A Comparison of Social Network Mapping and Personal Network Visualization

Abstract

This article presents an analysis of personal network visualization based on systematic evaluations of alter pairs compared to freestyle drawings respondents made of their personal network. In most cases, personal network visualization provided important details that are different from respondents' perceptions. Several case studies are discussed that highlight the additional data provided when using personal network visualization.

Keywords: *personal networks; visualization; cognition*

In this article, we focus on the visual representation of people a respondent knows—their *personal network*. Personal networks are a type of egocentric network; they consist of the set of family, friends, and acquaintances surrounding a focal person. In social network analysis, personal networks are contrasted with whole (sociocentric) networks in which the focus is on the pattern of interactions within a focal group.

Visual representations of personal networks are not used much in social science research but are common in counseling psychology and social work. *Genograms* are techniques used by mental health therapists to capture the relationships, both past and present, surrounding a client (DeMaria, Weeks, and Hof 1999; McGoldrick, Gerson, and Shellenberger 1999). By representing men, women, and children as circles and triangles, as in a kinship diagram used by anthropologists, therapists attempt to understand the social environment that may have contributed to the conditions that led them to seek help. The visual representation helps both therapists and clients understand the social environment that may be contributing to or hindering mental health. Genograms tend to focus on close, mostly family relationships and typically represent the social environment chronologically, including relatives who are both living and dead.

The *hierarchical mapping technique* (Antonucci 1986; Ajrouch, Antonucci, and Janevic 2001) uses three concentric circles to represent the personal network of the respondent. In the middle of the circle is the word "YOU." Respondents are asked to put the first name of people they know closely in the innermost circle and those they know but are less close to in the outer circle. The resulting map gives the researcher some sense of the size of the network and the distribution of their network based on closeness.

Carrasco, Hogan, Wellman, and Miller (forthcoming) used a similar approach with four concentric circles. In their study, respondents free listed alters first, then placed them on the network map—those closest to the respondent in the inner circles and those less close in the outer circles. Respondents were asked to place those who knew each other nearby and finally to draw circles around groups of respondents. This method adds network structural features to the hierarchical mapping technique.

Perhaps the most straightforward technique for acquiring an image of a personal network is to ask respondents to draw them freestyle, with little instruction as to how they are represented. For example, respondents can be told to represent people with dots and groups of people with circles. Unlike genograms and hierarchical mapping, both of which start with some structural constraints, freestyle drawing captures the variability in the way respondents represent their network. Despite its simplicity, there are few examples of this approach in the literature. Coates (1985) used this technique in the study of the personal networks of black adolescents.

Another approach is to elicit names of network members from the respondent, then ask him or her to evaluate the relationship between each individual pair of alters. We call this *personal network visualization*. This method differs from the others because the respondent is being asked to evaluate a set of binary relationships that are then built into a representation of personal network structure, as opposed to the respondent being asked to try to summarize all relationships into a structure from memory. McCarty (1992, 2002) used this approach in a study of structure within personal networks. Mitchell (1994) used this approach for a small sample of homeless women in Manchester, England. More recently, Widmer and La Farga (2000) used visualizations of personal networks to study the variability in the structure of families.

In this article, we contrast the two techniques that are the most different. At one end of the spectrum are freestyle drawings that allow respondents to represent their network however they like. At the other end are personal

network visualizations based on the systematic evaluation of the relations between all pairs of network members. We illustrate these differences using case studies showing the types of conclusions an interviewer might make about the respondent's personal network using each technique. In the next section, we outline the principles of personal network data collection for those who are unfamiliar with the process.

COLLECTING PERSONAL NETWORK DATA SYSTEMATICALLY

The study of personal networks typically involves, at a minimum, acquiring a list of a person's network members (alters). In studies of social support, for example, people are asked to name some number of alters (three, five, ten) on whom they rely for advice or material help (Burt 1984; Wellman and Wortley 1990). Respondents may be asked to think of five people they talk to about important matters, or three people they talk to about health-care decisions. In studies of support that involve weak ties (acquaintances—rather than relatives, close friends, or coworkers) respondents may be asked to list up to sixty people they know (McCarty 2002). The method for sampling respondents varies greatly depending on the study. A balance must be achieved between the number of respondents, the number of alters they will be asked about, the amount of information elicited about each alter, and the mode of data collection. Some network studies have only a handful of respondents whereas others have thousands.

Most analyses of personal network data summarize the *composition* of the network as a set of variables that become attributes of the respondent (Fischer 1982; Schweizer, Schnegg, and Berzborn 1998; Hampton and Wellman 1999). Along with the age, education, and income level of a respondent, the researcher may have the average age of their alters, the average strength of their ties with alters, the proportion of their network that is family or coworkers, or the proportion of their network from whom people say they can borrow money or get a ride to the doctor (Campbell and Lee 1991; McCarty et al. 1997). These measures may, in turn, be used as independent variables to predict other variables. They may also be used as dependent variables or predicted by typical demographic variables or variables more specific to the topic of interest.

Some personal network researchers also try to measure *structure* within each respondent's network (McCarty 2002). To do this, the researcher must ask respondents to report not only on their relationship with each alter but also on the relationships of all pairs of alters. The number of ties grows geometrically as alters are added (see Figure 1). For a network of ten alters, a

FIGURE 1 Respondent Burden when Collecting Structural Data

respondent must report on forty-five ties. For a network of fifty alters, they must report on 1,225 ties. There are conceptual and empirical issues surrounding the application of structural measures to personal network data (McCarty and Wutich 2005), specifically, whether to include or exclude ego for a given measure.

The collection and analysis of personal network structural data has been difficult in the past, given the absence of software devoted to that purpose. Recently, a program called EgoNet was developed that is designed specifically for the collection, analysis, and visualization of personal network data.

EgoNet consists of four modules—questions asked of the respondent about themselves, questions used to generate the names of network alters, questions asked of the respondent about those alters, and questions asked of the respondent about the existence of relations between alters. It is designed as a questionnaire authoring language that allows researchers to tailor the interview to their specific research interests. The program displays a visualization of the respondent's personal network. As an illustration, consider the example in Figures 2 and 3. Figure 2 represents an adjacency matrix for

a ten-alter personal network. In most cases, we ask the respondent to describe the relations between their alters as symmetric, meaning both alters agree to the level of knowing. In cases where the question being asked is simply the presence or absence of a tie, respondents are quite consistent in their assessments. With a ten-alter symmetric network, the respondent must evaluate forty-five unique pairs of alters. This matrix can then be used to calculate several measures, and to visually represent the ties in the network, as depicted in Figure 3. The visualization in Figure 3 used a spring-embedding algorithm to place the nodes relative to each other (see Freeman 2000).

Several attributes of this visualization immediately suggest questions we might ask the respondent. First, we can see that George is a central figure in this network and that he connects two groups of people. Depending on the research topic, we may first want to know who George is and how he relates to the respondent. Next, we may want to know what the two groups are and why George is or is not connected to all of them. Disconnections within a group may be a sign of the potential formation of factions. Finally, although Cindy is part of the personal network, she is disconnected from

FIGURE 3 Visualization of Ten-Alter Personal Network

everyone else. Is she a broker to another set of ties that may be potentially beneficial to the respondent? Or does she represent a social pressure that could impact the respondent negatively?

METHOD

To test the utility of personal network visualizations against that of freestyle drawings of networks, we conducted nineteen interviews in Barcelona, Spain (seven men and twelve women, with a mean age of 33). Respondents were selected from different ethnic groups to maximize the differences discovered through the qualitative interview (ten from Spain, three from Ghana, two from Serbia, one from Senegal, one from Croatia, and two from Bosnia).

Respondents were first interviewed without the aid of the personal network visualization. A paper instrument was used to collect the names of exactly forty-five free-listed alters. The criteria for including an alter were: "You know them and they know you, by sight or by name. You have had

some contact with them in the past two years (i.e. phone, face-to-face, e-mail, mail) and you could contact them again if necessary."

Respondents then provided data on each alter, including how they knew the alter, the language of communication, the intensity of the relation, frequency of contact, method of communication, occupation of the alter, and whether or not they consider them a foreigner. Respondents were then asked to draw a representation of their network using the following instructions:

We would like you to draw your *social circles*. The more people in each circle, the larger it will be. Circles that are farther apart mean that they are less socially connected. Circles can also overlap. You can also specify single individuals. When you are done drawing, you can put a label or name in each circle to tell us what it is.

Following this task, respondents were interviewed about the way that their network impacts their ethnic identity. The interview was recorded. Each of the three interviewers then entered the alter names provided by their respective respondents into EgoNet. Interviewers only entered the names for the forty-five alters. The interviewers then arranged a second session with each respondent, no later than one week after the original interview, having them complete the 990 alter-tie evaluations. The tie evaluation question was whether the two alters would talk independently of the respondent. Following

the fourth module, the program displayed a visualization of the personal network of the respondent based on the adjacency matrix from the tie evaluations. The interviewer, assisted by the personal network visualization, then asked the respondents the same questions they did during the first interview. The analysis consisted of the qualitative assessment of the benefit to the respondent and the interviewer of having the visualization as a cue. This method isolated the benefit specific to the visualization.

RESULTS OF PERSONAL NETWORK VISUALIZATION INTERVIEWS

Most of the respondents were surprised by the personal network visualization. The process of evaluating the 990 alter pairs gave no indication of the structure of the graph. Indeed, the task of making so many evaluations makes it virtually impossible to fake. After the alter pair evaluations, which on average lasted about 20 minutes, respondents were interested in the product of their efforts. Most respondents were excited about the opportunity to describe the visualization and talk about their network.

FIGURE 4 Drawing and Network Visualization of Elia, a 30-Year-Old Woman from Barcelona

With two exceptions, respondents verified that the personal network visualization made sense to them, given what they knew about the social environment around them. They were all able to identify groups of people and people in structurally important roles. In some cases, respondents made errors in some of the 990 alter-pair evaluations and recognized those in the personal network visualization.

Those respondents who did not recognize groupings are suspected of not entering the alter-pair evaluations correctly. For example, one respondent coded nearly all the potential pairs as ties, resulting in a visualization with one large grouping of all forty-five alters. Although this is not impossible, the respondent's reaction indicated that it did not match her conception of her network.

Comparisons between the initial drawing and the personal network visualization are more revealing. In some cases, the visualization closely resembles their initial drawings. Figure 4 shows the network of Elia, a 30year-old woman from Barcelona. Elia's drawing and her network visualization share many things in common. The drawing shows a large group of people at the center who are a mixture of family and friends. This is also depicted in the network visualization. In both, Elia separates maternal and paternal family and shows a strong connection with the central family and friend group.

In both graphs, Elia shows groups from a town in the Netherlands, the Halle, as well as groups in Florence and Berlin. However she shows a connection between the Halle group and the Florence and Berlin groups that

FIGURE 5 Drawing and Network Visualization of Marta, a Catalan, 26 Years Old

does not exist in the visualization. She also shows a connection between the Florence group and her family that is not shown in the visualization. The connection between the Halle group and Berlin in the social circles graph is mainly due to one respondent who is from Berlin, but lives in Halle. When asked about that connection, the respondent said that the nature of the tie question (would the two alters talk independently of the respondent) negated that tie. In this case, the social circles represents links based on category association (being from Berlin), whereas the personal network visualization represents actual communication.

Figure 5 shows the drawing and the network visualization of Marta, a 26 year old. Comparison of the drawing and the visualization show that the categories are very much the same. Marta is aware that she has a large family group that overlaps with her cousins' friends group. She also depicted a group of friends from school who are connected to her family. Marta is an Erasmus student, a European program that sends students from one European country to study in another. She maintains a group of friends from the Erasmus program who are depicted in both the drawing and the visualization. Similarly, she depicts a group of friends from a small town called Calella in both pictures.

There are, however, some distinct differences. The main difference is the ability to identify key people in the visualization. The drawing depicts only broad categories of people, and, in only one case, a connection between those categories. The visualization shows bridging between categories from

key alters. In this interview concerning ethnic identity, the role of bridging ties can be critical. For example, the visualization shows four key ties between the school group and Marta's family. There is also a bridging tie between the Erasmus group and her family. This raises two types of questions. Why do these people serve a bridging role? Why do the others within the group not serve one? The utility of the visualization for the interview would be made stronger by overlaying characteristics of the alters, such as sex, ethnic group, and age. Figure 6 compares the drawing and visualization of Milanka, a Serbian migrant in Barcelona. In this case, the two representations of her network are not quite so similar. She depicts her family group at the center, with a mixture of neighbors, extended family, friends, and work connected directly to it. The only indirect connection she shows is acquaintances from work through friends from work.

The personal network visualization tells a different story. Although the right side of the visualization does bear some similarity to the drawing, showing family work and neighbors, we see that the work group is actually connected through the neighbors by one key tie. On the left, we also see that Milanka has a set of family ties in Serbia that are connected to the family group on the left by one key tie. In the upper left, we see a group of five alters from a former job who were not represented in the drawing at all. Finally, in the far upper left is a single alter (an isolate), her hairdresser, who is not tied to anyone. The ability to identify isolates is another key advantage of the personal network visualization. Isolates represent interesting subject matter for discussion. In the case of migrants, an isolate may represent attempts to reach out to other groups. Discussion about their success or failure in doing so may be facilitated by discussion about the reason an alter is an isolate.

Figure 7 shows the network of Edin, a Bosnian migrant. The drawing depicts a well-organized network, with several groups nested within each other. We would conclude from this drawing that Edin's maternal family and his university friends were connected and at the center of his network.

The personal network visualization on the right shows no connection between his family on the lower right and his university friends. Edin verified that this was the case. He does have a set of friends who live in the same town in Spain as his family, but they are connected by only one person. Information about this friend and why he is so key is useful for understanding how Edin integrates into Spanish society. We also see from the personal network visualization that Edin has an adoptive family in Spain, something that is not depicted in the drawing. The long list of isolates in the upper right represent clients from his work. The fact that he chose six of his forty-five alter choices

FIGURE 6 Drawing and Network Visualization of Milanka, a 34-Year-Old Serbian Migrant

FIGURE 7 Drawing and Network Visualization of Edin, a 26-Year-Old Man from Croatia

for clients who did not know each other could be significant. The interviewer should explore whether Edin considers these clients to be potential bridges to new alters.

Finally, we show the personal network visualization and the drawing from Regina, a 33-year-old woman from Ghana (Figure 8). Regina obtained a Masters in Spanish translation at the University of Valladolid in Valladolid, a city in the north of Spain. She's kept some friends from this stage in her life, but the transnational community of students whom she met in Vallodolid are now in other countries. Some of them are represented as isolates in the upper left corner of the visualization. The two main groups of Regina's network are her family in Ghana and the people from Ghana who also live in Vic (a town in Barcelona). She met those people in Vic for the first time, with the exception of Sam, her husband. Sam is the dot connecting both worlds—the family and the transnational community. It is interesting to note the support role of the Evangelist church in Vic for migrants from Ghana.

DISCUSSION

In seventeen of the nineteen cases, both the interviewer and the respondent recognized lines of questioning that were available to them using the personal

FIGURE 8 Drawing and Network Visualization of Regina, a 33-Year-Old Woman from Ghana

network visualization as a cue that were not available without it. Memories and information are not stored randomly, but arranged in hierarchical sets that are quickly accessible. The same is true for names of people. When participants free list names, they tend to cluster or mention successively persons from the same social context (e.g., family, work, school, church, etc.; Brewer and Yang 1994). This suggests that memories of people are, to some degree, organized by social structure.

When we ask respondents to describe their personal network (i.e., the social environment in which each respondent lives), we are asking them to describe the structure of their memory, using those labels that they have available to them. This is not a task that most people ever do, and is thus affected by their ability to report the structure of their memory accurately. Even if respondents can report the structure of their memories, there is reason to believe that this system of storing information differs significantly across respondents and that the labels used between people are radically different, and, in many cases, ad hoc. Assuming people can report accurately and store information in the same way, we see no reason to believe that they store names based on an accurate representation of social structure, although there are suspicions that social structure is the basis for the organization of people in memory (Brewer and Garrett 2001; Brewer et al. 2005). Thus, the drawings that respondents made in the first interview represent their attempt to apply those labels they have available to describe this structure.

The fourth module of the interview—the alter-tie evaluation—is, on the face of it, a much easier set of questions to answer. But it is more than that. The perception that two people are connected in some way does not require the respondent to abstract the nature of the relationship and fit it into a category that then must be labeled. Relations that cross conceptual categories, such as people we both work with and socialize with, can be evaluated by one criterion: whether they are socially connected, given the definition of a connection. The respondent can consider the multiplex relationships they have with their alters so that they accurately answer the question. The result is a picture of the structure that shows groupings, when they exist, and bridges between groups. It also shows people who are isolated and groups who are isolated and allows for the exploration of those relations.

Another reason that the personal network visualizations may differ from the categories generated by respondents is that respondent-generated categories tend to follow a certain dimension, such as types of behavior the respondent engages in with the alter (e.g., family, work, church), whereas social structures do not necessarily conform to one domain. In small-world studies in which the object is to try to get a message to randomly selected targets, it is not unusual for respondents to use alters that fit a behavioral domain

for local targets and a locational domain for those far away. This can be observed in the personal network visualizations in which clusters of respondents are identified by a mixture of behavioral and locational domains.

As can be seen from the analysis above, it is also quite common for the personal network visualizations to make distinctions between categories. For example, it is typical for respondents to talk about family relations. Yet, personal network visualizations often show clustering within families, based on kinship, location, or interaction. It is not uncommon to see groups within families who have no ties whatsoever. Such distinctions cannot be realized without the systematic evaluation of alter pair ties.

One potential disadvantage of the personal network visualization, at least the one used here, is that it does not accommodate overlap. From the drawings, we see that some respondents indicate comembership of people within more than one group. This is shown by overlapping circles. This version of the visualization software does not accommodate overlap. Alters are only shown in one position.

This method is not a panacea. When the subject matter does not concern a topic that is fundamentally interpersonal, the personal network visualization would help very little, if at all. For example, if the subject matter of an interview were specifically about knowledge or technique (such as the names of medicinal plants or how to construct a hut), it is doubtful that the tedium of collecting personal network structural data would be worthwhile.

On the other hand, if the research topic is fundamentally interpersonal (such as influences on migration choices or political opinion), then the personal network visualization provides a perspective on these topics that cannot be gained otherwise. For example, in the case of the interviews above concerning ethnic identity, the personal network visualizations show how some respondents compartmentalize alters of different ethnicities. This is most evident in Figure 8, where Regina maintains ties to a group of Catalans and several groups of Ghanaians. With the personal network visualization, the interviewer could question Regina specifically about people within those groups and how they interact, rather than hypothetical relations between abstract categories of relations.

A new version of EgoNet has been released that provides some additional capability that will no doubt be useful (available at www.mdlogix.com). Figure 9 shows the visualization, using this new software, of a second-generation Gambian woman living in a Catalan city. The circles with numbers by them are hierarchical clusters calculated by the program. As we can see, in the previous examples the circles do not fully match the naturally occurring groups that the informants defined from the visualization. However, they do provide a standard and objective way for interviewers to talk to respondents about the groupings

FIGURE 9 EgoNet Visualization of the Personal Network of a 22-Year-Old Gambian Woman

in their personal network. The numbers make it easy to record these interviews and indicate to which group the respondent is referring. Having an objective way of identifying groupings increases the reliability of the qualitative interpretation of the visualization.

We can also see that the software has allowed us to represent attributes of alters. In this case, color is used to represent skin color (Black = Black, Light grey = White, Dark grey = Brown), size represents how close the respondent feels to each alter (larger nodes are closer), and shape represents whether or not the alter smokes (Circles = Nonsmokers, Squares = Smokers). The nodes are also labeled by the country in which the alter was born. Using these data gives a much more detailed view of the social context of the respondent. In this case, the interviewer can easily see how alter attributes are distributed through the personal network and if the respondent compartmentalizes alters based on that. For

example, most of the isolates the respondent lists are smokers. The respondent lives with her Muslim family. When questioned about the number of isolates and the fact that they smoke, she revealed that she also smokes and stays with these friends on overnight trips where she can smoke

freely and go to parties. The ability to overlay alter attributes over structure is quite powerful. Future modifications of the method should include ways to reduce the respondent burden, such as presenting alter-pair evaluations in a way that is easier for respondents to input, either visually or in groupings. More work must be done on perfecting name generators to elicit the names of alters in an unbiased way, or to elicit names so that the bias is known and manageable.

NOTE

1. McCarty (2002) found that respondents recoding a set of alter-pairs were 97% accurate in recoding ±1 point.

Recent Developments in Network Measurement

This chapter considers study design and data collection methods for social network studies, emphasizing methodological research and applications that have appeared since an earlier review (Marsden 1990). It concentrates on methods and instruments for measuring social relationships linking actors or objects. Many analytical techniques discussed in other chapters identify patterns and regularities that measure structural properties of networks (such as centralization or global density), and/or relational properties of particular objects/actors within them (such as centrality or local density). The focus here is on acquiring the elementary data elements themselves.

Beginning with common designs for studying social networks, the chapter then covers methods for setting network boundaries. A discussion of data collection techniques follows. Survey and questionnaire methods receive primary attention: they are widely used, and much methodological research has focused on them. More recent work emphasizes methods for measuring egocentric networks and variations in network perceptions; questions of informant accuracy or competence in reporting on networks remain highly salient. The chapter closes with a brief discussion of network data from informants, archives, and observations, and issues in obtaining them.

2.1 Network Study Designs

The broad majority of social network studies use either "whole-network" or "egocentric" designs. Whole-network studies examine sets of interrelated objects or actors that are regarded for analytical purposes as bounded social collectives, although in practice network boundaries are often permeable and/or ambiguous. Egocentric studies focus on a focal actor or object and the relationships in its locality.

Freeman (1989) formally defined forms of whole-network data in set-theoretic, graph-theoretic, and matrix terms. The minimal network database consists of one set of objects (also known as *actors* or *nodes*) linked by one set of relationships observed at one occasion; the cross-sectional study of women's friendships in voluntary associations given by Valente (Figure 6.1.1, Chapter 6, this volume) is one example. The matrix representation of this common form of network data is known as a "who to whom" matrix or a "sociomatrix." Wasserman and Faust (1994) termed this form a *one-mode* data set because of its single set of objects.

Elaborations of the minimal design consider more than one set of relationships, measure relationships at multiple occasions, and/or allow multiple sets of objects (which

may change over occasions). Data sets with two sets of objects – termed *two-mode* by Wasserman and Faust (1994)–are common; Table 7.4.1 of Chapter 7 in this volume gives an example, a network of national memberships in trade and treaty organizations. Many studies also measure multiple relations, as in Lazega's (1999) study of collaboration, advising, and friendships among attorneys. As Snijders (Chapter 11, this volume) indicates, interest in longitudinal questions about social networks is rising; most extant data sets remain single occasion, however. In addition to relationships, almost all network data sets measure attributes (either time constant or time varying) of objects, but this chapter does not consider issues of measurement for these.

A further variation known as a *cognitive social structure* (CSS) design (Krackhardt 1987) obtains measurements of the relationship(s) under study from multiple sources or observers. Chapter 9 in this volume presents models for such data. The CSS design is widely used to study informant variations in the social perception of networks. In applications to date, observers have been actors in the networks under study, but in principle the sets of actors and observers could be disjoint.

Egocentric network designs assemble data on relationships involving a focal object (*ego*) and the objects (*alters*)towhich it is linked. Focal objects are often sampled from a larger population. The egocentric network data in the 1985 General Social Survey (GSS; see Marsden 1987), for example, include information on up to five alters with whom each survey respondent "discusses important matters."

Egocentric and whole-network designs are usually distinguished sharply from one another, but they are interrelated. A whole network contains an egocentric network for each object within it (Marsden 2002). Conversely, if egos are sampled "densely," whole networks may be constructed using egocentric network data. Kirke (1996), for instance, elicited egocentric networks for almost all youth in a particular district, and later used them in a whole-network analysis identifying within-district clusters. Egocentric designs in which respondents report on the relationships among alters in their egocentric networks may be seen as restricted CSS designs – in which informants report on clusters of proximate relationships, rather than on all linkages.

Aside from egocentric designs and one-mode (single-relation or multirelational), two-mode, and CSS designs for whole networks, some studies sample portions of networks. Frank discusses network sampling in depth in Chapter 3 (this volume). One sampling design observes relationships for a random sample of nodes (Granovetter 1976). Another, known as the "random walk" design (Klovdahl et al. 1977; McGrady et al. 1995), samples chains of nodes, yielding insight into indirect connectedness in large, open populations.

2.2 Setting Network Boundaries

Deciding on the set(s) of objects that lie within a network is a difficult problem for whole-network studies. Laumann, Marsden, and Prensky (1989) outlined three generic boundary specification strategies: a positional approach based on characteristics of objects or formal membership criteria, an event-based approach resting on participation in some class of activities, and a relational approach based on social connectedness.

Employment by an organization (e.g., Krackhardt 1990)isone positional criterion. The "regulars" at a beach depicted by Freeman (Figure 12.2.3, Chapter 12, this volume; see also Freeman and Webster 1994) were identified via an event-based approach; regulars were defined as persons observed 3 or more days during the study period.

Doreian and Woodard (1992) outlined a specific version of the relational approach called *expanding selection*.Beginning with a provisional "fixed" list of objects deemed to be in a network, it then adds objects linked to those on the initial list. This approach is closely related to the snowball sampling design discussed by Frank in Chapter 3, this volume; Doreian and Woodard, however, added a new object only after finding that it had several links (not just one) to elements on the fixed list. They review logistical issues in implementing expanding selection, and compare it with the fixed-list approach in a study of social services networks. More than one-half of the agencies located via expanding selection were not on the fixed list. Added agencies were closely linked to one another, although the fixed-list agencies were relatively central within the expanded network. The fixed-list approach presumes substantial prior investigator knowledge of network boundaries, whereas expanding selection draws on participant knowledge about them.

Elsewhere, Doreian and Woodard (1994) suggested methods for identifying a "reasonably complete" network within a larger network data set. They used expanding selection to identify a large set of candidate objects, and then selected a dense segment of this for study. They adopted Seidman's (1983)"*k*-core" concept (a subset of objects, each linked to at least *k* others within the subset) as a criterion for setting network boundaries. By varying *k*,investigators can set more and less restrictive criteria for including objects.

Egocentric network studies typically set boundaries during data collection. The "name generator" questions discussed in this chapter accomplish this.

2.3 Survey and Questionnaire Methods

Network studies draw extensively on survey and questionnaire data. Surveys allow investigators to decide on relationships to measure and on actors/objects to be approached for data. In the absence of archival records, surveys are often the most practical alternative: they make much more modest demands on participants than do diary methods or observation, for example. Surveys do introduce artificiality, however, and findings rest heavily on the presumed validity of self-reports.

Both whole-network and egocentric network studies use survey methods, but the designs typically differ in how they obtain network data and in what they ask of respondents. A whole-network study usually compiles a roster of actors before data collection begins. Survey and questionnaire instruments incorporate the roster, allowing respondents to recognize rather than recall their relationships. Egocentric studies, however, are often conducted in large, open populations. The alters in a respondent's network are not known beforehand, so setting network boundaries must rely on respondent recall.

Whole-network studies ordinarily seek interviews with all actors in the population, and ask respondents to report only on their direct relationships. (The CSS studies

discussed later are an exception; they ask for much more data.) In egocentric studies, however, practical and resource considerations usually preclude interviewing a respondent's alters. Such studies ask respondents for data on their own relationships to alters, and also often ask for information on linkages between alters; moreover, they commonly request proxy reports about alters.

Surveys and questionnaires in whole-network studies use several response formats to obtain network data: binary judgments (often termed *sociometric choices*) about whether respondents have a specified relationship with each actor on the roster, ordinal ratings of tie strength, or rankings. Binary judgments are least difficult for respondents; ranking tasks are most demanding. Eudey, Johnson, and Schade (1994) found that a large majority of respondents preferred rating over ranking tasks. Ferligoj and Hlebec (1999) reported the reliability of ratings to be somewhat higher than that of binary judgments. Batchelder (1989) considered network data of different scale types (dichotomous, ordinal, interval, ratio, absolute) and the inferences about network-level properties (e.g., reciprocation, presence of cliques) that can be drawn meaningfully from them. Among other things, Batchelder showed that findings may be affected if respondents have differing thresholds for claiming a given type of tie when making dichotomous judgments; Feld and Carter (2002) referred to this as *expansiveness bias* (see also Kashy and Kenny 1990). Likewise, implicit respondent-specific scale and location constants for rating relationship strength can complicate inferences. Eudey et al. (1994), however, used both ratings and rankings in studying a small group, and found quite high correlations between measures based on the two response formats.

Surveys sometimes include "global" items asking respondents about the size, density, or composition of their egocentric networks. Such questions pose extensive cognitive demands. To answer a global network density question, for instance, respondents must decide who their alters are, ascertain relationships among alters, and aggregate (Burt 1987). Sudman (1985) measured network size using both a global item and a recognition instrument; the measures had similar means, but the global item had a far greater variance. Instead of global items, contemporary studies usually measure egocentric networks using multiple-item instruments that ask respondents for only one datum at a time.

(A) *Name Generator Instruments for Egocentric Networks*

Surveys have long collected data on a respondent's social contacts and relationships (Coleman 1958). Such egocentric network instruments typically include two types of questions (Burt 1984): *name generators* that identify the respondent's alters, and *name interpreters* that obtain information on the alters and their relationships. Name generators are free-recall questions that delineate network boundaries. Name interpreters elicit data about alters and both ego–alter and alter–alter relationships. Many indices of network form and composition are based on such data.

Instruments for egocentric networks use both single and multiple name generators. A single-generator instrument focusing on alters with whom respondents "discuss important matters" first appeared in the 1985 GSS, and later in several other studies (Bailey

and Marsden 1999). It tends to elicit small networks of "core" ties; Marsden (1987) reported a mean network size of 3.0 for U.S. adults in 1985, whereas Ruan et al. (1997) reported a mean of 3.4 for adults in a Chinese city in 1993. Hirsch's (1980) Social Network List (SNL) for social support networks is another one-generator instrument. Respondents list up to twenty persons they regard as "significant" and have seen during the prior 4 to 6 weeks.

Any given name-generating relationship elicits only a fraction of a respondent's social contacts. Moreover, many conceptual understandings of networks extend beyond "core" ties to include more mundane forms of social support. Fischer (1982a), for example, used name generators for instrumental aid and socializing, as well as confiding. Fischer and Shavit's (1995) U.S.–Israel support network comparison used a multiplegenerator instrument. Another example is the Social Support Questionnaire (SSQ; Sarason et al. 1983), a twenty-seven-generator instrument eliciting persons to whom respondents can turn and on whom they can rely in differing circumstances.

The first consideration in choosing between single and multiple name generator instruments must be a study's conceptualization of a network. Single-generator methods may be sufficient for core networks, but more broadly defined support networks almost certainly require multiple name generators. A practical issue is the availability of interview time. Multiple-generator instruments that elicit many alters can be quite long, and measuring egocentric networks must be a central focus of studies including them.

More extensive definitions of "a network" include alters and relationships that do not provide even minor social support. McCarty et al. (1997) sought to measure features of "total personal networks," including all alters "known" by a respondent, those who "would recognize the respondent by sight or by name" (p. 305). Networks thus defined are too large to enumerate fully. McCarty et al. sampled total network alters by selecting a series of first names and asking if respondents know anyone by those names; they posed name interpreter questions about the sampled alters. The authors acknowledge that age, gender, and race/ethnic differences in naming practices may limit the representativeness of their samples. Nonetheless, their sampled total networks are less dense and less kin centered than are core or support networks, as one would anticipate. Further investigation of this technique as a means of measuring extensively defined egocentric networks seems warranted.

Because name generator instruments are complex by comparison with conventional survey items (Van Tilburg 1998), they often are administered in person so interviewers can assist respondents who need help completing them. Such instruments have, however, appeared in both paper-and-pencil (Burt 1997) and computerized questionnaires (Bernard et al. 1990; Podolny and Baron 1997). Little research has examined differences in data quality by data collection mode.

Methodological research on name generator instruments rarely addresses questions of validity because criterion data from other sources are unavailable. Some test–retest studies of instrument reliability are reviewed subsequently. Most research, however, examines the in-practice performance of instruments: how name generators differ, how respondents handle sometimes challenging tasks that instruments pose, and how key terms are understood. Much of this research reflects attention to cognitive and

communicative processes involved in answering survey questions (Sudman, Bradburn, and Schwarz 1996).

Comparing Name Generators Several studies systematically compare properties of name generators. Campbell and Lee (1991), Milardo (1992), and Van der Poel (1993) highlighted conceptual differences between generators in criteria for including alters. Some refer to specific social exchanges, such as discussing important matters or borrowing household items; others use affective criteria ("closeness"); others specify particular role relations such as kinship or neighboring; and still others measure frequent interaction. Also, some generators specify temporal (e.g., contact within the prior 6 months) or spatial/organizational restrictions on eligible alters (Campbell and Lee 1991).

Varying name generator content influences egocentric network size, among other features. Campbell and Lee (1991) and Milardo (1992) showed that intimate name generators – whether affective or exchange based – elicit smaller networks than those specifying less intense thresholds for naming alters. Mean network sizes reported in seven intimate generator studies (all in North American settings) range between three and seven. Multiple-generator exchange-based instruments produce appreciably larger networks; across seven studies using such instruments, mean network size ranged between ten and twenty-two. Studies using exchange-based name generators tended to produce networks having smaller fractions of family members than did those using intimate generators.

Bernard et al. (1990) administered the GSS name generator and an eleven-generator social support instrument within a single study. The GSS instrument elicited smaller networks than did the social support instrument. These were core contacts: about 90% of GSS alters were also named for the social support instrument.

Instruments with many name generators impose appreciable respondent burden. Three studies suggest small sets of name generators for measuring support networks. Van der Poel (1993) identified subsets of name generators that best predict the size and composition of networks elicited using a ten-generator instrument. A three-generator subset consists of items on discussing a major life change, aid with household tasks, and monthly visiting; a five-generator version adds borrowing household items and going out socially. Bernard et al. (1990) isolated questions about social activities, hobbies, personal problems, advice about important decisions, and closeness as a "natural group" of name generators. Burt (1997) used a construct validity criterion – the association between network constraint and achievement – in an organizational setting. He concluded that a minimal module of name generators should measure both intimacy and activity; it might consist of the GSS "important matters" item, socializing, and discussion of a job change.

Recall, Recognition, and Forgetting Brewer (2000)reviewed nine studies that asked respondents first to freely recall lists of persons, and then to supplement their lists after consulting an inventory listing all eligible persons. For instance, Brewer and Webster (1999) asked dormitory residents to recall their best friends, close friends, and other friends; the respondents then reviewed

a dormitory roster and could add to each list of friends. Friends recognized on the roster were deemed to have been "forgotten" in the recall task.

Across studies, Brewer reported an appreciable level of forgetting, although it varied substantially across groups and relationships. In the dormitory study, one-fifth of all friends were not named in the recall task. As in several other studies Brewer reviewed, the likelihood of forgetting alters varied inversely with tie strength: students forgot only 3% of best friends and 9% of close friends, but added 26% of other friends after inspecting the dormitory listing.

Brewer's review makes it clear that name generators elicit only a fraction of those persons having a criterion relationship to a respondent, and that intimate name generators enumerate a larger fraction of eligible alters than do weaker ones. Implications of these findings depend on the purposes for which network data are used. If one seeks to describe a network precisely or to contact alters (e.g., partner notification concerning an infectious disease; Brewer, Garrett, and Kulasingam 1999), then any shortfall in the enumeration of alters is an obvious drawback. If instead a study seeks indices contrasting the structure and composition of networks, then forgetting is more serious to the extent that indices based on the recalled and recalled/forgotten sets of alters diverge. Brewer and Webster (1999), for example, reported relatively high correlations between measures of centrality, egocentric network size, and local density based on recalled alters only, and the same measures based on recalled and recognized alters. They found appreciable differences in some network-level properties, however.

Brewer (2000) suggested several steps toward reducing the level of forgetting. These include the use of recognition rather than recall when possible and, if using recall methods, nonspecific probes for additional alters. Using multiple name generators may limit forgetting because persons forgotten for one generator are often named in response to others.

Test–Retest Studies Brewer (2000) also reviewed eight test–retest studies. These used a variety of affective, support, and exchange name generators. Most test–retest intervals were 1 month or less. In all but one study, more than 75% of first-occasion alters were also cited at the second occasion. Brewer suggested that respondents may have forgotten the uncited alters.

Two studies examine over time stability in network size for social support instruments. Rapkin and Stein (1989) measured networks over a 2-month interval using both closeness and "importance" criteria. Between-occasion correlations of network size were 0.72 and 0.56, respectively. Size declined over time for both criteria, however, suggesting that respondents were unenthusiastic about repeating the task on the second occasion. Bass and Stein (1997) found higher 4-week stability in network size for the support-based SSQ (Sarason et al. 1983) than for the affective SNL (Hirsch 1980).

Morgan, Neal, and Carder (1997) conducted a seven-wave panel study of widows, using an importance criterion to elicit networks every 2 months. Core networks were very stable – 22% of alters were named on all seven occasions. These were often family members. There was also much flux at the periphery because 24% of alters were named only once. Morgan et al. found network properties to be more stable across

occasions than were alters. They suggest that between-occasion differences in alters mix unreliability (or forgetting) and genuine turnover.

Patterns in the Free Recall of Persons Several studies of social cognition have examined the free recall of persons under different conditions. Their findings suggest strongly that social relationships organize memories for persons. Understanding these principles of memory organization can improve instruments such as name generators that seek to tap into such memories.

Bond, Jones, and Weintraub (1985) asked subjects to name acquaintances ("people you know") and recorded the order in which acquaintances were named. Successive nominations tended to be clustered by affiliations with social groups, rather than by similarity in physical or personality characteristics. Moreover, the time intervals separating names within a given group tended to be short; subjects paused for longer periods between names of persons in different groups. Social relations thus appear to be an important basis for remembering persons: Bond et al. concluded that "the person cognizer is more a sociologist than an intuitive psychologist" (p. 336). Fiske (1995) reported results for two similar studies; clusters of persons named by his subjects were grouped much more strongly by relationships than by similarity of individual features such as gender, race, or age.

Brewer (1995) conducted three studies asking subjects to name all persons within a graduate program, a religious fellowship, and a small division of a university. He too found that memory for persons reflects social relational structures: names of graduate students, for example, tended to be clustered by entering cohort, and shorter time intervals intervened between the naming of persons within a cohort than those in different cohorts. More generally, perceived social proximity appears to govern recall of persons. Brewer also found that subjects tended to name persons in order of salience. Those in groups proximate to the subject tended to be named first, as were persons of high social status and those frequently present in a setting.

These studies suggest that respondents recall alters in social clusters when answering name generators. The basis for clustering likely varies across situations, but it is plausible that foci of activity such as families, neighborhoods, workplaces, or associations (Feld 1981)offer a framework for remembering others. Aiding respondent recall with reminders of such foci might encourage more complete delineation of alters. Brewer's studies also indicate that respondents tend to order their nominations of alters by tie strength (see Burt 1986).

The Meaning and Interpretation of Name Generators Name generators always refer to a specific type of social tie, and researchers assume that respondents share their understanding of this criterion. Fischer (1982b) questioned this assumption for "friends" (see Kirke 1996,however). He and others suggested that meanings are more apt to be shared for specific exchanges than for role labels or affective criteria. This calls for studies of the meanings attributed to exchange name generators.

Because it has been widely used, several studies have examined the GSS "important matters" name generator. Respondents decide what matters are "important" while

answering, so the content of the specific exchanges it measures may vary. Ruan (1998) investigated the intersection between the sets of alters named for the GSS name generator and those for several subsequently administered exchange name generators. In her Chinese urban sample, the GSS name generator elicited social companions and persons with whom private issues are discussed, but not alters providing instrumental aid.

Bailey and Marsden (1999) used concurrent think-aloud probes to investigate how respondents interpret the GSS name generator. Their convenience sample of U.S. adults offered a variety of interpretations: some respondents referred to specific matters, but others translated the question into one about intimacy, frequent contact, or role labels. When probed about the matters regarded as "important," most respondents referred to personal relationships; health, work, and politics were other often-mentioned categories. Differences in interpretive framework or definitions of important matters were not strongly associated with the types of relationships elicited, however.

Straits (2000) conducted an experiment: one-half of his student sample answered the GSS name generator, whereas the other half answered a generator about "people especially significant in your life." The two question wordings produced virtually identical numbers of alters. Only modest compositional differences were observed: women named a somewhat greater number of male alters for the "significant people" question than for the "important matters" question. Overall, however, Straits concluded that the "important matters" criterion also elicits "significant people."

McCarty (1995) investigated respondent judgments of how well they "know" others. Indicators of tie strength – closeness, duration, friendship, kinship – were associated with knowing alters well. Frequent contact was linked to knowing others moderately well. Low levels of knowing were distinguished by awareness of factual (but not personal) information and acquaintanceship.

Interview Context Effects When name generators contain terms requiring interpretation, respondents may look to the preceding substantive content of an interview for cues about their meaning. A context experiment was embedded in the Bailey and Marsden (1999) study. One-half of the respondents answered a series of questions about politics before the "important matters" name generator; the other half began with questions about family. When subsequently debriefed about what types of matters were "important," family-context respondents were considerably more likely to mention family matters than were political-context respondents. Because this study is based on a small sample, these findings only suggest the prospect that context influences the interpretation of a name generator.

Interviewer Effects Three nonexperimental studies document sizable interviewer differences in the size of egocentric networks elicited by name generator methods. Van Tilburg (1998) studied a seven-generator instrument with an elderly Dutch sample, reporting a within-interviewer correlation of network size of more than 0.2. This fell only modestly after controls for respondent and interviewer characteristics. Marsden (2003) studied a single-generator instrument eliciting "good friends" administered in the 1998 GSS,

finding a somewhat smaller (0.15) intraclass correlation than Van Tilburg's. Straits (2000) reported a similar figure (0.17) for the GSS "important matters" name generator administered by his student interviewers.

These interviewer differences are much larger than typical for survey items (Groves and Magilavy 1986). Large interviewer effects are, however, common for questions like name generators that ask respondents to list a number of entities. One conjecture is that interviewer differences reflect variations in the extent of probing. The findings highlight the need for careful interviewer training to ensure standardized administration of name generators. They also suggest the potential value of computer-assisted methods for obtaining network data, which operate without interviewers.

Name Interpreters Although name generators have attracted much methodological interest, name interpreter items provide much of the data on which measures of egocentric network form and composition rest. Once alters are enumerated, most instruments follow up with questions about each alter and about pairs of alters.

The survey research literature on proxy reporting (e.g., Moore 1988) includes many studies comparing self-reports with proxy reports. In most of these, proxy respondents report on others in their households, so findings may not apply directly to reports about alters in an egocentric network. Sudman et al. (1994) observed that memories about others (especially distant others) are less elaborate, less experientially based, and less concerned with self-presentation than are memories of the self. This implies that self- and proxy reporters use different tactics to answer questions. Proxy respondents are prone, for example, to anchor answers on their own behavior, rather than retrieving answers directly from memory (Blair, Menon, and Bickart 1991). Sudman et al. (1994) hypothesized that the quality of proxy reports rises with respondent–alter interaction, and offered supportive data from a study of spouses.

Studies in the network literature establish that survey respondents can report on many characteristics of their alters with reasonable accuracy (Marsden 1990). White and Watkins (2000) found that Kenyan village women could report observable data on their alters – such as number of children or household possessions – relatively well. Ego–alter agreement was much lower for use of contraception, something often kept secret. Respondents often projected their own contraceptive behavior onto alters.

Shelley et al. (1995) studied networks of HIV
+
informants. Most sought to limit knowledge of their HIV status to certain alters; only one-half of the relatives in these networks were said to know the informant's HIV status. Nonetheless, informants reported that this was a better-known datum than several others, including political party affiliation and blood type. Such findings call for caution in formulating name interpreters because respondents may often lack certain information about their alters.

In addition to proxy reports, important name interpreters refer to ego–alter and alter–alter ties. Studies of network perception discussed subsequently are relevant to understanding answers to such questions. Providing name interpreter data about a series of alters can be a repetitive, tedious task. White and Watkins (2000) noted that their respondents quickly became bored when answering such questions, and they therefore asked about no more than four alters. A

useful step toward limiting respondent burden is to ask some or all name interpreter items only about a subset of alters (or dyads), as in Fischer (1982a) and McCarty et al. (1997). Acceptably reliable measures of network density and composition are often available from data on only three to five alters (Marsden 1993).

(B) *Additional Instruments for Egocentric Networks*

Many name generator instruments do not elicit weak ties that are crucial in extending network range. In addition, even single-generator instruments require substantial interview time and pose notable respondent burdens. This section reviews alternative instruments developed to address such limitations.

Instruments for Measuring Extensive Network Size Estimating the size of extensive egocentric networks, including all alters someone "knows," is difficult in large, open populations. Several survey instruments have been developed for network size. The "summation" method (McCarty et al. 2001) uses global network questions to estimate the numbers of persons with whom respondents have sixteen relationships (e.g., family, friendship, neighboring), taking the sum of a respondent's answers as total network size. Two U.S. surveys using this method estimate that mean network size lies between 280 and 290.

Killworth et al. (1998b)developed "scale-up" methods that estimate extensive network size using data on the known size of subpopulations, such as people named "Michael" or people who are postal workers. These methods rest on the proposition that egocentric network composition resembles population composition, that is,

$$\frac{m}{c} = \frac{e}{t},$$

where m is the number of alters from some subpopulation in an egocentric network, c is network size, e is subpopulation size, and t is population size. Survey data on m, together with data on e and t from official statistics or other archives, lead to scale-up estimates of network size c.

The previous proposition will not, of course, hold precisely for all persons and subpopulations. Implementations of the scale-up approach estimate c using data on m and e for several subpopulations. Studies using the approach yield a range of values for mean network size. Killworth et al. (1990) obtained a mean of around 1,700 for U.S. informants, and one of about 570 for Mexico City informants; these estimates assume a broad definition of "knowing" ("ever known during one's lifetime"). Killworth et al. (1998a) reported the mean size of "active networks" (involving mutual recognition and contact within the prior 2 years) to be about 108 for Floridians; Killworth et al. (1998a) obtained a mean active network size of 286 from a U.S. survey. The authors note that scale-up methods depend heavily on a respondent's abilities to report accurately on the numbers of persons known within subpopulations.

The *reverse small world* (RSW) method (see, e.g., Killworth et al. 1990)isstill another approach to measuring extensive networks. It presents respondents with many (often 500) "target" persons described by occupation and location, asking for an alter more likely than the respondent to know each target. RSW identifies alters who could

be instrumentally useful; it omits those who are known, but not judged to be useful. Bernard et al. (1990) reported mean RSWnetwork sizes of 129 for Jacksonville, Florida, informants, and 77 for Mexico City informants.

Position Generators Rather than identifying particular alters and later ascertaining their social locations using name interpreters, the "position generator" measures linkages to specific locations directly. It asks respondents whether they have relationships with persons in each of a set of social positions. For example, Lin, Fu, and Hsung (2001) asked respondents if they have any relatives, friends, or acquaintances who hold fifteen different occupations. Follow-up questions may ascertain the strength of links to locations. Position generator data allow construction of indices of network range (e.g., number of occupations contacted) and composition (e.g., most prestigious occupation contacted).

Several empirical studies (e.g., Erickson 1996) use the position generator effectively. It identifies weak and strong contacts, if the threshold for contact with locations is of low intimacy; Erickson, for example, asked respondents to "count anyone you know well enough to talk to even if you are not close to them" (1996:p.227). Because position generators do not ask about individual alters, they require less interview time than do many name generator instruments. However, position generators measure network range and composition only with respect to the social positions presented. Most applications focus on class or occupational positions; thus, the resulting data do not reflect racial or ethnoreligious network diversity, for example.

Smith (2002)experimentally compared measures of interracial friendship based on a one-item position generator, a name generator instrument, and a global approach in the 1998 GSS. His global items asked for a respondent's number of "good friends" and the number who are of a different race. Percentages of respondents claiming interracial good friends were highest for the position generator (whites, 42%; blacks, 62%), intermediate for the global approach (whites, 24%; blacks, 45%), and lowest for the name generator instrument (whites, 6%; blacks, 15%). Smith suggested that the name generator approach provides the most valid figures because it enumerates friends first, and later determines their race. The other approaches focus attention on the particular social location (race) of interest, encouraging respondents to inventory their memories for anyone who might meet the "good friend" criterion. Respondents seeking to present themselves favorably might alter their definition of "good friend" so they can report an interracial friend. Smith's findings may or may not apply to position generators measuring contact with occupational positions. Further instrument comparisons like this are needed.

The Resource Generator Very recently, Van der Gaag and Snijders (2004) proposed the "resource generator" as an instrument for measuring individual-level social capital, which they defined as "resources owned by the members of an individual's personal social network, which may become available to the individual" (p. 200). Their instrument focuses on whether a survey respondent is in personal contact with anyone having specific possessions or capacities, such as the ability to repair vehicles, knowledge of literature, or high income. The resource generator does not enumerate specific social ties: in its most elementary

version it measures only whether a respondent "knows" anyone having each resource. Follow-up questions may ask about the number of ties to each resource, or qualities of the strongest tie to each resource. Using data from a Dutch survey, Van der Gaag and Snijders identify four social capital subscales, which they label prestige, information, skills, and support.

(C) *CSS Data*

As defined by Krackhardt (1987), CSS data consist of judgments by each of several perceivers about each dyadic relationship in a whole network. Such data offer many potential measurements of a network. Krackhardt called attention to three: a single observer's "slice" of judgments, a "locally aggregated structure" of judgments by the two actors directly involved in each dyad, and a "consensus structure" based on all judgments about a given dyad.

CSS data have been collected via several survey/questionnaire methods. Krackhardt (1987) used a checklist of dichotomous items about the outgoing ties of each actor in the network. Casciaro (1998) presented informants with a labeled matrix, asking that they mark pairs linked by directed ties. Batchelder (2002) used a questionnaire about outgoing ties, asking for dichotomous judgments at two thresholds of tie strength. A third response task asked informants to rank the three closest contacts of each network actor; some informants did not or could not complete the rankings, however. Johnson and Orbach (2002) asked informants for the three most frequent ties of each actor, but did not request a ranking.

These designs entail a considerable respondent burden that rises with network size, as Krackhardt (1987) noted. For example, Krackhardt asked twenty-one workplace informants for 400 dichotomous judgments about each of two types of tie (friendship and advice). Batchelder's ranking task or Johnson and Orbach's "pick three" task make fewer demands: each would require 126 judgments per informant for Krackhardt's group. Freeman and Webster's (1994) pile sort – which first asks that informants identify groups of closely related actors, and later permits them to combine groups linked at lower-intensity thresholds – is another less burdensome approach. Freeman (1994) suggested a graphic interface: informants position actors with respect to one another within a two-dimensional space. This requires only as many judgments as there are actors, albeit much more complex ones than those of other CSS tasks.

Batchelder (2002) found strong similarities among consensus structures based on dichotomous ratings, trichotomous ratings, and her ranking task. She concluded that dichotomous ratings may be sufficient for CSS data, given the volume of data in the design. The high between-task similarity found in her study, however, may result in part because informants could consult their responses on the rating tasks when providing rankings.

(D) *Informant Biases in Network Perception*

Several patterns recur in studies based on CSS data. These findings hold both substantive and methodological interest. They advance substantive understanding of social

perception by revealing schemas or models on which informants draw when describing their social environments, and indicate tendencies to anticipate when informants report on their own social ties and those of others.

Studying informants in an organizational department, Kumbasar, Romney, and Batchelder (1994) compared individual CSS slices to a consensus structure. Informants occupied more central locations in their slices than in the consensus structure; more than one-half placed themselves first or second in degree centrality, for example. Johnson and Orbach (2002) replicated this finding of "ego bias" in their study of a political network, finding it to be strongest among peripheral informants.

Kumbasar et al. (1994) also examined differences between reporting on relationships among adjacent alters and on ties involving actors not directly linked to informants. Reports about adjacent alters had higher density, reciprocity, and transitivity. The authors concluded that informants experience cognitive pressures toward reporting balanced local environments. This echoes Freeman's (1992) claim that informants simplify observations of interaction, imposing a "group" or "balance" schema by selectively creating or neglecting relationships among alters. His experimental evidence indicates that subjects had difficulty recalling relationships in unbalanced structures. Krackhardt and Kilduff (1999) too found that perceptions of relationships draw on a balance schema. Their studies of four CSS data sets, however, found higher levels of reciprocity and transitivity for both close *and* distant alters; perceived balance was lowest for alters at intermediate geodesic distances from the informant. Krackhardt and Kilduff reason that informants lacking detailed memories about distal relationships fill in details about them using the balance schema as a heuristic.

Johnson and Orbach (2002) suggested that, when information about social ties is limited, reports draw on a "status" schema giving positions of prominence to high-status actors. Webster (1995) too suggested that status considerations influence reports about relationships, and Brewer (1995) noted that high-status persons tend to be salient within informant memories.

Notwithstanding the various perceptual biases isolated, Kumbasar et al. (1994: p. 488) concluded that their informants were "fairly reliable" judges of the affiliation pattern in the group studied. Findings that informants employ a balance schema nonetheless suggest that relatively high local densities will be obtained using name interpreter items about relationships among alters because informants overstate the degree of closeness among alters they cite.

2.4 Informant Accuracy and Competence

Landmark studies by Bernard, Killworth, and Sailer (BKS; 1981) problematized the validity of respondent reports on social ties, documenting a far-from-complete correspondence between survey reports of interaction frequencies ("cognitive" data) and contemporaneous observations ("behavioral" data). BKS drew pessimistic conclusions about the utility of self-reported network data, stimulating many responses and much further research. Freeman, Romney, and Freeman (1987), for instance, showed that discrepancies between survey reports and time-specific observations of interaction

were not random, but instead biased toward longer-term regularities. They argued that informants can make largely accurate reports about enduring patterns of interaction (see also Freeman 1992). Research on the cognitive-behavioral correspondence continued throughout the 1990s. Closely related work examines variations in cognition about networks as a phenomenon in and of itself, revealing variations in reporting "competence" that might offer aid in selecting informants.

(A) *Correspondence Between Reports and Observations*

In a reexamination of the BKS data, Kashy and Kenny (1990) showed that actors who received many cognitive citations had high observed interaction levels; moreover, behavioral data tended – although not inevitably – to corroborate pairwise reports of unusually high or low interaction. There was little correspondence, however, between an actor's number of outgoing citations and observed interaction levels. Thus, a major source of inaccuracy lies in the different response sets or thresholds that respondents use when making citations. Kashy and Kenny nonetheless concluded that cognitive network data contain useful information about interactions.

Freeman and Webster (1994) compared cognitive data from a pile sort task with observations of interaction. They too found substantial correspondence between the two measurements. Freeman and Webster noted, however, that the structure of their cognitive data was simpler than that of their observations; discernable clusters in the observations were much more marked in the sort. They contended that cognitive data are based on observed interactions, but reflect the use of a "group" schema storing information about categorical affiliations rather than dyadic ties. Freeman and Webster observed, moreover, that informants made more nuanced distinctions about proximate actors, smoothing over details about ties among distant ones.

Corman and Bradford (1993) recorded interactions among participants in a simulation game, and subsequently asked them to recall their interactions. Highly active participants tended to omit observed interactions from their self-reports, an outcome attributed to communication overload. Corman and Bradford theorized that participants who are highly identified with a group will tend to overreport, but their study did not measure identification directly.

These studies provide some confidence in self-reports as a valid source of network data, albeit with caution. They also suggest that observing social ties is itself difficult. Kashy and Kenny (1990), for instance, noted that time sampling introduces random elements into observed interaction records. A limited cognitive-behavioral correspondence, then, may reflect flaws both in observations and in self-reports.

(B) *Studies of Informant Competence*

In an early reexamination of the BKS data, Romney and Weller (1984) found that reliable informants (whose cognitive data resemble those of other informants) tend to be accurate (i.e., their cognitive data are close to aggregated observational data).

They posited that some informants may be better sources than others in reporting on interaction patterns. Romney, Weller, and Batchelder (1986) subsequently developed a general model for inferring shared cultural knowledge from informant reports, in which informants have differential "competence" to the extent that their reports correspond with those of others. This notion of competence parallels Romney and Weller's (1984) "reliability."

Several studies using CSS data investigate variations in informant competence in reporting on a whole network. These studies often refer to an informant's "accuracy." Their assessments of accuracy, however, do not compare cognitive data to an external referent, as in the BKS studies or Romney and Weller (1984). Instead, they usually examine the difference between an informant's slice of CSS data and some representation (e.g., a locally aggregated or a consensus structure) based on data from all informants. Such comparisons reflect what Romney et al. (1986) termed competence. To avoid ambiguity, the following remarks refer to "competence" rather than "accuracy."

These studies consistently find that centrally positioned informants tend to have higher competence (Krackhardt 1990; Bondonio 1998; Casciaro 1998; Johnson and Orbach 2002). Central informants have more opportunities to observe and to exchange information with others. Casciaro's (1998) finding that part-time workers are less competent reflects similar considerations.

Bondonio (1998) pointed to proximity as a source of competence: informants were more competent in reporting on the networks of close than of distal alters. Casciaro (1998) suggested that individual differences in motivation might lead informants to be differentially attentive to their social environments. High need for achievement was associated with greater competence in her CSS study.

(C) *Prospective Uses of Informants*

Network researchers implicitly take reports by actors involved in a dyad to be more valid than those by third-party informants. Apart from CSS data and name interpreters on alter–alter ties in egocentric instruments, little use has been made of informant reports about relationships of others. Torenvlied and Van Schuur (1994), however, suggested a procedure for eliciting CSS-like data from key informants. Burt and Ronchi (1994) measured egocentric networks for a subset of managers in an organization, some of whom offered data on the same relationships. Burt and Ronchi used this overlap in reports to develop imputations for unmeasured relationships in the full managerial network.

Competence studies also suggest intriguing prospects for using informants. For instance, a whole network might be measured by asking a small number of informants to complete CSS-like instruments, rather than seeking self-reports from all participants. This would be viable if CSS data reveal a strong correspondence between, for example, a consensus structure based on reports by all informants and one based on reports of some subset of highly competent informants. It would also require data – on likely centrality or need for achievement, for example – with which to screen prospective informants for competence.

2.5 Archival Network Data

Network studies use much information residing in archives that were not created expressly for social research. Such data provide unobtrusive measures of social ties. They sometimes trace relationships of actors who are reluctant to grant interviews. Archival data are often inexpensive, especially when in electronic form; if maintained over time, archives support longitudinal network studies. Archival materials are a mainstay source for studying networks in the past.

Some recent examples illustrate the range of applications for archival network data. Podolny (1993) measured the status of investment banks based on their relative positions in "tombstone" announcements of syndicated securities offerings. Using patent citations, Podolny and Stuart (1995)developed indicators of niche differentiation for innovations. Alexander and Danowski (1990) coded links between actors in Roman society recorded in Cicero's letters. Hargens (2000) depicted the structure of research areas via citations linking scientific papers. Adamic and Adar (2003) mined homepages on the World Wide Web for connections among university students. Two-mode data on membership relations (e.g., Table 7.4.1, Chapter 7, this volume) often are to be found in archives. Relatively few explicitly methodological studies of archival data appear in the network literature. Although properties surely vary from source to source, a few generic issues and questions can be raised about such data.

The validity of archival data rests on the correspondence between measured connections and the conceptual ties of research interest. Sometimes this can be quite close; Podolny's interest in tombstone advertisements lies in the status signals (bank affiliations) they convey to third-party observers, and observers see exactly the information Podolny coded. In other cases, there may be slippage. Rice et al. (1989) observed that researchers often assume that academic citations track the flowof scientific information, but that in practice citations have many purposes, including paying homage to pioneers, correcting or disputing previous work, and identifying methods or equipment, among many others. Hargens (2000) conducted citation-context analyses revealing differences in citation practices – and the possible meanings of citations – across research areas.

Attention to the conditions under which archives are produced may be helpful in judging their likely validity with respect to any given conceptual definition of relationships. For example, Meyer (2000)reviewed the social processes underlying patent citations. Such citations acknowledge "prior art" related to a given invention, thereby distinguishing and narrowing an applicant's legal claims to originality. Interactions among applicants, patent examiners, and patent attorneys determine prior art citations. Examiners can add citations to an application before a patent is granted; applicants often claim to be unaware of the added works, although they do acknowledge other materials not included among the examiner's "front page" citations. Patent citations, then, are not simple traces of the process leading to an invention.

Likewise, the conditions under which objects come to be included in an archive merit attention. There are some reasons to anticipate that citation databases will be relatively comprehensive: authors have clear incentives to publish their works, much

as inventors have for guarding their claims. Rice et al. (1989), however, reminded us that editorial policies determine what journals are tracked by abstracting and indexing services, and thus what outgoing citations are recorded. In some instances, availability of archival materials may be quite selective. Adamic and Adar's (2003) homepage study, for example, notes that students decide whether to maintain a page. Moreover, some student pages exist, but reside in domains other than the one they examined.

Problems analogous to expansiveness bias in survey data (Feld and Carter 2002) arise by virtue of varying criteria for recording relationships in archives. Many affiliation data – such as corporate board memberships – may be relatively clear-cut. Patent citations should satisfy a common standard of "relevance" (Meyer 2000), although one might envision "examiner effects" on the number of outgoing citations. Academic citation practices, however, may differ appreciably across authors and fields. Authors of homepages have full discretion over page content, and pages almost certainly vary greatly in whether and why they include links. Adamic and Adar (2003) reported outgoing links for 14% and 33% of personal homepages in two universities.

Rice et al. (1989) also noted various mechanical problems that can introduce error into archival network measures. Journal-to-journal citation counts, for example, may be inaccurate if journal names change or if databases include "aberrant" journal abbreviations. Similar difficulties can affect author-to-author counts. Problems of this sort are easily overlooked, especially for electronically available archives. Computer-mediated systems (Rice 1990)offer potentially rich data on human communication that network analysts have only begun to exploit. Such records are, however, medium specific: e-mail archives, for instance, exclude face-to-face communication that may be highly significant. The volume and detail of the data recorded in some such sources raises important issues of how to protect the privacy of monitored communication.

2.6 Observation

Observations made as part of extended fieldwork were important sources of data in some early network studies (Mitchell 1969). Relatively fewer recent network studies have drawn on such data, by comparison with survey and archival sources. Gibson's (2003) real-time observations of conversations in managerial meetings are one recent example.

The difficulty of obtaining observational data should not be understated. Corman and Bradford (1993)experienced problems in coding dyadic interactions from video- and audiotapes; it was not always possible for coders to discern who was addressing whom. Webster (1994) commented on problems in focal behavior sampling as an observational method, remarking that the relevant behaviors must be readily visible in the context studied and of sufficiently low frequency to allow an observer to record all relevant instances. Corman and Scott (1994) added that observation of large groups may require multiple observers positioned in all locations of group activity. They suggested that wireless microphones might be used in place of human observers; using a small set

of recordings, they illustrated a procedure for establishing dyadic communications by matching digitized signal patterns.

2.7 Conclusion

Notable advances in network measurement have occurred since 1990, especially for survey and questionnaire data. Instruments for measuring egocentric networks are now much better understood, and much has been learned about cognitive processes and biases involved in answering questions about social relationships.

Important questions of validity and reliability for survey/questionnaire data remain. The number and range of network studies that draw on archival materials has risen. Given the opportunities that archival sources present, it is important to scrutinize the quality of such data as closely as data from self-reports. Assessments of data quality, regardless of source, will be facilitated if researchers clearly articulate their concepts of the “true scores” they seek to capture with empirical indicators of network ties.

How many people do you know?: Efficiently estimating personal network size

Abstract In this paper we develop a method to estimate both individual social network size (i.e., degree) and the distribution of network sizes in a population by asking respondents how many people they know in specifIc subpopulations (e.g., people named Michael). Building on the scale-up method of Killworth et al. (1998b) and other previous attempts to estimate individual network size, we propose a latent non-random mixing

model which resolves three known problems with previous approaches. As a byproduct, our method also provides estimates of the rate of social mixing between population groups. We demonstrate the model using a sample of 1,370 adults originally collected by McCarty et al. (2001). Based on insights developed during the statistical modeling, we conclude by ofiering practical guidelines for the design of future surveys to estimate social network size. Most importantly, we show that if the fIrst names to be asked about are chosen properly, the simple scale-up degree estimates can enjoy the same bias-reduction as that from the our more complex latent non-random mixing model.
Keywords: Social Networks; Survey Design; Personal Network Size; Negative Binomial Distribution; Latent Non-random Mixing Model

1 Introduction

Social networks have become an increasingly common framework for understanding and explaining social phenomena. Yet, despite an abundance of sophisticated models, social network research has yet to realize its full potential, in part because of the di–culty of collecting social network data. In this paper we add to the toolkit of researchers interested in network phenomena by developing methodology to address two fundamental questions posed in the seminal paper of Pool and Kochen (1978): fIrst, we would like to know for any individual, how many other people she knows (i.e. her degree, d
); and second, for a population, we would like to know the distribution of acquaintance volume (i.e. the degree distribution, p

Recently, the second question, that of degree distribution, has received the most attention because of interest in so-called \scale-free" networks (Barab¶asi, 2003). Some networks, particularly technological networks, appear to have power-law degree distributions (i.e

for some constant fi), and a number of mathematical and computational studies have found that this extremely skewed degree distribution may afiect the dynamics of processes happening on the network including the spread of diseases and the evolution of group behavior (Pastor-Satorras and Vespignani, 2001; Santos et al., 2006). However, the actual functional form of the degree distribution of the acquaintanceship network is not known, and that question has become so central to some researchers that Killworth et al. (2006) went so far as to declare that estimating the degree distribution is \one of the grails of social network theory."

While estimating the degree distribution is certainly important for understanding how networks afiect the dynamics of social processes, the ability to quickly estimate the personal network size of an individual is probably of greater long-term importance to social science. Currently, the dominant framework for empirical social science is the sample survey which has been astutely described by Barton (1968) as a \meatgrinder" that completely removes people from their social contexts. Having a survey instrument which allows for the collection of social content would allow researchers to address a range of questions. For example, to understand difierences in status attainment between siblings Conley (2004) wanted to know whether siblings who knew more people tended to be more successful. Because of di–culty in measuring personal network size, his analysis was ultimately inconclusive.

This paper develops a method to estimate both individual network size and degree distribution in a population using a battery of questions that can

be easily embedded into existing surveys. We begin with a review of previous attempts to measure personal network size, focusing on the scale-up method of Killworth et al. (1998b) which is promising, but known to sufier from three shortcomings: transmission errors, barrier efiects and recall error. In Section 3 we propose a latent non-random mixing model which resolves these problems. As a byproduct of the latent non-random mixing model we also obtain new information about the mixing patterns in the acquaintanceship network that we believe will be of substantive value to the social science community. We then flt the model to 1,370 survey responses from McCarty et al. (2001), a nationally representative telephone sample of Americans. In Section 5, we draw on insights developed during the statistical modeling to ofier practical guidelines for the design of future surveys. Most importantly we show that future researchers can achieve improved network size estimates without complex statistical computation if the names asked about are chosen properly. We conclude with a discussion of the limitations of this method, speciflcally how additional demographic information for flrst names (currently collected but not released by the Census Bureau) could improve network size estimates.

2 Previous research

The most straightforward method for estimating the personal network size of a respondent would be to simply ask them how many people they \know." Although we are not aware of any direct evidence that this procedure works poorly, we suspect it would not be very accurate because of the well-documented problems with self-reported social network data (Killworth and Bernard, 1976; Bernard et al., 1984; Brewer, 2000; Butts, 2003). A number of more clever attempts have been made to address these questions and we will review them
here. Because of space constraints we will not, however, review the larger literature on network data collection in general; interested readers should see Marsden (1990, 2005).

In the literature, we have identifled four main methods attempting to estimate individual personal network size|the reverse small-world method, the summation method, the diary method, and flnally the phonebook method/scaleup method|and these methods will now be described with strengths and weaknesses summarized in Table 1.

[2]

One of the earliest methods for estimating personal network size was the reverse small-world method (Killworth and Bernard, 1978; Killworth et al., 1984; Bernard et al., 1990) which, motivated by the small-world experiments of Milgram (1967), asked respondents to name someone they would use if they were required to pass a message to a given target. By asking respondents about a large number of such targets, it is possible that a respondent will enumerate a large proportion of his acquaintance network. Unfortunately, the required number of targets is quite large; most studies use 500 targets which at a rate 15 seconds per target would take more than 2 hours to complete. Also, this procedure of searching in one's social network for an appropriate contact is di–cult to model (Watts et al., 2002) and therefore is hard to embed within a statistical framework that would allow for formal inference and estimation of sampling uncertainty (i.e., standard errors).

Table 1: Strengths and weaknesses of methods for estimating person network size.

An additional procedure that cannot be modeled statistically, but which can be embedded in a survey is the summation method (McCarty et al., 2001). In this method, respondents are asked how many people they know in a list of speciflc relationship types, for example, immediate family, neighborhood, coworkers, etc., and these responses are then summed to yield an overall estimate. McCarty et al. (2001) propose 16 relation types which when added together should yield the total personal network size.

Unfortunately, since it is not possible to construct a list of mutually exclusive groups, this procedure will lead to double counting (e.g., someone who is a coworker can also be a neighbor) and respondents may not be able to answer these questions accurately.
In addition to the reverse small-world method and the summation method, there are two methods that were originally proposed by Pool and Kochen which have had substantial impact on later work. The diary method required subjects to keep a daily record of all known people encountered over the span of 100 days. This method, while yielding very rich and accurate data, requires too much cooperation and time to be employed in routine sample surveys.

Later efiorts have attempted to reduce the burden on respondents by using data on contacts that are recorded automatically; for example, Christmas card mailing lists (Hill and Dunbar, 2003), email logs (Kossinets and Watts, 2006), or cell-phone records (Onnela et al., 2007). Because these methods are not embeddable within the standard sampling survey framework, however, their general applicability in the context of this paper is limited.
The second method proposed by Pool and Kochen, however, has the potential to be employed in a survey framework and is amenable to statistical modeling. This method|the phone book method|has also received the most subsequent development. In its original form, a respondent was provided randomly selected pages from the phone book and based on the proportion of pages which contained the family name of someone known to respondent, it was possible to estimate the respondent's social network size. The estimation was improved greatly in later work by Freeman and Thompson (1989) and Killworth et al. (1990) which instead of providing respondents pages of phone books provided them with lists of last names. The general logic of this procedure was then developed further as the scale-up method (Killworth et al., 1998b).
We believe the scale-up method holds the greatest potential for getting accurate estimates quickly with reasonable estimates of uncertainty. The scaleup method, however, is known to sufier from three distinct problems: barrier efiects, transmission efiects, and recall error (Killworth et al., 2003, 2006). In Section 2.1 we will describe the scale-up method and these three issues in detail. Section 2.2 presents an earlier model by Zheng et al. (2006) that partially addresses some of these issues.

3.1 Latent non-random mixing model

We begin by considering the impact of barrier efiects, or non-random mixing, on degree estimation. Figure 4 gives a graphical representation of a hypothetical 30-year old male with the shaded oval representing the breadth of the individual's network. Following standard network terminology (Wasserman and Faust, 1994), we refer to the respondent as ego and the people to whom he can form ties as alters. In this case, the respondent's

alters are divided in 8 alter groups based on age and gender, though one could divide the
network based on additional characteristics as well. This example captures the well-documented tendency for people to form ties to alters that are similar (McPherson et al., 2001). In this case, 30 percent of ego's network is made up of individuals in the most similar alter category (males 21-40) while only 1 percent of his ties are to the more socially distant alter category of females 61 and older.
If we ignore non-random mixing and ask this respondent how many Michaels he knows, we will overestimate the size of his network using the scale-up method because Michael tends to be a more popular name among younger males (Figure 3). If we asked how many Roses he knows, in contrast, we would underestimate the size of his network since Rose is a name that is more common with older females. In both cases, the properties of the estimates are afiected by the demographic proflles of the names that are used in the estimate. The simple scale-up method, however, does not account for this problem.

Figure 4: Non-random mixing by age and gender in an example ego's network. In the latent non-random mixing model m(e; a) allows the propensity of ties to vary based on characteristics of both the alters and the egos. Here, by ego, we refer to a survey respondent and by alter, we refer to a member of subgroup a with whom the respondent could potentially form ties.

4 Results

To flt the model we used data from McCarty et al. (2001) which consisted of survey responses from 1,370 adults living in the United States who were contacted via random digit dialing.

We obtained approximate convergence
of our algorithm

(^ R< 1:1; see Gelman et al. (2003))

using three parallel chains with 2000 iterations per chain. We used the flrst half of each chain for burn-in and thin the chain every ten iterations. As we will demonstrate using a simulation study in Section 5.2 (see Figure 11) , the latent non-random mixing model estimates with more accuracy both the degree distribution and the individual degrees of the respondents, a major improvement over previous methods. Next we will present those estimates.

4.1 Personal network size estimates

We estimated a mean network size of 611 (median = 472) and the distribution of network sizes in presented in Figure 5. The solid line in Figure 5 is a log-normal distribution with parameters determined via maximum likelihood

Given the recent interest in power-laws and networks, we also explored the flt of the power-law distribution (dashed line) with parameters estimated via maximum likelihood (fi= 1:28) (Clauset et al., 2007).

The flt is clearly poor, a result consistent with previous work showing that another social network|the sexual contact network|is also poorly approximated by the power-law distribution (Hamilton et al., 2008). Together these results suggests that some of the interest around power-law degree distributions in social networks may be misplaced.
The estimated distribution is also presented separately for males and fe-males in Figure 6. Overall, we estimate that the degree distribution for males is similar to the distribution of females, though males have slightly larger networks on average. Amongst male respondents, we estimate a median degree of approximately 500 (mean 640) and we expect 90 percent of males to have degree between 172 and 1581. For females we estimate a median degree of 452 (mean 590) with 90 percent of females expected to have degrees between 157 and 1488.

Figure 5

5 Designing future surveys

In the previous sections we analyzed existing data in a way that resolves three known problems with estimating personal network size from \How many X's do you know?" data. In this section, we ofier survey design suggestions that allow researchers to capitalize on the simplicity of the scale-up estimates while enjoying the same bias-reduction as in the latent non-random mixing model. The flndings in this section, therefore, ofier an e–cient and easy-toapply degree estimation method that is accessible to a wide range of applied researchers who may not have the training or experience necessary to flt the latent non-random mixing model.

In Section 5.1, we derive the requirement for selecting flrst names for the scale-up method so that the estimator is equivalent to the degree estimator from fltting a latent non-random mixing model using MCMC computation. The intuition behind this result is that the names asked about should be chosen so that the combined set of people asked about is a \scaled-down" version of the overall population. For example, if 20% of the general population is females under 30 then 20% of the people with the names used must also be females under 30. Section 5.2 presents practical advice for choosing such a set of names and presents a simulation study of the performance of the suggested guidelines. Finally, Section 5.3 ofiers guidelines on the standard errors of the estimates.

5.3 Selecting the Number of Names

For researchers planning to use the scale-up method an important issue to consider in addition to which names to use is how many names to use. Obviously, asking about more names will produce a more precise estimate, but that precision comes at the cost of increasing the length of the survey. To help researchers understand the trade-ofi, we return to the approximate standard error under the binomial model presented in Section 2.1. Simulation results using 6, 12, and 18 names chosen using the guidelines suggested above agree well (details omitted) with the results from the binomial model in (5). This suggests that the simple standard error may be reasonable when the names are chosen appropriately.

To put the results of (5) into a more concrete context, a researcher who uses names whose overall popularity reaches 2 million would expect a standard error of around

for a estimated degree of 500 whereas with

6 million, she would expect a standard error of

for thesame respondent. Finally, for the good names presented in Table 2

4 million so a researcher could expect a standard error of 177 for a respondent

with degree 500.

6 Discussion and Conclusion

Using \How many X's do you know?" type data to produce estimates of individual degree and degree distribution holds great potential for applied researchers. These questions require limited time to answer, impose no more

demands on respondents than the average survey question, and can easily be integrated into currently existing surveys. The usefulness of this method has previously been limited, however, by three previously documented problems. In this paper we have proposed two additional tools for researchers. First, the latent non-random mixing model in Section 3 deals with the known problems when using \How many X's do you know?" data allowing for improved personal network size estimation. In Section 5, we show that if future researchers choose the names used in their survey wisely|that is, if the set of names satisfles the scaled-down condition|then they can get improved network size estimates without fltting the latent non-random mixing model. We also provided guidelines for selection such a set of names.

Though the methods presented here account for bias in individual degree estimation in ways that are not present in other methods, they are only as good as the available data on the demographics of flrst names. Using \How many X's do you know?" data to estimate person network size requires knowing the number of people in the population with the difierent flrst names. In many countries such information may not be available. Further, the scaled-down condition that we proposed can only control for non-random mixing across dimensions for which there are su–cient data. For example, even if the set of names used satisfles the scaled-down condition with respect to age and gender,

there still could be a bias in the individual estimates that is correlated with something that is not included in the model, such as race/ethnicity. We therefore believe that improved information about the demographics of difierent flrst names, information that is collected but not released by the U.S. Census Bureau, would be a great beneflt to social science, and as such we suggest that this information be released to the public.

A potential area for future methodological work involves improving the calibration curve used to adjust for recall bias. The curve is currently flt deterministically based on the twelve names in the McCarty et al. (2001) data and the independent observations of Killworth et al. (2003). In the future the curve could be dynamically flt for a given set of data as part of the modeling process. Another area for future methodological work is formalizing the procedure used to select names that satisfy the scaled-down condition. Our trial-and-error approached worked well here because there were only 8 alter categories, but if there were more, a more automated procedure would be preferable.

In addition to the general beneflt to social science from more accurate estimates of personal network size, we think that one of the most interesting and important potential applications of these improved network size estimates is for the study of \hidden" or \hard-to-reach" populations, such as injection drug users, men who have sex with men, and sex workers and their clients. In most countries these are the subpopulations at greatest risk for becoming infected with HIV, but, unfortunately, the sizes of these subpopulations are not known and this hinders efiorts to flght the spread of the disease (UNAIDS, 2003). As was shown by Killworth et al. (1998b) and Bernard et al. (1991), estimates of person network size along with \How many X's do you know?"

data can be used to estimate the size of hidden populations. For example, if you
know 300 people and 2 injection drug users, then we can estimate that there are about 2 million injection drug users in the United States (

= 2 million). Thus, the improved degree estimates described in this paper should lead to improved estimates of the sizes of hidden populations.

Ego's important discussants or significant people: an experiment in varying the wording of personalnetwork name generators

Abstract
There is considerable disagreement about the best personal network name generator to employ when only a single question is practical. One general approach is to ask the respondents _egos. to delineate the core members _alters. of their personal networks according to affective criteria _e.g., ''the most significant people in your life''.. Another approach provides more guidance to the egos by asking about alters with whom they have had specific interactions or social exchanges _e.g., ''discuss important matters''.. Finally, most name generators have been criticized for their preoccupation with positive ties to the exclusion of the difficult or negative relationships that may be an important part of ego's social world. An experiment _2=2 factorial design. was embedded within an interviewer-administered survey of 426 college students to explore the effects on reported network size and composition of _a. varying the delineation criteria _''significant people'' or the 1985 General Social Survey _GSS. ''important matters''. and _b. including or excluding a probe for negative interactions _''These may include people that sometimes make you angry or upset''.. The name-generator wording manipulations produced modest network compositional differences _ego–alter role relationships and discussion topics. that varied by the sex of both egos and their alters. Compared to the ''important matters'' criterion, the ''significant people'' generator elicited slightly more cross-sex relatives and fewer same-sex close friends and co-workers from female _but not male. respondents. The negative probe produced some statistically significant but substantively unimportant compositional differences. The results suggest that major differences in name-generator wording may in some situations have little or no effect on reported egocentric networks.

1. Introduction

Consider a personal _egocentric. network consisting of a focal individual _ego. and a set of significant others _alters. who know and interact with ego. Name-generator questions are used to elicit the important alters in ego's social world. In the 1985 General Social Survey _GSS., for example, respondents were asked a single question: From time to time, most people discuss important matters with other people. Looking back over the last 6 months — who are the people with whom you discussed matters important to you?

The criterion choice of ''discuss important matters'' is intended both to avoid undersampling certain relationships _e.g., asking instead about *close friends* undersamples kinship ties. and to elicit the core alters who influence the respondents' attitudes and behavior _Burt, 1984; Marsden, 1987..

The present study is limited to single-question name generators of core personal networks. Although asking a series of five or more name-generating questions provides better coverage of egos' core networks _Van der Poel, 1993b., practical considerations of cost, interviewing time, and respondent motivation often limit the instrument to a single question. Core personal networks have been variously defined as the small set of alters who are highly salient and important to ego _Hammer, 1983., ''to whom ego is directly connected by ties of varying intensity _e.g., frequency of interaction; emotional depth.'' _Knoke, 1990., and who have the most influence on ego's ''attitudes, behavior and well-being'' _McCallister and Fischer, 1978..

What delineation criteria should be used to operationally define core networks? The realist approach _Laumann et al., 1983. is simply to let ego define who is important in her or his life. Ego's perceived social world or psychological network _Milardo, 1992. may be elicited by affective criteria, such as asking about ''best friends,'' people ''they feel closest to,'' persons who ''mean a lot to them,'' and so forth. A drawback with the affective approach is the subjectivity of the criteria: ''close friends,'' ''feel closest to,'' and similar terms can mean different things to different people _Burt, 1990, pp. 413–415; Van der Poel, 1993a, pp. 51–52.. Defining a relative as a ''friend,'' for example, varies with people's social and cultural backgrounds. Research suggests that Americans of low socioeconomic standing _SES. reserve the label ''friend'' for frequent contacts compared to high-SES individuals who apply the label more ambiguously to a larger number of their alters _Burt, 1983..

The exchange approach elicits alters with whom ego has had, or might anticipate, rewarding social exchanges, such as receiving emotional support, instrumental assistance, or social companionship _McCallister and Fischer, 1978.. A series of questions are asked about very specific situations _e.g., ''who would care for their home if they went out of town,'' ''from whom would or could they borrow a large sum of money,'' ''with whom they engage in social activities like going to dinner or a movie''. that are less subject to varying interpretations than ''friends'' or other affective criteria. Usually, questions about previous social exchanges are limited to recent events _e.g., within the last 3, 6, or 12 months..

The 1985 GSS name generator _''people with whom you discussed matters important to you . . . over the last 6 months''. represents a single-question version of the exchange

approach. In contrast to the affective approach, the criterion of ''discuss important matters'' is more concrete and less ambiguous than intimacy or friendship criteria. Consequently, respondents presumably have less leeway in choosing alters compared to affective criteria as the delineation criterion directs them to focus on those with whom they discuss important matters. On the other hand, the 6-month time frame of the GSS name generator may exclude important core alters with whom ego has not had recent important discussions _Milardo, 1992..

Most name generators have been criticized for emphasizing rewarding interactions and exchanges to the neglect of stressful or negative relations that might be an important part of ego's social world _Wellman, 1981; Rook, 1984; Marsden, 1990b, pp. 442–443.. Presumably, egos will overlook or recall fewer alters with whom they have had negative or conflicting interactions compared to those providing positive and supportive experiences. Negative or aversive interactions may arise in ego's core network because ego is trapped and cannot avoid frequent contact with relatives, co-workers, and others _Wellman, 1988., or because highly valued alters provide negative as well as positive interactions.

The debate on egocentric network measurement is quite important since data quality appears to be highly dependent upon the name generator employed. The primary personal network information available for a representative sample of the American population, collected during the 1985 and 1987 GSSs, was based on the above-mentioned question concerning important discussants. A potential problem with this GSS name generator, which Straits _1996. encountered in studying gender differences in the inclusion of co-workers in personal networks, was the possibility that some respondents may have misconstrued discussions of important matters to include formal work activities. [1] Similarly, a replication of the American GSS name generator in a Chinese survey revealed differences between the two countries that may reflect differing core networks *or* differing definitions of what matters are important _Ruan, 1998..

The usual research design for studying name generators involves presenting the same subjects with a series of name-generator questions or instruments, and comparing the alters elicited by the different instruments _e.g., Van Sonderen et al., 1990; Van der Poel, 1993b; Burt, 1997; Ruan, 1998.. A major drawback to sequential _within-subject. administration of different generators is the possibility of unwanted cognitive, motivational, and conversational question-order effects _Tourangeau and Rasinski, 1988.. A generator appearing early in the sequence, for example, may start the respondent thinking in a way that will affect later responses by activating or changing the information readily accessible in memory. That is, an alter may come to mind in response to a later generator because of the content of an earlier question. Also, the effort of answering earlier questions may undermine respondents' motivation to the extent that they expend little or minimum effort to respond to the later questions. Finally, respondents will sometimes interpret additional questions as a request for new

[1] Although Burt _1984, pp. 317–320, 331. originally proposed the criterion choice of *important personal matters* to elicit intimate ties, the GSS name generator employed the more ambiguous wording of *important matters*.

information _Grice's nonredundancy principle of conversation. and consequently do not reiterate alters elicited by earlier name generators _Sudman et al., 1996, pp. 247–248.. Another evaluation design involves comparing the size and composition of personal networks elicited by different name generators used in separate studies. Campbell and Lee _1991., for example, compared Wellman's East York survey, Fischer's Northern California Communities Study, the 1985 GSS, and Campbell and Lee's Nashville, Tennessee neighborhoods survey. A major difficulty with this approach is that study differences in reported personal networks may be shaped by between-study variability in target populations, sampling, field administration, survey instrumentation, and other confounding factors, as well as by name-generator wording.

The present research overcomes some of the drawbacks of these other approaches by employing an experimental design _2=2 factorial. to investigate the effects of namegenerator wording changes in an interviewer-administered survey of 426 college students. The first experimental factor manipulates the delineation criteria _''significant people'' or the 1985 GSS ''important matters''., while the second manipulation includes or excludes a probe for negative interactions _''These may include people that sometimes make you angry or upset''..

2. Data, measures, and methods

2.1. The surÍeys

As part of a training exercise, 71 students enrolled in three advanced research method classes interviewed 426 UCSB undergraduates.[2] The face-to-face interview schedule _see Appendix A. included a name-generator question _the experimental manipulation. followed by name interpreter questions about ego–alter role relationships, frequency of contact, and discussion topics. The personal network questions, including interviewer instructions, were closely modeled after the 1985 GSS and Burt's _1984. original GSS proposal. Following in-class interviewer training and role-playing practice, the students were instructed to interview a simple quota sample _three males and three females. of undergraduates who were not their friends. Prospective respondents first were given a cover letter on departmental letterhead that stressed the importance of the study and assured anonymity.

2.2. Factorial design

Four versions of the name generator _Question 4. were randomly assigned to the interview schedules _and consequently to the respondents..[3] In the resultant 2=2

[3] First the interview schedules were grouped in batches of four comprising one version of each experimental condition. Random numbers were then used to rearrange the four schedule versions in random order within each batch. Finally, each interviewer was given six serially numbered schedules _1.5 adjacent batches., and was told to use them in order _1st schedule for 1st respondent, etc...

factorial design, the first factor manipulates the criterion _*important discussants, significant people*. and the second factor probes for negative interactions _excluded, included.. In the following descriptions, the conditions are: _A. *important discussants* and no negative probe _exact wording used in the 1985 GSS.; _B. *important discussants* and negative probe; _C. *significant people* and no negative probe; and _D. *significant people* and negative probe

A. **From time to time, most people discuss important matters with other people. Looking back over the last 6 months — who are the people with whom you discussed matters important to you? Just tell me their first names or initials.** IF LESS THAN FIVE NAMES MENTIONED, PROBE, **Anyone else?** ONLY RECORD FIRST FIVE NAMES.

B. **From time to time, most people discuss important matters with other people. Looking back over the last 6 months — who are the people with whom you discussed matters important to you? These may include people that sometimes make you angry or upset. Just tell me their first names or initials.** IF LESS THAN FIVE NAMES MENTIONED, PROBE, **Anyone else?** ONLY RECORD FIRST FIVE NAMES.

C. **Looking back over the last 6 months, who are the people especially significant in your life? By significant, I mean those who are most important. Just tell me their first names or initials.** IF LESS THAN FIVE NAMES MENTIONED, PROBE, **Anyone else?** ONLY RECORD FIRST FIVE NAMES.

D. **Looking back over the last 6 months, who are the people especially significant in your life? By significant, I mean those who are most important. These may include people that sometimes make you angry or upset. Just tell me their first names or initials.** IF LESS THAN FIVE NAMES MENTIONED, PROBE, **Anyone else?** ONLY RECORD FIRST FIVE NAMES.

3. Theoretical expectations

The four experimental conditions _name generators. are likely to produce differences in reported network size and composition. Some conjectural outcomes, based mainly on common sense and very limited previous research, are described below using the 1985 GSS as a comparison benchmark.[4]

A. Compared to *important discussants*, the *significant people* criterion will generate:

1. smaller core networks _People do discuss matters they consider important with some alters who are not necessarily important or significant in their lives. Thus, s *ignificant people* should be a slightly smaller subset of ego's *important discussants*..

[4] These predictions were formulated by the author and his undergraduate research methods students.

2. less contact frequency _ *Important discussants* generally are seen frequently, but *significant people* may be far away and seen less often. Once established, frequent contact is not necessary to maintain ties to significant alters _Milardo, 1992...
3. more significant others, close friends, parents, and siblings _The *significant people* wording will elicit stronger, intimate ties..
4. fewer roommates, neighbors, co-workers, group members, and other friends _As part of ego's day-to-day social interaction, these alters have more opportunity to discuss important matters with ego than do some *significant people* who are seen less frequently..
5. more cross-sex choices _This depends upon the elicited ego–alter role relationships. In the 1985 GSS ego–alter gender diversity was highest among kin, somewhat less for group members, and lowest for co-workers, neighbors, and other non-kin relations _Marsden, 1990a.. If the *significant people* criterion elicits fewer roommates, neighbors, co-workers, and other friends, there should be greater gender diversity compared to the *important discussants* generator..
6. more intimate and personal discussion topics _Strong ties are less likely to be undermined than more casual relationships by disclosure of sensitive or embarrassing information _Hays, 1989.. Consequently, if the *significant people* criterion elicits stronger ties, there should be more intimate and personal discussion topics compared to the *important discussants* criterion..

B. The inclusion of the negative probe will generate:
1. larger core networks _The negative probe condition will generate more names because otherwise egos will tend to overlook alters with whom they have negative or conflicting interactions. The probe also provides another way for ego to associate and recall names _Brewer and Webster, 1998...
2. greater contact frequency _Alters with whom ego has frequent contact are more likely to be a source of negative interactions than those seen less often. ''Overt interpersonal conflict depends on opportunities for social contacts'' _Blau, 1977...
3. more close friends _Strong ties are less vulnerable to erosion from negative interactions than weaker ties _Hays, 1989..
4. more significant others, parents, siblings, roommates, neighbors, and co-workers _Ego is trapped in a ''constraining foci'' _Feld, 1981. and cannot avoid frequent contact with these alters with whom they may have negative or conflicting interactions..
5. more cross-sex choices _Men and women differ in their attitudes, ideals, and goals, which sometimes leads to conflict.
6. Less intimate and personal discussion topics _People spend less time sharing intimate and personal topics with people who sometimes make them upset or angry..

4. Results

Before presenting the final results, it is useful to describe the earlier steps in the analysis. As the initial examination of the surveys conducted by my 1993 research methods class revealed surprisingly few egonet _personal network. differences across the experimental conditions, the experiment was replicated twice _1994 and 1995 classes. to ascertain if similar results would ensue with different student interviewers, an increased sample size, and more emphasis placed on certain facets of interviewer training. The results reported below are based on pooling the data from the three classes. Multivariate analyses _OLS, logit, and event count. were employed to test for main and interaction effects of the experimental conditions on network size and composition, as well as to model interviewer effects using respondent and interviewer characteristics.[5] As the latter revealed substantial differences between male and female respondents, the decision was made to perform separate analyses by the sex of both respondents and their alters.

4.1. Delineation criteria

The *important discussants* and *significant people* name generators elicited virtually identical personal network sizes _pooled means5.4 alters, standard deviations2.6.. As egonet size information _see ''Interviewer Check'' following Question 4. requires highly skilled interviewing _including probing if ego mentions fewer than five alters and tallying alters beyond the first five used for the subsequent name interpreter questions., it is subject to serious interviewer effects _Van Tilburg, 1998..[6] Indeed, improved interviewer training given to my 1994 and 1995 students increased average reported network size from that obtained by the 1993 class, but did not alter the nonsignificant relationship between size and the delineation criteria.[7]

Compositional information _the name interpreter questions. was collected for the first five alters _or fewer if less were named..[8] Reported frequency of ego–alter contact _Question 5. was unrelated to the delineation criteria. Table 1, which identifies ego–alter role relationships by sex, reveals that the *significant people* criterion elicited slightly more cross-sex choices among *female* respondents than did the *important discussants* generator. Compared to *important discussants,* the *significant people* criterion produced an average of 0.27 fewer female alters and 0.31 more male alters _see boldface totals.. These delineation effects are hidden _cancel out. when female respondents' male and female alters are combined. For the *male* respondents, on the other hand, alter gender diversity _boldface totals. did not significantly vary by the delineation criteria.

The relationships between egos and their alters _Question 7. summarized in Table 1 shed light upon the modest cross-sex delineation effects for the female respondents.

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[5] The interaction term was dropped later due to the absence of both main effects in models of network size and composition.

[6] The intraclass correlation coefficient _based on one-way ANOVA. revealed that about 17% of the variance in network size was between interviewers. Van Tilburg _1998. reports a corresponding figure of 20% for a more complex network generator involving professional interviewers.

[7] Mean egonet size increased from 4.9 _1993. to 5.7 _1994–1995..

[8] In the pooled sample of respondents, 3% cited two alters, 8% cited three, 16% cited four, and 73% cited five or more alters.

Table 1
Mean number of cited alter roles by delineation criteria and sex of respondents and alters

Compared to *important discussants*, the *significant people* criterion elicited from female respondents slightly fewer female close friends and female co-workers, and slightly more fathers and certain other males _friends and kin..[9] Please note that these relations frequently overlap _multiplexity. as an alter may be connected to ego in two or more different roles _e.g., as a co-worker, a neighbor, and a close friend.. These slight relation differences for female respondents are consistent with the expectation that *important*

[9] For example, the *important discussants* generator elicited a mean of 2.61 female close friends compared to 2.22 for the *significant people* criterion

discussant and *significant people* criteria respectively would evoke day-to-day interactions and psychological networks.

In contrast to the female respondents, the relation differences for male respondents are not easily interpreted. Compared to *important discussants*, the *significant people* criterion elicited from male respondents slightly fewer female neighbors and male other relatives, and slightly more male professional advisors. Although the three relations _female neighbors, male other relatives, male advisors. have statistically significant *t*-tests _*P*-0.05., they were found after examining 24 _12 female roles and 12 male roles. significance tests that are not independent _multiplex roles.. Consequently, these ''significant'' results for male respondents seem substantially unimportant because the differences _mean alters. are small, not easily interpreted, and emerged from a ''shotgun'' search of 24 sex-role comparisons.

Table 2
Mean number of discussion topics by delineation criteria and sex of respondents and alters

Table 2 summarizes the discussion topics _Question 8. that the respondents reported coming up frequently in conversations with their named alters. For example, female respondents responding to the *important discussants* name generator discussed ''personal problems'' on the average with 3.01 female alters and 1.13 male alters. Compared to *important discussants*, the *significant people* criterion elicited from female respondents slightly fewer female alter conversations about personal problems and sexual relationships, and slightly more male alter conversations about personal finances, work, family and relatives, and ''small talk.'' Alter discussion topics reported by the male respondents did not vary significantly across the delineation criteria.[10]

In summary, the delineation criteria manipulation produced very modest egonet differences for the female respondents. The *important discussant* condition, apparently reflecting day-to-day interaction opportunities, evoked slightly more female alters who tended to be close friends, co-workers, and confidants for discussions of personal problems and sexual relationships. In contrast, the *significant people* condition, apparently tapping into female egos' perceived social world or psychological network, elicited slightly more male alters who tended to be kin _especially fathers., friends, and discussants of personal finances, work, family matters, and ''small talk.'' These differences, however, are very small. A close inspection of role relationships and discussion topics in Tables 1 and 2 indicates that network composition for both male and female respondents is very similar under both delineation criteria conditions.

4.2. Negatiĺe probe

Although inclusion of the negative probe _''These may include people that sometimes make you angry or upset''. increased reported network size as hypothesized, the effect was small and not significant. The negative probe and no probe conditions respectively elicited alter means of 5.9 and 5.4 for female respondents, and 5.3 and 4.9 for male respondents.[11] Let us now consider if the negative probe affected egonet composition.[12] Both reported frequency of ego–alter contact _Question 5. and alter gender diversity _boldface totals in Table 3. were unrelated to the negative probe manipulation. A search of the 48 sex-role *t*-test comparisons for female and male respondents _Table 3. disclosed few cross-sex differences. The inclusion of the negative probe elicited slightly more male co-workers, male other family members, and male close friends from female respondents and slightly fewer female friends from male respondents. Although these differences are slight and may have happened by chance, they are suggestive of negative or adverse interactions arising from being trapped in constraining foci _female ego's male co-workers and male other family members. or in relations that provide positive as well as negative experiences _male close friends.. Additional evidence of the ineffective-

[10] Like the female respondents, reported discussions of sexual relationships and personal problems with female alters by male respondents was slightly higher in the *important discussants* than in the *significant people* generator.

[11] Two-sample *t*-values with unequal variances for these comparisons were 1.01 _ *p*s0.32. and 1.58 _ *p*s0.12. for female and male respondents, respectively.

[12] Since the name interpreter questions were limited to the first five alters _as in the GSS., no information is available on negative probe effects for the sixth or later cited alters.

Table 3
Mean number of cited alter roles by negative probe and sex of respondents and alters

ness of the negative probe manipulation may be found in Table 4, which shows that the probe did not produce any significant differences in the elicited male and female alters' discussion topics as reported by the male and female respondents.[13]
In summary, including a negative probe did not appreciably affect reported egonet size and composition. These results suggest that it is unnecessary to reword core network name generators to encourage ego to report stressful or negative relations. An

[13] Although individual role or discussion topic comparisons are not significant, Tables 3 and 4 suggest that the negative probe shifted male ego choices slightly toward male alters and away from female alters.

Table 4
Mean number of discussion topics by negative probe and sex of respondents and alters

alternative interpretation is that the negative probe manipulation was ineffective, perhaps because respondents may have tuned out the short probe. There is some evidence, however, that the probe did influence some responses. In a separate analysis of alter citation order, male alters with whom male respondents reported discussing work, family matters, sports, or television were cited significantly earlier under the negative probe compared to the no probe condition.[14] Thus, there is evidence that the probe produced recency effects for it prompted male respondents to name earlier male alters with whom

[14] A summary index was constructed by assigning a value of 5 if topic i was discussed with the 1st named alter, 4 if the 2nd named alter, . . . 1 if the 5th named alter, and 0 if no one. Among male respondents, the negative probe was significantly related to the summary index for male alter conversations about television _*t*s3.38., family and relatives

presumably they have conflicting relationships over certain discussion topics. It should be noted that the negative probe affected citation order, not the eventual inclusion of particular alters.

4.3. Validity checks: interÍiewer effects

Because major differences in name-generator wording had little or no effect on reported egocentric networks, it may be that the experimental manipulations were ineffective due to poor or sloppy interviewing. To explore this potential problem, each interviewer's batch of completed interview schedules was coded for obvious or suspicious departures from the interviewing instructions. Four performance warning flags _binary variables. were coded: failure to follow gender quota sampling _four out of 71 interviewers were flagged., failure to complete Question 4 interviewer check _36 schedules were flagged., if all six of the interviewer's respondents named exactly five alters _nine interviewers., and lack of multiplexity in any of the Question 7 ego–alter role relationships _17 schedules.. In addition, the interviewers' sex and final course grade were recorded. Inclusion of these variables _interviewer sex, final grade, and warning flags. in a multivariate model of reported network size did not change the results of the name-generator manipulations. Two other checks, dropping all schedules with one or more warning flags _22.3% of the schedules. or dropping the ones completed by interviewers earning less than a ''C'' course grade _9.9% of the schedules., again did not bring out effects for the name-generator wording manipulations.

5. DiscussioFPEn

Very often slight wording changes in survey questions will produce substantial differences in response patterns, especially when the wording alterations provide cues to the respondents as to either question meaning or appropriate answers. This did not happen here as the respondents reported quite similar egocentric networks in responding to the four different name generators. Apparently, the respondents noticed and processed the name-generator alterations as the wording manipulations produced some small effects. However, the respondents seemed to understand the purpose of the name-generator question even when it was formulated in quite different ways. Thus it may not be necessary, for example, to probe for conflicting relationships as the results suggest that egos do not perceive these alters as being excluded when asked about their core networks.

Since an affective _ *significant people*. criterion is generally viewed as more subjective and ambiguous than the GSS _*important discussants*. criterion, it is remarkable that the two approaches yielded similar results. Let us consider some alternative interpretations of these findings associated with the interviewers and with the respondents. First, the possibility that the effects of the delineation criteria were obliterated by sloppy or poor interviewing was previously discussed and dismissed for lack of supporting evidence. Two replications of the experiment, as well as controlling for certain interviewer characteristics _sex, course grade, and interview performance measures., did not alter the delineation results.

Second, another interpretation centers on the limited generalizability possible from a rather homogeneous sample of undergraduates. Perhaps the delineation manipulation would have stronger effects with a more heterogeneous sample or a cross-section of ''real people'' instead of students. However, as most UCSB students have experienced, a substantial environmental shift from their high school and parental residence to their current campus and community residence, their current day-to-day interactions and relations should be markedly different from the earlier significant people in their life. Consequently, these residentially mobile students should be ideal for testing the two delineation criteria.

Third, an obvious and simple interpretation is that the two tested delineation criteria elicit the same alters. That is, *significant people* are the same people with whom egos discuss important matters _*important discussants*.. Since serious questions have been raised about the subjectively, ambiguity, and scope of both the affective approach and the GSS name generator, establishing their practical equivalence would lessen these methodological concerns and facilitate integration of substantive studies using the two general approaches.

Fourth, *significant people* and *important discussants* may involve similar information retrieval processes _schema.. For example, in response to the *significant people* name generator, people evoke various schemas to recall these alters. For the GSS name-generator question, on the other hand, people may use similar schemas to retrieve the significant people in their life rather than trying the more difficult task of recalling past discussions of important matters and who was involved. Of course, there may be some gender differences in these cognitive information processes.

Finally, the results underscore the importance of considering the sex of both egos and their alters in personal network studies. Too often gender considerations stop at the ego level _e.g., Moore, 1990; Van der Poel, 1993a, pp. 68–69. and ignore important ego–alter differences _Straits, 1996.. The delineation criteria differences in the present study were hidden until alters' as well as egos' sex was taken into account.

Appendix A. Survey Instrument

1.CODE RESPONDENT'S SEX:

2. **What is your major?** IF UNDECLARED, ASK: **What do you think you'll end up majoring in?**

3. **What is your year in college?**

4. **From time to time, most people discuss important matters with other people. Looking back over the last six months — who are the people with whom you discussed matters important to you? Just tell me their first names or initials.** IF LESS THAN 5 NAMES MENTIONED, PROBE, **Anyone else?** ONLY RECORD FIRST 5 NAMES.

LIST ALL NAMES BELOW IN ORDER GIVEN:

INTERVIEWER CHECK: HOW MANY NAMES WERE MENTIONED?___

We'd like to find out a little about each of these people

5. **[FIRST NAME] is (malerfemale)?** _INSERT YOUR BEST GUESS BASED ON ALTER NAME. WAIT FOR CONFIRMATION OR CORRECTION FROM RESPONDENT. REPEAT FOR EACH NAME.

6. **Thinking about how often you usually talk to [NAME], on the average do you talk to (himrher) almost every day, at least once a week, at least once a month, or less than once a month?** ASK FOR EACH NAME

7. **Here is a list** _HAND CARD A. **of some of the ways in which people are connected to each other. Some people can be connected to you in more than one way. For example, a man could be your brother and he could belong to your church and be your lawyer. When I read you a name, please tell me all the ways that person is connected to you.** REPEAT FOR EACH NAME: **How is [NAME]**

connected with you? _INITIAL PROBE: **What other ways?**–SUBSEQUENT PROBES AS NEEDED: **Any other ways?**.

SpouserSignificant
Roommate
Parent
Sibling
Other Family
Co-worker
Group Member
Neighbor
Close Friend
Friend
Advisor
Other
_SPECIFY. _____ _____ _____ _____ _____
No answer
Not applicable

This card lists some topics that people talk about _HAND CARD B.. W**hat topics on the list frequently came up in conversations with [FIRST NAME]?** CIRCLE CITED CODES. REPEAT FOR EACH NAME: **What about [NAME]? What topics frequently come up in your conversations?**

Academic Matters

Personal Finances

Work
Sexual Relationships
Family and Relatives
Small Talk
Sports
Art, Music, Lit.
Personal Problems
Television
Religion
Politics
No answer
Not applicable

Thank you very much for your cooperation

A.1. Card A

Spouse or significant other	Your wife or husband, fiance´ or fiance´e, or person you are living with as if married
Roommate	A current or former roommate
Parent	Your father or mother _including step-parents.
Sibling	Your brother or sister _including half-and step-siblings.
Other family	For example, your son or daughter, grandparents, cousins, aunts, uncles, nephews, nieces, in-laws
Co-worker	someone you work with or usually meet while working
Member of group to which you belong	For example, someone who belongs to the same campus organization, off-campus club, church, fraternity or sorority
Neighbor	Someone outside your own apartment or house who lives close to you in your neighborhood
Close friend	Someone you could turn to if you needed advice or help with personal problems
Friend such	Someone with whom you get together for social activities, as meals, sports, parties, movies, or just to talk
Professional advisor or consultant	A trained expert you turned to for advice; for example, a lawyer or clergyman.
Other	

A.2. Card B

Academic matters
Academic matters
Personal finances
Work _current or previous jobs.
Sexual relationships
Family and relatives
Small talk _light conversation about people and events.
Sports
Art, music, and literature

Personal problems
Television
Religion
Politics

Simplifying the Personal Network Name Generator Alternatives to Traditional Multiple and Single Name Generators

For researchers interested in the study of personal networks, measures of network composition are often obtained through the use of name generators and name interpreters.
However, the cost of administering a survey with multiple name generators, in terms of
time and respondent motivation, is often prohibitive. Researchers seeking to minimize respondent burden routinely turn to time saving measures, such as the use of a single name
generator (i.e. the "important matters" generator used in the General Social Survey (GSS)).
We argue that the limitations of this approach are often understated. In the study of social
support, multiple name generators are required to ensure that researchers sample from the
full definition of support. Putting aside issues of construct validity, we compared measures
of network composition and structure obtained from stand alone generators to measures
obtained from a six-item multiple name generator. We found that although some single
generators provided passable estimates for some measures, all single generators failed to
provide reliable estimates across a broad spectrum of network measures, including key variables such as size and density. In an attempt to improve the reliability of network measures, beyond what could be obtained through single generator alternatives, and while
still reducing respondent burden, we evaluated two alternative methods; 1) the MMG, the
two most robust name generators from our first analysis and a full set of name interpreters,
and 2) the MGRI, a series of multiple name generators with name interpreters administered

to a random subset of alters. In comparison to single name generators, both the MMG and
the MGRI provided measures that were more strongly correlated with the full name generator model. In addition, the MGRI maintained the validity of the full generator approach, provided a perfect measure of network size.

Personal Networks

A personal network is a social network from the standpoint of the ego; a view of the network as perceived by the individual at its center (Wellman 1999: 19). When defined broadly, a personal network encompasses all ties to alters with whom an ego has had some social contact over the course of his lifespan. Conceptually, this includes strong ties as well as the weak social ties discussed by Granovetter (1973). When defined more narrowly, a personal network can refer to a smaller subset of ties: those who are in frequent contact, the most active social ties, those who are socially "close," those with whom an ego exchanges social support, or those who fill a specific role (e.g. friend, neighbor, colleague).

There are a number of ways to determine the composition of a personal network. V,A Methods vary by research question; from those that attempt to capture a large, broad sample of both weak and strong ties, to those that capture a smaller and narrower subset of ties. Killworth, Johnson, Bernard, Shelley and McCarty (1990) have estimated that the average person in the United States has 1700 ±

400 personal network members. Few, if any methods actually attempt to collect network measures on each alter in such a global network. The reverse small world (RSW) method enumerates the largest and broadest sample of alters, generating a list of 250-300 active network members (Killworth and Bernard 1978; Killworth, Bernard and McCarty 1984). However, in practice it is exceptionally burdensome and time consuming to administer the RSW, even if only basic measures of network composition and limited structural data are collected (Bernard, Shelley and Killworth 1997). For most research it is impractical to enumerate a sample of network members as large as can be obtained with the RSW. However, there are other methods of sampling from personal networks, such as the first-name cueing method (McCarty et. al. 1997; Brewer 1997) which has been used in an attempt draw small representative samples of alters from personal networks. Limited measures of network composition can also be obtained using methods like the position

(Lin and Dumin 1986) and resource generators (Snijders 1999). However, the position and resource generators focus on individual social capital and produce measures limited to network diversity and range. Position and resource generators do not enumerate individual alters nor can they generate more elaborate network measures (Lin, Fu, and Hsung 2001; Erickson 2001; Van der Gaag and Snijders 2005). Beyond attempts to measure the global size of a personal network, attempts at representatively sampling from the global network, and measures of network composition that are focused on very specific measures (such as access to resources), there are a broad range of researchers whose interests in personal networks focus on a subset of the personal network: such as ties to people with specific roles (Campbell and Lee 1991; Hampton and Wellman 2003), daily contacts or frequent interactions (Fu 2005), or ties that are socially close or provide various forms of social support (Wellman and Wortley 1990). It is these researchers, who focus on what are generally non-representative subsets of the personal network, who tend to employ name generators.

Name Generators

The study of personal networks can be divided into four approaches: the *role-relation approach*, *the interaction approach*, the *affective approach*, and *the exchange approach* (Milardo 1988; van der Poel 1993). The role-relational approach is primarily concerned with the influence or role of ties in a specific social domain, such as with neighbors, friends, or kin. The interaction approach aims to identify those ties with whom an actor is in contact over a specified period of time. The affective approach deals with the affective value of a tie, such as those whose opinions are "especially significant" or those to whom an ego feels "close" (Wellman 1979). The exchange approach focuses on the exchange of supportive content between ego and alters (McAllister and Fischer 1978). All four approaches deal with subsets of the full personal network and are theoretically valid and appropriate for different research questions. Although it is common for name generators to be used within all four approaches, name generators are often misused. The adoption of any research method

should be guided by the desire to minimize concerns regarding reliability and validity. Name generators on a whole are often less reliable measures of network phenomenon than available alternatives. When name generators are appropriate, individual generators also vary in the reliability of the measures they produce, and the validity of the constructs they report to measure.

Name generators such as, "With whom have you interacted over the last week, month, or year?" (Milardo 1988: 29) are used in the study of "daily interactions" or routine interaction networks. Yet, in most circumstances the interaction approach is perhaps least suited for the adoption of name generators. There are questions about both the validity and reliability of what the interaction approach measures. In particular, there is little correlation between routine contacts and those ties that people tend to evaluate as most important (Marsden and Campbell 1984), and there are questions about the stability of network measures within the interaction approach. Test-retests of the same participants from even one day to the next can produce significant variation in the alters with whom an ego interacts (of course, this may be a good thing if day-to-day or setting-to-setting variation is the focus of the research). In absence of the information generated by time diaries (Michelson and Tepperman 2003), it is unclear how setting, daily tasks, and daily stresses influence daily contacts. In addition, numerous studies question the validity of interaction data when respondents report on contact over an extended period of time or over a "typical day" (Bernard, Killworth, Kronenfeld, and Sailer 1984; Ver Ploeg, Altonji, Bradburn, DaVanzo, Nordhaus, and Samaniego 2000). With the possible exception of personal network studies of interactions within bounded groups or organizations, researchers with a clear interest in "daily contacts" and routine interactions may be better served by passing over name generators for diaries, or other procedures where respondents report on interactions shortly after they occur (Ver Ploeg et al 2000).

Name generators within the role-relation approach are particularly susceptible to problems of

reliability. Some of the most common relational categories included within role-relation name generators are interpreted differently across populations. In particular, Burt (1983) demonstrated that the construct of "friends" is interpreted differently across socioeconomic groups. A similar problem is encountered with name generators used within the affective approach. Generators that elicit alters by focusing on the subjective value of a tie, such as those who are "especially significant" or "close," risk problems with interpretation across populations. Still, this limitation aside, the concept of "closeness," as ambiguous as it may be, best represents the construct of "strong ties," and in turn the affective approach does have particular value for those interested in studying strong tie networks (Marsden and Campbell 1984; van Sonderen et. al. 1990). Despite the advantage of a recognizable theoretical framework, and because of problems with representative reliability, name generators under both the role-relation and affective approach are rarely ideal.

Unlike the interaction, role-relation, and affective approaches, the criteria for defining a subset of network ties in the exchange approach does not rely on time frames or ambiguous terms like "friend" or "especially close." The exchange approach argues that those people who provide regular supportive interactions are an important subset of a personal network (McCallister and Fischer 1978). By focusing on the exchange of support, the standards for inclusion and exclusion of ties are more clearly defined (Milardo 1988: 27). For example, generators such as, "who do you rely on for help with everyday tasks?" or "from whom could you borrow a large sum of money?" deal with supportive exchanges that have specific criteria. These generators have strong face validity and are less likely to be interpreted differentially across respondents (but see Bailey and Marsden 1999, Bearman and Parigi 2004). By focusing on instances of supportive exchange, this approach also has the advantage of a clearly defined universe of social ties from which to sample. However, even within the exchange approach, decisions about specific wording and the choice of how many generator to include in a survey shape the validity and reliability of the name generator approach.

Methods

Data

Network data for this paper was collected as part of the E-neighbors project, an investigation into how information and communication technologies are integrated into the social networks of middleclass residents in four Boston area neighborhoods. Two sites, each consisting of just over 200 homes, were located in the Boston suburb of Lexington. Located less than two miles apart, both neighborhoods consisted of low-density, single-family, detached homes. The third site, a 23 story, 174-unit apartment building, was the product of 1960s urban renewal and is located on the site of Boston's former West End (Gans 1962). The fourth site, located in the suburb of Quincy, is a 101-unit, medium-density, gated, multifamily condominium development.

In the spring of 2002 all households in the four field sites were hand delivered an information package. Each package contained a letter from the principal investigator, a university coffee mug, and a stamped return postcard. On the back of the return postcard residents were asked to print the name of each member of their household who was interested in receiving a survey (18 years of age or older). A total of 487 surveys were mailed to eligible participants, each survey included a stamped return envelope and a $20 gift certificate for a local grocery chain. After two reminder letters, 69% of those who received surveys returned a completed questionnaire. The precise size of the population of eligible participants remains unknown[2]. However, based on U.S. Census tract data on dwelling counts and the noninstitutionalized population over the age of 18, and a modest vacancy rate in each neighborhood, we estimate that 27% of eligible participants returned a completed survey[3]. This calculation likely underestimates the actual response rate as it does not take into account variation in the population distribution within census tracts (which encompass, but do not align with the boundaries of our neighborhoods) and over estimates our success in identifying and contacting all

eligible participants. There are unusual challenges inherent in trying to recruit participation from residents of a small geographic area and the successful involvement of over one quarter of the eligible population seems like at least a modest success. The randomness of the sample is unknown, however, we assume that considerable homogeneity exists within neighborhoods and this in turn reduces concerns about the representativenss of the sample. However, this data is used here in an attempt to draw conclusions about how the same sample would be presented using different survey methodologies, we do not draw conclusions about the represenativeness of the sample in terms of the neighborhoods they are drawn from or the population at large."

The project survey contained questions on time-use, the use of media and technology, organizational and political involvement, and personal and neighborhood networks. The personal network section included a series of six name generators, corresponding interpreters, and an adjacency matrix. Mail surveys were used over personal interviews as a means to contain survey costs. In addition, while the literature on survey administration tends to favor in-person and telephone interviews over mail surveys, there is evidence to suggest that name generators are susceptible to interviewer effects (Marsden 2003); mail surveys may be a preferred method of administering name generators.[4] Given the complexity of multiple name generators, there was the possibility that instrument error would replace interviewer error in self-administered surveys.

However, U.S. Census data indicated that all four field sites were contained within areas of above average educational attainment (a majority with at least a college degree), this suggested that the extra complexity of the survey instrument would not be as significant a problem as it might have been if administered to another population. Pretests with a population of similar educational attainment revealed no evidence that the complexity of the self-administered survey introduced errors.

The six name generators used in this survey were based on wording developed by van der Poel (1993), the GSS (Burt 1984), the East York Studies (Wellman 1979; Wellman and Wortley 1990),

and the Northern California Communities Study (Fischer 1982). The generators were amended to
reduce length, ease understanding, and eliminate the use of time-frames:[5]
1. From time to time, most people discuss important matters with other people. Who are the people

2. Who from outside your home has recently helped you with tasks around the home, such as
painting, moving furniture, cooking, cleaning or major or minor repairs?
3. Suppose you need to borrow some small thing like a tool or a cup of sugar, from who outside
your household would you ask to borrow it?
4. If you need to borrow a large sum of money, say $1000, whom would you ask for help?
5. Who are the people you really enjoy socializing with?
6. Please list anyone who is especially close to you who you have not listed in one of the previous
questions.
Five of the six name generators used in the survey were exchange-based (McCallister and Fischer
1978), and were selected to represent a broad, multidimensional view of social support that included
emotional support, companionship, and instrumental aid in the form of support with large services,
small services, and financial aid (Veiel 1985; Cohen and Wills 1985; Fischer 1982; Wellman and
Wortley's 1990).
A name generator usually associated with the affective approach, but used here as part of the
exchange-approach, was used as a final name eliciting question. An affective generator was included
for two reasons. Firstly, it was assumed that "strong ties" are encapsulated within support networks
and that these ties play an important role; they provide people with the most social support of all
kinds (Wellman and Wortley's 1990). Eliciting "anyone else" with whom respondents were
"especially close" was a catch-all to enumerate additional strong ties that were not provided in
response to the first five questions. Ordering the affective generator as the final name electing
question was done to take advantage of the context effect of the exchange-based generators and
reduce the problem of respondents interpreting closeness differently (Bailey and Marsden 1999,
Bearmand and Parigi 2004). Secondly, the "anyone else" criteria was used to overcome the

limitations of restricting the number of alters participants could list in response to each of the
previous five generators. Respondents were instructed that they could give the same names for more
than one question (first name and last initial), but that they could list only six alters for each name
generator. This limit was designed to reduce respondent burden in the most extreme cases, while still
allowing most respondents to list most alters that came to mind. Previous studies have found that
less than 3 percent of respondents listed more than 6 alters in response to the GSS and similar
generators (Marsden 1987: 130; Fischer 1982; Burt 1984: 313). By providing the sixth generator of
"anyone else," respondents had the opportunity to list important alters that otherwise would have
been omitted as a result of the survey's design.
Standard name interpreters were administered for each alter, including demographic
characteristics, frequency of communication between alters and ego, and information on the
relationship between alters. The average network consisted of 13.3 alters with a minimum of 1 and a
maximum of 34. Ten percent of respondents had six or fewer network members. Respondents listed
an average of 4.8 discussion partners, 1.3 alters who helped with small household tasks, 2.8 alters
from whom they could borrow small items, 2.2 alters from whom they could borrow money, 5.0
alters with whom they enjoyed socializing, and 2.5 others who were especially close. Respondents
could name the same alter in response to multiple generators and many chose to do so.

Comparing Approaches – Single Generators, Multiple Generators, and the MGRI
Measures of network composition include: *demographic composition* (e.g. mean age and education),
role relationships (e.g. proportion kin), *ego-alter characteristics* (e.g. mean closeness), *network*
activity (e.g. frequency of communication), and *network properties* (size and density). To compare
measures of composition generated through the use of a multiple name generator to measures
obtained through the use of single name generators, we calculated measures for 1) the complete list
of alters provided in response to all six name generators – the baseline full multiple generator model,
and 2) the same measures for each of the five exchange-based generators – the single, stand alone

generator comparisons. Measures for the five single generators were calculated based on only those alters elicited in response to the individual name generator. In this way, measures for each of the five generators recreated as closely as possible the data that would have been produced by administering that one name generator to the same sample of respondents.[6] No network measures were calculated for the final name generator, which asked respondents to list anyone especially close not listed in response to one of the previous questions, as this name generator would not be meaningful if used in isolation from the others. Bivariate correlations were calculated between network measures for individual generators and measures based on the combined six generator data[7]. This analysis puts aside the question of whether single generators are valid measures of multidimensional support, and focuses on the extent to which single generator methods are reliable in that they predict multiple generator measures.[8] As a final step, we compared the results obtained through the full multiple name generator and through the individual name generators to two alternatives 1) a modified multiple generator (MMG) consisting of the two most reliable generators as determined by the first analysis, and 2) a multiple generator random interpreter survey (MGRI), consisting of the full set of multiple name generators with interpreters administered to a random subset of alters.

Findings

Testing the Single Name Generator Approach

Demographic Composition

Through the use of name interpreters, participants provided demographic information on each alter in their support network. This information was summarized into the following variables:

· mean and standard deviation of alters' ages

· proportion of alters who were female

· alters' mean number of children

· mean education (as both categorical and continuous measures), the standard deviation of alters' years of education, and the range of alters' years of education

· the number and proportion of alters who were economically better off, worse off, and similarly situated.

· proportion of alters who were single, married, divorced, separated, or widowed

· proportion of alters with each employment status.

[TABLE 1]

The ability of individual name generators to predict demographic composition varied widely across generators and network measures (Table 1). The higher the bivariate correlation the more reliable the single name generator for that measure of composition. With the exception of measures of variability (i.e., the standard deviations of age and education and the range of education levels), name generators tended to be internally consistent in their ability to predict different dimensions of demographic composition. That is, individual generators were consistently good or consistently poor when compared to the results obtained from the full multiple name generator. The generators for "discussion" and "socializing" had the highest mean correlations across network measures, correlating with the full model at .711 and .736 respectively. On the other end of the spectrum, measures based on alters who "helped respondents with small household tasks," and those alters from who they could "borrow a large sum of money," had the lowest correlations across almost all summary measures. The "helped" and "money" generators had mean correlations across demographic measures of .409 and .434 respectively, making them the least reliable generators for measuring demographic composition.

Role Relationships

Participants selected from a list of eleven options, role relationships that described their tie with each alter in their network: met on the internet, spouse, parent, child, sibling, other relatives, friends, neighbors, coworkers, acquaintances, or common member of a club or organization. Respondents could select as many options as were applicable for each alter. Table 2 contains bivariate correlations of individual generators to the multiple generator for summary statistics based on the number and proportion of alters in each relationship.

[TABLE 2]

No single name generator reliably and consistently predicted the number of people in each role

relationship. Indeed, this is by design, specific name generators were designed to elicit network members who provided specialized types of support, and many relationships are known to specialize in the types of support they provide. For example, there are few people from whom you could ask to borrow a large sum of money other than your parents, and neighbors are particularly good at providing services, such as borrowing a cup of sugar (Wellman and Wortley 1990). As with measures of demographic composition, generators for discussion and socializing best predicted the number and proportion of alters in each role. The generators for aid with small services, "helped around the home" and "borrowed a cup of sugar," were the least reliable.

Ego-Alter Characteristics

Tie characteristics include the respondent's reported closeness to the alter (not at all close, somewhat close, very close), the number of years the respondent had known the alter, the distance between the respondent's home and the alter's, and the number of role relationships that the respondent and alter shared. Correlations of tie measures from each stand alone generator to those from the combined generators are shown in Table 3. Once again, the generators for discussion and socializing were the best single generator predictors, with average correlations across all measures of .720 and .750.

However, there were some surprising inconsistencies within generators. Most notably, even though the average correlation for the discussion generator was quite high, the correlation for the measure of closeness was very low, .529. Despite its popularity, including its use in the GSS, the low correlation between the discussion generator's measure of closeness and that of the multiple name generator suggests that it may be unsuitable as a stand alone generator for network studies in which tie strength is a theoretically important variable.

[TABLE 3]

Network Activity

Participants provided self-reported data on how many times in the past month they had communicated with each alter by telephone, cell phone, postal mail, email, instant messenger, and

in-person.[9] Based on these data we calculated three measures of network activity for each method of communication:

· mean number of contacts per alter
· total number of contacts
· proportion of alters contacted

Keeping with the established pattern, the discussion and socializing networks were most consistent with the results obtained from the multiple generator for the mean, total, and proportion of alters that respondents had contact with for each method of communication (Table 4). The discussion network was particularly strongly correlated with the total and mean number of communications for each alter.

[TABLE 4]

Network Properties

Consistent with van der Poel's (1993) findings, we found that in comparison to the multiple name generator, no single generator provided a reliable estimate of network size (Table 5). The strongest correlation between a single generator's measure of size and that of the multiple generator was obtained using the socializing question, with a correlation of .628. We also tested the reliability of logged network size, since many researchers may use a transformed variable to model non-linear associations. Reliability of the logged size peaked at only .693, also with the socializing generator.

[TABLE 5]

On the final page of the personal network portion of the survey, each respondent completed an adjacency matrix. Participants labeled the rows of the matrix with alter's names, each row was pre-

numbered, as was each column. Respondents were asked to go through their list of name and place an "X" in a cell if a pair of alters knew one another (for our purposes this may best be considered as the perceived presence or absence of a tie). For example, if alter number "2" knew alter number "3," the participant placed an "X" in the corresponding cell of the matrix.[10] To generate measures of network density as they would have been obtained through the use of single name generators, we calculated the density measure using only those ties between pairs of alters who were *both* named in

response to the single name generator in question. Comparing these single generator measures, to the
density measure obtained by the multiple generator, we found that the socializing network, with a
correlation of .737, provided the most reliable measure of networks density.

Is There a Single Generator Solution?

Using the multiple name generator as a baseline, the single name generators for "discuss important
matters" and "enjoy socializing with" produced consistently more reliable estimates of network
composition than the stand alone generators for "helped with tasks around the home," "borrow some
small thing," and "borrow a large sum of money." It was not surprising that most single generators
did not approach the reliability of the full multiple generator. Social support is a multidimensional
concept and a valid measure of support should require generators that tap different dimension of
support. What was surprising is that there were any stand alone generators that approximated
measures obtained through a multiple generator survey. Composite network measures based on
alters elicited from the generators for "discuss" and "socializing" correlated moderately to strongly
for many network measures used to describe alters' demographic characteristics, the relationship
between ego and alter, network activity, and density. Still, while it was surprising that one of these
two generators often produced reliable estimates, neither generator provided consistently reliable
estimates for all measures of network composition. For measures of role relationship, different
dimensions of support were clearly provided by alters in specific role relationships, and no one
generator served as a consistent predictor across roles.

Alternatives: A Modified Multiple Generator and the MGRI

While we have shown that researchers can obtain somewhat reliable estimates of most network
characteristics by using either the "discuss" or "socializing" generators, we found that neither of
these generators produced reliable results across all measures. Researchers interested in a broad
array of network measures would appear to have little choice but to administer a lengthy multiple

generator survey. However, we offer two alternatives that may produce outcomes across most
network measures that produce measures consistent with the multiple generator approach while
placing a lesser burden on respondents:
1) A modified multiple generator (MMG) that includes only the "discuss" and "socializing"
generators.
2) A multiple generator random interpreter (MGRI), which involved administering a full battery
of name generators, and thus maintains the validity of the multiple generator approach, but with
name interpreters administered to only a random sample of alters.[11] We suggest that the time

required to administer multiple name generators is marginal compared to the effort and burden
of completing a large number of name interpreters.
To simulate the data for the MGRI, as if researchers administered name interpreters on a random
sample of alters, we began with the full set of alters generated by the traditional multiple name
generator and randomly selected 6 alters from each respondent's network. Since respondents were
limited to six names per name generator, a sample of 6 or fewer provided a level of respondent
burden directly comparable to the single name generator option. For the ten percent of respondents
whose networks contained 6 or fewer alters, all alters were selected. To simulate the MMG we
selected those alters who were elicited in response to one or both of the "discuss" and "socializing"
generators. For each respondent, we calculated measures of network composition based on the alters
included in the MGRI and the MMG and correlated these measures to those of the baseline full
generator approach.
Demographic Composition
All measures of demographic composition produced by the MMG and MGRI correlated more
strongly with the full generator model than any stand alone generator (Table 1). The MMG and the
MGRI are almost matched in the strength of their correlations to the full generator model. Of the 25
measures we tested, the MMG came out on top 13 times, while the MGRI came out on top for 12. In

those situations where one outperformed the other, the difference tended to be marginal. As with measures based on single name generators, measures of dispersion from the MGRI and MMG tended to be less reliable than estimates of means. Across all demographic variables, the MGRI had an average correlation of .805 and the MMG had an average correlation of .827, reasonable improvements on the correlation of .711 for the stand alone discussion generator and .736 for the socializing generator.

While it was not surprising that the combined discuss / socializing generators outperformed their stand alone counterparts, there were also some indications that the random selection of alters offered through the MGRI may have been a better stand in for the full generator model than the MMG when dealing with measures of variability. The most dramatic improvements in correlations were for those variables that measured variation and range rather than means. It was with these same variables that the MGRI systematically outperformed the MMG. For example, looking at the standard deviation of ties' ages, compared to the stand alone discussion generator, the MMG correlation was higher by .131 while the MGRI was higher by .207. Compared to the socializing network, the MMG correlation was higher by .226 while the MGRI was higher by .302. Similar patterns could be found for both the standard deviation of alters' education and the range of education.

Role Relationships

The MMG and MGRI both performed well relative to stand alone generators when used to measure the number of alters in specific role relationships (Table 2). MGRI measures had a higher mean correlation (.707) than those based on discussion (.681) or socializing (.615) and the MMG had a moderately higher mean correlation (.777) than the MGRI. For six of the 11 role relational variables the MMG did as well as either the discussion or socializing generators and provided more reliable measures than the MGRI for the number of alters in a particular role. For example, the discussion network provided a better measure than the MGRI of the number of siblings in the network, the

socializing network was more reliable than the MGRI in predicting the number of friends, and as would be expected the MMG consistently provided better measures than an independent discuss or socializing generator. In particular, the MMG provided stronger correlations to the full generator model when the type of alters in a network were rare, and likely to be listed in response to these questions such as the number of spouses or the number of alters met on the Internet. A comparison between single name generators, the MMG and the MGRI in terms of the proportion of ties within each role relationship clearly favored the MGRI. With the exception of proportion of alters met on the Internet, measures based on randomly selected alters were consistently more reliable than those based on stand alone versions of the discussion or socializing generators, and moderately better or near equal correlations to the MMG. The particularly strong correlation between the full generator and the MMG for proportion of alters met on the Internet exists because of the very strong disproportionate likelihood that alters met online (a very rare alter in support networks) are only recalled in response to the discussion generator, with an added boost to the correlation from the occasional Internet alter in the socializing network.

Ego-Alter Characteristics

All six variables that we used to measure respondents' relationships to alters experienced considerable improvements in reliability when the MGRI or MMG were used in place of a single name generator (Table 3). For most of these measures he MGRI provided slightly more reliable or near equal correlations to the MMG. Mean closeness demonstrated a particularly dramatic improvement, especially for the MGRI (.898) when compared to correlations of .529 and .694 for stand alone discussion and socializing generators. For ego-alter characteristics, the alternative methods offered a clear improvement in reliability in comparison to available alternatives.

Network Activity

The stand alone name generator for discuss, and to a slightly lesser extent the stand alone generator for socializing both provided strong correlations for measures of network activity. It was not a

surprise that the MMG also proved to be very reliable in generating measures of network activity.
Compared to the MGRI, the stand alone discussion generator was more reliable for about half of the measures of mean communication, including phone, instant messaging and in-person contact, and almost all measures of total communications. For every measure of network communication, the MMG provided stronger correlations to the full model than did any stand alone generator. The MMG usually provided moderately stronger, and on a small number of measures much stronger correlations to what was obtained through the MGRI.
Network Properties

Since the MGRI involved the administration of a full set of name generators, it was identical to the full generator model for measures of network size. While the MMG and the stand alone socializing generator provided reasonable approximations of network size, they were far inferior to the full data provided by the MGRI. The measure of density generated through the use of the two alternative methods was superior to any single generators, with the MMG providing estimates that were moderately more reliable than those provided by the MGRI.

Discussion

The use of a series of name generators and interpreters, while the ideal way to conduct a personal network survey within the exchange approach, can be taxing on respondent's time and motivation.
We argued that traditional attempts to reduce the burden of administering name generators, by substituting a single name generator for multiple generators, undermines the validity of the exchange approach. We argued that no single generator adequately taps the multidimensional concept of social support and that measures of network composition from a single generator do not adequately represent measures obtained through multiple generators. We tested this hypothesis by comparing network measures obtained by five independent generators to a six-item multiple generator. We also tested two alternative methods aimed at reducing respondent burden.
As stand alone generators, two of the most widely used generators – "who are the people with

whom you discuss matters important to you" and "who are the people you really enjoy socializing with" – provided network measures that often correlated moderately to strongly with measures based on the full multiple generator model that described the demographic characteristics of alters, the relationship between ego and alter, network activity, and network density. When combined into a modified multiple generator (MMG), that consisted of only those two generators, they provided even stronger correlations with the full multiple generator model across many measures of network composition. A second alternative to stand alone generators, the multiple generator random interpreter (MGRI) was also shown to provide strong correlations on measures of network composition to the full multiple generator model.

We were surprised by the relatively strong performance of the stand alone discussion and socializing generators. One possible explanation, as to why the stand alone discussion and socializing generators performed as well as they did, may have been that they simply enumerated a large proportion of the personal network. Since different generators are designed to elicit alters from different domains of the support network it makes sense that some domains would be more encompassing than others. Participants placed a mean of 40% of their alters in the discussion network and 41% in the socializing network, a much higher proportion of alters than the other single generators: money lending (17%), helping (10%), and sugar borrowing (22%). This may also explain why the MGRI, which included a mean of 50% of each respondent's alters and the complete network for 10% of respondents, and the MMG, which included a mean of 60.8% of respondent's alters and the complete network for 7.3% of respondents, also produced measures that were highly correlated to the multiple generator. These methods may have been more reliable simply because they included a greater proportion of alters.

To test the size explanation, we compared measures from single name generators and the MGRI to measures based on alters that *were not* included when each measure was calculated. For example,

we compared the average tie strength of members of the discussion network to the average tie
strength of alters not in the discussion network. In doing this we compared one part of the network to

the other part, rather than one part to the whole, as we did in our earlier analyses.[12] We found that
the stand alone discussion and socializing generators did not owe their advantage to their large
number of alters, correlations to the full generator model continued to exceed those of other single
name generators. However, the MGRI did owe much of its success to size. This is not surprising,
since 92% of MGRI networks contained the maximum of six alters, compared to only 56% of
discussion networks and 52% of socializing networks. Similarly, the MMG clearly owed its high
reliability to the larger number of included alters. With the MMG only half of respondents had the
number of name interpreters reduced by more than 5 alters (from the mean of 13.3) and only one
third had networks of size 6 or fewer. The mean number of alters included in the MMG was 7.5.
These findings make obvious intuitive sense as well, as a sampling method the MGRI and MMG
should demonstrate greater reliability the more alters that are sampled from the full personal
network.
One explanation as to why the stand alone discussion and socializing generators and by
extension the MMG were so reliable relates to the type of measures we focused on and the type of
alters the stand alone generators tended to enumerate. The variables that we compared across
generators were of three types: *sum of alter-level variables* (such as total number of telephone
communications), *means of alter-level variables* (such as mean tie strength), and the *proportion of
alters in a given category* (such as proportion female). Single generators often had an advantage
when used to measure the number of alters in a role relationship or the total numbers of
communications. A relatively small number of alters accounted for much of the variation when
alter-level variables were totaled. These same alters were most likely to be elicited in response to

specific name generators and these specific generators provided more reliable estimates than the sampling achieved through the MGRI. As a result, single name generators and the MMG correlated more strongly with the full multiple generator for measures based on the *sum of alter-level variables*.

While sum of alter-level variables are of potential interest, we believe that most variables of substantive interest to personal network researchers tend to be *means of alter-level variables* and measures based on the *proportion of alters in a category*. These latter two types of measures tended to be well measured by both the MGRI and the MMG.

The variable for total number of communications by telephone is an example of a measure that was more reliable with a stand alone name generator and the MMG than with the MGRI. Each respondent had alters with whom they spoke more frequently and alters with whom they spoke less frequently. The lower end of this variable was constrained, as it could not fall below zero. All respondents' low-phone alters had scores that clustered around zero, these respondents contributed little or nothing to the sum and therefore did not account for much variation at the network level.

However, there was no upper bound to the number of telephone communications respondents could have in a month. Variation in communication totals was driven by how often each respondent had contact with *the alters they spoke to most often*. These variables were most reliably measured when high frequency (of communication) alters were included in the analysis. High communication alters were most likely to be elicited by the discussion and socializing generators, and the random, broad sampling of the MGRI sometimes overlooked these alters. As a result, the narrow focus of the single generator approach served as an advantage when predicting frequency of communication.

The number of alters in different role relationships was another example of where the narrow focus of a single name generator lead to higher correlations with the full multiple generator than what was achieved through the MGRI, and in more limited cases the MMG. The money borrowing

generator predicted the number of parents with a reliability of .801, and the sugar borrowing network predicted the number of neighbors with a reliability of .833. In each case the specific generator captured almost all the alters that contributed to variation in the parent and neighbor categories. The broad random sampling of the MGRI tended to miss the small number of parent alters, but in our example did pick up a reasonable number of neighbors. Since the MMG focused on discussion and socializing networks it was not strongly correlated with either number of neighbors or number of parents.[13]

If a researcher is unwilling or unable to accept the problems of administering multiple name generators and a complete set of name interpreters, they face difficult choices in selecting an alternative method to reduce respondent burden. You cannot have it all, strong content validity, a broad set of reliable personal network measures, and a simple, short, easy to administer personal network survey. There are short cuts, under the right circumstances single generators, the MMG and the MGRI can provide reasonable alternatives. The adoption of a particular approach must be based on the context of a specific project and a careful consideration of which network properties are of interest. No single stand alone name generator provides a broad spectrum of network measures comparable to those obtained through a multiple generator survey. Yet, there are examples of when a single generator may be a reasonable substitute for a multiple generator approach. For example, if the focus is on frequency of network communication, there are no reliable alternatives to asking respondents for those alters with whom they “discuss important matters.” When a more extensive set of network measures are desired, the MMG and the MGRI generally provide measures of network composition that are comparable to those obtained through a multiple generator approach. If there are reasons specific to the research design that specify an interest in the sum of alter-level variables, then the MMG is likely the best choice, otherwise the MGRI provides measures that are more strongly related to the ideal of a full multiple generator survey. Also, the MGRI maintains the

construct validity of the full model, where as the MMG does not. In addition, it is clear that the simple and often theoretically important measures of network closeness, density and size are best measured through the MGRI or a full multiple generator. In choosing between the MGRI and the MMG there is also a choice between the respondent burden of a full set of name generates and a small number of name interpreters, or a small number of name generators and a more extensive set

of name interpreters. We found with the MMG that only half of respondents had the total number of name interpreters administered reduced by more than 5, to us this suggest that under circumstances where reducing respondent burden is paramount the MGRI provides the best alternative to the full name generator model. The MGRI maximizes content validity, reduces respondent burden, and provides a reliable spectrum of network measures. The MMG while producing many reliable measures is not as strong in its construct validity or its reduction of respondent burden.

Structure in personal networks

Abstract

Most personal (egocentric) network studies describe networks using measures that are not structural, opting instead for attribute-based analyses that summarize the relationships of the respondent to network members. Those researchers that haveused structural measures have done so on networks of less than 10 members who represent the network core. Although much has been learned by focusing on attribute-based analyses of personal network data, the application of structural analyses that are traditionally used on whole (sociocentric) network data may prove fruitful. The utility of this approach becomes apparent when the sample of network members elicited is relatively large. Forty six respondents free- listed 60 network members and evaluated tie strength between all 1,770 unique pairs of members. Graph-based measures of cohesion and subgroups revealed variability in the personal network structure. Non- hierarchical clustering generated subgroups which were subsequently verified by respondents as meaningful. Further analysis of the correlation between subgroup types and overlap between subgroups demonstrates how the analysis of each network can be summarized across subjects. Four case studies are presented to illustrate the richness of the data and the value of contrasting individual matrix results to the norm as defined by all 45 subjects.

Discussion

This study demonstrates the potential of analyzing the structural aspects of personal networks. It is not unique in concept, as others have examined network density among core network members. Although free- listing of network members presents some problems with recall and the exclusion of weak ties (Brewer, 2000), expanding the list of network members to 60 from the typical 5 to 10 yields a more representative sample of the total personal network. Others have suggested that by including more distant ties, structural phenomena may emerge that explain respondents' behaviors in several areas,

particularly social support (Milardo; 1989; Walker, Wasserman and Wellman, 1993).
It is clear from these data that graph based measures of structure do indeed vary across respondents. One interpretation of this variability is that it reflects strategies of respondents in terms of compartmentalizing their networks and in time investment. With a more heterogeneous sample and the inclusion of additional measures, analysis of these structural measures may be useful for predicting respondent attributes, such as scores on a personality inventory or or a scale of depression.

Many of the categories that emerge from this analysis are unsurprising. I expect, for example, to find that people naturally categorize their network members into family, neighbors, people they know from work, people they went to (or go to) school with, and people with whom they share a hobby. I would, in fact, be skeptical if I did not find these results.

On the other hand, 42% of the respondents distinguish between people they know from their current job and people they know from some former workplace; 25% of members were named because they belong to the respondents' networks via some intermediary network member. Neither of these findings is intuitive, but it is precisely because of the intuitive findings that I have confidence in the surprising ones.

One of the reviewers of this article brought up an important point, suggesting that the structural analysis of the personal network doesn't tell us much about the respondent than we could get by asking them general qualitative questions about the people they know. Would such an interview generate the finding of a negative correlation between close family and hobby clusters? Would I find that clusters of network members tied to a particular intermediary are as prevalent as they appear to be?

It is unlikely that any person could make these assessments of their networks qualitatively. Trends in other structural characteristics that I did not report on in this paper, such as centrality and density, would be virtually impossible to detect without a systematic analysis such as this. Certainly more analysis of these data can, and will, be done that complement what one can learn simply from talking to someone about the people they know.

The case studies allude to a practical application of this method. One can imagine a therapist using the MDS plots, clusters and the relational data as a vehicle for analyzing the "health" of a client's support network. This assumes there are certain properties of social support networks which can be agreed upon as healthy or unhealthy. Already some studies have suggested clients are more satisfied with the existence of confidantes

(Conner, Powers and Bultena 1979), certain density levels (Hirsch 1979, 1980), or levels of network size (Polister 1980).

Finally, this study has shown how personal network matrices generated from several respondents can be analyzed across respondents to reveal personal network characteristics that have been ignored until now. The fact that cluster types were independently verified by a sample of respondents demonstrates the validity of the inter-network member tie evaluations. I have shown that the network characteristics derived from these matrices can be summarized across respondents to show trends in the composition of the networks.

What separates this paper from other studies of personal networks is nothing more than the extra time and effort of asking respondents about the relationship between all potential pairs in a large personal network. While this is tedious for respondents, computer software can make this task easier by taking advantage of patterns that emerge as the respondent evaluates pairs. The development of such software dedicated to the structural analysis of personal networks, and the aggregation across respondents' networks, would be a powerful tool.

Conceptual and Empirical Arguments for Including or Excluding Ego from Structural Analyses of Personal Networks

The structural properties of personal networks are potentially fruitful variables for explaining differences in attitudes, behaviors and conditions across individuals. When researchers apply structural measures to personal network data, they must decide whether to include or exclude ego from the adjacency matrix. This research note discusses several conceptual and empirical issues that should be considered in making that decision.

Most personal network research over the past forty years has focussed on network composition (summaries of alter attributes) rather than network structure (analysis of the pattern of ties between alters). While compositional analyses yield vital information about the network and how it impacts the respondent, structural properties of networks offer a unique perspective and are a worthwhile pursuit (McCarty, 2002). As researchers create new software that makes it easier to construct studies that collect alter-to-alter tie evaluations from respondents (the basis for structural analyses of personal networks), structural features will add to the set of network features that are used to explain respondent attitudes, conditions, and behaviours.

There is, of course, an established tradition of constructing egocentric networks within sociocentric networks. For example, Burt's notion of structural holes is a concept derived from looking at theegocentric network of individuals within a corporate setting (Burt, 1992). While this approach is useful, it is vastly different than the case of personal networks where the list of alters is constrained only by the existence of a link to ego and may span across many groups. We suggest that personal network research should be used primarily to determine the effects of ego's network on ego, or to compare differences in interaction patterns across egos.

Given the novelty of the structural approach in personal network studies, we expect questions to emerge over how personal network data and structural measures should be handled. For instance, when analysing personal network structure, particularly for personal networks with more than 30 alters, researchers will have to determine whether or not ego's ties to her alters should be included in the adjacency matrix that is the input for structural analyses. In this paper, we will explore the conceptual and empirical issues that go into making this decision.

CONCLUSION

These conceptual and empirical issues can be summarized as follows. If we are interested in the
impact of social networks on ego, then analyses should be limited to adjacency matrices that do not include ego. We should think of ego as a passive receiver of information and resources that are transmitted across the network. In this case closeness centrality, and any other measure that requires a connected graph, cannot be calculated.

If we are interested in the impact ego has in brokering their network, then we should include ego. We should think of ego as an active participant in information and resource exchange. Many of the structural measures will be functionally the same as the case where ego is excluded. If a tie is forced, components will be meaningless, and betweenness centrality will reduce to degree centrality.

Finally, we may be interested in how ego impacts their network, but using a definition that allows for null ties. The empirical issues are the same as those for adjacency matrices without ego, that is, closeness centrality cannot be calculated.

Measuring personal networks with daily contacts: a single-item survey question and the contact diary

Abstract
This paper examines two extreme approaches that are alternatives to measure egocentric networks with network generators. The single-item approach to measure daily contacts differentiates the individuals effectively, corresponds closely with complex network measures, and reveals well how individuals vary in both expressive and instrumental returns, as supported by 14 large-scale probability surveys from three Chinese societies over a decade. This paper also draws upon three sets of sophisticated contact diaries, which yielded rich data about the circumstance of each contact, the alter's characteristics and the ego–alter relationship. Along with the diary approach, which offers sophisticated data about contacts, ties and networks, the single-item survey approach is another extreme yet straightforward measure of daily contacts.

5. Conclusions

This article has evaluated two contrasting measures of daily contact and demonstrated how these measures may help advance our understanding of egocentric networks. The single-item survey question is so simple and straightforward that it usually takes only around 30 seconds to answer. More critically, it is so direct and universal that it easily can fit into any survey addressing any one of a variety of topics, thus allowing a very comprehensive examination of how it helps explain these topics with a basic network index. The measure has been highly stable and valid in distinguishing the extent of daily contact—the basic

dimension of personal networks—as confirmed by 14 large-scale probability surveys in three Chinese societies over a decade.

In contrast, the contact diary is so tedious to record that it is only suitable for highly committed respondents. For the three informants in this study, it took more than 30 minutes each day to record the essential contact information, adding up to at least 45–60 hours of hard work over the course of 3–4 months. The rich information in such a contact diary, however, provides extensive details of one's actual network over time. The data also facilitate complex analyses using the individual contact or tie as the unit.

The single-item survey question and the contact diary thus represent different approaches that are irreplaceable and not interchangeable. Both extreme measures offer great potential to the study of personal networks. Used as the sole indicator of an egocentric network, the single survey item reveals the extent of daily contact very reliably. In addition to being highly consistent with existing indices, the measure greatly complements them. Being parsimonious yet powerful, this single-item measure has a great potential to serve as a useful and efficient tool for collecting large amounts of data about total networks in a short time and at a low cost (cf. McCarty et al., 1997).

The contact diary provides information that differs sharply from the single-item approach. As sophisticated as the design is, the diary data are difficult to collect. But the rich details it reveals may be invaluable. With all the characteristics of each contact person, each specific contact and each ego–alter tie on a daily basis, the diary approach reveals every detail of an individual's actual network. Over time, it can become the most comprehensive and penetrating research instrument for measuring personal networks, which also shows the changes that shape and reshape the network structure.

Despite the obvious limits and risks involved in using the diary approach, the data it generates encompass all kinds of weak ties and contacts with strangers, as well as all forms of contacts with the intimates who live far away (cf. Killworth et al., 1990, p. 291). Instead of relying on a generator or an

aided recall, the contact diary enables researchers to collect actual, first-hand and complete contact data. Unlike those studies using pre-existing contact records (e.g., appointment books, cf. Pool and Kochen, 1978, p. 20), furthermore, the diary approach enables researchers to incorporate how the ego perceives or evaluates each alter and each contact. Such subjective perception and evaluation greatly add to its potential. As the preexisting network studies have called for more methods to produce both proxies and full networks (Killworth et al., 1990), the single-item survey question and the contact diary highlight two extreme measures that deserve further exploration and examination.

Impact of methods for reducing respondent burden on personal network structural measures

Abstract We examine methods for reducing respondent burden in evaluating alter–alter ties on a set of network structural measures. The data consist of two sets, each containing 45 alters from respondent free lists: the first contains 447 personal networks, and the second 554. Respondents evaluated the communication between 990 alter pairs. The methods were (1) dropping alters from the end of the free-list, (2) randomly dropping alters, (3) randomly dropping links, and (4) predicting ties based on transitivity. For some measures network structure is captured with samples of less than 20 alters; other measures are less consistent. Researchers should be aware of the need to sample a minimum number of alters to capture structural variation.

1. Introduction

Increasingly researchers who study personal networks are interested in collecting the data to calculate *structural variables*. By structural variables we mean measures that rely on the pattern of relationships within a network. These measures include network density (the most commonly applied structural measure for personal networks), centrality (degree, closeness and betweenness), centralization (degree, closeness and betweenness), components, core/periphery and isolates. These are in contrast to *compositional variables* that summarize the characteristics of alters within the personal network; such as the proportion of the network that are women, smokers, or family, the average age or the average intensity of the relationship between the respondent and their alters.

Of course the problem with collecting data on personal network structure is the issue of respondent burden. An adjacency matrix for a personal network requires the respondent to assess some portion of the ties between their alters. This task grows geometrically as the number of alters increases. If we make the assumption that the best assessment of personal network structure can be achieved by having the respondent evaluate all possible alter–alter tie evaluations, a network of 10 alters requires 45 evaluations and a network of 50 alters requires 1225 evaluations.

We have two goals for this paper. First is to determine which method for reducing respondent burden best approximates the structural measures from the unabbreviated network. Second, using this method, what is the minimum number of alters necessary to approximate the unabbreviated network. We approach this problem empirically using two datasets.

4. Structural measures

All of the structural measures were normalized as they are all sensitive to the number of nodes in the network. The following structural measures will be considered (grouped on diagrams by the letter shown):

1. Point degree centrality: • average point degree centrality (network density); • degree centralization; • change of person with maximum point degree centrality.
2. Closeness centrality: • average point closeness centrality; • closeness centralization; • change of person with maximum point closeness centrality.
3. Betweenness centrality
   - average point betweenness centrality;
   - betweenness centralization;
   - change of person with maximum point betweenness centrality.
4. Number of components of size 3 or more, *and* number of isolates (shown together on diagrams).

5. Number of alters in network core from core/periphery procedure.

The normalization follows Wasserman and Faust (1994) for the centrality/centralization measures. The number of components is unnormalized; the number of isolates and network core members is normalized by the number of the alters. The approach used to compute the alters in the network core follows Borgatti and Everett (1999) closely, and uses their continuous model and a function maximizer. Not all combinations of datasets and numbers of alters found a useful maximum fit to the core/periphery structure (though usually on more than 80% of occasions), and we cite figures for this measure only over those datasets where solutions were found. The measure of whether the most central alter changes when network size is reduced is defined by creating a binary variable that begins at zero, and changes to a one when the most central alter changes as a result of data excluded from analysis. The values cited represent the average of these 0/1's across all 447 respondents, and so are the fractional number of changes as one more alter is added (or removed).

10. Discussion

In this article we have examined the changes in personal network structural measures as a consequence of various strategies for reducing respondent burden in collecting structural data. The most surprising result is that for some measures, structural variability may be captured with fewer alters than we originally anticipated.

For most measures, a free-list of 25 alters will capture the same structural pattern as a network of 45 alters. The number of alters may be reduced to as few as 10 alters for most measures by randomly selecting alters from a larger list. For some measures, anticipating ties based on transitive triads produces similar results, but for others like number of alters in the network core, it produces very different results. Randomly selecting ties from a large set of alters is not recommended.

It is important to note that the results reported here say nothing about changes to personal network composition as a consequence of dropping alters from the end of a free-list task or randomly selecting alters from a larger list. Changes to personal network composition may be more sensitive to the way respondents have been sampled than personal network structural variables. This dataset was limited in our ability to test changes in composition given the dissimilar set of questions respondents answered about each alter. However, from the consistency of our results, we assume that the random selection of alters from a larger list would also be the best method for reducing the respondent burden of providing alter attribute data. In a personal network study this is typically the most time-consuming part. We do not know the number of randomly selected alters necessary to represent the composition of the 45-alter network. This probably varies by the particular alter attribute.

In practice the process of alter–alter tie evaluation is less burdensome than intuition might suggest. When alter pairs are presented to respondents in a systematic way (such as one alter with all other alters, the next with the rest and so on), respondents can get a feel for the way their alter lists are organized and anticipate their responses. In personal networks where there is less cohesion, many of the ties will be null, and having software that defaults to a null tie can save a lot of time. In the studies conducted here it was not unusual for respondents to complete all 990 tie evaluations in 30 min. Far more burdensome is the task of answering a set of questions about each alter. These cannot be easily anticipated. For a personal network of 45 alters, ten alter questions results in 450 different questions. Researchers must be acutely aware of the consequences of asking for too much alter information.

One caveat with the results presented here is that these adjacency matrices are the result of alters elicited by free-list and using a tie definition that focuses on independent interaction. It is entirely possible that the pattern in the change in structural measures will be different using different elicitation technique(s) and a different tie definition.

Sampling to Reduce Respondent Burden in Personal Network Studies and Its Effect on Estimates of Structural Measures

Abstract Recently, researchers have been increasingly interested in collecting personal network data. Collecting this type of data is particularly burdensome on the respondents, who need to elicit the names of alters, answer questions about each alter (network composition), and evaluate the strength of possible relationships among the named alters (network structure). In line with the research of McCarty et al., the authors propose reducing respondent burden by randomly sampling a smaller set of alters from those originally elicited. Via simulation, the authors assess the estimation error

they incur when measures of the network structure are computed on a random sample of alters and illustrate the trade-offs between reduction in respondent burden (measured with the amount of interview time saved) and total estimation error incurred. Researchers can use the provided trade-offs figure to make an informed decision regarding the number of alters to sample when they need to reduce respondent burden.

Conclusions and Discussion

Personal network studies are particularly burdensome for the respondents. In this article, we investigated the effect of randomly sampling alters to reduce respondent burden on the behavioroffourstructuralmeasures. We also assessed the range of the total amount of error we incur when computing these measures using a sample of alters and showed how this error varies as function of the number of alters sampled and the amount of time saved.

We provide researchers with a figure illustrating the amount of error they should expect to incur when sampling alters and the amount of time saved. This figure provides guidance for making an informed decision on the number of alters to sample when researchers have to reduce respondent burden. The only limitation to this figure is that the likely total amount of error was derived using a sample of 28 networks of homeless women. This sample might not be representative of the networks of other populations, although these 28 networks show a wide range of values for the four considered structural measures.

We think that sampling alters represents an effective way of reducing respondent burden. Although the focus of this article was on structural measures, it should be noted that sampling a smaller set of alters can also reduce the respondent burden for the network composition phase of the interview. The time savings, in terms of a shorter interview, can actually be more substantial for the composition phase than the structure phase. However, because most (if not all) of the composition measures are either means or percentages, such as the alters' mean age or the percentage of family members in the network, their statistical properties are well known. We know that composition variables computed on a sample are unbiased; hence, the only source of error is their variability. In the study that motivated this article, we reduced respondent burden for both composition and structure sections. Only a small set of the composition questions (4 questions) was asked of all 20 alters; the bulk of these questions (14 questions) was asked to the 12 sampled alters. Respondents on average took 5 seconds per composition question; this means that the second part of the composition phase took on average 14 minutes instead of 23.3 minutes. So, the total (composition and

structure phases combined) time saving per respondent obtained by sampling 12 of the 20 named alters amounts to about 20 minutes, a substantial reduction of the overall interview time.

In that study, we went a step further in that we took a stratified sample of 12 alters. More specifically, the 20 named alters were grouped into two strata: sex partners and nonsex partners. As one of the major goal of the study was analyzing the relationship between risky sexual behaviors (such as unprotected sex) and social network characteristics, it was important to include in the sample of 12 alters some of the sex partners the woman named. The use of stratified sampling is one solution to the situation in which researchers need to collect information on specific types of alters and find themselves in need of reducing respondent burden. The only drawback is that if alters from different strata are sampled at different rates, the sample measures need to be weighted (Lehtonen and Pahkinen 1994).

A stratified sample represents a potential solution to the disadvantage of randomly sampling alters noted by McCarty et al. (2007): Because the selection of the alters is random, it is likely that key alters are not sampled and therefore that the sample measures might be significantly different from the true structural measures. In a study like ours with 445 cases, the case in which for few respondents the sample structural measures estimate poorly the true structural measures might have very little consequence on the analysis results. It is unlikely that, for example, the correlation between drug use and network density is affected if the network density is poorly estimated for a few respondents.

This article focuses on measuring the quality of estimates for personal network structural measures, but that is rarely the end product of the analysis. More commonly, these network features act as explanatory variables in regression models. Including covariates measured with error, as would be the case with sample structural measures, results in their regression coefficients being biased toward zero. Methods for adjusting for this ‘‘attenuation bias’’ (Frost and Thompson 2000) use the estimated variance of the covariate to project what the coefficient would be if the true structural measure had been used. Explanatory variables measured with bias are more problematic. Future work should assess the impact of estimation error in the sample structural measures on estimated regression coefficients and develop methods for adjusting regression coefficients for bias and variance in the estimated structural measures.

This article shows that if researchers are interested in measuring network density, respondent burden can be reduced substantially because the overall

estimation error is low even for relatively small samples. For the other three sample measures, the overall estimation error tends to be higher. Therefore, researchers need to assess the amount of error that they are willing to tolerate to reduce respondent burden. This is particularly true for the percentage of isolates. The fact that three of the four considered sample structural measures are biased suggests that sample measures might not be the best estimators of the true structural measures. Future research should investigate alternative estimators that eliminate or reduce the bias and that ultimately exhibit a smaller overall estimation error. Although using the sample structural measures is advantageous as they require hardly any computation time, the use of alternative estimators is warranted only if the reduction in the estimation error outweighs the increase in computing time and complexity.

Asking Social Network Questions: A Quality Assessment of Different Measures

Research findings indicate that different types of social relations have an important influence on the performance of employees in organisations. This paper focuses on a comparison of different methods for acquiring information on advice, cooperation, friendship, adversarial and superficial networks in knowledge organisations.
We investigate the applicability of three distinct measurement methods to acquire different kinds of complete network data by means of the recognition method. Data were collected in a small governmental organisation consisting of knowledge workers. First, employees were presented a short description of a specific situation in which social relations with their colleagues might play a significant role. They had to indicate if (or how often) this specific situation occurred with each of the colleagues. Second, respondents were asked to indicate whether a specific relational concept (in this case 'advice' or 'friendship') applied to each of their relations with their colleagues. Third, we provided respondents with four semantic differentials (e.g. distrust-trust) on which they needed to position their relation with the other employees. Whether these different measurement instruments capture distinct aspects of the relation between employees, or whether they measure the same underlying concepts, is one of the major concerns of this paper. The aim of this paper is twofold. First of all, we want to know to what extent these different measurement instruments overlap. Second, we would like to find out to what degree these different methods as a whole give us conceptually different and complementary information. To the extent that items are correlated within one method and between methods we need to investigate which of these different instruments is best suited for our content related purposes. The criteria used for selecting the most appropriate method are minimal item non-response – i.e. from the viewpoint of measuring complete networks – and maximum relational diversity with a minimum of questions.

1 Introduction

Formal as well as informal social relations have become important explanatory variables in organisational research. Each individual is surrounded by a specific network of social relations. This structure of relations is referred to as the social network. The structure and the content of these social networks are believed to influence the attitudes and the behaviour of people in many ways. Because of the sensitive and threatening character of the questions measuring complete social networks, special attention is needed for their construction. This paper focuses on acquiring information on different sorts of social networks in a survey context, by using alternative question formulations. We investigate which questions included in our survey measure the same underlying concept and which capture different types of relations between employees. To know whether these different questions are measurement instruments of the same concept (e.g. a friendship relationship), we examine to what extent the answer patterns of these questions overlap. We subsequently evaluate the quality of each of the questions that measure the same underlying concept, by means of the item nonresponse rate. Our findings indicate that three different concepts are measured by the included questions: an advice dimension, a friendship dimension and a social support/social companionship dimension. Moreover, we find that some question formulations provide us with better results regarding the item response rate.

2 Theoretical background

Social networks have become more and more common in social science research. While the importance of social networks has become widely accepted, the problem of which questions are suitable for acquiring information on complete social networks has received little attention [2]. One of the difficulties social network researchers are faced with is the so-called nonresponse, i.e. unit as well as item nonresponse. Especially, when focussing on the measurement of complete social networks –as in our case–, both types of nonresponse need to be minimised. In ordinary survey research, nonresponse is highly problematic, especially when the nonrespondents possess characteristics that are different from these of the respondents (Groves and Couper, 1998). For measuring complete networks unanswered questions are even more problematic because each missing answer

brings about an additional gap in the social network under study. In order to reduce the item nonresponse, this paper focuses on different strategies that can be adopted when constructing social network questions. In general, well-constructed questions are questions that respondents will interpret in the same way, will be able to answer accurately and will be willing to answer (Dillman, 2000: 32-34). For the current purpose – namely the reduction of the item nonresponse – our focus lays on the problem of the willingness to answer.

Social network questions differ from ordinary survey questions in at least two ways. Firstly, social network questions often are "sensitive" (Tourangeau, Rips and Rasinski, 2000) or "threatening" (Sudman and Bradburn, 1982) questions. These questions invade privacy and people might be afraid that their answers will be disclosed to other people than the contacting agency. The answers on social network questions may be expected to suffer considerably from social desirability. Moreover, people possessing the most sensitive information (e.g. on hindrance networks) may be the least likely to report it (Tourangeau, Smith, 1996: 276). This sensitive nature of social network questions makes us expect higher item nonresponse rates. A second difference from other survey questions concerns the burdensome nature of social network questions. These questions are rather complex and demanding to fill out. Social network questions are designed to obtain specific information about the relations people have with all the other members of a particular group. When measuring a complete network, the researcher knows which people belong to the social group under study by depending on external criteria (such as the structure of the organization) or by questioning a core actor who reports on the composition of the group under study. In either case, i.e. when researchers (nominalistic approach) or respondents (realistic approach) define the social group (Lauman, Marsden and Prensky, 1983), respondents are offered some name interpreters in which a factual (e.g. frequency of informal contact [3]) or an attitudinal (e.g. trust in someone) question is asked for each of the names of the group members. This is a very demanding task on the part of the respondent and imposes a considerable cognitive burden on the respondent. A lot of information needs to be retrieved on a rather short time span. It can be expected that questions containing a high burden are more easily skipped or are more badly completed than questions with a relatively low burden (Tourangeau, Rips and Rasinski, 2000).

The combination of both of these characteristics –i.e. the high sensitivity and the burdensome nature– might increase item nonresponse rates of social network questions. Posing well-constructed questions may lower the nonresponse rate considerable. Especially when dealing with sensitive questions, researchers should pay attention to the construction of the questions itself. As such, the

sensitivity of these questions can be softened by choosing the appropriate wording (Dillman, 2000: 18). Good-written survey questions make it less difficult for the respondents to answer. In this paper different question formats are tested: hypothetical questions, factual questions, direct questions and semantic differentials (Section 3.2). In order to restrict the burden of completing survey questions our challenge is to obtain the greatest amount of information with as few questions as possible. Detecting underlying dimensions gives the opportunity to restrict the total number of questions. When two questions are measuring the same underlying concept, it is unnecessary to include both of them in a questionnaire. That way, the burden of the questionnaire is reduced, because redundant questions –i.e. without any substantive additional information– are avoided.

Little research literature pays attention to nonresponse reduction for complete social network questions. Most research focuses on the accuracy [4] of the acquired information on social networks (e.g. Bernard et al., 1990; Hammer, 1985; Brewer, 1993, Bondonio, 1998, Sudman, 1985, 1988, Feld and Carter, 2002; Huang and Tausig, 1990). The majority of these research articles conclude that individual reports about social interactions differ substantially from the objective observations of these interactions. Moreover, a first research attempt is made to explain variation in the accuracy of social network perception by means of both situational and individual differences (e.g. Casciaro, 1998). Some of this literature concentrates more specific on the problem of forgetting network members (Brewer and Webster, 1999; Brewer, 2000). Our research is more in line with the work of Ferligoj and Hlebec (1999), in which social network survey instruments are evaluated in terms of test-retest reliability.

Besides a focus on the cognitive abilities of people and/or on the accuracy of people's cognitive reports, research should consider the construction of social network measures. This paper concentrates on the 'ordinary' item nonresponse social network questions can suffer from. A missing answer on a social network question does not necessarily imply the absence of a tie. As is often the case, people might simply refuse to answer a particular question. Instead of the assumption that people might forget particular interactions, we should acknowledge the possibility that they refuse to report them. This refusal can be due either to the sensitivity of the questions (i.e. especially because they invade privacy) or to the high burden associated with filling out the questions. When questioning social networks in a small organization –i.e. all network members are known– by means of the recognition method, missing answers cannot be explained by respondents forgetting the presence of alters. Recall problems that are directly related to the subject of the question are the only memory difficulties that can

cause nonresponse. When people have difficulties with estimating for example the frequency of contact with a particular network member, they might be less prone to provide an answer to the questions. These memory problems are directly related to the complexity or the burden of the questions.
The purpose of this paper is to understand how social network questions can be constructed in such a way that network relations are measured in an accurate and effective manner within a survey context. As a result, our general research question is twofold:
(a) to what extent are the different measurement instruments indicators of the same underlying concept?
(b) if they are measuring the same concept, which question format is most accurate?
To answer the first question, the principle of trait validity –as part of construct validity– stands central. To check for trait validity different measures of the same trait should be highly correlated (Campbell and Russo, 2001). Questions measuring the same concept are expected to be strongly correlated. Lower, but significant correlations between questions measuring different concepts might exist, since different concepts can also be correlated. Diverse techniques will be used to examine whether the overlap between different questions is due to the fact that these questions are measuring the same concept or that the underlying concepts are correlated. If the constructed questions are measures of the same broader concept, it will be unnecessary to use each of these questions. In that case, it might be advisable to restrict the number of questions needed to get this information in an efficient way. Selecting the appropriate questions constitutes the core of the second part of this paper. The following criteria are used for selecting the most appropriate question for a specific dimension: minimal item non-response and maximum relational diversity with a minimum of questions. In the following part we will describe the questions that were included and the dimensions these questions are suspected to refer to.

3 Measuring social networks

3.1 Types of relations

Social network relations can have very different contents. Various types of networks (also called dimensions) can be important in organisations. A large number of researchers concentrates on different types of networks in an organizational context (Lincoln and Miller, 1979; Krackhardt and Stern, 1988; Hansen, 1999; Burt, Hogarth and Michaud, 2000; Lazega, 2001; Nelson, 2001; Sparrowe et al., 2001). In most studies the general aim of organizational

researchers interested in network relations is not only to measure formal networks (i.e. relations that are mostly a consequence of the organisational structure and of the function of the individuals in that network), but also to pay attention to more informal relational contents, such as support and friendship.
Our research focuses on different relations centred around five different topics: information, support, companionship, hindrance and superficiality. Each of these relations is believed to have an influence on the functioning of employees in companies. A first part of the information relation is the advice network and concerns knowledge sharing and knowledge creation (Cross, Borgatti and Parker, 2001). Initially, we included seven questions related to advice, capturing three different aspects of advice as developed by Cross et al. (2001), namely people tend to exchange "solutions, validation and meta-knowledge". A first type of advice considers those situations in which one turns to colleagues for finding a solution for a specific work related problem, one is not able to solve himself or herself (Q7 and Q8). "Validation" implies that people present their own solutions to colleagues in order to receive confirmation of their work (Q9 and Q10). Obtaining useful information about which experts to contact, where to obtain relevant documents, how to find data, etc., is a third type of advice, called meta-knowledge (Q11). The seventh advice question directly asks with whom one has an advice relation (Q32). Another measure related to the information transfer is the question about cooperation (Q15). Cooperation refers to a situation whereby employees have contact with each other to exchange information on a regular basis. When people cooperate, a stronger and more long-term relation exists than when they are involved in an advice relation (Lazega, 2001: 94-96). In a company context it is expected that relations concerning advice and cooperation have a substantial influence on characteristics of the employee, such as satisfaction and performance. Social support encompasses several dimensions: emotional support, instrumental support and social companionship (van der Poel, 1993). Two questions are included as a measure of emotional support. The first one asks to whom one goes to receive support for important work-related problems (Q12). The second question concerns support in the case of important problems related to their private life (Q13). Social support of co-workers has a strong influence on –for example– job satisfaction (Ducharme, Martin, 2000). Social companionship, as a dimension of social support, is measured by a question regarding the frequency of participation in social activities outside the work context (Q14). Since it is possible that in a work situation some colleagues do not get along with each other, have a row, etc., a negative or adversarial relation is included (Q16). Such conflict situations might be influential on the activities of people, such as individual performance (Baldwin, Bedell and Johnson, 1997; Sparrow et al., 2001). Another question refers to what we call a superficial relation (Q17). It might be the case that in an organisation people simply do not know each other very well or only know others very superficially. It seems unreasonable to

suppose that everyone should either be a friend, a co-worker, an adviser, etc. of someone.

Four semantic differentials about the informal – i.e. non-professional – relations between employees were also part of the questionnaire (Q18-Q21). A last question included asks for the colleagues with whom one has a friendship relation (Q31). Friendship is defined as a flexible form of open-ended support that is not related to the tasks themselves (Lazega, 2001: 96). Because of the exploratory nature of this research, we do not a priori assign each of these seventeen questions to a specific dimension. Table 1 shows for each question the relation it is expected to measure and the particular question type it belongs to. This last distinction is explained in the following chapter.

3.2 Measurement instruments

In questionnaires often a description of a certain situation or problem is used to generate the necessary network information. It might be that the often rather long and complex descriptions (e.g. Ferligoj and Hlebec, 1999; Burt, Hogarth and Michaud, 2000; Lazega, 2001) do not provide the researcher with the most highquality answers. Three different question formats were tested [5]. An example of each of these can be found in Figure 1. First of all, similar to the questions frequently used in literature, a description of a particular situation (or problem) is given to the respondents. Specific for the advice network, two alternative formulations were tested. In the first type of questions respondents were asked to indicate the other employees whom they *think* they *would* go to when confronted with a hypothetical situation or problem. In some sense this is an 'ideal' situation, since no reference is made to what had really happened before. However, this ideal situation might differ from what actually occurs. Therefore, an alternative question formulation was included, in which the respondents are asked to think back in time (i.e. over the last year) and to indicate the number of times a certain problem or situation actually occurred. A potential problem with this kind of question is that it can be more an indication of being confronted with a particular situation, instead of an indication of the availability of support givers in such a situation. In relation to our first research question it might be that there is a great discrepancy between the alters employees get advice from and the alters they would *like* to get advice from. However, it could be that they do not differ greatly. In that case it is better to ask respondents whom they would go to for advice, instead of asking them whom they really went to during the past year (for example to prevent recall errors). We will respectively call these question types: hypothetical (type 1a) and factual (type 1b) questions. The respective answer categories on each of those types are: "yes/no" and a five-point scale of frequency. Only for the advice network a hypothetical formulation makes sense. For all other dimensions only factual questions were developed.

A second sort of question used is called a 'direct' question. Instead of giving a description of the concepts measured by a particular question, we mention the relation in the question itself. Respondents are asked in what sense they consider their relation with someone as being of a particular type (in this case advice, friendship or superficial relation). When a question asks explicitly what type of relation one has with each of his colleagues, respondents might be more able to answer accurately. Notwithstanding this potential advantage, it remains problematic and doubtful whether everyone understands a certain concept – such as a type of relation– in the same way. Answers should be given on a seven-point scale.
Finally, we included some semantic differentials of rather straightforward concepts that are directly related to informal relations. Respondents needed to position their answers on a seven-point scale. It might be that respondents find it easier to think in terms of opposite adjectives, than in terms of described situations (as in type 1).

TYPE 1:
1.a.: hypothetical: Suppose that you have found a solution for a work related problem. You are not certain about it and confirmation of others would reassure you. To whom of the members of your research group would you go for confirmation? *(dummy : yes/no)1.b.: factual:*Consider all situations of the past year in which you think to have found a solution for a work related problem. You are not certain about it and confirmation of others would reassure you. How often have you been looking for confirmation to each of the members of your research group? *(daily – some times a week – some times a month – some times a year – never)* ***Type 2:*** Consider your relation with each of your colleagues. Can you indicate in what sense you consider that relation as a 'friendship relationship'? *(seven-point scale: not at all(-3)– totally (+3))* ***Type 3:*** Look at the following contradiction: "distrust – trust". The more left you tick of a box, the more you associate your relation with a particular colleague with "distrust". The more right you pick of a box, the more you associate you relation with that colleague with "trust". *(seven-point scale: distrust (-3)/ trust (+3))*
Figure 1: Type of question.

Table 1: Content, number and type of questions included.

4 Data collection

4.1 Methodological considerations

Since the sensitivity and the burden are inherent to the social network topic, methodological efforts are needed to minimise nonresponse already at the phase of the data collection. Self-administered surveys are found to increase the item response of sensitive questions relative to other data collection methods (Dillman, 2000: 38; Tourangeau, Rips and Rasinski, 2000: 288-312). A choice should be made between the paper and pencil mode and the more recently developed CASI (i.e. computer-assisted self-administered interview). Often researchers guide their decision in favour of the more or less established paper and pencil method, because of expected higher response rates and the lower data quality. Specific for e-mail surveys (e.g. Couper, Blair and Triplett, 1999) and sometimes for websurveys too (e.g. Crawford, Couper and Lamias, 2001) high nonresponse rates are found. Nevertheless, some research contradicts these findings (Schaeffer and Dillman, 1998; Dayton, 2001). Moreover, Tourangeau and Smith (1996) confirm that using CASI increases the item response rate of sensitive questions. Concerning overall data quality, some hopeful results indicate that CASI and 'paper and pencil' data collection generate comparable data, with a slight advantage concerning criterion validity and test-retest reliability in the case of CASI (Corman, 1990). Besides these nonresponse considerations internet research often suffers from coverage problems (Couper, 2000). While the usage of the phone is widespread, the availability of internet might still be troublesome. This is no real hindrance in this and many other cases, where specific populations with full access to the internet are surveyed. Moreover, when using CASI some major practical advantages accompany the data collection. Time intervals between different stages of the follow-up procedure are much shorter (Tailored design method (Dillman, 2000)) then in ordinary survey research (Total design method (Dillman, 1978)). In this way the duration of the burdensome data collection phase can be shortened. Another advantage of using CASI instead of a paper and pencil procedure is related to the specific cost efficient nature of CASI. The technical development of the CASI questionnaire itself is the financially most exigent part of the surveying process. In contrast with other survey modes, surveying additional respondents by websurvey or e-mail survey does only increase costs to a very small extent. Large scale data collection can be performed at considerably low

costs. Taking the abovementioned arguments and our research purposes into consideration it was decided to use a CASI procedure as method of data collection.

4.2 Data

This research is the first part of a more extensive research design with as a general aim the study of the relation between an actors' social networks in an organisation and his or her performance. This study is a small pre-test, set up to test the websurvey software and to study the answer patterns on the network questions. The data were collected by means of a websurvey in a small governmental organisation in Belgium (N=28)[7]. We made use of a multiple contact strategy, similar to the one Dillman (1978, 2000) proposed for mail surveys. We contacted each respondent four times by means of different e-mails: a prenotice, an e-mail containing the URL of the questionnaire and two thank you/reminders. Through the prenotice, respondents were asked to participate in the survey and they were informed that they would receive the questionnaire in a few days. Three days later, an e-mail with the URL of the website where the questionnaire could be found, was sent to every employee. Four and eleven days after they received the URL of the websurvey, every member of the organisation was sent a thank you/reminder. In this way, respondents were thanked for their participation and non-respondents were reminded about the presence and the location of the questionnaire.

Because of the use of cookies, every respondent could only participate once. The possibility to fill out the questionnaire in a paper and pencil format was given, but everyone responded by filling out the websurvey. In the end, 25 of the 28 contacted employees completed the questionnaire. This corresponds with a response rate of 89.3%[8]. The questionnaire consisted of some general questions concerning their job, a large network part (25 of the 51 questions), some personal and psychologically oriented characteristics of the respondent and their opinion about the questionnaire. In this paper we focus on the complete network of the respondent in the organisation under study, i.e. only seventeen social network questions are taken into consideration[9]. Every network question was asked by means of the recognition method, i.e. every respondent received (for each question) a list of all other members of the organisation. They were asked to answer the particular question for each of the – in this case – 27 other members of the organisation.

We now turn to the analysis itself. First we will outline which questions are measures of the same underlying relational concept. We do so through the use of QAP as a first step and subsequently by factor analysis, cluster analysis and MDS. In a last step we compare the quality of the questions that are measures of the same concept, by looking at the proportion of missing values.

5 Results

5.1 Qap correlation result

A QAP-correlation procedure (Quadratic Assignment Procedure) is used to calculate the overlap in answers given to each pair of questions. QAP is a permutation test that computes the correlation coefficient between the answers for two questions, where each answer that is given forms a separate case. In order to see whether the resulting correlation is significant we have to rely on a simulation test. In this simulation test, values for the correlation coefficient are calculated when the vertices (actor-labels) are reassigned randomly, and the resulting distribution is used to evaluate how extreme this correlation coefficient is.

This test procedure is available in UCINET V (developed by Borgatti, Everett and Freeman, 1999). We used a SPSS syntax in order to be certain that missing values would be ignored. The results can be found in appendix 2 (i.e. Tables A, B and C). The majority of the correlation coefficients is highly significant. This would indicate that all the different questions have significant overlap in their answers. However, almost all values of the correlation coefficients are rather low. A low but significant correlation could be an indication of multiplexity of these relations. The results do indicate that employees who give – different types of – advice are also named as cooperation partners and as friends. Moreover, it is shown that for friends, advisers and co-workers the superficial relation is not reported and a positive correlation is present with each of the semantic differentials. Only a high correlation would be an indication that the questions are measuring the same underlying relational dimension. The presence of some high correlation coefficients gives a first indication that separate groups of questions exist. In order to identify these groups we use three different methods: factor analysis, cluster analysis and multi-dimensional scaling. By using factor analysis different dimensions can be distinguished. Furthermore, a cluster analysis is performed in order to confirm or to shed new light on the solution from the factor analyses. Multi-dimensional scaling helps to visualize the results. The application of these techniques is rather explorative when dealing with network related data. Each of these techniques is discussed in the following sections.

5.2 Factor analysis

The factor analysis is based on a transformation of the original dataset. Each of the answers of each respondent about his/her relation to a specific other actor is used as a separate case in the factor analysis. We performed a principal axis factor analysis with listwise deletion of missing values. As a result the obtained correlations differ from those calculated by the QAP syntax (Appendix 2). Because of the assignment of Q15, Q16 and Q32 to more than one of the factors these questions are excluded from the analysis. On the basis of the eigenvalue criterion a three factor solution is preferred (Table 2).

Table 2: Factor analytical solution.

The first dimension consists of five questions. All of them were initially developed to measure the work related advice network as a broader dimension (Table 1). Contrary to our expectations the direct advice question is not included in this analysis because it could be assigned to more than one dimension (i.e. to the friendship as well as advice the dimension). This might be due to the fact that we did not specify whether we meant advice with respect to work or with respect to more private problems. The second dimension measures the concept "friendship". All semantic differentials [11], the superficial and the direct friendship question are included in this dimension. The third factor is named the social support/social companionship dimension and consists of three items: two measuring social support and one about social companionship. With regard to the different types of questions (i.e. factual, hypothetical, direct and semantic differential), no differences appear. The factor loadings are not systematically

higher or lower for alternative question formulations. Contrary to what was expected, alternative formulations of the same concept belong to the same factor. Although there are differences in the construction of the questions, they nevertheless measure the same concept.

5.3 Cluster analysis

QAP-correlations can be used as a measure of similarity between the different questions. Questions that are highly correlated are more similar than questions characterised by a low correlation coefficient. We used cluster analysis to assign the questions to different groups. The cluster analysis is performed in UCINET V, i.e. a Johnson's hierarchical clustering [12] with average linkage. The results of the cluster analysis are consistent with the results of the factor analysis. The three clusters are identical to the three different factors found. A first cluster corresponds to the advice dimension in the factor analysis, whereas a second cluster captures the social support/social companionship dimension and the questions measuring friendship can be found in the third cluster.

Figure 2: Cluster analysis: dendrogram.

5.4 Multi-dimensional scaling (MDS)

A third technique used is multi-dimensional scaling (more specific PROXSCAL). This method has the property of visualizing results according to a number of dimensions. The different factors are combined resulting in three figures. Dimension 1 represents the type of relation (more advice and more friendship). Figure 3 represents factor 1 (the advice dimension) and factor 2 (the friendship dimension). Figure 4 shows the distinction between factor 1 (the advice dimension) and factor 3 (the social support/social companionship dimension). Finally, Figure 5, visualizes factor 2 (the friendship dimension) and factor 3 (the social support/social companionship dimension). In each figure both of the factors are represented by two distinct groups. The overall results of the multidimensional scaling procedure are confirming the factor analytical solution.

Figure 3: Multi-dimensional scaling: factor 1 and factor 2 (stress < .005).

Figure 4: Multi-dimensional scaling 2: Factor 1 and Factor 3 (stress < 0.005).

Figure 5: Multi-dimensional scaling 3: Factor 2 and Factor 3 (stress < 0.005).

5.5 Qualitative considerations

Up until now, the second research question is left unanswered. Besides knowing which questions measure which underlying factor, it is important to examine which questions of a particular concept are best suited to be used in further research. In network analysis, more than in other research, restricting the number of questions is essential. As said before, the 'sensitive' and 'threatening' social network questions are supposed to generate more item missing values. This requires a well-considered decision about the number and the type of questions included.

An important criterion in order to select certain types of questions is the proportion of missing values for each of the questions (Table 3). We can distinguish three groups: one with a lot of missing values (Q13 and Q16), a medium amount of missing values (Q8, Q10, Q11, Q14 and Q15) and the rest of the questions with a small number of missing values. Questions having a binary scale (i.e. the type 1a) cannot be compared with questions having an ordinal scale as an answer category (i.e. type 1b, type 2 and type 3 questions). In the case of the dummy variables an answer "zero" might indicate either the absence of a relation or a missing answer. This makes it impossible to calculate the percentage of item missing values in the same way as it can be done for scale questions. Therefore, both groups of questions cannot be compared. Notwithstanding, comparisons within each group and between different groups with scaled answer categories can be made.

A substantial percentage of missing values is found for Q13 (talking about important private problems) and Q16 (people whom one has a row with) vis-à-vis the other dummy variables. Because of the highly sensitive nature of these questions, respondents are less prone to answer it. In comparing the factual questions (type 1b) with the direct questions (type 2) and the semantic differentials (type 3) it is clear that the last two types of questions generate the least amount of missing values. Moreover, within the type 1b group the questions on social companionship and on cooperation have a smaller amount of missing values, than is the case for the other factual questions.

When a choice needs to be made between two questions measuring the same trait, it is advisable to choose the one that provide the researcher with the most high quality data (i.e. with the least number of missing values and generating the largest amount of information). Concerning the advice factor, this means that the factual questions and the direct question need to be preferred above the hypothetical ones. Factual and direct questions generate a lot of information and make it possible to distinguish missing answers from the absence of a relation (by means of a 'never' answer). However, the direct advice question was excluded from the analysis, which makes the current advice factor consisting only of factual questions. None of the questions measuring factor 2, i.e. the friendship dimension, has a large amount of missing values. For future applications, a choice should be

made, depending on content-related criteria, between the different items, except for Q17 (i.e. a dummy scale). Factor 3 consists of three questions, one hypothetical question (Q12) and two scale questions (Q13 and Q14) from which one has a large amount of missing values. It seems necessary to improve the questions to measure this factor.

Table 3:percentage missing values, mean and standard deviation per question.

6 Conclusion

Interest in formal and informal relations as explanatory factors in the organisational research context has been growing steadily. However, little research has yet been devoted to the construction of questions measuring social relations in complete networks. Because of their specific character, social network questions should be developed very carefully. They are perceived as sensitive or threatening questions, that are very burdensome to fill out. Consequently, social network researchers are often faced with severe nonresponse problems. Especially, when estimating complete networks limiting the number of missing values is of major importance. In order to reduce the nonresponse, researcher may interfere at two different moments, i.e. at the data collection phase and/or at the questionnaire construction phase. Concerning the first phase, we made use of a self-administered data collection method – i.e. a websurvey – which makes people more prone to answer sensitive questions. With respect to the construction of the social network

questions, seventeen questions of three different question formats – hypothetical and factual questions, direct questions and semantic differentials – were proposed. Fourteen of these questions are found to measure three different types of relations. Besides on estimating which question measures which underlying concept, our focus is also on the quality of the questions. Notwithstanding the exploratory nature of this research, some interesting results were found.

The first step consisted of ascribing these questions to a particular underlying dimension. One method to detect the overlap between different questions is the QAP correlation procedure. The obtained results indicated that some underlying dimensions might be present. To discriminate between questions we made use of factor analysis, cluster analysis and multi-dimensional scaling. Three different factors were found, representing respectively the advice network (five questions), the friendship network (six questions) and the social support/social companionship dimension (three questions). These findings are confirmed by the cluster analysis and the multi-dimensional scaling procedure. The question about the adversarial relation was omitted from the analysis due to a high number of missing values. Nevertheless, further research is needed on the measurement of negative social network relations. Two questions (the direct advice question and the cooperation question) were found to be measures of more than one underlying concept.

In a second stage, a quality estimation is made for each of the questions belonging to one dimension by means of the item nonresponse rate. Our findings show that semantic differentials and direct questions generate the least number of missing values. On the other hand, factual questions should be preferred above hypothetical questions. They generate more information and have the possibility to distinguish item nonresponse from absent relations. With respect to the advice network a selection should be made from one of the following factual questions: solutions, validation and meta-knowledge (Cross et al., 2001). Further research should focus on the improvement of the item response rate for factual questions. For measuring the friendship network one can choose a question from the four semantic differentials or the direct friendship question. The measurement of the social support/social companionship dimension needs to be improved, since only one question generates a small amount of missing values. More research on this dimension is necessary. In general, this paper improved the measurement of social network relations in two ways. First, by defining different network dimensions that are measured by a limited set of questions. And second, by identifying question formats that produce more high quality data than others.

The preliminary nature of this research makes it necessary to devote attention to the limitations of this research and to the possible ways for future research. One of these limitations concerns the small number of respondents to draw conclusions from. Only 25 employees actually responded to the questionnaire. A large scale research should be developed to retest our main research questions. Moreover, in future research, a comparison between the reported and the actual social network should be made. Knowing how accurate respondents answer on questions of a

particular type, is an important field of research. The fact that people were contacted by means of a websurvey might have an influence as well. Experiments with different self-administered data collection methods – such as paper and pencil and other types of websurveys – might shed new light on the results. Another important restriction of this paper, is the fact that the techniques used to establish the different conceptual dimensions are statistical tools that are developed for data drawn from an independent sample. These methods are not especially developed to deal with network data. Being aware of this, we found it necessary to compare the results of three different techniques. In our case no differences between the techniques are found, but this does not imply that no better suited techniques are available or might be possible. In addition, the reliability of the present findings should be tested (e.g. by means of a test-retest design) in order to make the results more conclusive. Another recommendation for further research is that efforts should be done to integrate these questions into an MTMM design. This complex technique might solve some remaining questions in relation to the construction of appropriate social network questions. Future research should concentrate more on nonresponse reduction, especially in the case of complete networks. It might be possible that certain imputation techniques can solve the most important nonresponse issues. Though the results of this paper are hopeful, a lot of work still remains to be done

Appendix 1: Network question used in the questionaire

Q7: Suppose that you are confronted with a work-related problem, for which you couldn't find a solution yourself. To whom of the members of your research group would you go for advice? [multiple choice question: dummy] *Q8: Consider all work related problems you had during the past year and for which you couldn't find a solution yourself. How often have you been for advice to each of the members of your research group?* [Five-point scale: daily – some times a week – some times a month – some times a year – never]

Q9: Suppose that you have found a solution for a work related problem. You are not certain about it and confirmation of others would reassure you. To whom of the members of your research group would you go for confirmation? [multiple choice question: dummy] *Q10: Consider all situations of the past year in which you think to have found a solution for a work related problem. You are not certain about it and confirmation of others would reassure you. How often have you been looking for confirmation to each of the members of your research group?* [daily – some times a week – some times a month – some times a year – never] *Q11: Consider all situations of the past year in which you needed crucial information/data/software, etc. for your work, but you didn't possess it yourself. How often did you obtain this information with the help of each of the members of your research group?* [daily – some times a week – some times a month – some times a year – never]

Q12: Suppose that you are confronted with serious problems at work (e.g. lack of motivation, problematic relation with a colleague). With whom of the members of your research group would you discuss these problems? [multiple choice question: dummy]*Q13: Suppose that you are confronted with serious problems in your private life (e.g. relational problems, death of a beloved one) lack of motivation, problematic relation with a colleague). With whom of the members of your research group would you discuss these problems?* [multiple choice question: members of research group: dummy]*Q14: How often does it happen that you do a social activity outside the work context with the members of your research group(e.g. going for diner, doing sport, going to the movies, etc.)? [attention: activities that are organised by the university itself, such as following courses or participating in a conference do not belong to this type of social activities!]* (daily – some times a week – some times a month – some times a year – never) *Q15: Consider all situation of the past year in which you cooperated with some members of your research group. With cooperation we mean: working together on the same project, solving problems together, etc.. Occasional advice does not belong to this type of cooperation. How often have you cooperated with each of the members of your research group during the past year? [*daily – some times a week – some times a month – some times a year – never] *Q16: In a work situation it can happen that members of a research group do not get along with each other. It could be that you have a row with some members of the research group, it could be that you try to avoid contact with particular colleagues, that you can't get on with someone, etc. With whom of the members of the research group can't you get along?* [multiple choice question: dummy]

Q17: In an organisation it often happens that people have only superficial contacts with particular colleagues, such as doing a meaningless talk about the weather, etc. With whom of the members of your research group do you have a rather superficial relation? [multiple choice question: members of research group: dummy]*Q18: Look at the following opposite adjectives: "distrust – trust". The more left you tick of a box, the more you associate your relation with a particular colleague with "distrust". The more right you pick of a box, the more you associate you relation with that colleague with "trust".* [distrust (-3)/ trust (+3)]

Q19: Look at the following opposite adjectives: "hostile – friendly". The more left you tick of a box, the more you consider your relation with a particular colleague as "hostile". The more right you pick of a box, the more you consider your relation with that colleague as "friendly". [hostile (-3)/ friendly (+3)]

Q20: Look at the following opposite adjectives: "superficial – profound". The more left you tick of a box, the more you consider your relation with a particular colleague as "superficial". The more right you pick of a box, the more you consider your relation with that colleague as "profound". [superficial (-3)/ profound (+3)]

Q21: Look at the following opposite adjectives: "formal – informal". The more left you tick of a box, the more you consider your relation with a particular colleague as "formal". The more right you pick of a box, the more you consider your relation with that colleague as "informal". [formal (-3)/ informal (+3)]

Q31: Consider your relation with each of your colleagues. Can you indicate in what sense you consider that relation as a 'friendship relationship'? [not at all– totally]

Q32: Consider your relation with each of your colleagues. Can you indicate in what sense you consider that relation as an 'advice relation'? [not at all– totally]

Family comes first: Men's and women's personal networks in Tehran

Abstract This paper examines the characteristics of middle class Tehranis' networks, based upon a survey of 318 individuals from the 159 households. The results show that women and men have similar-size networks. However, their networks differ substantially in gender composition, with each having almost two-thirds of network members of their own gender. Men's and women's networks contain a large proportion of kin overall. Most ties tend to be with immediate kin: children, parents and siblings. An immediate kin is usually the socially closest member of a network. Apart from voluntary factors, the importance of kinship ties in men's and women's networks may be the result of the macro-structural conditions under which patterns of social relationships take place.

2. Personal networks

A personal network consists of a focal actor (Ego), a set of network members linked to Ego, and the ties between Ego and these network members. For instance, "when studying people, one samples respondents, and each respondent reports on a set of alters to whom they are tied, and on the ties among these alters" (Wasserman and Faust, 1994: p. 42).

Social networks are constructed and maintained by individuals within specific contexts and reflect a variety of personal and social constraints (Fischer, 1982: p. 4). As Wellman and Wortley note, "they are both a product and a cause of role relationships" (1990: p. 559). Therefore, men and women's different roles within the labor force, family, and community both shape and reflect their social environments.

The results of North American studies concerning gender differences in network structure have been fairly consistent (Moore, 1990; Marsden, 1987; Fischer, 1982). They show that while men and women generally cite the same number of persons in their network, men's networks consist of fewer kin and more nonkin, fewer neighbors but more coworkers and friends. Women's networks contain a larger proportion of kin overall, more different types of kin, and fewer types of nonkin. Women tend to be the kin-keepers in families: organizing family events and staying in touch with distant kin. Tasks associated with working in the home also tend to persist – even for women working outside of the home (Wellman and Wellman, 1992). Men and women also differ in the number of females and males they identify as network members, in frequency of contact, and in the average age of network members.

Studies in the developing countries show greater differences between men's and women's networks. They indicate that there is a considerable separation between the worlds of men and women. A man is likely to spend his time in public places with his male friends, while his wife visits with her female friends at her home or at theirs (Sharma, 1986; Peil, 1981; Lomnitz, 1977; Peattie, 1968). Relations with kin and neighbors tend to be more important to women than to men. For women, kinship ties have priority on their time and energies, and are of much practical and psychological importance.

The developing countries are divided into societies characterized by vastly different environmental, cultural, and political settings, and these differences are reflected in the nature of personal communities. Middle Eastern cultures, for example, emphasize personal contacts and relationships. These are combined with systems of relationship groups that may increase the number of primary ties to hundreds or possibly thousands of persons (Costello, 1977; Abu-Lughod, 1961). In Iran, although 83 percent of urban households are nuclear families, they have extensive socio-economic relations with the kinship network. Such kinship networks (*khanedan*) in their cities continue to play a significant role as a system of protection (Nassehi, 1985).

Fischer and Oliker (1983) argue that structural constraints are a primary cause of gender differences in networks. They point out that: "the differing positions of women and men in the work force, in marital roles, and in parenthood create different sets of opportunities for and constraints on friendship building" (1983: 30). The traditional home-based existence of women, their primary role as home-keeper and mother, and the differences in standards regarding sexual activity, all play a part in the differences in

the networks of women and men (Fischer, 1982; Wellman, 1985; Gerstel, 1988; Campbell, 1988; Moore, 1990).

2.1. The data

My analysis is based on 318 structured face-to-face interviews conducted with individuals from 159 households. We interviewed both the husband and the wife from each household. The sample represents Tehran's middle class households who were randomly chosen from five districts (10 neighborhoods). The approach I used in this survey is similar to the approaches developed by Fischer (1982) and Wellman and Wortley (1989, 1990) with a few revisions to suit Iranian conditions. It uses questions specific to network analysis to elicit the names of people linked to the respondents.

As the focus of the study was on middle class households, I selected districts which are predominantly middle class. Districts (2, 3, 4, 5, and 6) are all located in the northern and central parts of the city. There is a clear north-south divide in the urban structure. A wide range of social and physical privileges distinguishes the northern part of the city, where the middle and upper classes live, from the southern part. The north has tree-lined streets with larger houses, lower densities, higher land prices, smaller households, higher rates of literacy and employment, higher concentrations of modern facilities and amenities, and more green space (see Madanipour, 1998; Markaz-e Motale'at, 1998).

3. Network size

An individual who has connections to more network members is more socially integrated than someone who has few connections. Network size is often an indicator of social resources. For instance, in looking for a job, a person with more friends (particularly diverse friends) is likely to get more information faster, and obtain help more easily.

3.1. Measurement

In this study, network size is measured as the total number of persons who provide different types of support and who have an intimate or significant relation with respondent is the network

size (see Fischer, 1982; Wellman, 1988). Each respondent was asked the following questions to generate the names of network members:

Who are the people with whom you discussed matters important to you? Who do you turn to, when you feel depressed and you want to talk about it? Who has recently turned to you to talk when they were feeling depressed? Who would you ask for help, if you were in need to borrow money? Who have you recently loaned a large amount of money? Who watches over your house when you are not in? Who has recently asked you to watch his/her house? Who from outside of your home has recently helped you with tasks around the home? Who have you recently helped with tasks around the home? Who have you asked to look after your children when you were not at home? Who have you recently helped with their children? Who are the people who you know best living inside your current neighborhood? Who are the people you enjoy socializing with? Are there any other people, besides those that you already mentioned, who are important to you or significant in your life?

The names produced by each of these questions were combined to estimate total network size. After listing their network members, the respondents were asked to provide demographic information for each of the people they named, as well as information on frequency of contact, residential location, etc.

3.2. Results

The average size of the networks in Tehran is 9.6, with sizes ranging from 2 to 24 ties. The actual size of respondents' networks is probably larger than what is reflected here. Some respondents said that if they wanted to name all their kin it would take several hours to list them. Closer examination reveals that most respondents were selective in naming their siblings or other kin. If they told the interviewers they had five brothers and sisters, they might only name three as network members. To be sure, when the interviewers probed for detail, more kin were named. However, probing did not add to the number of friends and other nonkin. This finding is congruent with previous studies in the Middle East (Costello, 1977; Abu-Lughod, 1969).

Women have slightly larger social networks than men: an average of 9.8 ties per network, compared to 9.4 ties among men (Table 1). This is in accord with Fischer's Northern California study (1982: p. 41) and Wellman's study in Toronto (1992b: 80; see also Moore, 1990) for the overall network. There are no isolated respondents. Only one respondent did not name any person outside the household. He is

retired, with 3 children at home that range in age from 17 to 29 years. He spends most of his time with his wife and children.

Although older respondents have larger networks, regression analysis suggests that age itself has little impact on total network size. Education is the only characteristic that predicts the network size of women. Women with higher education tend to have smaller networks, which is often the result of having smaller number of kin. Education, place of birth, and number of children are the best predictors of their network size.

By contrast to women, men with higher levels of education tend to have larger networks. These findings are congruent with previous network studies that have shown that there is a positive

Table 1 Network characteristics by gender

relation between education and network size (Campbell et al., 1986; Marsden and Hurlbert, 1988). Men have more opportunities than women to develop relationships with other people because they tend to move in a variety of different social contexts.

4. Network composition

The composition of the networks is indicated by the percentage of specific relationships in the network: percent kin, friend, neighbor, coworker. Several studies have shown the existence of kin ties and the support provided by these relationships (Adams, 1968; Firth et al., 1969; Wellman, 1992a; Wellman and Wortley, 1989, 1990). There is also evidence of intimate relationships among neighbors (Gans, 1962; Keller, 1968; Gilanshah, 1978; Bastani, 1989; Sedigh-Sarvestani, 1991), and among friends and coworkers (Laumann, 1973; Shulman, 1975; Fischer, 1982; Wellman, 1979, 1982; Wellman and Wortley, 1989, 1990).

Most of the research in developing countries has looked at ties with kin, friends, and neighbors that individuals and households use for coping with daily life. In these studies, the household has been widely used as the unit of analysis in studies of survival strategies. The household must cope with unemployment, sickness, disablement, and the like. Thus, networks are a household's resources and not just the 'property' of individuals (Roberts, 1978; Sharma, 1986; Espinoza, 1999). Although these studies describe personal communities in general, they do not present detailed information about such network characteristics as size, density and composition

4.1. Measurement

Each respondent was asked a set of questions to generate the names of network members. For each of the persons named, an additional question focused on their relationship to the respondent. Respondents mentioned different role types: spouse ('*hamsar*'), parent ('*pedar*/*madar*'), child ('*dokhtar*/*pesar*'), sibling ('*khahar*/*baradar*'), other kin (in-laws, uncles, aunts, and cousins), friend ('*doost*'), neighbor ('*hamasieh*'), and coworker ('*hamkar*'). The first five relationships (spouse, parent, child, sibling, and other kin) were coded as kin and the last three (friend, neighbor, and coworker) were coded as nonkin.

4.2. Results

The data showthat most Tehranis have socially close ties with both kin and nonkin. Respondents tend to name their kin first. If many ties are mentioned, neighbors and coworkers are likely to be included.

Table 2 Percentages of role types by gender (all ties)

5. Network density

Social networks with high density are often considered a positive thing. They are generally associated with kinship circles and vital urban neighborhoods and invoke the images of "community" and "togetherness" (Wellman and Leighton, 1979). High density networks have great potential to provide strong social support, foster social control, and aid communication among members (Wireman, 1984; Erickson, 1988; Lin et al., 1986). By contrast, low density networks, are associated with the idea of impersonal, transitory and segmented relationships. They evoke the image of the loss of community (Wellman, 1988; Wortley, 1996). However, low density networks may be more flexible and consequently more adaptive to the demands of a modern society that is undergoing continuous social change and in which most individuals are likely to be highly mobile, both geographically and socially.

5.1. Measurement

Network density, the extent to which network members are connected to one another, is calculated from the respondents' reports of relationship between others. Measuring density is more complicated than measuring network size and composition. The main goal is to know which of the respondent's members are also involved with each other.

The interviewers first entered the list of their network members in a network matrix. Respondents were then asked to indicate if each of their network members knew one another. Each respondent's answer to this question provided a picture of the general connectedness of her/his network. By counting all the checks in the matrix, the density index was computed.

4

The results range from zero, when each alter knows only the respondent, to one, when the members of a network all know each other. In a network with a density of 1.00, every individual would have direct connection to others. A densely-knit network is often more homogeneous and has greater potential for both strong social support and strong social pressure for conformity. There is no standard definition of when a network is a densely-knit network, but most researchers would apply this term to a network with a density of at least 0.67, where two-thirds of all possible ties actually exist (Wellman, 1977).

5.3. Network heterogeneity

The heterogeneity of a personal network measures the diversity of persons an individual can contact within her or his interpersonal environment. High diversity indicates contacts with multiple spheres of activity. Hence a diverse network provides access to information from multiple sources. Researchers have found this to be advantageous for instrumental purposes, such as finding a job or locating an illegal abortionist (Granovetter, 1974; Lee, 1969).

5.4. Measurement

Each person's social network can be homogeneous in one aspect, such as gender, and heterogeneous in another, such as education. For example, if a woman's friends are all women, her friendship network is completely homogeneous with respect to gender. Social networks of Tehrani men and women differ significantly with respect to gender composition, with men's networks containing a higher percentage of male (64 percent) than female network members. By contrast, women comprise only 62 percent of women's networks. Put another way, almost two-thirds of men's and women's networks are of the same gender as the respondent.

Network heterogeneity was calculated for both continuous and categorical variables. Continuous variables were measured by standard deviation. Age heterogeneity, for example, is indicated by the standard deviation of age among network members. The larger the standard deviation, the more different are the members of a network in terms of age. Categorical variables, such as occupation, were measured by the index of qualitative variation (Muller et al., 1970).

5

6. Discussion

The main concern of this study has been to analyze the characteristics of Tehranis' networks and to compare women and men's networks. Women and men do not differ with respect to the size of their networks. Both women and men have almost the same percentage of kin in their networks. These findings are different from the previous American studies that have found that men are more involved with nonkin and women with kin (Fischer, 1982; Fischer and Oliker, 1983; Marsden, 1987; Hurlbert and Acock, 1990; Moore, 1990).

This contrast could be the result of the macro-structural conditions under which patterns of social relationships take place. It may also be due to differences in data collection methods. Studies that have used the same name-eliciting questions as the one that I used, have shown compatible results to this study's findings (Fischer, 1982; van der Poel, 1993). They also have found that the number of kin that people are involved with depends on the number of kin they have, and that men are slightly less involved with kin than are women (see Fischer, 1982: p. 87).

The social networks of men and women differ substantially – but symmetrically – in gender composition. Men have networks that consist of nearly two-thirds men; women have networks that consist of nearly two-thirds women. Only two percent of the networks have no gender heterogeneity at all. This means that the networks are not segregated. However, most of the opposite-sex ties are with people who are "*mahram*"
[8]
to the respondents. The majority of the friends and coworkers in women and men's networks are same-sex ties. Whenever respondents named an opposite-sex tie, they almost always referred to it as a colleague, previous classmate, or spouse's friend. Only a few named a tie as a friend, "*doost*". Women named more opposite-sex friendships than men.
[9]
Although marriage gives more freedom to both women and men in Iran, it seems that it gives more freedom of expression to women than to men.

Among the demographic characteristics, respondents' education has significant effects on network size and composition. Respondents with higher levels of education have larger networks and higher percentages of nonkin in their networks (see also Fischer, 1982; van der Poel, 1993).

Educated respondents, as Fischer states, do not "lack kin ties, however; they simply seem[ed] to be more selective in relying on kin" (1982: 252). Educated women have lower levels of density which is the result of having a larger number of nonkin, especially friends, in their networks. Education allows women to develop relations with people from different contexts.

Contrary to some studies which suggested that older people have smaller networks (Fischer, 1982), older Tehranis have larger networks. This seems to be the result of Iranian family structure and the importance of kin in their networks, because older respondents have more children and siblings in their networks.

Previous research found that household income has significant effects on respondents' network characteristics, e.g., size and composition of the network (Fischer, 1982). In Tehran, only household income is associated with the nature of women's networks. Women with more family income have enough resources to exchange with their network members. On the other hand, women with lower income have more gender heterogeneity in their networks which may be the result of their dependence on male kin.

Family structure also affects networks. Although the presence of children in the household does not have any effect on network composition (see also Moore, 1990), having larger number of adult children increases network size for both men and women. Spouses and adult children play important roles in networks and increase the possibility of greater involvement with kin (see also Wellman and Wellman, 1992; Shulman, 1975).

Why are kin so important in middle class Tehrani networks? Is it a matter of conscious choice on the part of the respondents or a result of the opportunity structure? People often make choices in their lives about establishing and maintaining social ties. Over time, some ties develop into intimate relationships and others do not. Sociologists believe that the choices people make are almost never the pure result of their individual preferences (Fischer et al., 1977; Feld, 1982; Howard, 1988). To understand the patterns of social relationships in a society, it is necessary to look at the macro-structural conditions under which these patterns take place.

Apart from voluntary factors, the importance of the kinship ties in Iranian society can be interpreted in the light of socio-economic constraints imposed by the wider society. Family and kinship are meeting places where socialization of the young and marriage are facilitated:

The advent of the revolution in Iran introduced new rules of conduct in the relationship between young men and women and revised the leisure time function of the family. It dismantled some of the youth clubs that had been set up for the young and were being especially used by the middle classes. Although the revolution brought in some newavenues, such as mosques and other centers of political and social activities, socialization of the young remained under severe constraint. As a result, a new emphasis was put on the family and kinship as the centers for socialization (Madanipour, 1998).

The importance of kin ties may also be the result of the ambiguity of the criteria used for the allocation of resources and promotion in the socio-economic ladder. In Iran, informal connections still play a major role in the allocation of resources and in the labor market. In such situations, kinship ties are the best means to achieve the desired connections. Larissa Lomnitz's (1987) description of the family's role in middle class Mexican networks corresponds to that of Tehranis:

[The family] is the pivot of the culture and the core of social networks. Thus the family defines the strategies for gaining access to resources (economic and social) by members of the society. For example, in the early days of faltering state power, weak institutions, and frequent political changes, the system increasingly relied on personal connections. Social

networks became the main vehicles for mobilizing available resources: they became social capital Lomnitz (1987: p. 232).

Iran's young population structure and high fertility rate are other factors that can explain the presence of the high number of kin in personal networks. They increase the number of siblings and children, and as a result, the number of kin ties in networks. As the findings of this study indicate, the number of children is one of the main factors that predicts a network's structure and composition. On the other hand, people who are in middle age groups were born at a time when family size and fertility rates were much higher than today. This increases the number of their siblings and consequently the number of immediate kin in their networks.

The newkinship structure differs from the traditional Iranian one in the nature of the relationship between individuals and their kin. In the traditional structure, emphasis was placed upon group solidarity and the subordination of the individual to the group interest. In the new structure, the group is utilized by its members for social and political mobilization and for economic mobility. While the nature of kinship has changed over time, it still provides a strong and highly valued basis for life in Iran.

The height of the revolution was a period of intense politicization of households and of pluralism in political views and loyalties. In that situation, political differences caused wide variety of changes in social relations. Some ties with kin or friends had broken off and some new ties had been replaced. Some people tried to replace family and group loyalty with religious and political loyalty. After two decades, however, the intensity of the moment, and with it the collective loyalties, have weakened. The family has survived, broken kin ties have been revived, but what has also emerged from the ashes of collective emotions is a rising tide of individualism (Madanipour, 1998).

To be sure, kin ties are important throughout the world, yet, compared to North America, kin play a more important role in Tehranis' networks. In Iran, the family serves as an economic and political institution as much as a social one, and individuals maintain close ties to their kin throughout their lives. Compared to Tehranis, North Americans have larger number of friends in their networks, which can be the result of their higher levels of geographic mobility. Geographic mobility leads to a loosening of kinship ties, and therefore a greater reliance on nonkin ties, especially friends.

Yet, when I compare the Tehran's sample to a subsample of middle class, married people in Toronto and North California, the networks are similar in many ways. This leads me to conclude that while the

personal networks described in this study are products of interactions between the social and cultural circumstances in which Tehrani respondents are embedded, it is not correct to “over emphasize the cultural uniqueness” of Iranian society. Interestingly, this quotation by Shinsuke Otani (1999: p. 293) refers to Japan.

HOW FAR AND WITH WHOM DO PEOPLE SOCIALIZE? EMPIRICAL EVIDENCE ABOUT THE DISTANCE BETWEEN SOCIAL NETWORK MEMBERS

ABSTRACT

Hagerstrand's seminal argument that regional science is about people and not only locations is
still a compelling and challenging idea when studying the spatial distribution of activities. In the context of social activity-travel behavior (hosting and visiting), this issue is particularly fundamental since the individual's main motivation to perform social trips is mostly *with whom* they interact rather than *where* they go. A useful approach to incorporate the travelers' social context is by explicitly studying the spatial distribution of their *social networks*, focusing on social locations as *emerging* from their contacts, rather than analyzing social activity locations in isolation. In this context, this paper studies the spatial distribution of social activities, focusing on the home distances between specific individuals (egos) and their network members (alters) with whom they socialize -- serving as a proxy to study social activity-travel location.

Using data from a recent study of personal networks and social interaction, and multilevel models that account for the hierarchical structure of these networks, this paper provides empirical evidence on how the characteristics of the individuals and their social context relates with the distance separating them. The results strongly suggest that, although the spatial distribution of social interaction has idiosyncratic characteristics, there are several systematic effects associated with the characteristics of egos, alters, and their personal networks that affect the spatial distribution of relationships, and which can aid understanding of where people perform social activities with others.

1.1.

More generally, Tindall and Wellman (*11*) define the social network approach 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 (p. 265-6).

Hence, two components define this paradigm: **actors,** representing in this case the different persons composing the social network; and **relationships** or **ties,** representing flows of resources that can be related with aspects such as control, dependence, cooperation, information interchange, and competition. The core concern of the social network paradigm is to understand how social structures facilitate and constrain opportunities, behaviors, and cognitions (*11*). Social network analysis conceives the overall behavior as more than the sum of individual behaviors, and contrasts with explanations that treat individuals as independent units of analysis, as those traditionally used in travel behavior research. Thus, behavior is explained not only through personal attributes, but also by using social structural attributes that incorporate the interaction among the different social network members. From a travel behavior perspective, ties among people can be conceived as not only interactions between actors, but also as *links that represent potential activity and travel between them*. Consequently, the characteristics of these social networks – and the underlying individual relationships – become *sources of explanation* of activity and travel, as relevant as the traditional socio-demographic attributes.
Since a "whole" social network approach – which enumerates all the interactions in bounded social collectives (*12*) – is not feasible in large urban settings (lists of the population are not known in advance), this paper uses an **egocentric** or **personal networks approach.** Personal network studies focus on specific actors (**egos)**, and those who have relations with them (**alters)**. That is, from the respondent's perspective, egocentric networks constitute a "network of me" or a network of actors (alters) with whom the respondent has some relationship. Personal networks are thus composed of two *levels*: i) an ego-network level, constituted by the ego's characteristics and the overall features of an ego's personal network; ii) an ego-alter level, constituted by the characteristics of each alter and alter-ego tie.

2. DATA AND METHODS

2.1. Data: The Connected Lives Study

Specifically, the data consist of two instruments: i)A survey of a random sample of 350 people of overall interaction patterns, media use,
and general social network characteristics; ii)An in-depth interview of a subsample of 84 people that collected personal network data

(including alter's characteristics, such as relationship, home locations, and frequency of face-to-face and telecommunication interaction); as well as a sample of social activities between the respondents and their alters.

As noted above, these personal network data are composed of two levels: i) *egonetwork*, constituted by the ego's characteristics and overall social structure features; ii) *egoalter*, constituted by the characteristics of each alter and ego-alter ties.. *Ego-network* explanatory variables include attributes both of egos and their overall personal network. Ego attributes are age, presence of children in the household,

whether the they live with a stable partner, household income, years living in the study area, language spoken at home, and internet access. Personal network attributes are: -Network size (number of alters) -Number of isolates (alters only connected to the ego) -Density (ratio between the number of ties present in the network and the maximum possible ties in a network of alters), including and not including isolates -Level of sub-grouping -Proportion of alters with the same characteristics -Difference in the "level of activity" between alters

A summary of the most important findings of this multilevel analysis is the following:
-Lower income egos tend to have more distant personal contacts, but spatially closer socializing alters than their counterparts. The same effect occurs for older egos, who are likely to have more distant overall alters but closer alters with whom they actually engage in social activities.
-Immigrants tend to have more distant alters in their overall personal networks, but no farther alters in their socializing personal networks
-More years in the city and working at home are associated with more local personal networks.
-Ego-alter role relationships are associated with ego-alter distances. In particular, kin alters are more likely to be located farther than alters with other roles, both in the overall as well as in the socializing networks. Egos perform longer social trips when alters are kin.
-There is a relationship between network composition and ego-alter distance patterns. The effect of higher proportions of alters in the network with the same attribute "counterbalances" the effect of that attribute at the ego-alter level. For example, although extended kin have an *individual* tendency to live far away, higher proportions of extended kin in the networks make them more likely to be spatially closer to the ego.
-Social network structure measures are less relevant than ego and alter characteristics, and the network composition.
The results are discussed next in more detail, grouped into three categories: egos' characteristics, alters' characteristics; and social network composition and structure.

3.1. Ego s characteristics Egos that have *children at home* are more likely to have alters physically close, a result that also occurs when only socializing alters are considered. A possible explanation about this effect can be drawn from time constraints, which are probably higher for egos with children, making both tie maintenance and social activities more difficult with people located far away. In addition, the presence of children in the household is also relevant as a cross-level

effect with immediate family members considering all network members, although with a different sign: if egos have children, they are more likely to be further from their immediate family members. This result contrasts with the hypothesis that families with children would tend to live closer to their immediate family members so that they could receive support, such as

daycare. On the contrary, this result suggests that other location dynamics associated with the lifecycle stage of having children (e.g., job location, household size, immigration) may be more powerful than the potential support from immediate family members.

Although the *ego's age* is significant at the ego-network level only in earlier multilevel models, it becomes a much stronger explanatory variable crossed with *alter's age* in the final model 5 of both Table 1 and Table 2. In the model of all network members (Table 1), the *alter's age* slope indicates that, in general, older alters tend to be located closer to their egos. However, the crossed effect alter's age - ego's age suggests an opposite trend, indicating that, when ***both*** egos and alters are older, the previous tendency of alters locating closer is counterbalanced, with egos and alters tending to locate further than if any of them would have been young. In other words, although older alters have a higher probability of being located close to egos, this tendency becomes the opposite when the ego is also older. A possible explanation comes from mobility biography: older egos tend to have personal network members they know for a long time; and these alters have a higher propensity to locate further away (e.g., in other cities and countries) due to the ego and alter's spatial mobility in time. In contrast, the model with only socializing alters shows a negative effect of the ego's age, crossed level with alter's age, instead of the positive sign in the all alters model. That is, when egos and alters are older, they tend to perform social activities when they are spatially closer, possibly due to greater needs for accessibility and social support. In sum, when egos *and* alters are older, their distances are more likely to be longer, but if they socialize, alters are more likely to live closer to egos, as compared to their younger counterparts. Besides *age*, the other explanatory variable that changes signs between the two sets of models is *income*. In fact, ego-alter distances in egos with higher income tend to be shorter overall, but at the same time, when only socializing alters are considered, ego-alter distances in egos with higher income tend to be longer. This result suggests that equity issues may play a role in the spatial scope of individual networks, with higher income egos having higher mobility to perform social activities both from a spatial point of view – as seen here – and from the frequency of interaction perspective, as the results from Carrasco and Miller (*2*) suggest. In other words, although low-income egos may have a more dispersed personal network, their mobility constraints lead them to socialize less frequently and in a smaller spatial scope than their higher income counterparts.

The negative sign of *English spoken at home* in the all-alters model shows that recent immigrant egos tend to have more distant networks, confirming that the geographical scope of relevant contacts is heavily influenced by personal biography and mobility (*6*). At the same time, recent immigration does not play a significant relationship with

ego-alter distance when only socializing alters are considered. This latter result suggests that, although recent immigrant egos tend to consider alters living farther as relevant (possibly maintaining the relationship using communication technologies), their socializing patterns do not differ too much from non-immigrant egos, from a distance viewpoint, controlling for factors such as income. This latter result is also consistent with the inexistence of ethnic enclaves in the study area (*31*). Finally, three other personal and socioeconomic attributes show a significant effect on ego-alter log-distances. The *years the ego has lived in the city* shows a statistically significant effect in both final models (Tables 1 and 2): egos that have lived longer in the city are more likely to have closer contacts both overall and for social activities. Then, people who probably have longer-time local social networks tend to value these contacts both when they define their close alters, as well as when they perform social activities. This result is also consistent with Fischer's finding (*54*) that newcomers in the city tend to name twice as many middle distance alters and an even higher proportion of long distance kin alters. Note that this variable does not

show high levels of correlation with that of recent immigration, since captures egos that have moved both internationally and nationally. *Egos who work at home* are more local in their overall social networks, as the negative relationship with log-distance shows, an effect that is significant only in the all-alters case, but not in the only socializing network. Complementing Harvey and Taylor (*51*), who found that people who work at home spend more time with family at home or alone, they presumably also have a higher chance of interacting with more neighbors and, in general with more local alters. However, at the same time, these more locally relationships in egos who work at home do not translate into less long-distance socializing contacts compared with to those egos working outside home. This latter result is also consistent with Harvey and Taylor's evidence that, despite the potential low social interaction with work/student mates, working at home does not translate into less travel (*51*). When egos have *Internet access at home*, they are more likely to include longer distance alters in their networks. In fact, this variable serves as an indicator of whether the ego uses communication technologies to maintain relationships. In this sense, the sign of Internet access precisely shows part of the egos' capability of maintaining their longer distance alters. Note that this effect is only significant for the overall alter model, but has no relevant effect when only socializing alters are considered. Then, Internet access involve the ability to contact alters living at a long distance and maintain these relationships, but not necessarily to socialize with them. Distance is still an important barrier to face-to-face social interaction (*30*).

3.2. Alter s characteristics In the case of the influence of the alter's role, network members who are *immediate* or *extended kin* are more likely to live further from the ego. Mobility biography can be a potential source of explanation about this phenomenon: egos are more willing (or have more obligations) to maintain their ties with kin. The positive relationship between ego-alter distance and kinship relationship remains when only socializing alters are considered, that is, kin are those who locate farther in the socializing personal network. This result is interesting to complement with the evidence by Carrasco and Miller (*2*), who – using the same data – showed

that, controlling for the negative effect of ego-alter distance, individuals tended to socialize less frequently with kin, compared with other roles. In this sense, the frequency of kin social interaction is lower than with other alters, not only due to spatial separation but also because other factors (such as socializing being felt to be a kinship obligation). However, at the same time – since kin are located farther than other roles in the socializing personal network – egos are more willing to travel longer distances to socialize and maintain their ties with kin, compared to other roles. These results can be explained both because of kinship norms of connectivity and because kinship systems foster connectivity.

By contrast, n*eighbors* (as obviously expected), *work/student mates* and *friends* are more likely to locate closer to the ego (the latter having a very weak association). Note that out of those three roles, only *neighbors* have a significant positive effect when only socializing alters are considered. Interestingly, Carrasco and Miller (*2*) showed that, controlling for the negative effect of ego-alter distance, egos tended to have more frequent social activities with *neighbors*, *work/student mates* and *friends*, compared with *kin*. In this sense, the results in this paper show that, although egos socialize more frequently with these three roles, they are less willing to travel longer distances to socialize with them, as compared with *kin*.

Finally, the degree of centrality – which accounts for the alter's number of links with others in the personal networks – shows a positive relationship with ego-alter distance, in the overall contact network. Although the effect is weak, a possible explanation is that egos tend to maintain ties at longer distances with more connected alters, since they are more structurally

important in their personal networks: for example, kin or friends who know most of the other persona network members. Note that a similar result was found regarding ego-alter frequency of social interaction (*2*).

3.3. Social network composition and structure The composition of the social network, measured by the proportion of each role in the network, has some statistically significant effects, which tend to be in the opposite direction as the effect of their corresponding role in distance. For example, although *extended kin alters* tend to be located at far distances, if the ego has a higher *proportion of extended kin in the network*, they tend to be located closer, all else equal. By contrast, higher *proportions of neighbors, work/student mates or strong ties* are related with alters of each role locating at further distances. Note that, with the exception of the *proportion of strong ties*, these role composition effects are present only in the socializing alters model (Table 2). Thus, alters with roles that tend to locate further (closer) overall will locate relatively closer (further) if their proportion in the network is high. Possibly, there is a compensation mechanism between having long distance and short distance alters. For example, if a high proportion of alters in an ego-network are kin (i.e., who have some tendency to be located farther from ego), it will be more likely that at least some of these alters will be located closer than the average corresponding to their specific role.

Finally, network structure explanatory variables are almost absent as significant explanatory variables in the log-distance between egos and alters. The *number of components in the network* (excluding isolates) shows a weak negative relation with distance, suggesting that egos with more subgroups will tend to have spatially closer

network members. The crosslevel effect of *network degree of centrality* with the *alter's degree of centrality* also shows a negative effect, suggesting that the longer distance trend between well-connected alters and their egos is counter-balanced when the personal network has high differences in the degrees of connections with others. Overall, these results suggest that, although network composition and structure are associated with the physical distribution of alters, they are somewhat weaker as explanatory variables than when they are used as explanatory variables for the frequency of social activities (*1*, *2*).

4. CONCLUSIONS Although the spatial distribution of social interaction is a key characteristic of social activity-
travel behavior, our current knowledge about this issue is very scarce. This paper has studied the spatial distribution of social networks, recognizing that home locations of alters and egos constitute a key element to understand where social interaction occur. Using a data collection procedure that captures a relevant portion of the overall individual's social contacts, and through the multilevel analysis technique, the analysis focuses on the distances between egos and alters, explicitly considering the embedded social networks. The multilevel models employed in the study are capable of accounting for the statistically relevant intra-class variance produced by the nesting structure of ego-alter attributes embedded in specific egonetworks. The results show that a relevant portion of the variance of ego-alter distances cannot be explained without considering the personal networks where these egos and alters belong. The empirical models presented in this paper explicitly make the distinction between ego-alter distances in networks considering all alters and only those alters who actually socialize with egos. The distinction is important both conceptually and empirically because

people tend to maintain certain contacts, but without interacting socially face-to-face (or at a very low frequency). In general, the dichotomy all-alters / socializing-alters proved to be relevant in the analysis, especially for attributes such as income and age. For example, the results on this paper suggest that low income egos tend to have more spatially distant alters overall, but at the same time, they tend to have spatially closer socializing alters than their higher income counterparts. Similarly, older egos tend to have more spread networks overall, but more local socializing networks accessible for support and interaction. These relationships suggest an interesting venue for linking social network spatial distribution, and equity and social exclusion issues, where the focus on accessibility to people is put upfront. Several other ego characteristics have a statistical relevant relationship with respect to the personal networks spatial patterns. For example, the relevance of egos' age and the presence of children at their homes, give empirical ground to the importance of lifecycle in the personal network distance patterns, as was theoretically recognized long ago by Horton and Reynolds (*15*). Another significant result respect to the egos' attributes, suggests that more years living in the city involves shorter distances with alters, showing that newcomers in the city have more contacts at farther spatial scales, consistently with previous findings (*50*). In addition, the empirical evidence in the paper shows that egos that work at

home tend to have spatially closer networks overall, but not necessarily closer socializing distances, showing that telework does not decrease all travel distances necessarily. The nature of ego-alter ties are associated with the spatial distribution of social networks. Kin tend to live farther than friends, and social activities between kin tend to be at longer distances than between friends. Thus, individuals maintain kinship ties at longer distances than with friends and are more willing to travel longer distances to socialize with them. From a transportation policy perspective, this finding suggests that patterns of travel distance certainly vary according to whom is involved in the social activity.

Aside from ego and alter attributes, the analysis presented in this paper explicitly tested whether social network characteristics have some influence in the spatial distribution of alters. Network composition shows a compensation effect, where a higher proportion of a certain role in the network balances the spatial scope of that role. For example, although kin alters tend to live farther than other roles, networks with a higher proportion of kinship ties involve some of them living closer.

Finally, except for weak negative associations with the number of components and network degree of centrality, there is no evidence of strong systematic effects of network structure in spatial distance. This result contrasts with the important influence of structural measures such as size and the number of components in the frequency of social activities between individuals (*2*). In that sense, understanding the spatial structure of relationships and consequent trips does not need a strong knowledge of the embedded social structure of these interactions. More generally, the analyses performed in this paper reveal that, although the spatial distribution of personal networks can have some idiosyncratic characteristics, there are several systematic effects that affect the spatial distribution of ties and which can aid understanding of where people perform social interactions with others. Furthermore, from a transport policy viewpoint, the dependency of the spatial distribution of personal networks on aspects such as income, and lifecycle point to the relevance of studying the spatial distribution of individual's home locations as potential source of social activity travel.

The analyses presented in this paper also highlight the importance of explicitly studying with whom egos interact, and the composition and structure of the personal networks in which these ties are embedded, as such network characteristics influence and constitute sources of explanations of ego-alter distances and the spatial distribution of social activities.

Overall, the empirical evidence presented in this paper give illustrate the need for understanding social activity-travel from a person-to-person perspective rather than focusing only on physical place (and destinations), analytically isolated from the traveler's social context. In that sense, the explicit incorporation of personal networks provides a useful and sensible approach to go beyond the traditional individualistic paradigm in the study of the spatial distribution of social activity-travel, and situate travel behavior in social and physical space.

The social dimension in action: A multilevel, personal networks model of social activity frequency between individuals

abstract
This paper presents a social activity-travel generation model, which explicitly incorporates the individual's social dimension through the concept of personal networks, modeling the multilevel structure of social relations defined by these networks. The objective of the analysis is to study the relevance of the social dimension as a source of explanation of social activity-travel generation behavior between an individual and each relevant person of their social life. The paper uses a disaggregated perspective of personal networks, explicitly incorporating the characteristics of each network member as well as the characteristics of the overall social structure. Using an ordinal multilevel specification that accounts for the social network in which individuals are embedded, four dimensions are studied: personal characteristics, "with whom" activities are performed, social network composition and structure, and ICT (information and communication technology) interaction. The results show that a proper and complete understanding of social activity generation requires going beyond the individualistic paradigm, explicitly incorporating the role of the social dimension in the study of this decision-making process.

1. Introduction

1.1. The context

Activity-based approaches recognize the need of more truly behavioral explanations considering travel as a derived demand, triggered by the desire to perform activities with others (Axhausen and Gärling, 1992). Although this recognition has been around for a long time, the need to complement the dominant individualistic approach is still an important research challenge. Travel demand models in general, and those that explain the generation of trips ("why" travel is performed) in particular still heavily rely on the individual socioeconomic characteristics of travelers, rarely considering the importance of the individual's social dimension. In the context of social activity-travel generation, this omission is even more crucial since precisely "with whom" individuals interact constitutes the main motivation to perform the social activity and related travel. In fact, as Bhat and Lawton argue, our understanding of social interactions in travel demand analysis is very scarce:

(...) interactions among decision-making agents, and the effect of such interactions on activity patterns, are topics that have received limited attention thus far in the travel demand analysis literature. Interactions among decision-making agents might take the form of joint participation in certain activities, such as shopping together or engaging in recreational/social activities... (Bhat and Lawton, 1999, p. 3).

Complementarily, there is a growing interest in the study of social activities, recognizing their importance in the overall travel patterns, and their behavioral difference with more studied purposes, such as work and shopping (Bhat and Gossen, 2004). Despite this interest, theoretical and empirical analyses that explicitly link social travel behavior and social interactions have been very limited. Moreover, although there is considerable progress understanding and modeling activity-travel decision-making processes in time and space (e.g., Timmermans, 2005), little is known about the linkages between social interactions and travel behavior. A main reason about this gap in the literature is that only recently reliable data have been collected that could link social activity-travel and social networks. Still, the interest and study about the role of the social dimension in transportation is increasing over time, both using simulation studies (e.g., Dugundji and Walker, 2005; Pinjez and Scott, 2007), and empirical studies (e.g., Larsen et al., 2006).

In this context, this paper presents a social activity-travel generation model, which explicitly incorporates the individual's social dimension through the concept of personal networks, modeling the multilevel structure of social relations defined by these networks. The objective of the analysis is to study the relevance of the social dimension as a source of explanation of social activity-travel generation behavior. Although the emphasis of the paper is on understanding the behavioral processes of social activity-travel generation, the final aim is to provide a "proof of principle" about the importance of explicitly incorporating the social dimension on future operational, forecasting models, especially microsimulation-based approaches, which may capture more complex activity-travel behavior at the disaggregated level (Miller, 2003).

The paper uses a disaggregated perspective of personal networks, explicitly incorporating the characteristics of each network member as well as the characteristics of the overall social structure, such as size, density, composition, and other related aspects. The method employed to model all these dimensions uses the advantages of this disaggregated approach, in terms of being able to study in detail the role of each of these previous aspects in the social activity frequency between individuals.

Thus, two key sources explain behavior: personal attributes and relational attributes,

2. Data and methods

2.1. Data: the Connected Lives Study

The data used to perform the analysis is part of connected lives study, a broader study about people's communication patterns, conducted in the East York area in Toronto by the NetLab group at the Centre for Urban and Community Studies, University of Toronto, between May 2004 and April 2005 (Wellman et al., 2006). The East York area is located east of downtown Toronto, and is fairly representative of overall inner city characteristics regarding socio-demographics and general transportation characteristics. The data were collected in a survey and a follow-up interview of 84 people, which elicited their personal network members (a total of 1019) and interactions with them.

Personal networks concentrate on specific people or egos and those who have relations with them, called alters. From the respondent's perspective, these networks constitute a "network of me" or a network of alters with whom the respondent has some relationship. The data are thus composed by two levels: (i) ego-network, constituted by the ego's characteristics and overall social structure features and (ii) ego-alter or ego-tie, constituted by the characteristics of each alter and ego-alter ties. The personal networks collected in this study concentrated on the individual's affective network or people the respondent defines as emotionally close, an approach that seems useful to understand communication and social activity-travel patterns. Concretely, respondents named people who lived outside their household, with whom they felt very close and somewhat close. Very close consisted of "people with whom you discuss important matters with, or regularly keep in touch with, or they are there for you if you need help". Somewhat close consisted of "more than just casual acquaintances, but not very close people".
This "closeness" approach defines two aspects. First, closeness measures tie strength: strong and somewhat strong. Second, closeness defines the personal network "boundary", excluding casual acquaintances and the social activity generation that arise from those contacts.
In addition, respondents were asked to record the existing strength they believed existed among alters; these connections are used to study the structure of the resultant personal networks. Finally, the data collection process also collected two sets of information regarding each alter. First, information about alters' characteristics was gathered, including age, relationship, job, and ethnic heritage as well as their home location and most frequent place of interaction with the respondent. Second, information about the communication and interaction patterns between each alter and the respondent was gathered, by face-to-face, socializing, telephone, e-mail, and instant messaging. For further details about the collection procedure and main data characteristics, see Hogan et al. (2007) and Carrasco et al. (forthcoming).
All these characteristics constitute a rather unique data set, where not only the respondents' characteristics are collected, but also specific details about with whom they interact, as well as the characteristics of the respondents' personal networks. The respondents' networks included detailed information not only about the alter composition by role or other attributes, but also about their structure (such as size, density, and subgrouping). In that sense, the analysis of this data set constitutes a unique opportunity of testing the social dimension in an approach that will truly go beyond the individual as the unit of analysis.

Social network structure includes:
– Size (number of alters). – Number of isolates (alters only connected to the ego).

– Density (ratio between the number of ties present in the network and the maximum possible).

– Network subgrouping.

– Difference in the potential "activity level" between alters.

3. Results

3.1. Model development

The results from the models are presented in Table 1. Models were estimated using the statistical package HLM (Raudenbush et al., 2006). As discussed before, the PQL estimation procedure does not compute reliable likelihood values to perform overall model statistical tests. For this reason, the main goodness of fit measure in the fixed coefficients are t-statistics; v
tests are only used to highlight the statistical significance of the random errors. The models were specified using a sequential procedure inspired by Hox (1995) and Van Duijn et al. (1999), consisting of six 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) Add random slopes to fixed ego-network explanatory variables. (5) Using model 3 as base, add cross-level explanatory variables. (6) Add random slopes to model 5. Models 1 to 4 constitute a reference with respect to the more complex structures of models 5 and 6. These last two models are the more interesting from a theoretical viewpoint since they incorporate the cross-effect between both levels, that is,

the combined effect that alters (and ties) and egos (and networks) have on the frequency to perform social activities. Model 6 also incorporates random effects in some coefficients. Note that some explanatory variables that were statistically significant in ego-network and/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 in order to prevent the intrinsic bias of this type of forward specification.

A summary of the most important findings from these models is the following:
– Individuals earning high incomes, being male, not living with a partner, and/or working at home, have more frequent social activities with their social network members.
– Younger individuals tend to have higher frequency of social activities. At the same, when both ego and alter are old, their social activities are more likely to be more frequent, suggesting a homophily effect.
– People who have lived longer in the city, have an overall lower frequency of social activities. – Longer distances between individuals involve a lower probability of frequent social interactions. This effect is stronger for distances not reachable by car in one day. – "With whom" egos interact has a relevant role in the social activity generation. – Individuals tend to have more frequent social activities with friends, males, and very close alters. – Personal network composition mostly influences the frequency of social activities as a cross-level effect between the alter's attributes (role, closeness) and the proportion of those who share similar characteristics. – Three network structure measures have a significant effect in social activity frequency: number of components, density, and degree of centrality. – Telephone has a complementary role, and instant messaging has a substitution role with respect to social activities. – E-mail seems to play both a strong substitution role for distant alters (who have low frequency of social activities) and a complementary role for closer alters (especially for those with medium intensity of social interaction).
The next sections present these results in more detail, grouping explanatory variables in four categories: ego and alter's personal and household attributes, personal network composition, personal network structure, and ICT interaction.

3.2. Personal and socioeconomic attributes

Egos with higher income are more likely to perform frequent social activities with each alter; a result complemented by their higher propensity to perform social activities, as seen using the same data in (Carrasco and Miller, 2006). Female egos, on the other hand, are less likely to socialize frequently with each alter. Female alters tend to have lower social frequency than males; however, there are no significant cross-level gender effects, that is, each gender effect is independent to the other. This lack of cross-level effects shows that there is no presence of homophily, that is, higher social activity frequencies are not related with egos and alters having the same gender. An opposite result occurs with age, where the only significant effect in the final models is the cross-level interaction, which shows that when both ego and alter are older, they are more likely to have frequent social activities. This positive cross-level effect is consistent with the positive effect of the alter's age found in models 2–4, which becomes statistically not significant in the final models. This result is also complemented by the lower propensity to perform social activities in older egos (Carrasco and Miller, 2006). Then, older egos overall tend to perform less social activities, but at the same time, if the alter's age increases, they are more likely to perform more frequent social activities. Note that these results are consistent with the literature review by McPherson et al. (2001), who show that in general homophily is much stronger with respect to age than gender.
When egos have a stable partner, their frequency of social activities with each alter is relatively lower than without a stable partner. Egos who work at home are more likely to socialize frequently with each alter, which is an aspect that can be explained by their potentially higher flexibility in managing their time budgets; this explanation is consistent with their higher propensity to perform social activities (Carrasco and Miller, 2006).
The more years egos have lived in the city the less frequently they socially interact with each alter, contrasting with the result that more years in the city involves a higher propensity to perform hosting/visiting social activities with strong ties, as shown in Carrasco and Miller (2006). That is, egos with older local social networks – as expected with those living more years in the city – specifically are more likely to host or visit strong tie people, but overall they are less likely to perform frequent social activities. Note that years in the same household does not show any significant effect in any model, contrasting with the results in Carrasco and Miller (2006) of a high propensity to host/visit with strong ties. This explanatory variable does not show in these models presumably since neighborhood socializing propensities are more explicitly tested in network composition variables such as neighbor alters and the proportion of neighbor network members.
Finally, distance shows a strong negative effect in the probability of higher frequencies of social activities, both at the close spatial scale (alters reachable by car in one day of travel) and at the far spatial scale (alters not reachable by car in one day of travel). In addition, the absolute value of the coefficient of far spatial scales is higher than closer scales, that is, alters who are not reachable by car have proportionally a lower probability of higher social frequencies than those closer. These tendencies complement the result found in Carrasco and Miller (2006) regarding the positive propensity to perform social activities for egos that have a higher proportion of alters living in Canada at more than one hour of travel. In the case of the analysis of the propensity to perform social activities, distance is a network composition variable – involving how many people lived at

more than one hour's travel – which measures the propensity to maintain those relationships. On the contrary, in this paper, distance measures how each ego-alter physical separation affects their social activity frequency. Then, the

combined results show that, on the one hand, egos who have a high proportion of network members living relatively far away have a higher propensity to perform social activities, and that at the same time, longer distances between ego and alter involves a lower probability of frequent social activities between them.

3.3. Social network composition and "with whom"

Social network composition has an important effect in the frequency of social activities; although the effect varies according to alter type. If the alter is a friend, social activities are more likely to be more frequent, independently of the proportion of friends that the egos have in their network, that is, independently of the ego's network composition of friends. On the contrary, the effect of alters who are extended family members, neighbors,orstudent/work mates is only relevant in relation to the overall proportion of people with the same role in the network. In these three cases, higher proportions of alters in the network involve higher probability of frequent social activities. In other words, egos who are more oriented to a specific role (e.g., neighbor-oriented egos,with a high proportion of neighbors) tend to have higher social activity frequency with those kind of people than thosewho are not. This intuitive result illustrates the importance of knowing not only "with whom" activities are performed with, but the social networks within which they are embedded, that is, the egos' overall social network composition.

A much more complex set of explanations involve the effect of immediate family alters. First, and differently with respect to the previous roles, the proportion of immediate family has a negative incidence in the probability of higher social activity frequencies. That is, egos with a higher proportion of immediate family alters tend to have a relatively lower tendency of socializing than thosewho have a higher proportion of alters with other roles. Second, two specific ego characteristics affect the social activity frequency when the alter is immediate family: living with stable partner and presence of children at home. Egos with stable partner tend to have more frequent social activities, possibly since they may have more social obligations with family members. Note that the effect of this variable when the alter is an immediate family member goes in the opposite direction with respect to the overall effect of having a partner. On the other hand, children at home make less likely frequent social activities with immediate families; a possible explanation are time pressures due to more children-based obligations.

Finally, as intuitively expected, if the alter is very close, the ego is more likely to have more frequent social activities, that is, emotional closeness is positively related with more frequent social interaction. However, if egos have a higher proportion of very close people in their network, they are relatively less likely to have frequent social activities with very close alters. Then, there is a two-way effect: very close alters imply a higher probability of frequent social interactions, but when the ego has too many of them, this probability decreases. An explanation of this phenomenon comes from the definition of strong ties. Very close people are not necessarily thosewith whom egos regularly keep in touch and socialize, but also those with whom important matters are discussed or are available if help is needed. Then, egos with a lower proportion of very close people match the networked individualism hypothesis of egos,which argues about very intense interactions in networks with more weak ties (Wellman, 2001). Therefore, egos not matching those patterns may have less intense social interaction.

3.4. Social network structure

Three measures are statistically significant in the models: number of components, density, and degree of centrality. The number of components, which measures the number of disconnected subgroups in the network, has a positive influence in the frequency of social activities. This contrasts with the possible expectation that more components involve the egos' need to "divide" their social activity "time budget" among more alters, having as a consequence lower social activity frequency with each alter. However, the number of components better reflects the different subgroups that individuals are willing to manage and maintain. In other words, those egos with a higher number of components in the network are consistent with the network manager figure argued by the networked individualism hypothesis in sociology (Wellman, 2001; 2002a,b): people maintain more specialized, role-to-role relationships, with memberships in several networks, and intense relationships with each of them. Each component probably represents these different specialized subgroups. Note that the intensity of contact is better captured by the number of components rather than by other alternative indicators, such as network size and number of isolates (alters only connected to the ego).

A second key structural explanatory variable is network density, which shows a positive effect, that is, egos with denser networks are more likely to have higher frequency of social activities with each alter. Since density is measured considering both strong and somewhat strong ties, higher values denote more connectivity among alters. Then, greater overall connectivity implies a higher probability of more frequent social interaction with each alter. In other words, in denser networks, if the ego has a social interaction with a specific alter, there is a higher likelihood that is also interacting with others.

The final structural measure found statistically significant in the models is the degree of centrality. Although this measure has been traditionally used in social network analysis as a measure of "power", it can be interpreted in this context as a general indicator of network activity level (McCarty, 2002). Although alters' point degree of centrality becomes non-significant in the final cross-level models, the positive sign in simpler models is consistent with the intuition that alters with higher

degrees – that is, alters with more direct connections with other network members – have a higher probability of frequent social interaction with the ego. This explanation is similar to the previous argument used with density. The network centrality degree – which measures the variability in the point centralities in the network – has also a positive influence in social activity frequency, as a stand-alone measure in models 3 and 4, and as a crossed-level effect with point centrality degree in models 5 and 6. Although this cross-level effect is statistically not too strong, a possible explanation is the role that high degree alters play in networks with high centrality degree. These alters may play a

role linking several other low degree alters with the egos in social activities (e.g., parents attracting siblings, friends attracting ego and other alter friends).

4. Synthesis and conclusions

In this paper, social activities have been explored from the perspective of the frequency of social interactions between egos and alters, explicitly considering their embedded social networks, and the effect of their interaction using ICT. In order to capture these complex effects, multilevel models provide a very useful approach since they take into account the nested structure of ego–alter relationships within specific ego-networks, modeling the systematic effects as well as the random variations of each level. The overall results show that if the frequency of social activities is only explained by the socioeconomic characteristics of egos, a whole set of important behavioral processes are completely overlooked.

Socioeconomics provide some explanations, mostly in terms of income, gender, and age, as well as lifecycle, working at home, and years living in the city; some of these aspects have been recognized long ago as important attributes influencing the frequency of interaction (Fischer et al., 1977; Fischer, 1982). However, the characteristics of "with whom" social activities are performed also play a crucial role, which is intertwined with the ego's characteristics. The case of age is a good example, where the ego's age is relevant mostly with respect to the age of the alter. A second key example is the effect of distance, which shows the alter's location as one of the strongest effects in the frequency of social activities; this result is consistent with previous similar studies (Fischer, 1982; Mok et al., 2007). The importance of "with whom" as an explanatory variable is more explicit when the effect of the alter's role is considered. If the alter is a friend and/or is very close, the ego will tend to have more frequent social interactions with her/him. This association between frequency of interaction and strength of relationship is consistent with previous results in the literature (Wellman and Wortley, 1990). A second key aspect linked with the alter's characteristics is the ego's network composition, measured by the proportion of network members who share the same role or characteristic. In fact, as recognized by Wellman and Frank (2001), emergent properties in behavior arise from the network composition as well as its structure. The results show that higher proportion of extended family or neighbor or student/work mates involve egos more willing to have frequent social activities with that kind of people, all else being equal.

A further exploration of the importance of social networks in social activities would not be complete without studying the effect of structural measures. The significant explanatory variables highlight the relevance of connectivity and specialization within the network. In the case of connectivity, the fact that higher network densities involve more frequent social activities highlights the intuitive result that the more other network members an alter knows, the more social activities potentially she/he can participate. In a similar way, degree of centrality (both at the alter and network level) proves to be a good measure of the "network activity" (McCarty, 2002), where alters with higher degrees are more likely to perform frequent social activities (they "know" more people). The second relevant aspect corresponds to the egos' specialization in their social contacts, measured by the number of existing subgroups in their networks. In fact, more subgroups imply that the ego is willing – and capable – to "maintain" different specialized subnetworks, following part of Wellman's networked individualism hypothesis (2001, 2002a, 2002b). In particular this specialization was found in the significant positive effect of the number of components (number of disconnected subgroups in a network) in the frequency of social activities.

A fourth and final aspect investigated is the alternative ways egos and alters have to socially interact, using telephone, e-mail or instant messages. The results showed dissimilar trends, suggesting that the effect of ICT over social face-to-face interaction is very media specific. Telephone shows a strong complementary effect with social activities; that is, more frequent telephone contact involves more frequent social activities, which is consistent with the intuition of considering phones as key coordinating devices between people (Wellman and Tindall, 1993; Mok et al., 2007). E-mail, on the other hand, is a completely different medium with respect to its effects on social activities. In fact, the model does not show a significant effect of e-mail frequency on social activity frequency. However, as the follow-up analysis argues, e-mail is a key media for people located very far from egos (e.g., international contacts) with whom social activities are very rare. Conceptually, this result can be defined as "substitution" – as some authors such as Larsen et al. (2006) argue – since more e-mail frequency involves less frequency of social activities.

However, the behaviorally relevant aspect here is that, since distance involves a higher difficulty of social interaction with these far located alters, e-mail plays a key role in maintaining the contact with these alters, potentially providing the opportunity – if conditions arise – for face-to-face social activities. In addition, for closer distances, e-mail is found to be coupled with social activity frequency: if an ego never performs social activities with an alter, there is a high probability of no e-mail contact between them; a relationship that is also very similar for medium to low frequency of social and e-mail interaction.

A caveat of the previous analyses is that social networks are considered as a "static" rather than dynamic entity. This is acceptable from a short to medium term perspective, but is potentially incomplete from a point of view of long-term processes. Furthermore, since social networks provide useful insights about the social activity generation process, a step toward understanding this phenomenon necessarily involves the study of social network dynamics. Other aspects that potentially can expand our understanding of social activity generation within a social network framework

include the explicit consideration of time use and activity scheduling processes; the study of the importance of agency in ego-alter interactions (i.e., how "proactive" seeking interactions egos and alters are); and the study of the role of personal networks in different urban and cultural contexts.

Overall, the explanation given by the four aspects studied in this paper (personal characteristics, "with whom" activities are performed, social structure, and ICT interaction) shows that a proper and complete understanding of social activity generation requires going beyond the individualistic paradigm, explicitly incorporating the role of the social dimension in this decision-making process. In that sense, a main contribution of this study is providing empirical results about the role of the social context in the frequency of face-to-face (i.e., travel related) and virtual (i.e., ICT related) interactions, showing that both "with whom" and the embedded social networks do matter on understanding social activity-travel generation. In that sense, the great level of detail of the data and consequent analysis regarding the traveller's social context gives the novel opportunity of understanding an aspect that rarely has been in the transportation researchers' radar in the past, precisely due to the lack of these kinds of data in the past.

In that sense, two further research opportunities from this research can be distinguished: modeling social networks in travel demand models, and new transport-related policy insights. Although still it is early days for an explicit implementation of social networks in a working travel demand model, this seems to be a feasible proposition, considering promising approaches in travel demand, such as microsimulation (Miller and Roorda, 2003; Salvini and Miller, 2005), which in principle can incorporate the role of personal networks in the decision to perform a social activity and the associated trip. A key research question in this regard is the need of explicit models of social network formation; and although some attempts have been recently made (Hackney and Axhausen, 2006), much more research is needed for a practical implementation.

Finally, from a transportation policy perspective, an explicit incorporation of the social dimension in the social activity-travel context provides the opportunity of linking the study of transport and accessibility provision policies with broader societal concerns, such as the access to people and their resources in the individual's network (social capital) as well as the relationship between low spatial accessibility and social exclusion. In fact, the data, methods, and results from this paper put upfront the relevance of the social dimension in social travel, showing that explicitly studying personal networks in this context can serve as a useful hinge between transport and broader urban policies aimed to encourage the connectivity among people.

Entrepreneurship Research on Network Processes: A Review and Ways Forward

Although entrepreneurship research on networks has studied issues pertaining to network content, governance and structure, we believe it requires a greater understanding of network processes. In this paper, we review how the entrepreneurship literature interprets and applies the concept of process to the study of networks. This allows us to identify areas for future investigation. Our work is also informed by social network theory and research on dyadic interactions in business networks. The paper concludes by presenting a theoretical framework for conceptualizing and studying the various processes associated with network development.

Introduction

In recent years, an interest in networks has permeated entrepreneurship research. A review of network research by Hoang and Antoncic (2003) demonstrates that the entrepreneurship literature emphasizes network content (the nature of relationships and the resource access they provide), network governance (how networks and resource flows are coordinated) and network structure (the patterns of relationships within the network). In their discussion, studies are categorized as either: (1) focusing on how networks impact the entrepreneurial process; or (2) focusing on how entrepreneurial processes impact network development. This categorization is consistent with Borgatti and Foster's (2003, p. 1000) observation that a "fundamental dimension distinguishing among network studies is whether the studies are about the causes of network structure or their consequences." In this article, we build on Hoang and Antoncic to examine how the entrepreneurship literature views networks and how it interprets and applies the concept of process to the study of networks. We also assess other approaches to conceptualizing and studying networks and use this comparison to identify a number of issues for entrepreneurship research. Finally, we develop a theoretical framework to capture the various processes associated with network development. The background to this research and our specific research objectives are outlined in the next section.

Background

A primary contribution of Hoang and Antoncic (2003) is their timely and rich critique of the network literature in entrepreneurship that culminates in directions for further inquiry on network process issues. This stimulated our thinking for the current research for three reasons. First, we note that in the relatively short period of time since Hoang and Antoncic, a number of studies focused on network processes have appeared; studies that could be examined with the sole purpose of understanding process-related issues. Related to this, we are aware of other, earlier, studies that escaped Hoang and Antoncic's attention; studies that could also provide insight.

Second, we note that while Hoang and Antoncic (2003) imply the need for research that addresses the concept of process, it is not clear how they interpret this concept nor how process may have been defined in past entrepreneurship network literature. For example, while Hoang and Antoncic seem to consider process as involving general sequential activity, Van de Ven (1992) explains that a developmental sequence of events can be explained by four different abstract ideal theories. He also suggests that the developmental view of process is the least understood with researchers more likely to adopt other meanings of the concept. That is, where process is viewed as a logic to explain causation between variables or alternatively, variables are measured over time to capture change. This complexity around the "meaning of process" provides another opportunity for our study since we believe it is important to understand the various meanings used to guide the theoretical arguments and empirical investigations of networks in entrepreneurship.

Third, as a result of conducting our own research we are aware of the range of scholarly areas interested in network phenomena. Thus, while we agree with Hoang and Antoncic's (2003) approach to their review, we see the opportunity for an extension that would: (1) focus on process-related network literature in entrepreneurship, but also, (2) import knowledge from other approaches to help inform future entrepreneurship research.

Following from this, we have a number of specific objectives for this study. First, we extend Hoang and Antoncic (2003) by assessing other network process literature published since their review or not included in their original arguments. This allows us to develop a greater understanding of network processes and to identify areas worthy of further attention. Second, we combine the research from our review with that discussed by Hoang and Antoncic to assess which meaning(s) of process are applied by entrepreneurship scholars as they study networks. This provides insight as to how our understanding of network phenomena reflects the interpretation of process we use. Third, since networks have been studied outside entrepreneurship, scholars can likely benefit from being familiar with different perspectives on the topic (Berry et al., 2004; Zahra, 2007). Consequently, we compare two particular approaches with the entrepreneurship literature in order to identify issues relevant to future research. One has its roots in sociology and focuses on measuring the structure of networks. The other is commonly found in the industrial marketing literature, and emphasizes dyadic interactions within the network. As an outcome of addressing these objectives, we identify the need to more fully conceptualize network development processes. Accordingly, we advance a theoretical argument on this issue. This effort integrates multiple views of process, multiple levels of analysis, and multiple perspectives on network development. We now begin by reviewing the conclusions of Hoang and Antoncic and the meaning of "process."

Revisiting Hoang and Antoncic (2003) and the Meaning of Process

Early entrepreneurship research focused on the characteristics of the single entrepreneur. Scholars then began to question: (1) why entrepreneurs were viewed in isolation, and (2) why the entrepreneurial process was separated from other social phenomena. This led to research examining "the causes and consequences of embeddedness in the entrepreneurial process" (Hoang & Antoncic, 2003, p. 167). In particular, Birley (1985) recognized that networks play a catalytic role in organizational emergence, and Aldrich and Zimmer (1986, p. 17) proposed a perspective "which views entrepreneurship as embedded in networks of continuing social relations." Since these studies, networks have been embraced as an instrument for investigating the creation and development of new ventures. This is largely because networks have been shown to improve entrepreneurial effectiveness by providing access to resources and competitive advantage without capital investment.

In a detailed review of network research in entrepreneurship, Hoang and Antoncic (2003) assess the then-extant literature and define two categories of research. The first positions the network as an *independent* variable by trying to understand how networks affect the entrepreneurial process and outcomes. The second positions the network as a *dependent* variable by focusing on how entrepreneurial processes influence network development. Contributions from each category are identified as they relate to understanding the content of network relationships, network governance, and network structures. From this base, a set of recommendations are offered. For example, Hoang and Antoncic identify the need to improve our understanding of networks as an independent variable by using longitudinal research to examine how the network shapes the opportunities being pursued or how different governance characteristics affect entrepreneurial outcomes. Recommendations for research where the network is positioned as the dependent variable include understanding the influence of the entrepreneur on the network and examining how interorganizational relationships are developed at the dyadic level. Underpinning all these ideas for research is a conceptualization of process that is characterized by change. For example, implicit in the argument for longitudinal research is the need to track change. Similarly, understanding how dyads are developed or how the network shapes an opportunity implies a need for process research that reflects change over time.

Beyond change, however, what is actually meant by the term "process"? As argued by Van de Ven (1992), scholars tend to adopt different meanings for this concept; meanings which then influence the questions, methods, and contributions of their research. In an effort to reduce confusion in the strategy literature, Van de Ven delineates three meanings of process: (1) when a process logic is used to explain a causal relationship between variables, (2) where concepts are operationalized as a process construct and measured to assess their change over time, and (3) where process is depicted or described using a developmental event sequence.

Within the latter meaning, Van de Ven and Poole (1995) outline four underlying theories of explanation. First, one might apply life cycle theory to describe a linear and prescribed sequence of events. Second, one might adopt a teleological approach by arguing that an end goal is obtained through a discontinuous and adaptive approach manifest in cooperation. Third, a dialectic view would argue that a discontinuous sequence is driven by ongoing conflict or contradiction that resolves itself by balancing power from opposing forces in the development of the entity in question. Fourth, the evolution-based argument would suggest that development is a function of competitive survival whereby change is environmentally influenced and proceeds through a continuous cycle of variation, selection, and retention.

Distinguishing the meanings of process does not however, suggest they are independent. Indeed, Van de Ven and Poole (1995) note it is logical to assume that theories can be combined. One example is Greiner's (1972) model of organizational development depicting a progression of stages for the entrepreneurial firm where each stage and development within it is triggered by conflict and synthesis. This model is argued by Van de Ven and Poole to reflect a combination of the life cycle and dialectic theories within the general meaning of process that refers to a developmental event sequence.

Having summarized Hoang and Antoncic's (2003) arguments and clarified how the concept of process might be interpreted, we turn to a discussion of the entrepreneurship literature pertaining to network processes.

Reviewing the Network Process Literature

In this section, we first consider conceptual arguments and then turn to empirical studies. Our focus is on research published post-Hoang and Antoncic (2003) or not included in their original review. We then discuss which meaning(s) of process seem to be applied in the extant literature and how this influences our understanding of network phenomena. Finally, we examine how other areas of scholarly inquiry view networks and issues of process. To maintain focus in our review, we restrict our efforts to understanding the contributions of those studies focused on either how networks affect the entrepreneurial process and outcomes, or how the entrepreneurial process and outcomes influence the network. Accordingly, we do not address literature at the network/entrepreneurship interface specific to (for example) immigrant entrepreneurs, social capital, or internationalization. While such research is important, each represents a significant body of literature in its own right and as such, their examination is beyond the scope of this article.

Contributions to Our Understanding of Network Processes

Hoang and Antoncic (2003) specifically call for further research on network development processes and our search to extend their work identified six empirical articles focused on this topic. The other eleven articles pertain to how networks influence entrepreneurial processes. Beyond these seventeen studies, only one conceptual argument is identified (Hite & Hesterly, 2001). We note this because Hoang and Antoncic also identify a single theoretical contribution: Larson and Starr's (1993) model of organizational formation. This dearth of conceptual work appears to support the concerns of Busenitz, West, Shepherd, Nelson, and Zacharakis (2003) and Zahra (2007) that theory building is a challenge for entrepreneurship researchers. This is perhaps because process-variables are ". . . messy and difficult to capture" (Zahra, p. 448).

If we consider Larson and Starr (1993) relative to Hite and Hesterly (2001), the former discusses how the entrepreneurial firm's network develops through three stages. Within each stage, there is a process of exploring, selecting, and using dyadic ties. This process is driven by the entrepreneur or firm, and actions are shaped by the actor's social context. Larson and Starr argue that over time, the network reflects increasing density, complexity, and interdependence of actors, leading to the creation of an organization. In comparison, Hite and Hesterly argue that networks change from being identity-based to more calculative and the network shifts from being dominated by socially embedded ties to having a balance of embedded and arm's-length ties. As the firm develops, the initially cohesive network is expected to shift to one that is sparse or loosely integrated, and characterized by structural holes. The network also shifts from being path-dependent (reliant on history and chance) to one that is more proactively or intentionally managed by the entrepreneur. Hite and Hesterly's

concluding argument is that new firms can benefit from networks that are cohesive (following Coleman, 1988) but also networks that emphasize structural holes (following Burt, 1992). As such, they suggest that one type of network will serve the firm at emergence and another will be more appropriate at early growth. The network and organization are seen to codevelop and are understood relative to the environmental influences or challenges of resource availability, access, and uncertainty.

Drawing these two conceptual arguments together, we see that Larson and Starr (1993) and Hite and Hesterly (2001) both agree that networks become more complex over time. Both also portray process as a developmental course of activity and base their arguments on a rational-action view whereby entrepreneurs create and manage their networks; networks that are adapted and aligned to gain resources. Interestingly, while both contributions focus on describing network development, the Larson and Starr model is one of "organizational formation" and Hite and Hesterly (p. 275) develop arguments to explain which kinds of networks are "more conducive to the success of new firms." Thus, the intent of both arguments can be placed in Category 1 where the network is an independent variable, although each can straddle both categories identified by Hoang and Antoncic (2003).

A notable point of difference in the two conceptualizations is that Larson and Starr (1993) emphasize the relational dimensions of dyads and argue that with time, the network becomes increasingly dense. In contrast, Hite and Hesterly (2001) emphasize the structure of the overall network and argue that network density and cohesion will decrease. We suggest that this "difference" might be more usefully considered as complementary, since the broader arguments provide a conceptual basis for understanding *both* dyadic relationships *and* the overall network and allows for the network to be viewed as either a dependent or independent variable (or both).

Turning to the empirical literature addressing network process issues, our review identified 17 articles either published since Hoang and Antoncic (2003) or not analyzed by them. Each of these articles can be placed within Hoang and Antoncic's two categories for analysis. We begin with Table 1, which summarizes the empirical studies we identify with Hoang and Antoncic's Category 1 (where the network is positioned as an independent variable).[1] One group of studies emphasizes analysis at the level of the dyad. For example, Elfring and Hulsink's (2003) case research shows that a mix of strong and weak ties influences how the start-up discovers opportunities, secures resources, or obtains legitimacy. They also highlight the context of radical innovation, where strong ties are emphasized for securing resources and weak ties help obtain legitimacy. This adds to Hoang and Antoncic's discussion about *when* strong and weak ties impact entrepreneurial processes.

The various ethnographic studies by Jack also expand our understanding of tie strength and in particular, Jack, Drakopoulou Dodd, and Anderson (2004) demonstrate the need to move from the dichotomy of strong vs. weak ties toward a more multiplex perspective. That is, where ties are differentiated not only by intensity, but also the content of the relationship. This is extended by Jack (2005) who argues for an appreciation of information requirements, tie usefulness, and trust. She also notes the existence of dormant ties; ties which may awaken or be reactivated later in time. Interestingly, the

1. Tables 1 and 2 include a summary of both: (1) the studies identified in the current research, and (2) those discussed in Hoang and Antoncic (2003). This facilitates the later discussion on how process is interpreted in the extant literature but the current section is focused on the literature not included in Hoang and Antoncic.

Generally common to the research placed in Category 1 is the use of cross-sectional data to compare variables across defined stages. While this is a practical approach to data collection, it highlights Hoang and Antoncic's (2003) concern regarding the methodologies used in network process research since cross-sectional studies do not capture the dynamics of change. Even those studies using historical data (Havnes & Senneseth, 2001; Littunen, 2000; Watson, 2007) only capture surface-level patterns of change because their focus is on testing causal relationships.

We now turn to Category 2, where networks are considered to be the outcome of an entrepreneurial process, i.e., a dependent variable. As seen in Table 2, we identify six new studies beyond Hoang and Antoncic (2003).[2] One of these (Greve & Salaff, 2003) offers a (rare) international comparison of how different phases of establishment impact the network. In an approach reminiscent of Butler and Hansen (1991), this study uses cross-sectional survey data from the United States, Italy, Sweden, and Norway to assess how advice networks differ across the development phases of motivation, planning, and establishment. Rather than finding network stability, Greve and Salaff show that the smallest networks are used in the first phase of development. These grow in the second phase, but then decrease and become more focused in the third phase.

Of the remaining five studies, three provide a retrospective analysis (Hite, 2005; Larson, 1991; Lorenzoni & Ornati, 1988) and two offer a longitudinal perspective to understanding networks (Schutjens & Stam, 2003; Steier & Greenwood, 2000). A notable pattern across Category 2 studies is therefore the use of methodological designs that provide time-sensitive insight and fine-grained data regarding network development issues—designs argued by Hoang and Antoncic (2003) to be lacking in the entrepreneurship literature.

The most recent example of a Category 2 type of investigation is from Hite (2005). She employs case research to understand how the entrepreneurial firm transforms network ties toward full relational embeddedness. Her results show that the shift is influenced by network entry, social leverage, and trust facilitation, and she describes a dynamic and strategic picture of transformation. Hite also discusses the disadvantages and risks of relationships. For example, continuous change in social components may increase the need for formal governance mechanisms. Her results suggest a switch in character within relationships rather than a switch between relationships. This is consistent with Lechner and Dowling (2003), who conclude that weak ties must be transformed into strong ties for value exploitation, although firms differ in their relational and combinative capabilities and absorptive capacity.

Like Larson and Starr (1993), Hite (2005) highlights the additive nature of ties whereby social relationships can develop toward business ties in a path-dependent pattern. However, Hite also suggests that firms can control social leveraging by being proactive. This is consistent with the early work of Lorenzoni and Ornati (1988), who use case data to portray the growth patterns of entrepreneurial networks as shifting from unplanned (loose) to planned (efficient) to structured (effective). Similar patterns are seen in Larson's (1991) case research. She shows that network relationships are not formed by chance, but reflect predicted exchange patterns based on a company's changing needs in a context

2. In reviewing the articles discussed by Hoang and Antoncic (2003), it became evident that certain studies presented by them as Category 2 were better placed in Category 1 (e.g., Birley, 1985; Greve, 1995). These were re-classified accordingly. As a result, only Hara and Kanai (1994) remain in Category 2. Further, those studies discussing network process in a tangential manner or outside the context of entrepreneurship were excluded from our review (e.g., Gimeno, Folta, Cooper, & Woo, 1997; Ibarra, 1992). We also excluded conference proceedings unless they have since appeared in a journal (e.g., Davidsson & Honig, 2003).

influenced by competitive forces. Of additional interest is her conclusion that relationships between network partners develop in parallel with the firm itself; i.e., codevelopment occurs.

Turning to longitudinal work at the network level, Steier and Greenwood's (2000) case study suggests that to overcome the liability of newness and competitive pressures, the entrepreneur should develop a network that is diverse rather than uniform, and extensive rather than limited in size. Consistent with many of the other studies, Steier and Greenwood conclude that the network requires strong rather than weak ties. Like Jack (2005) and Hite (2005), they note the benefit of dormant ties, and redundant ties were found to be advantageous if the tie provided (for example) future potential.

The other longitudinal study is from Schutjens and Stam (2003), who extend Butler and Hansen (1991) with an examination of the major contacts of 313 new firms. They find that as the firm develops, upstream contacts (i.e., with suppliers) become more commercial, while downstream contacts (i.e., sales relationships) change from being business-focused to include both business and social relationships. In clarifying which ties become more commercial and which become more social, Schutjens and Stam provide a bridge to Larson and Starr's (1993) discussion on tie complexity and whether the network changes to become more social or business-oriented. Although Schutjens and Stam find that firms become more selective with customer relationships over time, they provide little evidence of how and why changes take place, i.e., how interorganizational relationships and their resultant networks develop. Larson (1991) and Steier and Greenwood (2000) provide some insight into this issue, with the former suggesting that networks evolve in a goal-oriented rather than reactive manner. The latter provides a rich description of how a network develops by continuously constructing and reconstructing ties that become more multiplex and robust, with network reconfiguration characterized by pivotal years or punctuation points. An appreciation of "how and why" networks develop is also offered by Lorenzoni and Ornati (1988) and Hite (2005). This contrasts with the studies discussed by Hoang and Antoncic (2003), many of which use comparative data to test for differences in the networks developed by (for example) male vs. female entrepreneurs rather than developing rich insight to the development process *per se*.

Summarizing this, it seems that by extending Hoang and Antoncic (2003) to focus on research inadvertently excluded or published since their review, we are able to identify a small group of studies that further our understanding of network development issues. Nevertheless, it is clear that, as noted by Hoang and Antoncic, our understanding of this topic is relatively limited. This conclusion is supported by the patterns of Tables 1 and 2, which show a clear emphasis on research where the network is the independent rather than dependent variable. Beyond the question of where research is focused, a further question arises. That is, in categorizing networks as either an independent or dependent variable, it might be suggested that entrepreneurship scholars view networks through a positivistic lens; a lens that is causal and explanatory in nature. Is this appropriate given the concept under discussion is that of "process"? To help understand this, we now assess how the concept of process appears to have been applied or interpreted in both: (1) the studies in our review; and (2) those reviewed by Hoang and Antoncic.

Interpretations of Process

As summarized in Table 1, all 22 studies in Category 1 seem to interpret process using Van de Ven's (1992) first definition. That is, process is a form of logic used to explain a cause-and-effect relationship. In contrast, the seven studies in Category 2 (Table 2) demonstrate a primary view of process that reflects either Van de Ven's second meaning (four studies interpret it as a concept that can be measured and tracked for change over time), or his third meaning (three studies depict process as reflecting a developmental sequence).

Taking this analysis further, we see in Tables 1 and 2 that eight studies use what Van de Ven and Poole (1995) refer to as a single-motor, i.e., a single interpretation of process to focus their work. Using Van de Ven and Poole's terminology, four studies incorporate a triple-motor perspective (Davidsson & Honig, 2003; Lechner & Dowling, 2003; Littunen, 2000). Most common, therefore, are investigations with a dual-motor (17 of the 29 studies). This pattern is consistent with Van de Ven and Poole's observations that most arguments related to organizational development and change are composites of two or more ideal-type motors. What is notable here, however, is that the composite approach integrates not only theories pertaining to process as a developmental sequence but also the other, separate meanings of process that focus on causation or measurement of variable change. Further, the rich perspective made possible by viewing process as a developmental sequence, argued by Van de Ven (1992) to be the least understood approach, is limited to a secondary role in most of the research reviewed here. This is particularly evident in Table 1.

If we focus on how the "developmental sequence" meaning of process is characterized in our literature, prescriptive life-cycle theories dominate. Beyond this emphasis, three points are noteworthy. First, while teleological views of process are somewhat in evidence (most notably with Larson, 1991, or Hara & Kanai, 1994), they tend to be used in a summary format to portray an unpredictable or divergent view of process that has been measured in other ways (see Elfring & Hulsink, 2003; Hite, 2005; Jack, 2005; Schutjens & Stam, 2003). Second, although Greiner (1972) depicts venture development as a dialectic process, only Hara and Kanai move in this direction. Even then, this is only when summarizing the nature of interactions during tie formation, and they do not take a dialectic perspective in their main discussion. Third, although most studies use the term "evolution" interchangeably with "process," only three examine networks in a manner that reflects Van de Ven's (1992) definition of evolutionary theory (Hite; Lechner & Dowling, 2003; Steier & Greenwood, 2000). Of these, only Steier and Greenwood view their entire study through an evolutionary lens by describing the network in terms of a progression of variation, retention, and selection.

Again, however, most of the investigations in Tables 1 and 2 seem to interpret process using a meaning other than "developmental sequence of events" and as a result, track change in either a causal or descriptive manner. While this might facilitate the conduct of a focused investigation with a relatively straightforward approach to data collection and analysis, it also leads to a somewhat predictive view of process. This is further reinforced by the fact that most of the developmental process arguments tend to apply life cycle theory, possibly to enable retrospective analysis. Life cycle theory is by its nature, however, prescriptive. This may explain the rather positivistic references to the network as either a dependent or independent variable, but we caution that one consequence of this approach is a lack of depth in understanding the "how and why" of network processes. It also implies that network processes are clear-cut, predictive, and involving a single entity. We suggest this misrepresents reality and believe that the studies offering the richest understanding of this are the empirical articles underpinned by teleological theory (Larson, 1991) and evolutionary theory (Steier & Greenwood, 2000). The former shows that network processes can be viewed as constructive rather than prescribed, and the latter highlights the need to accommodate multiple entities and multiple levels of analysis (in comparison to the single entity approach of the life cycle argument).

At this point, we have addressed our first two research objectives. Our third objective is guided by the suggestion that entrepreneurship research on network processes may benefit from being informed by different perspectives on the topic. Accordingly, we now review two other approaches to network research.

Other Views on Networks

By distinguishing between studies that position the network as either an independent or dependent variable, Hoang and Antoncic (2003) imply there are different ways to study network processes. To represent the school of thought that generally examines the impact of the network on the social group or organization (e.g., where the network is an independent variable), we discuss social network (SN) research. In contrast, the business network (BN)[3] approach emphasizes an understanding of the interactions that create dyadic relationships and consequently, the wider network. It therefore represents the second category: networks as a dependent variable.

The Social Network Perspective

The SN literature has a foundation in Simmel's (1955) arguments regarding the importance of understanding group composition in order to understand social life (Smith-Doerr & Powell, 2005). Later efforts emphasized network structure and over the years, concepts from SN research have been widely adopted in various literatures including entrepreneurship. Indeed, the studies summarized in Table 1 draw heavily on the SN literature. Within this perspective, the structural aspects of networks are generally emphasized with a reliance on mathematical models of the motion of change (Kilduff & Tsai, 2003). These models apply a variety of measures to assess tie configurations and identify similarities or differences across networks (Smith-Doerr & Powell). Theoretical arguments include Coleman's (1988) explanation of the importance of a cohesive network, Burt's (1992) argument for structural holes, and the extensive discussion of strong and weak ties (Granovetter, 1973).

Importantly, the SN literature provides a rich discussion of the concept of embeddedness (Granovetter, 1985; Uzzi, 1996) and argues that economic behavior is embedded in a social context or in a network of relationships. The SN research also considers political, cultural, economic, and technological development as exogenous influences on both individual and interorganizational levels of cooperation. In this perspective, a specific environment is understood to "constitute an opportunity structure containing a resource pool uniquely suited to organizational forms that adapt to it or help shape it" (Aldrich & Zimmer, 1986, p. 10). Arguments pertaining to this concept of a resource niche are found through the SN literature and are consistent with Aldrich (1999) in positioning the environment, be it the social context or others, as determinant. At the same time, SN research recognizes endogenous influences such as efforts by the focal firm to access resources by structuring relationships in an efficient manner. Koka, Madhavan, and Prescott (2006) refer to this as purposeful network action.

Of particular interest in the SN tradition are studies on the networks of individuals. Examples include research on the impact of social ties in job-seeking (Granovetter, 1995) and career advancement (Podolny & Baron, 1997). In such studies, the SN approach uses the formation and dissolution of ties (i.e., the appearance and "death" of nodes) to

3. Much of the literature in this tradition has been contributed by the Industrial Marketing and Purchasing (IMP) group. They refer to it as the Business Network approach.

measure network change, and analysis is focused on structural characteristics such as network size, density, or the position of actors in the network. This enables an understanding of (for example) the potential for innovation or the identification of power bases for information control and brokerage (see Ahuja, 2000, for an empirical example).

Another feature of SN research is the common use of longitudinal studies of large datasets to examine networks (often interorganizational) at different points in time to identify aggregate tie patterns. For instance, Owen-Smith, Riccaboni, Pammolli, and Powell (2002) compare university–industry relations in the United States and Europe. They analyze 12 years of data consisting of 1,026 linkages and use network visualization methods and large scale network analysis techniques to identify different collaborative systems. Other work involving clusters and their patterns of interaction includes Powell, Koput, and Smith-Doerr (1996) while Seabright, Levinthal, and Fichman (1992) explore how the nature of attachment between organizations impacts the dissolution of auditor– client dyads. This study is relatively rare within the SN approach since it provides some insight as to the impetus for severing a tie. As with much SN research, however, it does not capture the actions and explanations underlying tie dissolution and network change, although Kim, Oh, and Swaminathan (2006) recently argued for research on implementing network change within existing relationships.

If we shift our focus to consider levels of analysis, Ibarra, Kilduff, and Tsai (2005) argue that little attempt has been made to link individuals and their networks with larger network systems. However, Liebeskind, Oliver, Zucker, and Brewer (1996) study the biotechnology industry to understand how individual and firm-level networks impact organizational learning and flexibility. Oliver and Liebeskind (1997) then draw on this data to argue, like Ibarra et al., that networks must be understood at both the individual and organizational level, as well as within and across organizations. Some SN studies also consider both dyadic ties and the broader network. For example, in addition to Seabright et al. (1992), Powell, White, Koput, and Owen-Smith (2005) examine how the formation, dissolution, and reestablishment of ties by 482 firms over a 12-year period shaped the network structure of the biotechnology industry. Uzzi (1999) combines ethnographic research (used to understand the difference between embedded and arm's-length ties) with a survey of 2,300 U.S. firms to examine how embeddedness can influence which firms access financial capital and at what cost. In doing so, he assesses: (1) the dyadic ties between the entrepreneur and the loan managers at a bank, and (2) the ego network of direct ties between a firm and all its banks. This study is similar to other works by Uzzi (e.g., Uzzi, 1996) and his approach is somewhat unique in SN research because he examines tie quality and how network configuration influences a firm's ability to perform. In crossing different levels of analysis, these studies represent arguments in the SN literature regarding the need to develop a multilevel understanding of interorganizational networks (Contractor, Wasserman, & Faust, 2006; Hagedoorn, 2006).

Overall, the SN literature generally emphasizes the identification and measurement of tie and network characteristics to understand the influence of structural change. This means that if we apply Van de Ven (1992), a common interpretation of process in this type of research is one that examines how variables change over time. The SN literature also tends to view process as a logic to explain causation. Importantly, even the stream of research that connects the dyad with the network tends to focus on structural analysis with a positivist lens. For example, although Uzzi (1996) considers how ties become embedded in the apparel industry, his primary interest is to assess the impact of ties on economic performance. Further, his general approach to research considers only one actor in the dyad and is cross-sectional rather than longitudinal. This leads us to an alternative approach to understanding networks: the business network perspective.

The Business Network Perspective

A particular characteristic of BN research is that it accounts for both actors in a dyad and investigates how and why relationships change over time. This perspective argues that a change in the dyad results from: (1) actors learning about how to utilize new combinations of resources, (2) the contrasting perceptions of actors in relationships, and (3) actors continually looking for opportunities to improve their position towards important partners (Håkansson & Snehota, 1995). Following from this, BN research suggests that network development is cumulative in that relationships are continually established, maintained, developed, and broken to provide satisfactory economic return or to create a position in the network. This implies change is driven by factors endogenous to the firm. The BN approach also argues that neither a hierarchy nor a single central actor is in charge of organizing the network *per se*. Instead, networks are seen as multiplex adaptive systems, where actors are simultaneously involved in ongoing network management (Ritter, Wilkinson, & Johnston, 2004). Thus, change is also endogenous to the network. This is reflected in Freytag and Ritter's (2005, p. 644) statement that it is not a question of managing *a* network but managing *in* networks and thus, it is "more appropriate to talk about networking, influencing and interacting, i.e., processes instead of outcomes."

At the most macro level, the BN perspective argues that exogenous influences such as economic conditions or technological advancement will be transformed into or combined with endogenous factors such as confrontation between actors. Thus, changes originate in the dyad (Halinen, Salmi, & Havila, 1999) in a manner that can be positive or negative (Ritter, 1999), and any change in one part of the network will produce change throughout the whole network. Any dyad causing network change will also receive and transmit change (Håkansson & Snehota, 1995; Halinen et al.; Hertz, 1996); change that can be proactive or reactive as the nature of any relationship shifts. This is exemplified in Hertz's (1998) longitudinal case research on how change in one relationship explains sequential consecutive change in others.

This focus on connected change allows for BN researchers to study transformation within networks. They do so by investigating the concept of "interaction" between parties, where relationship development is conceptualized as interaction (rather than action) between independent firms or actors (Ford & Håkansson, 2006). Relationship development and transformation are therefore believed to be reciprocal and dependent on the expectations of both parties regarding their future interactions (Håkansson & Snehota, 2006). Further, relationship development increases each actor's knowledge and helps them create realistic expectations of one another (Selnes & Sallis, 2003). In this sense, the network is understood to coevolve with the relationships that form it, and experiences from one relationship are transferred to another in the network (Håkansson, Havila, & Pedersen, 1999). This highlights the interplay between dyads and the overall network.

As Johanson and Mattsson (1994, p. 325) note, research in the BN tradition "emphasizes dynamic, individual and interconnected exchange relationships within systems that contain interdependencies of both a complementary and a substitutive nature." Accordingly, BN research takes the position that the network structure is never stable. That is, "it is a structure with inherent dynamic features, characterized by a continuous organizing process" (Håkansson & Snehota, 1995, p. 271). Even if network patterns appear static, the BN perspective recognizes that existing relationships can change their content and strength. That is, change occurs *within* relationships.

BN research also regards the network as being comprised of different types of relationships. At one level, it recognizes they may be positive or negative and allows for both cooperation and competition. Going deeper, Hertz (1996) distinguishes between one-way, passive, infrequent, or temporary relationships and argues that in order to have interactions, a certain degree of frequency, intensity, and stability must exist. This is connected to the fact that the BN perspective is not restricted to the present, but takes into account the past and future of relationships. As part of understanding network history for example, BN research acknowledges the concept of "sleeping ties," referring to existing but dormant relationships that can be reactivated (Johanson & Mattsson, 1992).

To summarize, the BN perspective focuses on understanding how to establish, build, and maintain or change relationships to create a position within a network. This signals the connection between various levels of the network. Further, the BN approach is focused on *how* relationships change and *why* change occurs (unlike SN research). Thus, compared with the methodologies prevalent in SN studies, those in the BN tradition are generally more case-based and interpretivist in nature. While analysis of network structure is not paramount, an understanding of all potential relationships is considered relevant (including their history and role), and the focus of analysis is on the interaction between actors. Accordingly, if we apply Van de Ven (1992), BN researchers tend to assess how variables change over time but do so using "process as development" theories that portray interaction as being: (1) purposeful and adaptive but not necessarily sequential, (2) characterized by opposing forces that can lead to the status quo or change, or (3) involving a course of action characterized by continuous variation, selection, and retention. Thus, they are teleological, dialectic, or evolutionary in nature, or possibly a combination of these, rather than based on life cycle theory. The BN perspective also discusses the multi-directionality of change, not often considered by SN research.

Informing the Entrepreneurship Literature

Up to this point, we have reviewed the entrepreneurship network literature for recent contributions and interpretations of the term "process." We have also discussed two other approaches to network research. We now integrate this information to identify potentially fruitful areas of inquiry for entrepreneurship scholars. To facilitate this, Table 3 summarizes what is currently understood from the entrepreneurship, SN, and BN literatures.

We begin by assessing the most common level of analysis in network research. Relatively little research in entrepreneurship provides a link between multiple levels in the network. This is in spite of an appreciation in the SN and particularly, BN literatures that it is important to understand how the dyad and network are interrelated. Of interest here for example, is understanding how observed changes within or across specific relationships impacts the entire network and in turn, how change at the network level influences identified relationships. This could be as simple as applying the SN perspective to consider how the addition or deletion of ties changes the network. It could also involve using the BN approach to explore how different dyads perceive trust and mutuality and how this benefits the broader network. Alternatively, one could examine how information sharing across the network allows for learning and other cognitive benefits at the level of the dyad.

As regards the type of network studied, the entrepreneurship literature tends to focus on networks with the horizon or boundary defined by the focal firm. This differs markedly from the BN perspective, which views networks as borderless and the SN approach which considers networks to have clear membership boundaries. Both the BN and SN approaches also tend to examine the broader network, including all potential relationships connecting all the actors. At the same time, the lens applied by each view is different. For example, SN scholars tend to be interested in the wider system of ties and their various characteristics. Consequently, the full network is relevant. In contrast, BN researchers

Table 3

Comparing the Three Perspectives of Network Research

Entrepreneurial Social network Business network Research dimension network research research research

Comparing the Three Perspectives of Network Research

Research dimension	Entrepreneurial network research	Social network research	Business network research
Primary level of analysis	Focuses on either dyads of the focal firm or the firm's egonet. Increasing recognition of the interface between the dyad and the network.	Studies patterns of whole networks of individuals or organizations, occasionally including dyads.	Focuses on dyadic interaction (specific inter-organizational relationships within the broader network) but argues it is possible and necessary to understand the mutuality of tie and network development.
Network type	Considers individual entrepreneur or firm networks with defined borders. Often studies advice or discussion networks.	Considers individual, intra- and inter-organizational networks; defined borders.	Considers inter-organizational networks based on dyadic ties (both formal and informal); borderless.
Network management	Generally argues the network must (and can) be understood and managed.	Considers tie and network formation as calculative, thus assuming some ability to intentionally manage the network within the constraints of the environment.	Considers networks as non-hierarchical multiplex adaptive systems, where actors are simultaneously involved in on-going network management.
Endogenous and exogenous influences	The entrepreneur and firm are positioned as central to decision-making (as primary endogenous influences) although influenced by numerous external factors.	Exogenous influences or external intervention can impact network structure but actors seek to form a beneficial network.	Distinguishes between three levels where the network is exogenous to the entrepreneur or firm and the enacted context is exogenous to the network. Endogenous influences occur at the level of the firm and network, and are always present.
Tie characteristics	Emphasizes mostly tie content (social vs. economic) and tie strength. Some appreciation of other characteristics, e.g., tie usefulness, durability, direction, and dormancy.	Emphasizes tie existence and tie strength. Distinguishes between social and economic ties.	Considers multiplex characteristics: tie content, tie intensity, tie reciprocity, positive and negative ties, tie duration, sleeping ties.
Network and tie change	Provides descriptions of tie and network change but little assessment of how and why this occurs.	Assesses how the addition or deletion of ties impacts network structure.	Follows relationship development to understand change *within* relationships as well as across relationships and the impact of change on the wider network.
Assessment of tie or network influence on performance	Provides some understanding of the impact of the network on performance and offers some understanding of which types of tie matter when.	Assesses network structure for efficiency, with insight on how the network impacts firm growth and other outcomes.	Appraises positive and negative aspects of ties with regards to firm and network development. Longer-term ties considered essential and efficient for the firm and stabilizing for the network.
Primary view of process	Studies tend to assess causation and change in variables, although the results are mostly placed in the context of a predictive sequence of stages often reflecting life cycle theory.	Process is seen as a way to explain variance in the structure of networks over time, through causal influence of in- and output variables.	Process is viewed primarily as a developmental event sequence underpinned by teleological, dialectic, and evolutionary theory.

tend to study the interplay within and between dyads as they relate to the broader context of an inter-organizational network and the external influences that shape it. Thus, the fluidity of a borderless network is appropriate as is viewing all relationships as part of the same network. This differs from some entrepreneurship research where functionally different networks are considered (e.g., Lechner et al., 2006). Entrepreneurship research also tends to focus on network processes as they pertain to a particular venture and consequently, the defined egonet is most relevant. We suggest, however, that all three perspectives may be useful in entrepreneurship research. For example, to understand a venture's position in the network, it would be appropriate to adopt the SN approach of examining (for example) centrality in the full network rather than the egonet. Similarly, analysis of the egonet or full network often identifies dyads of particular interest and brings forth questions regarding the endogenous or exogenous influences on the entrepreneurial network. The theoretical arguments and methodological approaches to examine such issues can be found in BN research.

This leads us to consider the issue of network management. The entrepreneurship literature generally portrays network development as being controlled by the focal firm or entrepreneur as per Weick (1979). The SN literature also sees network formation as calculative but often reflects Aldrich's (1999) view that the driver of change is the context rather than the entrepreneur. An alternative view (typical of the BN literature) is that the entrepreneur both engages in purposeful action and is externally controlled (Johannisson, 1988; Koka et al., 2006). That is, rather than behaving as a reactive economic actor (as per Aldrich & Zimmer, 1986), the entrepreneur enacts their organizing context (network) to managing within the broader set of environmental influences. As noted in the BN literature, this involves managing *in* a network rather than management *of* a network. We suggest that by adopting the BN approach, entrepreneurship scholars might expand their understanding of the role of the entrepreneur relative to the environment in different contexts and over time.

Related to the discussion on network management is the question of how the different approaches view exogenous and endogenous influences. Generally speaking, the entrepreneurship literature tends to emphasize the endogenous influence of the firm or entrepreneur on the network and the SN literature studies the exogenous influences of the environment. Further, the concept of embeddedness is present in both the entrepreneurship and SN literatures, with the BN perspective noting that since the firm is dependent on other organizations in a network, it needs to be in constant interaction with this context. We suggest however that embeddedness needs to be understood beyond the social contexts influence on the focal firm, entrepreneur, or specific tie. Rather, both these levels are influenced by a broader set of environmental factors (Hagedoorn, 2006). This view is consistent with the BN literature and suggests that it would be appropriate for entrepreneurship scholars to distinguish between: (1) the focal firm and entrepreneur that are endogenous to the network and broader system, (2) the network or social context that is exogenous to the focal firm or entrepreneur and also endogenous to the broader system, and (3) the macro environment or context that is exogenous to the network, focal firm, and entrepreneur (e.g., sector influences, market, economic, or legislated conditions, technological or cultural change). Taking this approach would provide specific parameters for study and the potential to compare multiple levels of analysis.

Turning from the network to characteristics of the ties that form it, we see in Table 3 that the SN approach tends to emphasize tie existence or tie strength, and recognizes that ties can be both social and economic. In contrast, entrepreneurship research has begun to take a broader outlook by incorporating (for example) tie usefulness, trust, and information requirements. Certain entrepreneurship scholars also note the existence of dormant

ties, but to this point, the array of tie characteristics is not yet well explored in this literature. This, however, is where the BN perspective is useful since the richness of tie characteristics is perhaps best captured by this approach. For example, BN researchers recognize that relational content can and will change in intensity, length, and depth, and can include contradicting (positive and negative) dimensions. Interestingly, while the SN literature views constraint as a negative concept, the BN perspective views it as offering a positive trigger for tie development or change. The notion of "reciprocity" from the BN perspective is also relevant since it is not self-evident that a relationship means the same thing to both partners. As such, it would be appropriate for entrepreneurship research interested in tie and network development or the influence of ties on firm growth, to understand both actors in a dyad and the process of change within dyads.

In terms of measuring change at the level of the dyad or network, Table 2 suggests that empirical efforts to track how a network develops are relatively rare in entrepreneurship. This is in spite of the foundation arguments offered by Larson and Starr (1993) and Hite and Hesterly (2001). We suggest this provides an opportunity to integrate these two complementary yet competing theoretical views on network process phenomena. Doing so would also offer an understanding of change across levels given Larson and Starr's focus on the dyad while Hite and Hesterly emphasize the network. Further, in spite of recognizing that a network is comprised of component ties, the entrepreneurship literature has only just begun to investigate how relationships are developed and transformed. More specifically, the entrepreneurship literature lacks a rich understanding of when, how, and why ties shift from weak to strong, social to economic, or short-term to long-term (or vice versa). It is the BN approach that could be helpful here, in terms of following development and change within relationships to identify how actors adapt and learn over time, or how changes in dyads affect the network and vice versa. For those interested in assessing specific tie characteristics and their impact on the organization, Uzzi's (1996) approach to integrating depth interviews with either an egonet or full network analysis could be helpful. We also suggest it is important to extend beyond descriptions of "how" and "when" the network or ties change to more fully understand "who" drives the change. Longitudinal case research in the BN style would be useful here, but so too could the SN approach to structural analysis if actor power and position were examined as part of measuring network change over time.

Finally, some entrepreneurship network research has begun to identify what kinds of ties are needed at different stages of firm development. Other research examines the influence of network characteristics on entrepreneurial outcomes. This approach to studying how the network affects performance is consistent with the SN literature, as is discussion on the risks of "overembeddedness." Lacking, however, is rich investigation along the lines of Hite (2005), including macro level research that helps us understand either the general effects of ties on the network or at a more micro level, ties on other ties. That is, are such effects useful and constructive or are they deleterious? These types of questions would be best addressed with the BN approach, which has a tradition of studying the positive and negative aspects of relational change in a time-sensitive manner. We also suggest it is important to understand both the connection between network interactions (i.e., ties), network structure, and performance outcomes, and the dynamics of how these change over time. Entrepreneurship research in this area would be aided by integrating the SN approach by first assessing how interactions lead to network structure and then linking structural changes in (for example) network density or actor centrality to organizational performance. This approach accommodates both the causes of the network and the effects. As such, it takes the holistic view that entrepreneurial and network processes are intertwined with entrepreneurial and network outcomes.

Discussion

In reflecting on the issues raised in the previous section, we suggest that future entrepreneurship research on networks would benefit from: (1) applying multiple theoretical perspectives regarding process, (2) integrating the SN and BN approaches to investigate both the macro level of network structure and the micro level of dyadic interactions, and (3) shifting away from the emphasis on networks as an independent variable to studying them as a dependent variable or perhaps more appropriately stated, a developmental outcome. We expand on this later.

If we refer to the interpretation of process summarized in Table 3, it appears that entrepreneurship researchers have been strongly influenced by the language and tenor of the SN approach. Accordingly, they tend to set research questions necessitating the development of hypotheses where process is viewed as a logic to explain causation or, requiring variable change to be measured. In contrast, the BN approach generally depicts a developmental sequence of events. There is, however, evidence from Tables 1 and 2 of a dual-motor perspective in entrepreneurship and we suggest this hybrid view has the potential to accommodate the complexity of process. What concerns us however is that the entrepreneurship literature lacks the richness that is offered when a study is grounded in teleological, dialectic, or evolutionary theory. We suggest this is a result of not assessing the wider context and forces within which relationships are initiated, developed, and transformed over time, as is more common in BN research. Entrepreneurship research also tends to take a fairly clinical and positivistic approach to understanding network process (similar to SN research) and lacks the realism of the interpretive approach common to BN studies. This emphasis on the structuralist approach is perhaps not surprising if we consider the entrepreneurship field to be relatively young and seeking legitimacy. Similar arguments are made by Borgatti and Foster (2003) as regards network research in general.

One consequence of this is that we tend to view networks through a lens of progression. Reality suggests, however, that relationships and networks involve both progression (forward growth and advancement) *and* regression (backward movement and deterioration). Another influence on network development is randomness. Unpredictable incidents may occur exogenous to the network in the form of (for example) regulation encouraging (or prohibiting) a certain alliance. Another random incident may be (for example) one firm going bankrupt thus destabilizing a tie and consequently, the network. As a result, it is important to allow for such occurrences when investigating, interpreting, and depicting network process. This might best be captured in a spiral of development that incorporates progression, regression, increases and decreases in network size, as well as change within relationships. Again, this requires theory that recognizes and incorporates teleological, dialectic, or evolutionary arguments.

Turning to the lens through which we view network research, early arguments suggest that theory should include bot*h* the structure of the network an*d* the interactions between actors (Burt, 1992; Coleman, 1988; Granovetter, 1985). In spite of this, most studies in entrepreneurship consider either aggregate network patterns (structure) o*r* the ties (interactions) forming the network. To some extent, this dichotomy is captured by the SN and BN literatures. That is, the former focuses on the construction of an efficient and effective network and thus allows for research on the structural dimensions of networks and their impact on firm growth and other outcomes. In contrast, the focus of the BN approach is on understanding development and change within relationships as well as between and across relationships. In some ways therefore, the SN and BN perspectives offer opposing views for network scholars. If, however, we consider these approaches integratively, they offer a useful "bifocal" lens for the entrepreneurship researcher interested in issues of network process. Stated most simply, adopting the BN approach can offer a deep understanding of specific relationships, particularly in terms of assessing interactions and change within a tie, while a macrolevel understanding of structural change and influence in the network can be aided by the SN literature.

Finally, if we are to conceptualize and study networks as a developmental outcome in entrepreneurship, what is the theoretical foundation for moving forward? We agree with Hoang and Antoncic (2003) that entrepreneurship research could benefit from examining Larson and Starr (1993) in a longitudinal study. As we note previously, however, that model is complemented by the more recent efforts of Hite and Hesterly (2001). Accordingly, a first step would be to combine these two arguments into a framework that incorporates both the dyad and network as units of analysis. Additional steps include augmenting this framework with: (1) insight from the empirical findings on network processes, and (2) an understanding of the different ways the meaning of process has been (and might be) applied to network research. Furthermore, a theoretical foundation should apply a combination of the SN and BN perspectives since as noted by Hoang and Antoncic, we need to be able to explain not only the effect of networks but how and why they form and may be managed over time.

This leads us to the theoretical arguments in Figure 1 where the network is positioned as a developmental outcome of a new venture's entrepreneurial process. In Part A, we ask the question "what develops?" and integrate the arguments of Larson and Starr (1993) with Hite and Hesterly (2001). Here, we see that both the new venture and the network develop in a predictive manner that follows a life cycle approach and indeed, the firm and network codevelop (Hite & Hesterly). Of note, network development moves through a life cycle of: (1) variation (new ties emerging blindly or intentionally), (2) selection (ties contributing something and therefore being selected), and then (3) retention (the embedding and transformation of ties discussed by Hite, 2005). This process of tie variation,

Figure 1

Conceptualizing Network Development

What develops? How and why does the network develop? What occurs over time?

A B C D

Predictive states of development for single entities (the firm, the network) where the firm and network co-develop

Constructive processes of teleological development driven by purposeful enactment of a network) over an extended period of time

Predictive evolution of a single entity (the single entity *or* through the dialectic interaction through ongoing variation, selection, and and synthesis of multiple entities retention of ties, and environmental alignment

selection, and retention parallels the arguments of Larson and Starr, and occurs within and through the organizational stages discussed by Hite and Hesterly. Of note, however, we refer to these as "states" in Figure 1, allowing for the possibility of both progression and regression. This is consistent with Hite's finding of the "lack of evolution and presence of de-evolution" (p. 138). We also note that while we portray the V-S-R phases as sequential, they occur simultaneously in practice (Aldrich, 1999) and are influenced by the phases of organizational development.

Moving to the question of "how and why does the network develop?" (Parts B and C), all of the activities in Part A are influenced by the focal firm or entrepreneur purposefully respecifying goals where s/he initiates change in ties (and therefore the network) to either accommodate or enact the external environment (Hite, 2005; Larson, 1991; Schutjens & Stam, 2003; Steier & Greenwood, 2000). Although the environment may limit entrepreneurial action (Van de Ven & Poole, 1995) and unexpected events may occur (Larson), this strategic adaptation influences tie selection and retention and results in the development of management knowledge. It also reflects the constructive process that is teleology (Part B).

In parallel with this, organizational development efforts will create interactions between multiple entities (e.g., two actors in a dyad or a number of actors in a network) or between the network and the environment. Over time, network members will come and go (Greve & Salaff, 2003; Lorenzoni & Ornati, 1988) and may cause a dialectic opposition between thesis (current path) and antithesis (new entrant) that results in synthesis (Part C). Further, the network will adjust to the cultural and social context as well as market conditions. Another form of dialectic resolution may occur in the interactions between actors to overcome (for example) conflict in goals or implementation strategies. Overall, we see the new venture conform with or deviate from the environment in terms of (for example) the social or economic context in which it operates. Like Part B, this dialectic perspective is constructive rather than prescriptive. Together, Parts B and C extend our view of network development from "what happens" vis à vis the life cycle argument to "how and why it happens" from a teleological and dialectic perspective.

Finally, we ask "what occurs over time?" (Part D). Since the cycle repeats itself during an organizing episode, the evolutionary motor is evidenced with the passage of time through the variation, selection, and retention of certain network configurations over others. Here, the immediate influence of organizing is driven through a life cycle motor as noted by Larson and Starr (1993). It is, however, also influenced by a teleological motor of participant's choices of adaptations and a dialectic motor of interaction and synthesis. For example, selection activities seek to align the network with the environment over time, but these are punctuated at points where the focal firm shifts direction as a result of purposeful enactment (e.g., entering a new market). This is similar to what is described in Steier and Greenwood (2000) as part of the overall development of the network. Thus, over the longer run, short-term actions contribute to an evolutionary process and what we see is an overall path of development that incorporates change with stability. This is consistent with arguments in the BN perspective and also Aldrich's (1999) view that evolutionary theory comprises a metatheory. That is, it borrows selectively from the other (related) process theories.

In relation to Figure 1, we argue that network change occurs over space and time for the new venture. This implies that several motors can come into play with no single one offering a complete and sufficient explanation of process (Van de Ven & Poole, 1995). We therefore accommodate multiple motors and levels of analysis. The life cycle and evolutionary motors (common to SN research) pertain to the network as a whole, while the teleology and dialectic motors (found in BN studies) pertain to the actions of actors within

the network and their dyads. Thus, we connect the macro (SN) and micro (BN) levels that are pertinent to network studies. Since there has been a tendency in the entrepreneurship literature to rely primarily on life cycle theory and to a lesser extent, teleological arguments (both of which focus on single rather than multiple entities), our inclusion of dialectic and evolutionary theory helps balance the overall argument. It also allows us to better appreciate how and why the network develops. The notion of balance is further reflected in the observation that if a theoretical model is overly prescriptive (i.e., it follows the life cycle argument in particular, but also the evolutionary view), it does not allow for sufficient innovation. Similarly, an overemphasis on teleology or the dialectic argument would create too much variety. Consequently, in light of the BN perspective's stance regarding the inherent balance between stability and change in the network, our model accommodates both predictive and constructive views of process.

Inherent in this model is the argument that the essence of entrepreneurship is the entrepreneur (Bygrave, 1993) and human volition. Similar arguments are made by Stevenson and Harmeling (1990) so while we allow for the influence of the environment, change can be made with conscious intent (Weick, 1979). Thus, a strategic adaptation perspective is employed, consistent with Larson and Starr (1993) and Hite and Hesterly (2001). The model also allows for both exogenous and endogenous influences in network development. Although Weick (1979) puts decision makers at the center of organizational development, Aldrich (1999) generally argues that the entrepreneurial process takes on meaning only in the context of the broader social context (e.g., the network) and that environmental selection procedures are determinant. Our model attempts to reconcile these two classic arguments in a manner that allows for both to co-exist. That is, we recognize that the tie coevolves with its social context (the network), and the organization and the network coevolve. Further, both the organization and network coevolve with the environment.

Conclusion

With this article, we have attempted to contribute to the entrepreneurship literature in four ways. First, we extend one aspect of Hoang and Antoncic (2003) to offer a summary of the current state of entrepreneurship knowledge specific to network process issues. Second, we assess this literature to understand which meaning(s) of process are applied by entrepreneurship scholars and to identify how this influences our understanding of network phenomena. A particularly notable finding is the continued dearth of studies focused on the processes associated with network development. Third, we examine how the social and business network literatures view networks and then use this to generate a number of considerations for research. Finally, we offer a theoretical foundation for conceptualizing and studying networks as a developmental outcome. In doing so, we integrate multiple perspectives, levels of analysis, and views of process.

In moving forward we acknowledge certain limitations in our work. As explained early in the paper, we confine our discussion to issues of network process. We also note that our review of studies outside entrepreneurship is limited to the social and business network literatures. We consider these to be particularly informative to our research, but acknowledge that both literatures are richer than what we could capture here. Further, we limit our conceptualization to one that describes process as a developmental event sequence. This, however, complements the extant literature where attention has focused on capturing network processes through causal research or studies measuring variable change.

As presented, Figure 1 incorporates a set of questions to guide researchers. These are reflected in the four components of the model: (Part A) "what develops?", (Parts B and C) "how and why does the network develop?", and (Part D) "what occurs over time?" In combination or as a collective, these components offer a purposefully broad and integrative overview of the ways in which network development can be understood. Consequently, testing it within a single research study would present a considerable undertaking. Indeed, it is not our intent to position this model as one which is testable in its entirety. Rather, we position it as a means to an end. That is, we feel there is clear opportunity for developing a range of more precise models that fall within the umbrella of our general conceptualization. For example, some researchers will be interested in how patterns of tie variation, selection and retention change through the stage of network and new venture codevelopment. Other researchers may investigate why such patterns emerge by studying the degree and nature of purposeful enactment or dialectic tension (or both) as perceived by multiple actors over time. Yet others may focus on understanding how the entrepreneur's actions influence tie creation or dissolution and thus, how the network develops in a teleological manner. Researchers might also assess the evolutionary development of a network by deconstructing it to identify (for example) specific exogenous influences that created a disruption or change in the network. Overall, we suggest that future research should examine parts of our "general" model. They should also treat such parts as pieces of an emerging puzzle whereby adding one piece at a time helps to reveal the nature of the bigger process in question.

Turning to managerial implications, our theoretical arguments suggest that while the entrepreneur engages in purposeful action, these actions are influenced by forces external to the venture or to the network. Further, while the entrepreneur's horizon might be egocentric, their venture operates within a broader system of ties. Following from these points, the entrepreneur should be aware that they are involved with managing *in* a network rather than management *of* a network. This requires the entrepreneur to build insight as to the complexity of tie interactions since ties will differ in (for example) their intensity, reciprocity, or impact over time. Similarly, entrepreneurs require an understanding of the overall pattern of the network they operate in. They will also benefit from an appreciation that the network is a dynamic system where ongoing change occurs at different levels: in dyads, across several actors, and within the broader environment.

Measuring ego-centered social networks on the web: Questionnaire design issues

abstract
Collecting survey data on ego-centered social networks is a difficult task, owing to the complex questionnaire format. Usually, the interviewer handles the dynamics of the question–answer exchange, motivates the respondent and ensures the proper recording of the data. Self-administered modes of data collection, especially web data collection, are more problematic, as the respondents are left alone with a complex and burdensome questionnaire. Therefore, questionnaire layout is crucial for ensuring cooperation and data quality. In this paper we examined three key components of the corresponding web questionnaire: the number of name boxes using a single name generator, question format for assessing alter characteristics (i.e. alter-wise vs. question-wise) and number of name interpreters (i.e. alter characteristics). The number of name boxes was found to be essential for the reported size of social networks and also for some aspects of data quality. Specific data quality effects were also found with respect to variations in question format, where question-wise format performed better than alter-wise. The number of name interpreters had a relatively minor effect. Suggestions for possible standardization of the web interface layout are also given, so that equivalence with other data collection modes can be established.

1. Introduction

In general, the web survey mode is in rapid expansion; however in data collection involving specific ego-centered social networks it is less often used than interviewer assisted modes because of complex data format. The corresponding survey process is relatively complicated, and several steps have to be taken. First a list of persons (i.e. alters) according to a specific social tie is obtained from the respondent (i.e. ego), using one or several network generators (i.e. a survey question to obtain the list of alters). In the second stage, additional information on the characteristics (i.e. name interpreters) of (all) listed alters is collected and on the characteristics of the ties linking ego to their alters, and sometimes also on alter-to-alter ties. Throughout this multistage process, a considerable amount of information is required from the respondent, so that their cognitive effort necessarily impacts on the quality of the data obtained.

While in interviewer assisted surveys we can train interviewers to handle the survey process in a desired way, the absence of an interviewer in web surveys means that the respondent receives no additional help apart from instructions given in the questionnaire. The respondent gets no external motivation to continue and complete the survey process, nor do they obtain any feedback or
judgment on any misunderstood questions. Even more, owing to various technical problems and browsers' specifics, in web surveys the researcher sometimes has no control over what the respondent actually sees on their screen. In any case, with web survey mode the questionnaire is the only communication channel between the researcher and the respondent, and therefore special attention should be paid to designing the questionnaire.

In this paper we explore three essential components of a web survey questionnaire when collecting ego-centered network data. First, the (1) number of name boxes
[1]
is studied (i.e. 1, 5 and 10 name boxes) as a key element in the graphic design of the name generator (Fig. 2), with respect to the effects on network characteristics (size and composition) and data quality (non-valid responses, item nonresponse, drop-out rate). Next, we test the effects of (2) the format of name interpreters (i.e. alter-wise vs. question-wise) and also (3) the number of name interpreters required (6 or 11) in the questionnaire. There, we also observe the corresponding impact on the survey process and data quality (i.e. item nonresponse, drop-out rate, time needed for completion). We tested all those issues on a version of Burt's name generator (1984).

The structure of the paper is as follows. We first review past research (Section 2). Next, we formulate the research questions

and describe the research design (Section 3), addressing the abovementioned methodological issues (number of name boxes, the format of name interpreters, number of name interpreters) and their impact on network characteristics as well as on data quality. We then describe the experiment (Section 4) and present the results (Section 5). We conclude with a discussion (Section 6), where we also address the issue of standardized design for ego-centered data collection in web surveys.

2. Review of previous research

A number of studies have already focused on various aspects of collecting data on ego-centered social networks in recent years, ranging from reliability and validity issues (e.g., van Groenou et al., 1990; Hoffmeyer-Zlotnik, 1990; Bien et al., 1991; Marsden, 1993; White and Watkins, 2000; Kogov ˇ sek et al., 2002; Kogov ˇ sek and Ferligoj, 2005; Coromina and Coenders, 2006; Kogov ˇ sek, 2006; Marin and Hampton, 2007) to the effects of measurement instruments on the characteristics of the networks (e.g., Burt, 1984; Marsden and Campbell, 1984; Bernard et al., 1987; Wellman and Wortley, 1990; Milardo, 1989; Bernard et al., 1990; van Sonderen et al., 1990; Campbell and Lee, 1991; van der Poel, 1993; Bailey and Marsden, 1999; Straits, 2000; McCarty et al., 2001; Feld and Carter, 2002; Marsden, 2003; Lozar Manfreda et al., 2004; Marin, 2004; Kogov ˇ sek and Hlebec, 2005; Van der Gaag and Snijders, 2005). Several studies also assessed techniques for collecting information on alter-to-alter ties and their impact on ego-centered network structure (e.g., McCarty, 2002; McCarty and Wutich, 2005; McCarty and Govindaramanujam, 2005; McCarty et al., 2007a,b).

Particularly frequent are evaluations related to the American General Social Survey (GSS) network generator (e.g., Burt, 1984; Burt, 1987; Marsden and Bailey, 1999; Straits, 2000; Marsden, 2003). Marsden (Marsden and Bailey, 1999; Marsden, 2003) discussed the GSS network generator using cognitive methods to assess how question position and the role of the interviewer affect network composition and size. The analysis showed that network generators are sensitive to the questionnaire's context (i.e. the position within the questionnaire, which can follow various topics), and that the interviewer does affect the respondents' estimate of network size. Straits (2000) compared two single name generators ('discussing important matters' and 'the most significant people in your life') and a change in wording of the namegenerator (the probe for negative interactions). His analysis showed that these two name generators produced similar networks; however, the experimental probe for negative interactions produced significant, although relatively unimportant compositional differences. In another survey setting, Kogov ˇ sek and Hlebec (2005) evaluated the effects of a limitation on the number of alters (first five vs. all listed alters) and a 6-month time frame (discussion partners in the last 6 months vs. usual discussion partners); they found only minor variations in network composition, namely a larger percentage of women and kin with a limited number of alters.

Most of these studies used the face-to-face data collection mode to evaluate ego-centered networks. Some studies (Kogov ˇ sek et al., 2002; Kogov ˇ sek and Ferligoj, 2005) also focused on a comparison of face-to-face and telephone surveys; they showed that telephone data collection was as reliable and as valid as face-to-face data collection modes. A telephone survey even gave more valid measures when all characteristics of each alter were measured individually (i.e. *alter-wise*), than when one question was asked for all alters on the list (i.e. *question-wise*).

As mentioned, web surveys that implement the network generator approach to measuring ego-centered networks are problematic, owing to the complex research design and large respondent burden involved (e.g., Marin, 2004; Lozar Manfreda et al., 2004;

Coromina and Coenders, 2006; Kogov ˇ sek, 2006; Gerich and Lehner, 2006; McCarty, 2002; McCarty and Wutich, 2005; McCarty and Govindaramanujam, 2005; McCarty et al., 2007a,b). In contrast to Marin (2004), who is critical of underreported ties, Lozar Manfreda et al. (2004) and Gerich and Lehner (2006) suggest a limitation of the number of alters in web surveys. In the study Lozar Manfreda et al. (2004) showed the strong effect of the number of name boxes from the network generator on the reported network size. They used four different network generators (measuring four different types of social support, including Burt's name generator, 1984) with the same graphic design. The essential component of their design was an input table with 30 name boxes for reporting the names of alters on a single page. The accompanying instructions suggested that the respondent fill in as many names as they wanted but only one name in each name box. On average, 15% of respondents actually filled in all 30 name boxes, which is believed to have been in large part caused by the design with 30 name boxes (Lozar Manfreda et al., 2004). At the same time, the percentage of nonvalid responses on the network generator question (i.e. names in plural or phony names) tended to be relatively low. On the other hand, Gerich and Lehner (2006) Gerich and Lehner (2006, pp. 1112) report that, in spite of detailed instructions, having only one text field for entering alters' names and interviewer presence in laboratory, some respondents still misunderstood the network generator question and entered names like 'mum and dad', 'friend 1', 'friend 2', etc.

Studies on the reliability of web surveys for measuring egocentered networks show that telephone surveys are slightly more reliable than web surveys when evaluating the frequency of contacts along with the closeness and importance of ties (Kogov ˇ sek, 2006). Coromina and Coenders (2006) showed that the *questionwise* format is better in web surveys than the *alter-wise* format and that one should label all response categories in ordinal scales not only extreme values. It was also shown that an advanced graphic layout of the questionnaire can substantially improve the reliability and validity as compared to a plain questionnaire format (Coromina and Coenders, 2006).

We should also mention here that interactivity and visualization were demonstrated to be very beneficial in collecting data on social networks (Hogan et al., 2007). In principle, this opens up various possibilities for web data collection because one of the Internet's inherent characteristics is to provide a whole array of options for visual interaction.

In this study we do not evaluate the entire web survey process (Vehovar et al., 2002), which includes several stages: sample selection, contacting respondents, completing the questionnaire, and the transmission of responses. We also do not focus on comparisons of different survey modes. We are only interested in the responding stage, i.e. in the completing of the web questionnaire. In addition, we specifically concentrate here on very specific ego-centered networks providing social support measured with name generators (for a review of earlier studies, see Cohen and Wills, 1985). This approach differs from analyzing large networks with a fixed number of alters (e.g., McCarty and Govindaramanujam, 2005; McCarty et al., 2007a). With respect to scope of the investigation, we basically analyze the size and composition of the social networks, while we discuss neither methodological problems nor the consequences of data collection related to alter-to-alter ties.

Nevertheless, we address in this paper very important issues in collecting ego-centered social network data on the web. Some of these issues have already been broached by someprevious research, but not fully elaborated, i.e. we in large part upgrade the research of Lozar Manfreda et al. (2004), which indicated that the number of name boxes may play a crucial role in estimating social support network size and composition; however, they did not vary the number

Table 1 Experimental design

of those name boxes to observe these effects more closely. Similarly, the mixed findings for the two formats of name interpreters (*alter-wise, question-wise*) need to be further explored, replicated and confirmed (Coromina and Coenders, 2006; Kogov ˇ sek, 2006) in order to find the optimal social netw ork web data collection approach. In addition, we also test the number of nameinterpreters, to see if they affect various aspects of data quality (McCarty et al., 2007b).

3. Research questions and experimental design

Based on the studies described in the previous section, the following research questions were formulated:

1. Does the number of text name boxes,which are provided for reporting the names of alters, influence the number of reported alters? How does a change in the number of the reported alters affect the composition of the network? How does the number of name boxes affect the proportion of non-valid responses, itemnonresponse (i.e. the missing answers to a specific question), the drop-out rate (i.e. partial nonresponse,where respondents quit in the middle of the questionnaire after providing some answers) and time needed to complete the questionnaire?
2. How does the format of name interpreters (*alter-wise vs. question-wise*) affect the proportion of item-nonresponse, dropout rate and the time needed to complete the questionnaire?
3. How does the number of name interpreters affect the proportion of item-nonresponse, drop-out rate and the time needed to complete the questionnaire?

The experimental design is presented in Table 1 and described below.

As shownin Table 1, the questionnaire design was varied at three stages:

(1) When providing the *name generator* to the respondents, three variations of name generatorwere used, varying the number of name boxes. Respondentswere randomly assigned to one of the designs w ith 1, 5 and 10 *name boxes* per page. Of course, the respondent was able to fill in as many names as needed—when the respondent had filled in all the boxes on one page, they got the next screen with a list of all names which had already been mentioned and a new block of empty boxes for providing new names.
[2]
If the respondent left one or more name boxes onthe screen blank, w e presumed that all alters had already been mentioned, and we proceeded w ith the questionnaire. Thus, the questionnaire's logic was explained in the instructions beside the question (name generator) text. Our main interest concerning the influence of name box design was network size and network composition: how does a different number of name boxes influence the number of alters mentioned? Additionally, w e also examined the data quality as measured by non-valid responses, item-nonresponse and the drop-out rate.

(2) Moreover, when collecting data about alters (*name interpreters*), the format of name interpreters was varied (*alter-wise and question-wise*). In the *alter-wise* data collection format, all name interpreters (i.e. variables like gender, age, relationship characteristics etc) are asked for the first alter, and then for the second and so on until all the alters have been evaluated, whereas in the *question-wise* data collection format one name interpreter (e.g., gender) is posed for all alters at the same time (we continue until all variables are filled in). Data quality was assessed by item-nonresponse, the drop-out rate and time needed for completion.

(3) Two questionnaire lengths for name interpreters were employed; a short one with six questions per mentioned alter and a long one w ith an additional five questions per mentioned alter (11 altogether). Data quality was assessed by item-nonresponse, the drop-out rate and time needed for completion.

4. Data collection

The data w ere collected within a specially designed web survey from August 28 to 20 September 2003. The invitation was published on two major Slovenian web search engines at that time (Najdi.si [http://www.najdi.si/] and Mat'Kurja [http://www.matkurja.com/]). In addition, several e-mail invitations w ere sent out to personal addresses fromthe researchers' address books, with a request to further pass on information about the survey.

The non-probability sampling method w as used to select the participants. This is called a *web survey with a general invitation* (Lozar Manfreda, 2001, pp. 12–46) and therefore a *non-probability web survey* (Couper, 2000). The generalization of substantive results to the general population would not be possible here because the respondents have an unknown probability of being selected in the sample. Nevertheless, our primary focus here is the experiment w ith randomly assigned groups, where we observe differences among various survey instruments. Experiments do not suffer from probability sample assumptions and are increasingly often performed on-line (Lozar Manfreda, 2001, pp. 32–34).

As shown in Fig. 1, the questionnaire was divided into four stages: (1) introductory questions on Internet demography and the

Fig. 1. Questionnaire schema.

current mood of the respondent (ego); (2) a network generator; (3) name interpreters (alters) and; (4) demography of the respondent (ego).
Altogether, 327 respondents who mentioned at least one alter completed the survey. Some general questions about the egos' characteristics were included in the first part of the survey before the network generator. Since we are examining the number of name boxes effect of the network generator, and some further results of various data collection methods, only those respondents who mentioned at least one alter (filled in at least one name) are relevant. All other respondents were excluded from further analysis.
We used an adapted version of Burt's (1984) name generator. The wording was as follows:
'From time to time, most people discuss important personal matters with other people, for instance if they have problems at work, at university, with partner or parents or other similar situations. Who are the people with whom you discuss personal matters that are important to you?'
No time frame was used in the question eliciting alter names, and several examples of personal matters were added to ease the respondents' task.
According to data from the project RIS (Research on the Internet) in Slovenia [http://www.ris.org/], the main Slovenian project measuring use of the Internet and ICT in Slovenia, in October 2003 (1 month after the completion of our survey) there were approximately 44% of Internet users in the Slovenian population (10–75). Compared to the general population of Internet users, our respondents were more intense Internet users (a higher share of daily users), more educated, and there was a larger percentage of women (Table 2).

5. Results

This section is organized in such way that each subsection gives answers to a research question outlined in Section 3. Research ques-

Table 2 Characteristics of the sample

Table 3 Number of mentioned alters according to the number of name boxes

tions 2 and 3 are presented in joint subsections (Section 5.2) owing to specifics of the experiment.

5.1. Number of name boxes

5.1.1. Effects on network size and composition Filling out the network generator is the first crucial and the most demanding task of the respondent. When the respondent is exposed to the network generator, a significant cognitive effort is needed to understand the requirements of the question exactly. The usual behavior of the respondent in a web survey (similar to the behavior of a visitor to a web page) is to quickly scan the contents. Therefore, the respondent is highly influenced by the graphic outline of the question and much less by the surrounding textual instructions, which require detailed reading (Spool et al., 1999; Tourangeau et al., 2005; Couper et al., 2007).
The example in Fig. 2 demonstrates an instance when a respondent was exposed to a network generator design involving five name boxes per page.
Technically, the upper limit of possible alters was 30, but it was not reached by any respondent (the highest number was 16). Before we did the quantitative analysis, we manually cleaned up the database and excluded all respondents who provided non-valid answers to the network generator (Table 3). A more detailed analysis of non-valid responses can be found in Section 5.1.2.
One of our main interests was the impact of the number of name boxes in the network generator on the number of alters provided (network size). As shown in Table 3, the number of name boxes has a strong influence on the network size.
By design, the minimum number of alters was one,
regardless of the number of name boxes. This means that we always had at least one person who mentioned only one alter in all graphic designs. The maximum number of alters was 14 when we provided 10 or 5 name boxes per page and increased to 16 when we provided only one name box per page. More affected by number of name boxes was the average number of alters. The average number of alters
decreased from 4.7 in the 10 name-space design and 4.0 in the five name-space design to 3.1 for the one name-space design. This leads to the conclusion that the number of alters is clearly influenced by the visual design of a name generator. If a respondent is exposed to a larger number of name boxes, they tend to provide more names to fulfill the anticipated requirements of the questionnaire. This is also in accord with the previous study of Lozar Manfreda et al. (2004), where the average was 7.6, because 30 name boxes were used. Gerich and Lehner (2006), on the other hand, obtained an average network size of 6.9 but used five different network generators about social companionship and on a special student population using a single text field to enter all names
at once for the first name generator.

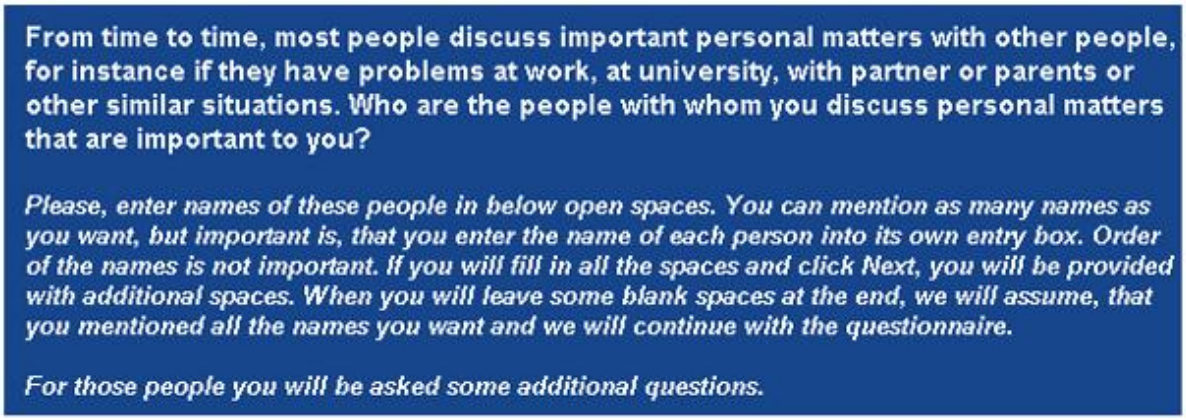

Fig. 2. Network generator with five name boxes per screen.

The analysis of the frequency distribution shows the number of respondents according to the number of alters provided (Fig. 3). In the design with 10 and 5 name boxes, we can observe a heaping of the number of alters around the numbers 5 and 10. There is a significant decrease (heaping) in the frequency distribution after 5 and 10 names (10 name boxes design) and after 5 names (5 name boxes design). Heaping is often found in responses to open-ended questions with discrete values (Roberts and Brewer, 2001, p. 887), especially when the respondent is supposed to make an estimate of the number or frequency or do a free listing of names. When heaping occurs, it indicates problem in data collection. For the five name boxes design, this was the point in the survey process when
the respondents had completed the first screen with all name boxes and were exposed to another screen with a blank name box and a list of already mentioned alters.
When considering network composition for different numbers of name boxes, we could not observe any significant differences at less than the 0.05 level (one-way ANOVA) according to the different network generator designs. There were slightly more female alters in the networks of the respondents which were assigned to the one name-space design (significant 0.067) and slightly more friends among alters with the five name boxes design. We actually expect weaker ties in the 5 and 10 name boxes design, owing to the larger size of the network (Table 4).

Table 4 Effects on network size and composition

Fig. 3. Frequency distribution of alters according to the name generator design.

Table 5 Frequency of contact (daily contact)

Also if we consider the frequency of contacts among egos and their alters (Table 5), we can not prove any statistically significant difference within the networks provided by the different number of name boxes. However, in the one name box format we did observe more geographically close alters.
We can conclude that network composition was not influenced by the number of name boxes used in this experiment. Nevertheless, the measured networks were relatively small networks (averages ranging from3.1 to 4.7), regardless of the number of name boxes, and in such small networks strong variations in network composition are not expected, as we are still observing relatively strong ties.
5.1.2. Effects on data quality We concentrate here only on key selected measures of
data quality (Groves et al., 2004): the percentage of non-valid answers, item-nonresponse and drop-out rate (as shown in Tables 6A, 6b and 7).
Probably the most commonly used set of technical controls in web surveys are field validators which control user input in real time. Even though there are many possibilities in using form validators, most of today's web surveys are limited to controlling responses with hard or soft reminders. A soft reminder means that, in case a question is not answered properly (or is not answered at

Table 6A
Effects of number of name boxes on data quality

Table 6B
Effects of measurement instruments on data quality

all), a warning message or some type of pop-up alert appears, but the respondent is still allowed to proceed. On the other hand, hard reminders do not allow respondents to proceed before answering the previous question properly. This can effectively prevent non-valid responses and item nonresponse, but can stimulate more drop-outs (Fuchs, 2003). Nevertheless, neither soft nor hard reminders were used in this experiment, to obtain more insight into data quality without interfering with reminder strategy.
In this study, the web questionnaire was publicly available, so we can expect that some percentage of the respondents would not have taken the questionnaire seriously or would not read and/or understand the survey questions. The most common mistake was to answer with plural social constructs (e.g., '*family*', '*friends*'...) instead of providing the exact name of a person, or even to enter some suspicious fake name (e.g., cartoon characters); there were some names repeated several times, or several names typed into the same name space. Overall, 8% of the responses to the network generator were incorrect. In terms of the different graphic designs, the smallest percentage (2%) of non-valid responses was produced when the 10 name boxes design was used. This increased with a decreasing number of spaces provided on each screen –when the five name boxes design was used, it rose to 7%, and when only a one name box design was used, we got 13% non-valid responses.
If we look at the non-valid responses individually, we see that most of them are plural social constructs. When the respondent is confronted with a network generator that asks about a specific social tie, they usually come up with more than one person. However, a single name box may give the impression (if one does not read the question thoroughly) that a category of people is expected instead of individual names; therefore it is not surprising that the number of non-valid responses is largest with the single name box.
The percentage of item-nonresponse is larger for 10 name boxes and 1 name box, which can be explained, on the other hand, by the larger measured networks for 10 name boxes and, on the other hand, by the tendency to a higher rate of non-valid responses for one name box name generators.
The drop-out rate, on the other hand, falls with the decreasing number of name boxes per page in the network generator. We should bear in mind that drop-outs are not directly affected by the

Table 7
Percentage of item-nonresponse according to the different survey designs

graphic design itself, but rather by the burden because of the length of the questionnaire and the time needed to complete it. As the length of the questionnaire increases with the number of alters provided, this is likely to be the reason for the decreasing drop-out rate.
5.2. Effects of the format of name interpreters (alter-wise vs. question-wise) and number of name interpreters (6 vs. 11) on data quality
The respondents in our experiment were divided into four groups according to the two variables: the format of name interpreters (*alter-wise vs. question-wise*) and the number of name interpreters (*6vs.11*).
The difference between *alter-wise* and *question-wise* format is important when we are asking the same questions of different objects/persons especially in web surveys (Kogovˇsek, 2006; Coromina and Coenders, 2006; Gerich and Lehner, 2006). So far, recommendations were different for different measures (*questionwise* for closeness and importance, and *alter-wise* for measures of frequency). The advantage of the *alter-wise* format is that the respondent is able to estimate the burden (the number of name interpreters times the number of alters) in advance (hence the increased threat of drop-out is burden is estimated as too high); on the other hand, the *question-wise* format requires less cognitive effort (all alters are evaluated along one attribute) and presumably less time, which is crucial in web surveys.
Our assumption was that *alter-wise* questioning takes more time and is also more burdensome, given the process of answering the questionnaire, as the respondent must answer a set of questions repetitively for each alter. The *alter-wise* format produced a larger percentage of item-nonresponse on average, as expected; yet what is even more interesting is that the long version of the questionnaire produced smaller item-nonresponse. However, as we will see further on, *alter-wise* questioning and the long questionnaire produce a higher drop-out rate, which is in line with our assumption of increased threat of drop-out when the respondent realizes the response burden, and given our assumption that the *question-wise* format is superior to the alter-wise format in some respects.
Moreover, the alter-wise format produces more itemnonresponse, in both the long and short versions, so we can conclude that the question-wise format is superior in web surveys.
Drop-outs are the most undesirable respondent actions in the survey process. A drop-out occurs when a respondent does not refuse to undertake the survey in the first place and starts answering the questionnaire but, usually for unknown reasons, never finishes it. This kind of behavior is not as common in interviewer administered surveys but is much more common in web surveys. In contrast to most of the survey modes in web surveys, we can more or less measure the point at which some respondent dropped out. Usually we store all the data that the respondent provided up to that point and can analyze at least some responses.
Drop-outs in web surveys may be connected with: (1) technical problems (i.e. a lost connection); or, more likely (2) a loss of focus

Table 8
Drop-out rate by the number of mentioned alters in the network generator (network size)

on the part of the respondent (high respondent burden), which is often related to complex (e.g., grid) or sensitive questions. If we analyze the drop-out rates according to the number of alters mentioned (Table 8), we clearly see that drop-out numbers rise with the increasing number of alters mentioned. Obviously, each alter mentioned prolongs the questionnaire significantly. When comparing the data collection mode, we see that the *alter-wise* format causes a slightly higher drop-out rate (17%) than the *question-wise* format (12%). The alter-wise format causes a significant burden with its repeated questions and discourages respondents from continuing, especially if they have a large network. However, we cannot prove a statistically significant difference (^{2}) between these two categories. On the other hand, we cannot see any difference in drop-out rates between the long and short versions of the questionnaire. This indicates that the burden of the survey arises more from the data collection format than from the length itself. *Alter-wise* questioning, where the same questions are repeated several times (once for each alter), is much more aggravating than *question-wise* questioning, where the respondent gets each question only once and answers it for all their alters.

We also examined the overall time needed to complete the questionnaire for those respondents who completed the survey (n = 282). As mentioned, the respondents who dropped out of the survey process were not included in this analysis. Table 9 shows that the average time needed to complete the survey was 810 s (13.5 min). According to expectations, respondents who answered the longer version of the questionnaire (with 11 name interpreters) needed more time to complete it—on average, 147 s (approximately 20%) more.

If we compare the name interpreter formats, we see that the *alter-wise* format was approximately 20% faster than the *questionwise format*. This was somehow contrary to our assumption that the *question-wise format* would be faster. According to Fuchs (2000), *question-wise* interviewing reduces segmentation of the questionnaire (providing a higher level of flexibility of the questionnaire and a better overview of the questionnaire flow) and slightly shortens the time needed to complete the questionnaire. One possible explanation is that the *alter-wise* format had more drop-outs, especially more drop-outs from those respondents with large personal networks. If we consider only respondents who completed the questionnaire, we see that the average network size for those

Table 9
Time needed in seconds for each type of questionnaire

respondents who answered the *alter-wise* format was 3.5 and 3.7 for those respondents who answered the *question-wise* format.

6. Discussion

When using the Internet our behavior is somewhat specific. Owing to an overflow of information and interesting materials, our focus is much more scattered and our decision to do something (or not) is a matter of seconds. Because we feel as if we are safely 'hidden' behind our monitor, we can also change decisions very easily. The decision to participate in a survey (or abandon the questionnaire) can, for example, be changed very quickly whenever we get bored or we encounter a set of questions that are irritating, or if we estimate that it would take too much time to complete it (Dillman, 2007). As a consequence, respondents often do not carefully read the text on the screen but only scan it; they are prone to lose attention very quickly if the task (survey) is not sufficiently interesting, and they are very sensitive to graphics (e.g., Couper et al., 2007; Couper et al., 2004a).

Some studies on the role of the graphic elements in web surveys warn that graphic elements do not even increase the motivation of respondents, while they can have a very powerful and sometimes unpredictable effect on answers (Couper et al., 2004b). More specifically, since the textual and visual elements are cognitively processed in parallel, various problems may arise when they are not consistent. A well-known example is the "Stroop effect", where subjects were asked to identify the color of the printed word: e.g., if the word "red" was in blue letters this would substantially slow the response process (Couper et al., 2004b, p. 256).

We have confirmed in our paper that specifics of the graphic layout do matter: different numbers of name generator name boxes gave radically different network sizes. When we exposed the respondent to a smaller number of name boxes, we obtained much fewer names (i.e. smaller social networks) and vice versa. We may thus treat the effects of the redundant name boxes in the name generator interface as having an effect counter to text instructions. The remaining name boxes implicitly suggest a specific (i.e. larger) number of alters, which may contradict the text instructions, where respondents are asked to enter only as many names as needed for the specific name generator definition of the social tie.

Closely related to this problem is the heaping to specific 'round' numbers (5, 10), which is in part influenced by the design, in our case by the 5 or 10 name boxes option. We thus expect that the 3 name boxes design would generate heaping around 3, 6, 9, etc. From this aspect, the smallest number of name boxes (i.e. a one name box design) seems to be superior. In addition, since Lozar Manfreda et al. (2004) showed that heaping also appears for other round numbers smaller than the number of name boxes offered, there is an additional advantage to the one name box design. In their case of a 30 name boxes option, the heaping occurred not only around 30, but also around 10 and 20, as well as around 5 and 15.

When considering the format of data collection (*alter-wise vs. question-wise*), we found that the *question-wise* format, which is not as common, produces a smaller percentage of item-nonresponse and drop-out rates. It is true that in this experimental setting it took slightly more time for the respondents to complete the questionnaire; nevertheless, in line with other studies (Coromina and Coenders, 2006; Kogovˇsek, 2006), we still strongly support the use of *question-wise* question format in this type of web questionnaire. We can also add here the findings of Coromina and Coenders (2006) that this question format provides more reliable data when egocentered networks are collected on the web.

Although our research did not show directly that a larger number of name interpreters increased the drop-out rate – contrary to the negative effect of a large number of alters – a smaller number

of name interpreters definitely lowers the response burden indirectly. To reduce respondent burden, it is thus still reasonable to select a smaller number of name interpreters. Alternatively, other techniques for reducing the response burden can be used, such as random sub-selection of name interpreters or alters (McCarty et al., 2007b).

With respect to general recommendations, we should first state that there are hardly any generally accepted standards for web questionnaire design, although there do exist some conceptual outlines (e.g., Dillman, 2007; Couper, 2000) and specific guidelines (e.g., AAPOR, 2005; ESOMAR, 2005). However, practical solutions always depend heavily on the specific context (technology, type of survey, target population). For this reason, especially with complex web survey data collection, intensive questionnaire pre-testing is recommended, particularly because default solutions are not always the best choice. In any case we should be aware that graphic elements are extremely powerful and may have unpredictable or contradictory effects. Some authors thus report that graphics stimulate the response process (Coromina and Coenders, 2006; Hogan et al., 2007; B ¨ alter, 2005), while others report no effect (Couper et al., 2004b). At the other extreme, there is even some clear evidence that new technologies, flexible layouts and fancy designs may have damaging consequences (Dillman et al., 1998; Coates, 2004). When we collect ego-centered social network data on the web, the other general recommendation – besides extensive testing – would be to use simple, familiar web forms to help users understand the meaning of the question as quickly as possible, on the other hand, and to ensure questions which are not suggestible on the other.

With respect to the specific problem of the number of name boxes, following our summary above, we suggest the one name boxes solution. Of course, we should be aware here of the related data quality problems (i.e. a large percentage of non-valid responses). However, this should be addressed with a smart input data quality validator or graphic stimuli to prevent invalid entries. The vast majority of invalid responses are very predictable (e.g., family, friend, mother, etc.). Future solutions should also incorporate the recent increase in possibilities for dynamic interaction (i.e. Web 2.0) between respondent and web questionnaire. This interaction should also be used to add more dynamics to the layout of the one name box design: After each name entry is confirmed, the option to continue (i.e. another name box) or to conclude the list should dynamically appear on the screen.

An alternative option that also deserves future research is to have only one very large name box with more implicit lines (e.g., 30 or 50) accepting a single name in each line. A variant of this approach is to have a smaller box (e.g., 10 lines) but with dynamically added empty space lines after each name entry, so that we always have a fixed number (e.g., 10) of empty lines below the last entry. Apart from that, other encouraging techniques for listing alters (Brewer, 2002) can be applied, either using prompts specifically related to the content of name generator such as “Please consider all the listed names; is there any other person that you discuss...with?” or using free listed names as semantic clues. However, one should always balance time versus the cognitive effort of the respondent in web surveys. One very appealing option worth exploring is to ask first for the size of the network and then tailor the number of name boxes accordingly. A very specific possibility would be to use multiple name generators, on the assumption that respondents will learn how to fill in the web name generator. The researcher should then consider the first name generator with greater caution as to measurement error.

We did not discuss mode comparisons issues in this paper; however, it is worth mentioning the obvious problem of methodological equivalence with face-to-face and telephone survey modes. Owing to the somewhat larger network sizes reported by web data collection and particularly owing to the sensitivity of the survey instrument, the obvious question arises: what is the *true* size of the social network with a given name generator for a certain respondent? The web interface that would provide approximately the same average size and composition of the ego-centered social network as in face-to-face and telephone surveys (Kogov ˇ sek, 2006) seems to be closer to the one name box design; nevertheless, the issue of equivalence is still very much open for future research.

Ego-centered networks and the ripple effect

Recent work has demonstrated that many social networks, and indeed many networks of other types also, have broad distributions of vertex degree. Here we show that this has a substantial impact on the shape of egocentered networks, i.e., sets of network vertices that are within a given distance of a specified central vertex, the ego. This in turn affects concepts and methods based on ego-centered networks, such as snowball sampling and the "ripple effect." In particular, we argue that one's acquaintances, one's immediate neighbors in the acquaintance network, are far from being a random sample of the population, and that this biases the numbers of neighbors two and more steps away. We demonstrate this concept using data drawn from academic collaboration networks, for which, as we show, current simple theories for the typical size of ego-centered networks give numbers that differ greatly from those measured in reality. We present an improved theoretical model which gives significantly better results.

V. CONCLUSIONS

There are a number of morals to this story. Perhaps the most important of them is that your friends just aren't normal. No one's friends are. By the very fact of being someone's friend, friends select themselves. Friends are by definition friendly people, and your circle of friends will be a biased sample of the population because of it. This is a relevant issue for many social network studies, but particularly for studies using egocentered techniques such as snowball sampling.

In this paper we have not only argued that your friends are unusual people, we have also shown (in a rather limited sense) how to accommodate their unusualness. By careful consideration of biases in sampling and correlation effects such as transitivity in the network, we can make accurate estimates of how many people your friends will be friends with. We have demonstrated that the resulting formulas work well for real social networks, taking the example of two academic coauthorship networks, for which the mean number of a person's second neighbors in the network can be measured directly as well as estimated from our equations.

It is important to note however that application of the formulas we have given requires the experimenter to measurecertain additional parameters of the network. In particular, it is not enough to know only the mean number of ties an actor has. One needs to know also the distribution of that number. Measuring this distribution is not a trivial undertaking, although some promising progress has been made recently.

One must also find the clustering coefficient of the network, which requires us to measure how many pairs of friends of an individual are themselves friends. This may require the inclusion of additional questions in surveys as well as additional analysis.

To return then to the question with which we opened this paper, can we estimate how many friends of friends a person will have on average who fall into a given group or who were involved in a given event? If the number involved in the event is e as before, and the total population is t, then the number we want, call it

m_2, is given by $m_2 = c_2 e/t$.

Thus, once we have c_2

we can answer our question easily enough. Using figures appropriate for the United States and the simple estimate of c_2

that it is equal to the square c_2

of the number of acquaintances the average person has, we get

$$c_2 = 290^2 = 84100$$

$$t = 280 \text{ million, and } m_2 = e/3330.$$

As we have seen here, however, this probably underestimates the actual figure considerably. The real number could be a factor of five or more greater than this formula suggests. Unfortunately, as far as we know, the necessary data have not been measured for typical personal acquaintance networks to allow us to estimate c_2 by the methods described here. In particular, measurements of the clustering coefficient are at present lacking. We encourage those involved in empirical studies of these networks to measure these things soon.

Entrepreneurial resource acquisition via personal networks: an empirical study of German start-ups

This paper presents a resource-based theoretical model for an extended version of the network success hypothesis. It derives four main hypotheses for the relationships between resources obtained from personal networks of the founders and a new venture's success. The model takes into account a broad range of control variables. In the empirical study, based on a sample of 123 German entrepreneurs, we do not find much support for our hypotheses. We conclude that, quite in contrast to most existing theories, network links have close to no impact on getting cheap or exclusive resources.
Keywords: networks; start-up success; social embeddedness; costs of networking; network dynamics

Entrepreneurship theory has a long tradition of studying entrepreneurs' networks and their effects on the success of start-ups. The term 'entrepreneurial network' refers to the personal network of information contacts and exchange relationships that an individual team of entrepreneurs can utilise for the purpose of creating and nurturing their venture. The most common hypothesis, the network success hypothesis, postulates a positive relationship between the networking activities of founders and their start-up's success (Birley, 1985; Bru ¨ derl & Preisendo ¨ rfer, 1998; Hoang & Antoncic, 2003; Johannisson, 1996; Lechner & Dowling, 2003). The rationale behind this hypothesis is the theory of socially embedded ties (Granovetter, 1985; Gulati, 1995; Uzzi, 1997) or social capital (Adler & Kwon, 2002; Florin, Lubatkin, & Schulze, 2003). It allows entrepreneurs to get two benefits: (1) to get resources cheaper than they could be obtained in markets; (2) to secure resources that would not be available in markets at all. These benefits are relevant for all industries, i.e. service firms as well as manufacturing firms, even if the types of resources they need may partially differ. The use of personal information networks for resource acquisition purposes has been shown to be a common practice in start-ups, especially among ethnic minority-owned firms (Collins, 2002; Deakins, Ishaq, Smallbone, Whittam, & Wyper, 2007; Kloosterman, Leun, & Rath, 1999) and in high-tech firms that face high levels of uncertainty in both technology and market as well as interdependencies in technology development with other firms (Moensted, 2007).

Unfortunately, the chain of association between networking activities and entrepreneurial success is long. It starts with activities to build up a network and their effect on network structure. Typical measures for the network structure of an individual entrepreneur are the number of direct information partners or the diversity of network partners in terms of occupation, age, income, etc. The more time and money the entrepreneurial team invests in the maintenance and the extension of its information network, the larger and the more diverse it should be (Dubini & Aldrich, 1991). But it depends on the founders' networking abilities and on national cultural settings (Dodd & Patra, 2002) whether and to what extent networking activities really lead to larger or more diverse networks.

The second link is between the structure of information networks of the founders and resources received from network partners. Literature has considered a large variety of types of resources that entrepreneurs could receive over network ties, e.g. financial means, know-how, reputation, physical assets, etc. (Westhead, Wright, & Ucbasaran, 2004). Whether entrepreneurs can and do really utilise their network to obtain a valuable resource (Barney, 1991; Wernerfelt, 1984) depends on the firm's existing resources and on the availability of that particular resource on the market. The better the initial endowment with resources is, the less incentives entrepreneurs have to engage in networking or to utilise existing network ties to obtain resources for their venture (Bayer, 1991). The less available a resource is on the market, the more entrepreneurs need to rely on personal networks to get that resource. Marketing experts serving on the new venture's board (Witt, 2004) or professors from research institutions providing technology information (Moensted, 2007) are examples.

The final association in the network success hypothesis is between the resources drawn from network partners and the economic success of the new venture. We investigate this link, in particular, in this paper. Our study tries to make a novel methodological contribution to the existing research on the network success hypothesis. Methodologically, we refine the measurement of the resource and the success variables, we account for a number of control variables that have been overlooked in many of the earlier studies, and we allow for nonlinear associations between these variables.

In terms of measurement, we distinguish between four types of resources: personal contacts, experience and knowledge, physical resources, and financial resources. We do so for two reasons. First, these are the types of resources that have been investigated most frequently in earlier studies on the network success hypothesis (e.g. Brown & Kirchhoff, 1997; Bru ¨ derl & Preisendo ¨ rfer, 1998; Kirby & Kaiser, 2005; Lechner & Dowling, 2003). Secondly, these are the types of resources that we have extracted empirically from an explorative factor analysis of a very broad range of resources that German entrepreneurs from the service sector as well as from manufacturing sectors reported to have received from network partners and that they utilised to build their new venture. To measure the start-up success, we use three variables: adaptiveness, customer orientation, and market success. Market success refers to survival after a number of years, profitability, value creation, or growt h. We do so for two reasons. First, all three success measures have been thoroughly developed and validated in earlier management and marketing studies (Irving, 1995; Ruekert, Walker, & Roehring, 1985; Walker & Ruekert, 1987). Secondly, we used an empirical approach and extracted our success measures by means of an explorative factor analysis from a broad range of potential indicators that entrepreneurs themselves use to measure the success of their ventures.

In terms of control variables, we take a closer look at the cost of networking as suggested by Johannisson (1996), the experience of the entrepreneurs (Cohen & Levinthal, 1990; Cooper,

Folta, & Woo, 1991), and the initial endowment of the start-ups with resources as suggested by Bayer (1991). All these variables potentially blur the link between resources that entrepreneurs obtain via network ties and the success of their start-up. In controlling for their influence, we try to get a more precise estimate of the core hypothesis that personal networks help entrepreneurs to get exclusive and cheap resources and thus foster the success of their new ventures.
In terms of the type of association between resources obtained from personal networks and start-up success, we follow up on the idea of potentially inversely U-shaped relationships between both variables as suggested by Witt (2004). This methodological extension is important, because nonlinear links are well known in management theory. The dominating approach in entrepreneurship research of conducting linear correlation or regression studies is prone to failure in finding support for the network success hypothesis, although a causal relation between the variables under survey exists.
The paper is organised as follows. In the first section, theories and empirical evidence on entrepreneurial networks are reviewed. It depicts the classical network success hypothesis as well as its extensions and the hypothesis is formulated. In the second section, the design of the empirical study, i.e. data collection and sample, the measurement of variables, and the methods for testing the hypotheses are explained. In the third section, the results of the empirical study are presented and the major findings are discussed. In the fourth section, the summary and some suggestions for further research are given.
Theories and empirical evidence on entrepreneurial networks The classical network success hypothesis and its extensions
The 'network approach to entrepreneurship' (Bru ¨ derl & Preisendo ¨ rfer, 1998) studies the entrepreneurial networks and their effect on a start-up's success (Aldrich & Reese, 1993; Birley, 1985; Johannisson, 1988). This prominent line of entrepreneurship research is based on the idea that founders use their personal network of private and business contacts to acquire resources and information they would not (or not as cheaply) be able to acquire on markets. Entrepreneurs with larger and more diverse networks are expected to get more support fromthis network and thus to be more successful than entrepreneurs with smaller networks or less support from their network.
Diversity matters, because different people can contribute different benefits to a new venture. Recent empirical research showed that entrepreneurial networks support the development of a start-up more effectively, if there is a 'relational mix', not only of strong and weak ties (Granovetter, 1985) but also of ties to people from different industries and with different educational backgrounds (Casson & Della Giusta, 2007; Lechner, Dowling, & Welpe, 2006; Ripolle ´ s & Blesa, 2005). Figure 1 depicts the 'classical' version of the entrepreneurial network success hypothesis.
In a more recent research, the network success hypothesis has been extended considerably. One important extension is to control for different starting conditions of new ventures. Empirical

Figure 1. The classical version of the entrepreneurial network success hypothesis.

studies have found the start-up's industry, its strategy, the founders' gender, and the initial endowment of resources to have an effect on entrepreneurial networking activities (Hoang & Antoncic, 2003; Lee & Tsang, 2001). In this study, we control for various other influences, mainly different variables representing the cost of networking.

Another extension of the classical network success hypothesis affects the relationship between the network structure and the benefits received fromthe network. Acontrol variable for this relationship is the absorptive capacity of the founders and their organisation (Cohen & Levi nthal, 1990), which is not a static variable but rather develops over time. The better the network partners know each other and the more trust has been established in their relation, the more effective is the knowledge transfer between them (Casson & Giusta, 2007; Levin & Cross, 2004; Welter & Kautonen, 2005). In general, it is the quality of individual network links that determines the quality of the resources and the information entrepreneurs can obtain from them. In this paper, we approximate the founders' absorptive capacity by their experience in various fields. Experience types examined include management, technical, and entrepreneurial experience as well as professional experience in the respective sector.

The quality of network ties depends on the degree of mutual trust between the partners which in turn is formed by individual network competence (Ritter & Gemu ¨ nden, 2003; Welter & Kautonen, 2005) and the history of mutual benefits in that relationship (Starr & MacMillan, 1990). Similarly, the costs of maintaining a certain network structure need to be taken into account when investigating the relationship between network structure and the benefits received from network partners (Johannisson, 1996). Increasing marginal cost of utilising network ties in combination with decreasing marginal benefits from resources obtained from the network lead to nonlinear relationships between network structure and net benefits (Witt, 2004). Both factors, marginal costs and marginal benefits of network ties, strongly depend on the size of the existing network. The more links an entrepreneur already has, the less likely it is that a new partner will add as much value to the new venture as one of the early new contacts did, simply because the degree of redundant information and resources increases and the opportunity costs of acquiring and maintaining a new link rise. Bearing that in mind, in this study, respondents were explicitly asked about the resources they actually received from their personal networks (Premaratne, 2001).

Another extension mainly clarifies that the relationship between net benefits from the network and entrepreneurial success largely depends on how you measure success and what the entrepreneurs are able to do with the resources. As start-ups typically do not publish financial data, many empirical studies need to rely on subjective estimates for success as stated by the founders themselves which, at least partly, depend on their entrepreneurial intentions. In this paper, three different success measures are used, all of which have been validated in a factor analysis.

Formulation of hypotheses In our empirical study, we try to assess whether and how four different types of resources that

entrepreneurs potentially receive from network partners contribute to three different measures of success (most similar to this procedure is the empirical study by Bru ¨ derl & Preisendo ¨ rfer, 1998). The main reason for this approach is to shorten the long causal chain between networking activities of founders and their start-up's success that has in effect blurred much of the theoretical and empirical evidence so far. We utilise a network measure that is as close as possible to the success measures in the causal chains between network utilisation and new venture success

(Ripolle ´ s & Blesa, 2005). Rather than measuring 'net benefits', a variable that comprises many kinds of information, services, resources, and their cost and thus is extremely difficult to quantify, we directly ask for resources that the founders received from network partners (as suggested by Premaratne, 2001). In doing so, we can benefit from a rich body of economic research on resources and their effect on companies' success.

It has been shown empirically that the use of external resources can help start-ups to grow faster and to be more successful in the long run (Jarillo, 1989; Premaratne, 2001). The resource-based theory (Barney, 1991; Wernerfelt, 1984) and its extension, the theory of dynamic capabilities (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997), allow for a specification of this positive effect of external resources. External resources that a start-up receives from network partners or other sources contribute to entrepreneurial success if they have been acquired at less than market costs or if they are resources that are not available on markets at all. Especially difficult to copy, non-transferable and non-substitutable resources create competitive advantages and could be termed 'strategic resources'. Start-up-specific examples of strategic resources are access to large customers, reputation from well-known business people on the board of directors, or exclusive technology know-how from universities (Zucker, Darby, & Armstrong, 2002). As independent variables for our model, we distinguish between four different factors, i.e. types of resources: personal contacts, experience and knowledge, physical resources, and financial resources.

The dependent variable in all versions of the network success hypothesis is the long-term success of a newventure. In order to come up with a reliable and valid measure, we use three dimensions of entrepreneurial success: adaptiveness, customer orientation, and market success. All three have been thoroughly developed and validated in earlier studies, predominantly in the fields of strategic management and marketing (Irving, 1995; Ruekert et al., 1985; Walker & Ruekert, 1987). We assume that there is a causal relationship between these three dimensions. The ability to adapt well to the environment makes it possible to be customer-oriented and satisfy customer needs which in turn leads to market success in the sense of sales growth (Ripolle ´ s & Blesa, 2005) and profits (Premaratne, 2001). Using all three dimensions has the advantage that start-ups in different stages of their development can be evaluated. Depending on the industry and the business model, some standard performance measures cannot be applied well to young start-ups. Sometimes, start-ups may be very successful, although they have not realised profits or even sales yet, e.g. biotechnology ventures (Zucker et al., 2002).

The relationship between resources that entrepreneurs receive from their personal network and the venture's success, i.e. the effects to be postulated in our hypotheses, is affected by a number of external factors. Rather than building a structural equation model that tries to capture the causal relationship between the variables under survey and the external factors, we keep the model as simple as possible. We treat external factors as control variables for one simple core relationship (that between network resources and success). This has the advantage that we can do robust testing without too severe demands on sample size and distributional properties of the variables under survey. It also has the advantage that, in fact, we ask for no more than correlations, not necessarily causal relationships. If the empirical tests of our hypotheses do not find any significant correlations between the four independent and the three dependent variables, we can still conclude that there is no causal core relationship.

With regard to control variables, we first take the costs of networking into account, as suggested in earlier theoretical contributions (Johannisson, 1996; Witt, 2004). A well-known

approach is to measure the time to take care of existing relations, e.g. as indicated by the frequency of contacts (Ripolle ´ s & Blesa, 2005), as well as the time to build new relations. But the costs of networking do not only comprise time. Good network relations require reciprocal behaviour, i.e. entrepreneurs have to do favours to those people who do favours to them, at least in the long run. Few resources received from network partners are really 'gratis' (a term used by Premaratne, 2001), but their cost may be social rather than monetary. In this paper, we use a broad range of measures for the costs of networking, including time, reciprocal actions, expected favours, and reduced freedom in decision-making.

Secondly, we measure the experience of the entrepreneurial team in years and in four dimensions: management, technology, entrepreneurial, and industry-specific experience. Experience and qualification are classical moderating variables in strategic management research. They determine whether and to what extent companies can transfer resources into competitive advantages (Cohen & Levinthal, 1990). In the context of network success hypothesis, the experience of the founding team again determines how well the network resources can be utilised, and also which alternative ways of securing cheap or strategically valuable resources the venture has (Bru ¨ derl & Preisendo ¨ rfer, 1998; Cooper et al., 1991; Johannisson, 1996).

Thirdly, we measure the initial endowment of the venture with physical, financial, and immaterial resources, all in comparison to its major competitors. We do so, because theoretical and empirical studies have found the initial endowment with resources to strongly affect the networking activities of founders and the types of resources they ask for from network partners (Bayer, 1991; Chicha, 1980; Lee & Tsang, 2001). The idea of the so-called 'compensation hypothesis' (Bayer, 1991) is that especially less well-equipped founders use their networks to get access to resources while others can use markets for that purpose. In that respect, social capital is a substitute for financial capital (Casson & Giusta, 2007).

To summarise, we focus our attention on the relationship between resources from entrepreneurial networks and the success of the respective new venture, as well as external factors with a potential influence on that relationship. As there are four different types of potentially beneficial resources, we formulate the following four hypotheses (Figure 2).

H1: The more personal contacts a start-up receives from the personal networks of its founders, the more successful it is (H1a: in terms of adaptiveness, H1b: in terms of customer orientation, H1c: in terms of market success). H2: The more experience and know ledge a start-up receives from the personal networks of its founders, the more successful it is (H2a: in terms of adaptiveness, H2b: in terms of customer orientation, H2c:in terms of market success). H3: The more physical resources a start-up receives from the personal networks of its founders, the more successful it is (H3a: in terms of adaptiveness, H3b: in terms of customer orientation, H3c: in terms of market success). H4: The more financial resources a start-up receives from the personal networks of its founders, the more successful it is (H4a: in terms of adaptiveness, H4b: in terms of customer orientation, H4c: in terms of market success).

Design of the empirical study Data collection and sample

Our empirical study targeted German start-ups from service industries to manufacturing industries. By focussing on one country, Germany, we control for national culture, political context,

Figure 2. Model and hypotheses.

and national institutional structures that can have a major impact on the extent to which personal networks are being used by entrepreneurs. We defined a start-up as an independent venture run by the founders and being less than10 years old. We identified the companies, the names of their founders, as well as the founders' email-addresses through a systematic search in different databases. The starting point was a database that had been created by Rode (2004) to do research on the brand building activities of German start-ups. Furthermore, we got the permission to use a database created by Brachtendorf (2004) on German high-tech start-ups that received funding from venture capital firms. Finally, the German Federal Ministry of Education and Research granted access to its database on German ventures that were supported by the so-called EXIST programme, a system of loans and subsidies for new ventures. After eliminating double entries as well as companies with unclear or inconsistent data on their founders and managers, we had created a unique data set of 1182 German start-ups.

After pre-tests of our questionnaire with 12 people (researchers, industry experts, and founders), we sent out personalised emails to the founders of all 1182 companies in our data set. Each email provided a link to a secured website, where respondents could answer the questionnaire online. The survey took place from November 2003 to February 2004. We sent reminder emails twice to those start-ups that had not responded to our earlier email. In total, we received 123 completed and usable questionnaires from founders still running their own independent ventures. 74 of them are service firms [for a very useful typology of service firms, see Noteboom (2007)], 49 are manufacturing firms. Thus, the response rate was 10.4%. As we used personalised emails to entrepreneurs and were referring to their personal network we safely assume that these entrepreneurs were the ones who answered our questionnaire. It seems very unlikely, although not impossible, that the entrepreneurs delegated the task of answering our questions to employees in their firm. As we could identify no more than one member of the entrepreneurial team per company in our database, there was now an opportunity to control for an informant bias by asking a second respondent per company to answer our questions. To control for biases in our sampling procedure, we conducted two types of analysis. First, we measured the non-response bias as differences between respondents who answered early and respondents who answered late (Armstrong & Overton, 1977). As we could not find any significant differences, we conclude that our sample

has no non-response bias. We were unable to check a non-response bias by getting data from nonrespondents. Secondly, comparing the descriptive characteristics of the firms in our sample with corresponding data from 'Statistisches Bundesamt' for all start-ups in Germany, we identified no major biases for variables such as gender of the founder, industry, and company size. Hence, our sample is representative of the population of German start-ups in this respect.

The 123 entrepreneurs in our sample are on average 37 years old. The youngest person is 23, the oldest 54. Seventeen percent of our respondents are female, 83% are male. Sixty percent of the entrepreneurs have a university degree and 26% even hold a Ph.D. degree. The mean of the management experience in the sample is 8 years per person, 7 years for technical experience, 8 years of industry experience, and 5 years of entrepreneurial experience. In summary, our sample consists of fairly experienced and well-educated entrepreneurs. In this respect, it may not be representative of the German population of all founders.

The ventures in our sample are on average 3.7 years old, the youngest had been found just a couple of weeks before our survey took place and the oldest was 10 years old. At the time of the survey, the start-ups in our sample employed a mean of 20.3 people and the median is 5. The largest venture had more than 100 employees. This confirms that the distribution of firm sizes in our sample is pretty skewed. The same is true for the distribution of sizes at the foundation date, the mean starting number of employees of the start-ups in our sample was 1.8 and the median was 1.

Measurement of variables In answering the questions in the questionnaire, we asked the respondents to focus on their direct

network partners, i.e. what the 'action set' is. In the questionnaire, we did not use the term 'action set' but asked our respondents to refer to those persons with whom they felt most comfortable discussing about their business and who have been actively involved in the start-up process (Aldrich, Rosen, & Woodward, 1987). In doing so, we deliberately leave out those parts of each entrepreneur's personal network that have not been used in the process of starting a new venture. We also neglect the second-tier network of entrepreneurs, i.e. the friends of friends. A valid evaluation of second-tier networks requires access to all first-tier contacts of an entrepreneur which is simply not feasible for a large-scale empirical survey. Theoretically, respondents could have been asked to give information on each of their partners' networks (Birley, 1985; Johannisson, 1996), but that procedure has the disadvantage of potentially strong perception biases.

We furthermore restricted our respondents' attention to the last 6 months for two reasons. First, earlier research has shown that contacts between entrepreneurs and their network partners take place at least every 6 months and typically much more frequently (Johannisson, 1996). If an entrepreneur has not had any contact with a certain person for the last 6 months, it seems very unlikely that that person belongs to the entrepreneur's active and relevant network partners. Secondly, the ability of entrepreneurs to recall exactly their network partners at the time when their company was started is limited. The vagaries of memory recall for busy entrepreneurs would undermine the empirical findings.

The downside of our measurement approach is the risk that for some proportion of the sample the recent networking activities of the entrepreneur have not been predominantly with direct contacts that were involved in the start-up process. Network contacts may evolve over time, and the entrepreneurs may simply have moved on. Fortunately, recent research on different

resource requirements of start-ups in different stages of their development shows that key actors and key network partners stay the same over time (Franklin, Wright, & Lockett, 2001; Lechner et al., 2006; Vohora, Wright, & Lockett, 2004).

Independent variables The independent variables in our study measure the output or the benefit from networking activi-

ties and a certain entrepreneurial network structure, i.e. the resources that were received from network partners. In doing so, we distinguished between four different factors, i.e. types of resources: personal contacts, experience and knowledge, physical resources, and financial resources [a very similar typology is being used by Premaratne (2001)]. These four factors were the result of an explorative factor analysis for all sample firms, in which we included 21 different items that have been tested in earlier empirical studies on the relationship between support from the network for founders and the start-up's success [Witt (2004) for a survey of these studies]. From these 21 items, four had to be eliminated due to insufficient factor loadings. The others could all be grouped well into the four factors we will explain subsequently (main component analysis, all factor loadings .0.5; Bartlett test for significance of the factor grouping ¼ 0.000). Conducting the explorative factor analysis only for the 74 service startups in our sample rendered identical factor groupings, which proves that the resource needs of start-ups are not industry-specific.

To quantify resources in terms of personal contacts, we used seven indicators: direct orders for products or services from the start-up, help to establish contacts to potential customers, the provision of reputation for the start-up (e.g. serving as a board member, as a reference customer or in advertising), contacts to potential suppliers, direct work for the start-up, and providing access to intellectual property rights (patents, brands, software, etc.) and contacts to potential employees. For experience and knowledge as resources received from the personal network output we used five indicators: consulting services in organisational issues, help in designing the organisational structure of the start-up, help in writing the business plan and in strategy formulation, emotional support, and consulting services with respect to immaterial resources. With regard to physical resources, we asked for the support entrepreneurs received from network partners in terms of three indicators: help in getting real estate and office room, help in getting raw material and equipment, and consulting services to procure physical resources. To measure financial resources received from the network, we took the following two indicators: help in securing equity, banks loans, or other forms of credit and the provision of collateral or security. Again, we used 5-point Likert scales to measure all these variables.

Dependent variables In the previous studies, a large variety of measures for company success has been used (Witt &

Rosenkranz, 2002). Typically, sales growth (Ripolle ´ s & Blesa, 2005), financial performance (Premaratne, 2001), and related market success measures (Rode, 2004) are preferred. However, although being successful in the long run, many ventures do not show any revenues or profits during their first years after foundation. Hence, 'classical' measures of company success are not suitable for new ventures. An appropriate measure of start-up success should also be applicable to pre- and early stages of long run venture success. So does our threestep approach which has already been validated in a number of other empirical studies

(Sandt, 2004; Spillecke, 2006; Willauer, 2005). The three factors to measure a new venture's success, adaptiveness, customer orientation, and market success were the result of an explorative factor analysis of all sample firms, in which we included 12 items that have been tested and validated extensively in earlier empirical studies on the different stages of market success (Irving, 1995; Ruekert et al., 1985; Walker & Ruekert, 1987). From these 12 items, three had to be eliminated for further analyses due to insufficient factor loadings. The others could all be grouped well into the following three factors (main component analysis, all factor loadings .0.63; Bartlett test for significance of the factor grouping ¼ 0.000). To measure the construct 'adaptiveness', we used three indicators: the ability to utilise new market chances, the ability to find innovative solutions for changing customer needs, and the quick reaction to new market threats. We used two indicators for the construct 'customer orientation': the creation of customer satisfaction, and the ability to keep existing customers. Finally, for the construct 'market success', there are four indicators: reaching the desired market share, reaching the desired sales growth, profit in the last 3 years, and the ability to get new customers. Our respondents gave their subjective estimates on the success dimensions by looking back at the last 3 years of their venture (or the time since its creation if the venture was ,3 years old) with 5-point Likert scales for all indicators.

To check for structural differences between service and manufacturing firms in terms of appropriate success measures, we also conducted the explorative factor analysis of the success measures only for the 74 service firms in our sample. The three factors 'adaptiveness', 'customer orientation', and 'market success' with their corresponding indicators remain the same, but the factor loadings for the success measure 'adaptiveness' are somewhat weaker than for the total sample. We conclude that adaptiveness is somewhat less important in service firms than it is in manufacturing firms. The main explanation we propose is that service firms need lower investments in physical assets and thus can more easily adapt to changing customer needs or new technologies.

To avoid common source biases, it would have been very helpful to get secondary data for success measures, rather than primary data from the same respondents who gave information on the independent variables. In our sample, this was, however, not feasible because most of the start-ups we surveyed are neither listed companies nor do they voluntarily publish financial data. So, all our results may indeed suffer from a common source bias. To avoid biases fromdifferent expectations of the entrepreneurs in our sample, we asked the entrepreneurs to always give their estimates for all indicators by comparing their own venture to the major competitors.

Control variables The first important control variable covers the entrepreneur's costs of building and maintaining

network ties. We measured the amount of time invested by each respondent per link on a 5-point Likert scale and for the last 6 months. With respect to the invested time, our questionnaire distinguished between time to take care of existing relations and time to build new relations. As good network relations require reciprocal behaviour, the costs of maintaining a network generally rise with the number of partners in that network. But they also depend on individual expectations of network partners. Therefore, we use three additional variables to measure the costs of networking, all with 5-point Likert scales: the size of the network, a subjective estimate for the returns which networks partners expect, and a subjective estimate for the extent to which network ties restrict the individual's freedom in decision-making (Donckels & Lambrecht, 1995).

The second control variable measures the experience of the entrepreneurial team in years and in four dimensions: management experience, technology experience, entrepreneurial experience, and industry-specific experience. As a third control variable, we measure the initial resource endowment of the venture in terms of physical, financial, and immaterial resources, all in comparison to its major competitors.

Methods for testing the hypotheses First of all, we had to test the validity and reliability of our main factors. To do so, we conducted

a factor analysis for all constructs, using the software SPSS for Windows. To check the validity of the measurement, we calculated rotated factor loadings per indicator, demanding values .0.4. (Results of the factor analyses are displayed in Appendix 1).

To judge reliability, we calculated Cronbach's a, demanding values 0.7, and the corrected item-to-total correlation, demanding at least 50%. When the factor analysis rendered unacceptably low a values, we tried to eliminate indicators with low item-to-total correlations to see whether the a could be improved. In general, the results indicate good validity and reliability of all our factors, for the total sample as well as for the sub-sample of service firms.

To test the hypotheses, we used simple correlation analysis (Appendix 2) as well as multivariate hierarchical regression analysis (Appendix 3). The hierarchical regression analysis started with a base model focusing on the control variables alone and subsequently added the individual variables necessary to test the hypotheses. The software chosen was SPSS for Windows again. Whenever all the requirements to do so were met, we used ordinary least squares estimates.

Results of testing the hypotheses The tests of the four core hypotheses render surprisingly few significant findings. All regression

results are without evidence of heteroscedasticity or multicollinearity. Our three measures for entrepreneurial success are highly correlated, as expected. We conducted all regressions for the total sample as well as for the sub-sample of service firms. The results were the same for both groups of regressions, proving that the effects of resources obtained by entrepreneurs on their ventures' success are independent of the respective start-up's industry. In the following, we will only report the results of testing the hypotheses for the total sample including service as well as manufacturing firms.

Personal contacts, the independent variable of hypothesis 1, show a significant positive relationship with market success and customer orientation respectively, which supports hypotheses H1b and H1c, but no relationship to adaptiveness, so that hypothesis H1a has to be rejected. The second independent variable, experience and knowledge, is correlated with none of our measures for success. Therefore, hypothesis 2 has to be rejected. Physical resources show no correlation to the success measures either. As a consequence, we reject hypothesis 3. The same is true for financial resources, so that hypothesis 4 gets no empirical support from our data either; please see Appendix 3 for detailed regression results. In summary, our findings raise serious doubts on the network success hypothesis in its general form.

These findings make the analysis of control variables all the more important. The first and perhaps most important control variable for the test of our hypotheses is the cost of networking.

As the analysis of the plotter charts suggested potentially U-shaped relationships between the cost of networking and resources received from the network, we ran a regression analysis with natural logarithms of the time spent to keep contacts, the time spent to establish new contacts, the number of contacts per partner per week, and the number of people contacted within the last 6 months. For the network resources 'personal contacts' as well as 'experience and knowledge', we find a number of significantly positive relationships (all R^2_{corr}, 0.1, sig. 1 and 5%). For physical resources or financial resources, there is no significant correlation which indicates that network ties may not help much to get equipment or money. There is no correlation between the cost of networking and any of the success measures either. We interpret this finding as an indication that network ties are indeed reciprocal in nature. Reciprocal exchanges are easier to accomplish and more valuable to both participants if the goods and services being exchanged differ in their subjective value, i.e. have no clear and valid-for-all market price.

The control variable 'experience of the founders' renders surprising and partly contradictory results. Experienced entrepreneurs invest the same amount of time in networking activities and contact similarly many people as less experienced colleagues. What is perhaps more surprising is they also receive similar amounts of resources from their network. Thus, experience does not seem to make entrepreneurs more efficient in utilising network ties. Interestingly, technical experience has, contrary to entrepreneurial experience, a negative impact on customer orientation. Companies of sector-experienced founders are more successful in terms of customer orientation and market success than those of founders without sector experience. Management experience of the founders is negatively correlated to market success of the venture. Overall, there is no clear relationship between experience of the entrepreneur and the three measures of venture success. Experience seems to be irrelevant for networking and only partly meaningful for entrepreneurial success.

To control for the potential influence of the venture's initial endowment with resources on our hypotheses, we first looked for correlations of the initial endowment with the founders' networking activities, i.e. the time invested to maintain ties or establish new ones. There are none. Secondly, we checked whether founders with higher initial endowments received more resources from the network. There is no such effect. In a multivariate regression model, we tested for direct effects of the initial endowment on the dependent variables adaptiveness, customer orientation, and market success. Again, there is no significant relationship.

Summary and suggestions for further research Our study aimed to investigate the theoretically most meaningful version of the network

success hypothesis, i.e. the positive relation between resources obtained from personal network ties of the entrepreneurs and start-up success, using a large sample of German start-ups from services as well as manufacturing industries. Our goal was to take into account the important control variables and to use reliable and validated measures for dependent and independent variables. Our findings indicate that this network success hypothesis has to be rejected in most dimensions. The only valuable resource that the entrepreneurs in our sample received from network partners was personal contacts. These contacts helped the entrepreneurs to be more customer-oriented and to be successful in their markets. Other resources obtained from networks, i.e. experience and knowledge, physical resources, and financial resources, do not correlate with any success measure.

At first sight, this result is not very surprising because it seems to be in line with earlier empirical studies from the USA, Sweden, and Finland that could not find empirical support for the network success hypothesis (Aldrich & Reese, 1993; Cooper et al., 1991; Johannisson, 1996; Littunen, 2000). At second sight, our findings are slightly more surprising, because some of the earlier empirical studies did find a significantly positive relationship between network variables and success variables (Hansen, 1995; Ostgaard & Birley, 1996; Premaratne, 2001; Ripolle ´ s & Blesa, 2005), also for German samples (Bru ¨ derl & Preisendo ¨ rfer, 1998). Networks and their utilisation for entrepreneurial activity may be a culture-specific phenomenon (Dodd & Patra, 2002). Our findings suggest that Germany is a country in which network ties are of little relevance for entrepreneurial success.

Yet, our results are also important for further theory-building in entrepreneurship. They rule out some of the earlier explanations for insignificant empirical support for the network success hypothesis. First, we did control for a number of potential external influences on the relationship between resources obtained from the network and start-up success. In doing so, we can reject the compensation hypothesis (Bayer, 1991) and the notion of absorptive capacity as a prerequisite for entrepreneurs to benefit from personal networks (Cohen & Levinthal, 1990). Neither the initial endowment with resources nor the experience of the entrepreneurs as a proxy for their absorptive capacity do explain the differences in start-ups' success. In our sample, technical experience even led to less customer orientation. Management experience is negatively correlated with market success. Only industry experience makes entrepreneurs more successful. Secondly, we used a set of validated measures for independent and dependent variables and thus ruled out measurement problems that have been referred to as a major reason for the huge variance in empirical results on the network success hypothesis (Witt, 2004).

In summary, these results render much of the existing theoretical research on entrepreneurial networks obsolete. Entrepreneurial networks are irrelevant for the success of new ventures, at least in Germany. Our findings suggest that network links do not help German entrepreneurs to get cheaper or exclusive resources. The existing theories on entrepreneurial networks overlook the fact that network exchanges are reciprocal in nature and thus costly as market transactions. Whenever an entrepreneur gets something from a network partner, he or she always has to give something of equal value back to that partner, at least in the long run (Fehr & Ga ¨ chter, 1998). Transactions over network ties are much more similar to market transactions than scholars have been suggesting in the past (Casson & Della Giusta, 2007; Granovetter, 1985; Gulati, 1995; Uzzi, 1997).

As a consequence, future research on entrepreneurial resource acquisition strategies should turn back to economic theories and not delve too deeply into sociological considerations. Current theories on the effect of personal networks on new ventures' success in the marketplace appear not to be 'undersocialised' (Larson, 1992) but rather 'oversocialised' (Witt, 2004). Future research on the network success hypothesis, if it is felt to be a priority topic at all, should try to put a stronger focus on the costs of networking and the total prices (cash price plus social price) of resources obtained from network sources. Doing so has the advantage to link entrepreneurship research closer to economic theory.

Another conclusion from our empirical findings is the support for the plea that entrepreneurship research needs more dynamic theories on entrepreneurial network utilisation, i.e. better theoretical explanations for the development of entrepreneurial networks over time (Hoang & Antoncic, 2003; Johannisson, 1996). In dynamic models explaining the growth of new ventures,

the process of network building is assumed to involve the exploration, screening, and selective use of network dyads to match the business goals of the firm in each phase of its development (Larson, 1992; Larson & Starr, 1993). By increasing the number of business ties in the personal network and by layering the existing relationships with additional business functions and contact partners, the entrepreneurs permanently develop their personal networks to yield an organisational network of the start-up. In recent years, there have been some important empirical studies in that direction (Lechner & Dowling, 2003; Lechner et al., 2006). But there is still no clear understanding as to when a start-up should best try to get what resources via personal network ties rather than via market transactions. More longitudinal studies using qualitative and quantitative data over many years as well as studies using panel data would be very helpful to further develop a dynamic theory on entrepreneurial resource acquisition.

The main conclusion from our study for entrepreneurs and other practitioners dealing with new ventures is to not focus too much on networking when starting a company. Resources that entrepreneurs receive from partners in their personal networks may be more costly than they appear. Taking into account the opportunity cost of time and the social obligations coming along favours from network partners, market transactions may actually be a cheaper way of acquiring resources in comparison to the utilisation of networks. While we do acknowledge that some resources such as highly reputable board members are not available on markets and, therefore, entrepreneurs have to try to obtain them from personal network links, our study suggests that in Germany these types of resources may be an exception rather than the rule.

Measuring entrepreneurs' social networks and their economic impact in African informal economy

Abstract

Social relations and networks constitute a major form of social regulation in urban African informal economy. Their nature, configuration and impact on entrepreneurs' economic performances represent a crucial issue for policy intervention. In order to explore the subject this paper focuses on entrepreneurs' social or personal network instead of inter-firms linkages. Indeed, observed networks go through usual frontiers of social institution and categories. We thus propose an 'ego-centred' network perspective which is particularly relevant to study informal entrepreneurs' networks that are often composed of a mixture of business, friendship and kinship ties. Such an approach allows to measure social networks according to three salient dimensions: network structure (size, density), content of ties (strength, social role, exchanged resources), and members' attributes (sociodemographic, social status, professional occupation). From an empirical standpoint we use an original dataset collected in 2007 on a representative sample of 317 entrepreneurs in the informal economy of Bobo-Dioulasso (Burkina Faso). The 'multiple name generators' instrument implemented to collect 'ego-centred' network data produces a rich set of information describing social networks' configuration according to their three dimensions. Quantitative measures of networks' structure and composition allow to produce well-informed typology of entrepreneur's social networks. Multiple regression analysis then shows that linking networks with members enjoying privileged social status have no significant impact on entrepreneurs' economic performances. Conversely, solidarity networks have a significant positive impact. Moreover, business ties and business networks also have an impact, but not anyhow. The differentiated impacts of flexible and dense business networks suggest the need for institutions encouraging equitable interactions between entrepreneurs and moderating social constraints.

1. Introduction

Described as an extremely heterogeneous collection of activities, partly conducted on the fringe of state rules, informal economy has shown rapid expansion in developing countries during the last decades, especially in urban African cities where it contributes on average to 61% of employment (Xaba and al., 2002). In this context, understanding informal dynamics represents a crucial issue for policy intervention. One little-known aspect of these dynamics is the role of social networks as a major form of social regulation.

The role of social networks in markets and economic action, outcomes and institutions is recognized and has been studied for long time by social scientists, notably sociologists (Granovetter, 1985; Coleman, 1988). Economists also recently picked up this problematic, notably by demonstrating the role of social networks in market efficiency and the reduction of

transaction costs (Kranton, 1996). Obviously, such a subject as social networks favors crossfertilization among social sciences. In African societies, the nature and role of social networks have been widely studied by anthropologists, historians and sociologists, notably concerning wide trading networks from pre-colonial to contemporary periods (Mitchell, 1969; Cohen, 1969, Meillassoux, 1971). In the current framework of urban informal economy, and in an African context of states and modern institutions failure, social networks and personal relations inevitably play an important part in structuring economic activities. Indeed, they may facilitate access to diverse useful resources for entrepreneurs, as for example information, ideas and knowledge (about markets, activities, and skills) or financial

and material support (notably in time of crisis). Regarding informal activities, it is of special importance as it compensates for the weakness of small firms internal resources.
From an economic standpoint, the study of contemporary social networks in urban entrepreneurship and informal economy has been constructed within two interrelated perspectives (Barr, 2002; Knorringa and van Staveren, 2006). The first relates to the analysis of inter-firm networks in industrial sectors or clusters in developing countries (McCormick, 1999; Brautigam, 1997, Meagher, 2007). The second rests on the social capital literature and focuses on entrepreneurs‟ social networks. It attempts to evaluate their nature, role and impact on entrepreneurial success and economic performances. However, quite surprisingly, this perspective remains few developed as most of the empirical literature about individual social capital in developing countries focuses on household level rather than entrepreneur one (see, for example, the literature review of Durlauf and Fafchamps, 2004). Moreover, the concept of social capital does not exclusively refer to social networks, but also to social norms and trust. Nevertheless, as Durlauf and Fafchamps (2004: 46, 57) argue, it may be more fruitful for empirical analysis to „step back from grandiose approaches‟ and focus on some specific social components of social capital like social networks. That is the reason why our approach is firmly rooted in this second perspective and specifically focuses on social networks
. However, another important difficulty of such perspective, that probably explains its lack of empirical investigations, rests on the ability to measure and collect exploitable data on social networks.
Our paper contributes to the literature on entrepreneurs‟ social networks by analyzing and evaluating their economic impact in the informal economy of Bobo-Dioulasso (the second city of Burkina Faso). More precisely, it challenges one of its main difficulties that rest on social networks‟ measurement and data collection. We thus propose an approach based on the notion of „ego-centred network‟ that partly draws on the Social Network Analysis (SNA) research tradition (Wasserman and Faust, 1994; Scott, 2000). An „ego-centred‟ (or „personal‟) network is defined as one actor‟s set of connections with others (Wellman, 2007a). This perspective is particularly relevant to study informal entrepreneurs‟ social networks that are often composed of a mixture of business, friend and kin ties. Network is thus defined as entrepreneurs‟ regular social relations conveying essential resources for activities‟ current exploitation. Such an approach allows to describe social network‟s configuration according to three salient dimensions: network structure (size, density), content of ties (strength, social role, exchanged resources), and members‟ attributes (sociodemographic, social status, professional occupation). As it necessitates specific personal networks data (Wellman, 2007b), we consequently conducted an original survey on a representative sample of 317 Bobo-Dioulasso‟s entrepreneurs from February to July 2007. In addition to sociodemographic and economic data, personal networks data have been collected on a sub-sample
of 278 entrepreneurs. That part of the questionnaire is based on an adaptation of the multiple names generators method (Fischer, 1982; Burt, 1984; Campbell et Lee, 1991; Marsden, 2005). The explanatory power of this approach rests on its ability to produce rich statistical information about the complex nature of informal entrepreneurs‟ networks in regard to the three above-mentioned dimensions. Quantitative measures of networks composition and structure are then computed. They permit to produce a well-informed typology of entrepreneurs‟ social networks which is used to test and discuss the relevance of networks‟ configuration as a predictor of entrepreneurs‟ economic outcomes.
This paper is organized as follows. After a brief overview of social networks‟ measurement problems in the literature about African informal economy, section 2 presents the ego-centred network framework. Section 3 reviews the alleged impact of the three dimensions of

egocentred network on entrepreneurs and firms‟ economic performances. Data, survey methodology, especially the multiple names generators instrument, and measurement options are discussed in section 4. Section 5 proposes a typology of entrepreneurs‟ social networks and then tests the potential effects of the different networks configurations on informal entrepreneurs‟ outcomes. Finally, discussion and concluding remarks are presented in section

2. Entrepreneurs' social networks in African informal economy: a framework for measurement

There are two interrelated strands in the literature about social networks and African entrepreneurship that have evolved quite separately until the late 1990s (Barr, 2002; Knorringa and van Staveren, 2006). The first relates to the analysis of inter-firm networks in industrial sectors or clusters in developing countries. The second relies on the social capital literature. After a brief overview of the linkages between these two corpuses, we discuss the way authors apprehend the concrete measure of entrepreneur‟s social networks. We then support the argument that ego-centred network constitutes an appropriate framework for measurement.

Inter-firm networks vs. entrepreneurs' social networks Literature about inter-firms networks attempts to analyze the role of industrial clusters in Africa‟s industrialization and development. It notably questions the significant lack of industrial clusters in Africa (McCormick, 1999). The core idea is that clusters, or inter-firms networks in industrial sector, may permit small and micro-enterprises to overcome growth constraint by the so-called „collective efficiency‟. One dimension of collective efficiency, named „active‟ or „planned‟ efficiency, rests on firms‟ linkage and entrepreneurial networks. Nadvi and Schmitz (1994) argue that collective efficiency in clusters depends on dense cooperative networks embedded in local socio-cultural relations. For example, Brautigam (1997, 2003) demonstrates the positive role of ethnic business networks in the industrial dynamics of Nigeria and Mauritius. Conversely, Meagher (2006, 2007) stresses that in times of economic crisis, increasing competition and state neglect, social networks and their organizational capacity tend to be disintegrated or fragmented. She adds that such effects may lead to the collapse of entire industrial clusters in African informal economies. Thus, by exploring the role of entrepreneurs‟ social networks as a possible support of industrial sectors and clusters, connection is made with the second strand of literature focused on social capital. This one attempts to identify and analyze the nature and types of networks in which entrepreneurs are embedded (not only for clustered enterprises). Then, it evaluates their role and impact on entrepreneurial success and economic performances in African economies

(Fafchamps and Minten, 2002a, b; Barr, 2002). Whereas the first approach is mostly based on sectoral level analysis and relies on qualitative surveys, the second produces quantitative measure of individual firms or entrepreneurs‟ social networks

. *The problem of measuring entrepreneurs' social networks*

[2]

Two main social networks‟ measures have been proposed in the framework of social capital literature. It is common to use entrepreneurs‟ membership in various (formal or informal) organizations, groups, clubs and communities (as business communities or ethnic groups forexample, see Fafchamps, 2000; Knorringa and van Staveren, 2006). However, these measuresare likely to ignore the less formalized relations developed outside organizations and social groups, which have an important role, notably in the formation of trust (Lyon, 2000). Yet, themain function of social networks is precisely to go through frontiers of

institutions andconstituted groups. As suggested by Mitchell (1969:49): „Social networks ramify across andbetween institutions". Moreover, membership of identity-communities (as ethnic groups) isalso problematic in contemporary urban Africa. Indeed, economic pressure and urbanizationtend to encourage the decoupling of interpersonal relations, within and outside communities,and to favour the development of more personalized networks (Lourenço-Lindell, 2002; Meagher, 2006). Consequently, the second measure focuses on entrepreneurs" inter-personalrelationships, and notably business relationships (Fafchamps and Minten, 2001, 2002a, b;Barr, 2002). It is, in concrete terms, based on the number of social links a firm ownermaintains with some category of agents. Fafchamps and Minten (2002a, b), in their studies ofsocial capital in Madagascar"s agricultural trade, use five measures: the number of relatives inagricultural trade, the number of traders known, the number of people who can help financially, the number of suppliers and clients known personally. Actually, most measures essentially focus on the number of contacts an entrepreneur keeps going in the business ormarket sphere. However, as Barr (2000) and Fafchamps (2001) have quite rightly pointed out, relations with agents outside market may also be useful. Therefore, Barr (2002), in her studiesof Ghanaian entrepreneurs, measures social network through the number of contacts theymaintain with six categories referring to business relations and three categories referring to privileged social categories outside business sphere (bankers, public servants and politicians). But even though such studies provide some useful general insights on social networks and African entrepreneurial dynamics (see section 3), we consider that it still rest on unconvincingproxies for entrepreneurs" social networks. Three major flaws shall be considered. First, the focus on the „number" of contacts may disembed personalized relations from their socialcontext. Indeed, these measures essentially depend on network size and give little qualitativeinformation about the complex nature of social ties and network"s structure. Of course, contacts" social group bears some information but here lies the second limit. Such categories are pre-defined and it is thus quite risky to predict what type of social group is useful forentrepreneurs before having demonstrated it. In addition, important ties maintained byentrepreneurs outside these categories could be missed.

[3] This method may so be unsuitable tocapture the multidimensional nature of entrepreneur"s network. The last point is about thesocial relation definition. In fact, to „know" someone does not necessarily mean that the

entrepreneur can get resources from this person when necessary (financial support in time of personal crisis for example). It"s just a „potential" social support tie. Moreover, to „know" someone is not an unequivocal criterion and it is likely to be interpreted quite differently among entrepreneurs. As a result, we suggest that in order to produce richer and relevant quantitative measure of entrepreneur"s social networks, it may be fruitful for economists to be inspired by the social network analysis (SNA) tradition of the sociologists and their methodological toolkit (Borgatti and al., 1998; Van Der Gaag and Snijders, 2003).

Entrepreneurs' ego-centred network framework The use of SNA to study economic action, outcomes and institutions has known considerable expansion since Granovetter"s (1985) seminal paper on „structural embeddedness". This literature rests on the legacy of different research traditions but is the first to formalize the social network notion in a quantitative approach (Wasserman and Faust, 1994; Scott, 2000) . Generally speaking social relations between individuals are commonly viewed in this frame as inter-personal experience based on interactions that permit resources" transmission. Then, a social network is just considered as the aggregation of social relations. SNA rests on two methodological corpuses. In the first one, social network is defined from a socio-centered

standpoint as a finite set of actors and the relations between them (Wasserman and Faust, 1994: 20). It is called „whole" or „complete networks
5
. The second one defines social network from an ego-centred standpoint (Wellman, 2007a, b). An „ego-centred" (or „personal") network is defined as one actor"s set of relations with others. It is composed of a focal actor (named ego), a set of ego"s direct social contacts (named alters) and the ties between them (figure 1)
6
. This perspective is particularly appropriate to analyze actors" networks whose composition is diversified and not limited by some geographical, organizational or community boundaries. It is thus particularly relevant for the analysis of urban African informal entrepreneurs" networks, often composed of a mixture of business, friendship and kinship ties developed within several social circles. Instead of focusing on ties with some specific social category, entrepreneur"s social network directly refers, in our approach, to its *regular social relations conveying useful resources for activities' current exploitation* (both tangible and intangible, economic and social)
7
. Such ego-centred networks can be described by three salient dimensions: network structure, content of ties, and members" attributes (figure 1). It allows to analyze and evaluate how different configurations of personal networks, with regard to the three dimensions, influence entrepreneurs" economic outcomes
. Before going into the matter of data and methods used to construct specific networks" indicators of each dimensions, we have to clarify how each dimension is articulated with economic outcomes, notably in small African entrepreneurship.

Figure 1: Configurations of entrepreneur's personal network and economic outcomes

3. The three dimensions of ego-centred networks and their economic impact

Each dimension has been subject to several discussions and theories in the literature; we will
here focus on the essential contributions cited in figure 1. The strength of a tie is defined by Granovetter (1973: 1361) as „a (probably linear)
combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie". Importance of weak ties results from their bridge function
9
. Weak ties play a crucial role to access information, as in labour market (Granovetter, 1995). However, strength of ties" effect on economic activities is not univocal and may be contingent to the social context or to the type of resources exchanged (Granovetter, 1983; Krackhardt, 1992). Strong ties are more approachable and may insure a better quality in the transmission of resources. It could thus be useful for vulnerable actors. The empirical literature on small entrepreneurship in Sub-Saharan Africa confirms these two aspects. In her case studies in Guinea, Lourenço-Lindell (2002) stresses that if weak ties are more flexible and easily manipulated; they are also more vulnerable in time of crisis (conversely to strong and affective ties). In the case of agricultural traders in Madagascar, Fafchamps and Minten (1999, 2002) underline that weak ties, like non-kin relations, are determinant to access and share market information. But at the same time, they also underline the importance of strong ties in risk sharing or social insurance, so as for market relations with suppliers and customers

(regular relations ensure secured supply and demand, reduce transaction costs, favour credit or delayed payment). The role of strong ties, notably kin relationships, in access to capital needed to start business has also been widely demonstrated.

Concerning alters‟ attributes dimension, it has been essentially studied under the frame of the social resources theory of Nan Lin (1999, 2001). Within a hierarchical view of social structure, he considers that the success of an action depends on two aspects: the presence of high social status contact in the personal network (which permits access to better quality and relevant resources) and the network‟s status diversity (which increases the probability of access to appropriate resources for any problem). The adaptation of this theory in African informal economy has not been much empirically analysed and tested. Some exceptions are Barr‟s (2002) study of Ghanaian manufacturing sector and Meagher‟s (2006) analysis of Nigerian clusters. They distinguish what they respectively call „solidarity‟ or „survival‟ networks from „innovative‟ or „accumulation‟ ones. Survival networks tend to be small, dense, locally concentrated and with poorly resourced personal relations (with no access to advantageous economic position or privileged commercial groups). It is very homogeneous in terms of members attributes. Though it reduces risks and incomes variability, it has little impact on economic performances and tends to undermine rather than enhance profits (Barr, 2002)
[10]
. Conversely, accumulation networks are wide, geographically dispersed, and much more diversified regarding members‟ status. They are composed of advantageous ties with privileged access to resources (ties with privileged social classes, civil associations and successful traders, notably international traders).

Barr and Meagher‟s typology allows to further with the last ego-centred network dimension. Indeed, the opposition between dense solidarity networks and open wide accumulation ones is one of the rare empirical insights into networks structure in African entrepreneurship. Relevant measures of networks structure are absent from most empirical surveys, if we consider that network‟s size is inadequate. This is precisely Burt‟s (1992) „structural holes‟ argument. According to Burt (1992:17), what matters is not the number of contacts, but „the numbers of non-redundant contacts‟. „Contacts are redundant to the extent that they lead to the same people, and so provide the same information benefits‟. A structural hole is then the gap between non redundant contacts
[11]
. The more structural holes in actor‟s network, the more the returns in terms of information access and control (position of „tertius gaudens‟). However, Burt‟s argument has to be discussed as it is in sharp contradiction with other approaches to network structure. Coleman (1988), and to some extent Granovetter (1985), argue that dense and cohesive networks permit the emergence of collective norms and have thus a strong impact on actors‟ behaviour. Social control and pressure may limit treachery and favour trust and cooperation. Finally, structural holes effects on economic outcomes may be contingent to the social context and type of activities considered. For example, Fafchamps (2006) pointed out that the exclusion or collective punishment of cheaters is a difficult strategy to sustain in African entrepreneurship.

4. Data and measurement options *The data*

The data have been collected in the informal economy of Bobo-Dioulasso in Burkina Faso. Burkina Faso is one of the poorest countries in the world. Real GNI per capita is estimated at US$ 430 in 2007 (World Bank, 2009). 46.4% of its population lives under poverty line (INSD, 2003). Thus, although Burkina Faso knew considerable economic growth since 1990 (more than 4% per year in average) it had to support a strong increase of urban poverty. This phenomenon, common in most West-African countries, has led informal economy to become a major source of earnings and livelihoods for urban population. In Burkina Faso, the

importance of informal economy matches regional tendencies (Webster and Fidler, 1996; Gaufryau and Maldonado, 2001; Brillaud and al., 2004). In Bobo-Dioulasso, informal economy represents 49.5% of local value added and 68.2% of employment (Fauré, Soulama, and al., 2000).

From February to July 2007 we have conducted a survey on a representative sample of 317 entrepreneurs [12]. Firstly, sociodemographic and economic data were collected concerning entrepreneurs features, type of activity, employment, economic capital and outcomes. Secondly, that statistical information has been completed few weeks later by collecting personal network data on a sub-sample of 278 entrepreneurs [13]. The survey focused on small urban private economic activities carried on apart from fixed homes. Only owners, or real managers of activities, have been interviewed [14]. The boundaries of the informal economy have been empirically defined according to three aspects: (i) administrative registration (commercial register, fiscal register, national social security fund); (ii) activity‟s size defined by the number of employees (with a five wage workers threshold); (iii) accountancy‟s type (quite formal, personal diaries, no accountancy). According to our definition, an informal activity is an activity that does not fall under the formal institutional framework for at least two of these selection criteria. The sample is representatively distributed by economic sectors (production, trade and services) and sub-sectors, and by geographical area, regarding the results of the last exhaustive census of economic activities carried out in Bobo-Dioulasso (Fauré, Soulama, and al., 2000). In practical terms, the respondents were mainly selected in an anonymous way by using a random walk technique through the city. Some were selected in dense activity locations (marketplaces, major roads) and other in more isolated places.

The multiple name generator instrument Different instruments for collection of personal networks data are conceivable (Marsden, 2005, Wasserman et Faust, 1994). The name generators method is the most commonly used in the field of entrepreneurship. It is structured around individual questionnaires that can be easily integrated in traditional quantitative survey (Burt, 1984).

Name generators consist of one or several questions inviting respondent (ego) to recall and elicit peoples (alters) with whom he maintains certain types of direct relationships. They are usually followed by questions, called „name interpreters‟, that gather information on alters‟ attributes, on the relationships between ego and each alter, and on the relationships between alters [15]. Name generators‟ purpose is obviously not to obtain the total number of alters existing in entrepreneurs‟ personal network, but to elicit a representative sample of them as to delineate the core members of the network (Marsden, 2005) [16]. Thus, in order to identify ego‟s relationships, several criteria can be used as a basis for the construction of the generators (Campbell and Lee, 1991). Criteria of specific social exchange (persons involved in regular relations of material or intangible support) have the advantage of being clear and unequivocal,as it is less likely to be interpreted differently across respondents. Name generators method has already been implemented in studies of women‟s social support network in rural Africa. It has revealed a reasonable reliability, particularly in its capacity to delineate the core ofpersonal networks (White and Watkins, 2000; Bignami-Van Assche, 2005; Adams and al., 2006). In the field of entrepreneurship, it has been commonly used in

studies aboutindustrialized societies (Greve and Salaff, 2003; Renzulli, Aldrich and Moody, 2000), but itremains rarely used in Sub-Saharan Africa.
Our instrument has been constructed after several tests in order to take account of differentbias identified in the literature (as memory and cognitive bias). It is based on multiple namesgenerators (Fischer, 1982; Burt, 1997). Eight name generators are used (see the detailedgenerators in box A1). They are defined on the basis of a criterion of interdependency orregular interaction of people involved in social relations conveying resources needed forinformal activity‟s current exploitation (during the last twelve months). Seven types ofexchanges, or resources, are used to construct the first seven generators: (i) advices, information and ideas (concerning markets, management, investment, partners); (ii) support inadministrative or bureaucratic relationships (with local institutions, to obtain favoursconcerning tax payments, local placement or conflict resolution); (iii) regular suppliers (access to goods and raw materials); (iv) faithful customers; (v) cooperation or partnership(entrepreneurs who assist each other, sometimes pooling resources and contacts); (vi)financial support (in time of crisis for example); and (vii) contact for recruitment (access to employment). Lastly, a „contextual name generator‟ (Bidart and Charbonneau, 2007) has beeninserted. It refers to important support relations at the moment of business start-up (whether itis material, financial or advices supports) which are always active in entrepreneurs‟ network. So as to limit interviews‟ duration (average of 45-60 minutes), the number of alters cited for each generator was restricted to three (two for the second generator)
[17]
. Moreover, in additionto the eight generators, a final name eliciting question has been added for additional importantcontacts that may have been forgotten. Once the entire name list elicited (1964 names), it was asked respondents to characterize each relation from a social role standpoint (kin, friend, neighbour, business tie, acquaintance). Then, for a representative sub-sample of relations(1324), complementary name interpreters were focused on tie‟s content (duration, contact frequency, trust intensity, context of creation), alters‟ attributes (age, gender, ethnicity, schooling, occupation, status), and ties between alters (none, acquaintance, especially close)
. Name interpreters regarding alters‟ attributes only concern observable characteristics as it isbetter informed than alters‟ attitudes or opinions (Marsden, 2005). Data on ties between alterswere collected through matrices crossing elicited names.
Measuring dimensions of ego-centred networks The data collected during our survey divides in two datasets. The „entrepreneurs dataset‟
(n = 317) is made of variables concerning entrepreneurs features and economic activities. The„ties dataset‟ (n = 1324) concerns the data of the sub-sample collected through namegenerators and interpreters. Such data provides individual profiles of respondents‟ personal network members that can be aggregated into measures of entrepreneur‟s network

configuration according to the three dimensions (ties‟ content, alters‟ attributes, network structure).
The content of social relations composing entrepreneurs‟ personal network can be divided in three salient dimensions: normative content or social role, transaction or exchange content and strength. Regarding the first two dimensions, the proportion of professional ties in network and that of ties conveying tangible resources have been considered
. More importantly, the strength of ties has to be examined. As such an issue is obviously multidimensional (see Granovetter‟s definition above and Marsden and Campbell, 1984), we need to compute an only quantitative measure inferred from available variables: tie‟s contact frequency, duration, intensity (or trust closeness) and reciprocity (or mutual aid). To do so, we use multiple correspondence analysis (MCA) to compute a succession of quantitative

variables summing up our four initial categorical variables. As shown in table A.1 and figure A.2, the first principal component generated by MCA offers a trustworthy weighted combination of the initial variables. Thus, individuals‟ coordinates on this first component can be used to evaluate ties‟ strength. For clarity purpose, these coordinates have been transformed in an ordinal variable ranging from the weakest to the strongest tie in the sample [20]. Our analysis of alters‟ attributes in entrepreneurs‟ personal networks focuses on three different aspects. The first one is social status (Lin, 2001). Considering ego, we distinguish alters enjoying an *intermediatestatus* (business owners of the upper part of informal sector, formal small and medium-sized enterprises owners, and workers and non qualified employees of private formal and public sector) and alters enjoying an *higher status* than his (executives, managers and officers of private formal and public sector, intellectual and intermediary professions of private formal and public sector) [21]. Another side of alters social status is proxied by the average level of education of ego‟s relations. In order to avoid a restrictive view of alter‟s attributes we have also considered the socio-demographic similarity between ego and his alters (homophily, or its reverse, heterophily). This similarity is evaluated considering four socio-demographic characteristics (age, ethnicity, religion, and geographical location) [22]. In other words, this dimension reflects the socio-demographic opening of entrepreneurs‟ network. The last aspect concerns the professional occupations of network‟s members. It is appreciated through the diversity of alters‟ occupations, measured by the ratio between the number of distinct occupations among ego‟s relations and the total number of ties in its network. Lastly, regarding the opening of ego‟s relations onto other occupations than his, we consider the proportion of ties involving alters belonging to the same profession as ego.
Networks‟ structure and the idea of structural holes can be measured in different ways. A first simple measure is network‟s density (number of existing ties between alters divided by the total potential ties). More in-depth is Burt‟s famous measure of „structural constraint‟, as it simultaneously expresses both size and density of personal network. It measures to what extent the overall relational investment of ego implies, directly or indirectly, a same alter. It is computed as the sum of structural constraints exerted by each alters, which themselves depend on ego‟s relational investment and alters‟ connections [23]. Measures of the structural constraint for each respondent have been calculated with UCINET VI (Borgatti and al, 2002). It ranges from zero for wide networks of non redundant contacts to one for limited and tightly interconnected networks.

5. Empirical findings Before we investigate the configuration of entrepreneurs‟ network and test its possible impact on economic performances, some brief statistical overview presents the main sociodemographic and economic characteristics of our sample (see table A.2).

Main features of the sample In Bobo-Dioulasso as in most informal economies, the dominant form of business is self-employment. Entrepreneurs are relatively young (35.5 years in average) and their households are composed of 7.5 members in average. Only 26% of them have a higher level than primary education. These last are more represented in the sector of services and notably in catering activities. In the informal economy, training is essentially ensured through traditional on-thejob apprenticeship. Most of entrepreneurs followed a mainly informal route (from familial assistant to apprentice and then owner). The average duration of activities shows their relative youth (7.6 years in average), with some significant differences according to sectors of

activities. In particular, production activities have a much higher average longevity (9.5 years) than others. Regarding legality, 11% of the enterprises are registered in an official commercial register (mostly trade activities). The localization of economic exchanges confirms the autarkical confining of informal activities, as it mainly concentrates in the perimeter of the city for both customers and suppliers. The measure of economic performances reveals that earnings are higher in trade and catering activities than in production and other services
. However, the production sector is the most important in terms of employment and wage distribution. Trade and production clearly dominate other sectors regarding the average value of economic capital.

Entrepreneurs' social networks typology Cluster analysis is a multivariate procedure for detecting groupings in some data. More
precisely, we use k-means cluster analysis
[25]
to identify homogeneous groups of entrepreneurs based on the whole selected characteristics describing networks‟ dimensions. The analysis suggests the existence of four homogenous clusters categorizing the different kinds of

networks supported by entrepreneurs. As all observations are classified in such procedure, the produced typology may be blurred by individuals whose network‟s profile is in fact not really distinct from the average one. To avoid such flaw, we create a fifth category that gathers entrepreneurs whose network is indistinct regarding the categories produced by cluster analysis
[26]
. In order to describe the produced typology, table 1 shows the average values of the whole ten classification variables for each category. Moreover, to facilitate the interpretation of results, table 2 shows the average values of some other relevant variables dealing with the entrepreneur, his activity and his network itself.

The last columns of tables 1 and 2 give some interesting general insights about the average nature of entrepreneur‟s personal network in the sample. The average size of entrepreneurs‟ network is of 7.1 members and structural constraint is moderate (average of .564) although more than a half of ties composing their networks are strong and created before activities‟ start-up. This is partly explained by the strong proportion of business ties in entrepreneurs‟ networks (average of 57.8%). Conversely, the proportion of kinship ties remains quite weak (average of 24.9%) compared to business and also sociability‟s ties (average of 51.6%)
. These results suggest that informal entrepreneurs in Bobo-Dioulasso are not completely embedded in „bonding ties‟ (intra community and family ties). Moreover, about a half of all business ties are also described as sociability ties (labour colleagues and close friends especially) whereas only 9% of them are also described as kinship ties. So, when business relations are embedded in other social relationships (than the labour relationship itself), it is rarely in kinship ones. Unsurprisingly, most of networks‟ members enjoy the same or a lower status than the entrepreneur‟s one (average of 64.5%). As indistinct networks do not require specific comments, we will now focus on the four specific identified networks
. Network A is rather typical of informal entrepreneurs‟ *solidarity network* identified by Barr (2000) and Meagher (2006). It is essentially composed of strong kinship and sociability‟s ties and thus has the poorest proportion of business relations.