPUM 05*, London, UK.
- Carrasco, J. A. and Miller, E. 2006, "Exploring the propensity to perform social activities: a social network approach", *Transportation*, 33, p. 463-480.
- Carrasco, J.A., Hogan, B., Wellman, B. and Miller, E. 2008, "Collecting social network data to study social activity-travel behavior: an egocentric approach", *Environment and Planning B*, 35, p. 961 – 980.
- Carrasco, J.A., Miller, E. and Wellman, B. 2008, "How far and with whom do people socialize? Empirical evidence about the distance between social network members", Paper presented at *Transportation Research Board*, Washington D.C.
- Carrasco, J. A. and Habib, K. N., 2009, "Understanding the social embeddedness of activity travel participation: the case of frequency and duration of social activities", Paper presented in *International Conference on Travel Behavior Research*, Jaipur.
- Connerly, C. E. 1985, "The Community Question: An Extension of Wellman and Leighton", *Urban Affairs Quarterly*, 20, p. 537-56.
- Connerly, C. E. 1986, "The impact of neighbourhood social relations on prospective mobility", *Social Science Quarterly*, p.186-195.

- Dawkins, C.J. 2006, "Are Social Networks the Ties that Bind Families to Neighborhoods?", *Housing Studies*, 21(6), p. 867-881.
- Due, P., Holstein, B., Lund, R., Modvig, J. and Avlund, K. 1999, "Social relations: network, support and relational strain", *Social Science and Medicine*, 48, p. 661-673.
- Dugundji, E. and Gulyás, L. 2008, "Sociodynamic discrete choice on networks in space: impacts of agent heterogeneity on emergent outcomes", *Environment and Planning B*, 35, p. 1028-1055.
- Ettema, D.F., Schwanen, T. and Timmermans, H.J.P. 2004, "The effect of locational factors on task and time allocation in households", Paper presented at *Transportation Research Board*, Washington D.C.
- Ettema, D. F., Arentze, T., and Timmermans, H.J.P. 2007, "Social influences on household location, mobility and activity choice in integrated micro-simulation models", Paper presented at the *Workshop Frontiers in Transportation*, Amsterdam.
- Ettema, D.F. and Kwan, M-P. 2010, "Whom to hang out with: the influence of social ties on social and recreational activity participation and travel of various ethnic groups in the Netherlands", Paper presented at *Transportation Research Board*, Washington D.C.
- Frei, A. and Axhausen, K. W. 2007, "Size and structure of social network geographies", Paper presented at the *Workshop Frontiers in Transportation*, Amsterdam
- Hackney, J. and Axhausen, K. W. 2006, "An agent model of social network and travel behavior interdependence", Paper presented in *International Conference on Travel Behavior Research*, Kyoto.
- Hackney, J. 2007, "Social networks in transportation microsimulations", Paper presented in *Swiss Transport Research Conference*, Monte Verità.
- Han, Q., Arentze, T., Timmermans, H.J.P., Janssens, D. and Wets, G. 2007, "The effects of social networks on choice set dynamics: results of numerical simulations". Paper presented at the *Workshop Frontiers in Transportation*, Amsterdam
- Hummon, N. P. 2000, "Utility and dynamic social networks", *Social Networks*, 22, p. 221-249.
- Illenberger, J., Flotterod, G., Kowald, M. and Nagel, K. 2009, "A model for spatially embedded social networks". Paper presented in *International Conference on Travel Behavior Research*, Jaipur.
- Kan, K. 2007, "Residential mobility and social capital", *Journal of Urban Economics*, 61, p. 436-457.
- Karsten, L. 2007, "Housing as a way of life: towards an understanding of middle-class families preference for an urban residential location", *Housing Studies*, 22(1), p. 83-98.

- Lai, G. 2001, "Social support networks in urban Shanghai", *Social Networks*, 23, p. 73-85.
- Myers, S. M. 2000, "The impact of religious involvement on migration", *Social Forces*, 79, p. 755-783.
- Molin, E.J.E. and Timmermans, H.J.P. 2003, "Testing hierarchical information integration theory: the causal structure of household residential satisfaction", *Environment and Planning A*, 35, p. 43-58.
- Molin, E.J.E. and Timmermans, H.J.P. 2007, "Social activities and travel demands: a model-based analysis of social-network data", Paper presented at the *Workshop Frontiers in Transportation*, Amsterdam.
- Molin, E.J.E., Arentze, T. and Timmermans, H.J.P. 2008, "Eliciting social network data" Paper presented at the *International Conference on Survey Methods in Transport: Harmonisation and Data Comparability*, France.
- Ohnmacht, T. 2009, "Social-activity travel: do the 'strong-tie relationships' of a person exist in the same community? The case of Switzerland", *Environment and Planning A*, 41, p. 3003-3022.
- Páez, A., Scott, D. M. and Volz, E. 2008, "A discrete-choice approach to modeling social influence on individual decision making", *Environment and Planning B*, 35(6), p. 1055-1069
- Páez, A. and Scott, D. M. 2007, "Social influence on travel behavior: a simulation example of the decision to telecommute", *Environment and Planning A*, 39(3), p. 647-665.
- Richtey, P.N. 1976, "Explanations of migration", *Annual Review of Sociology*, p. 363-404.
- Ronald, N., Arentze, T. and Timmermans, H. J. P. 2009, "Modelling social interactions between individuals for joint activity-travel scheduling", Paper presented in *International Conference on Travel Behavior Research*, Jaipur.
- Roper, A., Volker, B and Flap, H. 2009, "Social networks and getting a home: do contacts matter?", *Social Networks*, 31, p. 40-51.
- Scweizer, T., Schnegg, M. and Berzborn, S. 1998, "Personal networks and social support in a multiethnic community of southern California", *Social Networks*, 20, p. 1-21.
- Shklovski, I. A. and Mainwaring, S.D. 2005, "Exploring technology adoption and use through the lens of residential mobility". Paper presented in *CHI*, Portland.
- Shklovski, I. A., Kraut, R. and Cummings, J. 2006, "Routine patterns of internet use and psychological well-being: coping with a residential move", Paper presented in *CHI*, Montréal.
- Silvis, J., Niemeier, D. and D'Souza, R. 2006, "Social networks and travel behavior: report from an integrated travel diary", Paper presented in *International Conference on Travel Behavior Research*, Kyoto.

- Stoloff, J. A., Glanville, J. L. and Bienenstock, E. J. 1999, "Women's participation in the labor force: the role of social networks", *Social Networks*, 21, p. 91-108.
- Tillema, T. and Dijst, M. 2007, "Electronic and face-to-face communication in maintaining social relationships", Paper presented at the *Workshop Frontiers in Transportation*, Amsterdam.
- Van den Berg, P., Aretnze T. and Timmermans H. 2009, "Size and composition of ego-centered social networks and their effect on geographical distance and contact frequency", Paper presented in *Transportation Research Board*, Washington D. C.
- Van den Berg, P., Aretnze T. and Timmermans H. 2010, "Factors Influencing the Planning of Social Activities: Empirical Analysis of Social Interaction Diary Data", Paper presented in *Transportation Research Board*, Washington D. C.
- Watts, A. 2001, "A dynamic model of network formation", *Games and Economic Behavior*, 34, p. 331-341.
- Wellman, B. 1979, "The community question: the intimate networks of East Yorkers", *The American Journal of Sociology*, 84 (5), p. 1201-1231.
- Wellman, B. and Frank, K. 2000, "Network capital in a multi-level world: Getting support from personal communities". In: *Social Capital: Theory and research* (N. Lin, R. Burt and K. Cook eds.) Aldine de Gruyter, Chicago.
- Zhang, J., Timmermans, H.J.P. and Borgers, A.W.J. 2005, "Comparative analysis of married couples' task and time allocation behavior on weekdays vs. Weekends", Paper presented at *Transportation Research Board*, Washington D.C.