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Network Analysis

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Anchor The central person within the network; the person providing information on who belongs to his or her network.
Full Personal Network Network in which information is available on all the network relationships; in most cases the information is collected from all the network members; also referred to as complete network.
Network Analysis Analytical methods used to compute measures of network structure and content.
Network Content The type of interaction that takes place within pairs of network members.
Network Delineation Procedure used to identify the personal network.
Network Structure Aspects of the total network derived from combining features of individual relationships and the linkages between these relationships.
Personal Network The group of persons (network members) with whom anchor has a direct relationship.
Star Personal Network Network in which information is available on relationships between network members and the focal individual; in most cases the information is collected from the focal individual; also referred to as egocentric network.

The personal networks of older people reflect their social opportunities and personal choices to maintain a specific set of relationships with relatives, neighbors, friends, acquaintances, and so on. NETWORK ANALYSIS is the method used to identify and examine the structural and functional features of the network of the older adult. The conceptualization and operationalization of the personal network depend on the subject of research. Five approaches to define personal network membership are presented and discussed. The five approaches differ regarding the part of the personal network that is mapped, and result in networks of different sizes and compositions. Regardless of the type of network delineation, a distinction can be drawn between the star network (data available on relationships with the focal person) and the full network (data available on all the network relationships). Features of the structure and content of both types of personal networks are presented. Finally, network analysis methods are presented and discussed, including ways to analyze hierarchical databases.

I. AGING AND THE PERSONAL NETWORK

A. The Personal Network of Older Adults: An Introduction

The personal network occupies an important place in the lives of individuals. The mere existence of a certain number of relationships has been shown to have beneficial effects; regular interaction with network mem-

bers (children, relatives, neighbors, friends, and fellow members of organizations) enhances the feeling of being socially integrated and decreases feelings of loneliness. The positive effects of the network are also reflected in better health and a longer life. [*See* SOCIAL NETWORKS, SUPPORT, AND INTEGRATION.]

Old age has often been associated with loneliness and with social isolation. However, numerous studies have shown over the past decades that the large majority of older adults has at least a few relationships available. The networks of older people usually enclose both kin and nonkin with whom regular contact is maintained. In general, the core of the network consists of close kin (e.g., spouse and children, siblings, parents) and close friends. Depending on the identification method of the network, other network members as extended kin, neighbors, co-workers, acquaintances, members from organizations and so on, may also be identified. The younger old who are socially active in many parts of society and who experience few physical restrictions in general have large networks that are composed of a large number of nonkin. The oldest old, who often experienced life transitions as widowhood, retirement, and a decline in physical mobility, usually have smaller networks that enclose network members that are emotionally close (children, friends) or geographically close (neighbors). [*See* LONELINESS.]

In addition to the mere presence of relationships, interaction with others is important for daily functioning, coping with life events and maintaining well-being. Feelings, information, services, material goods, and so on can be exchanged between two individuals. These exchanges are often assumed to be supportive in nature. The support provided by network members helps protect individuals from experiencing negative outcomes, helps them in their efforts to improve their situation and helps them respond to adverse events. It has to be noted here that interactions with others may also be of a negative nature, existing, for example, of criticism and disapproval of one's behavior, or of episodes of conflict and quarreling. In particular these negative interactions are found to be related to loneliness and psychological distress. However, studies have revealed that these types of negative interactions occur relatively seldom within network relationships, and, when they do occur, it most often concerns strong and close relationships with the spouse or children.

Many studies on supportive relationships of older adults deal with the question, "Who provides what type of support to whom?" Within some studies this issue is closely related to the issue of caregiving and network relationships are categorized according to their capacity to provide either acute or daily long-term care to frail older adults. It has often been found that the spouse and the children (in particular the daughter) are the most important caregivers of frail older adults. When these types of relationships are not available, close kin (e.g., siblings), neighbors, and friends are the next preferred source of instrumental support. With respect to emotional support a same type of hierarchy in network relationships seems to exist, but relatively few studies have dealt with this type of support to older adults. Within support research gerontologists often perceived the older adult as a dependent person who needs to be taken care of. More recently, researchers take the perspective that older people are able to actively maintain their network relationships by negotiating balanced exchanges of support. The opportunities of older adults to remain active in providing support to others may be limited during the aging process, at least where the provision of instrumental support is concerned. The impact of aging on the structure and the supportive functions of the network are discussed more extensively further below (section I.C). [*See* CAREGIVING AND CARING; HOME CARE AND CAREGIVING.]

Social researchers have often studied the personal relationships of individuals without taking the linkages between various network members into account. However, network members do not function independently of each another. It is crucial to regard the interaction between the focal individual and one network member in relation to the interaction with other network members. For example, which of the adult children is to provide support for an elderly parent might be the outcome of a family meeting where it is decided to take turns in caregiving. The study of personal relationships evolves into the study of the personal *network* if relationships are viewed as part of a large network and if linkages between these relationships are also taken into account. By combining the features of individual relationships, one gains insight into the structural aspects of the network. Examples of structural aspects are size, composition (e.g., proportion of kin), and homogeneity (e.g., proportion of same-sex network members). Information regard-

ing the content of the network can be obtained by aggregating the qualities of the individual relationships. Examples of network content are network interaction (e.g., number of network members contacted at least once a week) and support intensity (e.g., proportion of instrumentally supportive relationships). Features of the structure as well as the content of the network will be elaborated on in section III.

B. Determinants of Personal Networks

The development and maintenance of a personal network can be viewed as the outcome of social context combined with individual properties. The social context sets the opportunities to engage in social interaction and determines what sets of relationships are available to people. The conditions shaping the opportunities have been affected by the economic, demographic, and cultural changes of recent decades. For example, the rise in one-person households among the aged has forced a large number of elderly people to seek social contacts outside the home. Demographic developments have led to extensive changes in kin networks. Altered fertility and mortality patterns are leading to shifts in the number of intragenerational versus intergenerational ties, and in the balance of young and old in the family. Economic developments have led to changes in nonkin networks. The organization of the labor force requires greater geographic and job mobility. As a result, the fields from which relationships are recruited change, and there is a greater turnover in relationships during the life course. One implication of these developments is that greater efforts must be expended in initiating and maintaining nonkin relationships. [*See* DEMOGRAPHY; ECONOMICS: SOCIETY.]

Personal characteristics determine the sets of relationships that are developed within the opportunities set by society. Characteristics such as age, income, and health can restrict interaction with others as well as the provision of support to others. In addition, individual standards and decisions affect the choice of relationships. Individuals can take an active stand in determining which relationships they wish to develop and maintain and what quality standards these relationships have to meet with. Individual characteristics such as social skills, coping styles, and other personality traits are also relevant here.

C. The Impact of Aging on the Personal Network

The personal network is developed and shaped during the life course. From early childhood to old age, one is surrounded by a variety of persons with whom one develops relationships. During the life course some relationships end due to major transitions (divorce, death of the spouse) or minor transitions (moving, changing jobs, entering or leaving organizations), while others may last a lifetime. New members may enter the network as a result of marriage, a new job, becoming a parent, and so on. The importance of relationships also changes over time. For example, the function of parents differs at different stages of the life course. Likewise, the function of friends varies across the different social positions people occupy in the course of their lives. For elderly people, a personal network can be viewed as the result of earlier transitions affecting their opportunities and individual choices to maintain and develop relationships. [*See* LIFE COURSE.]

Aging is often associated with relationship losses. Usually persons from older generations (parents, uncles, etc.) are the first to be lost, followed by same-age associates (spouse, siblings, friends). Relationship losses have an immediate impact on kin and nonkin networks. [*See* BEREAVEMENT AND LOSS.]

The effects of other aging factors are more indirect. As people enter old age, they are generally in a position to exercise greater choices in their relationships. Unfettered by employment obligations and the responsibility for children at home, they generally have greater opportunities to organize and structure their social lives. Other changes that tend to come with age pertain to relational needs, for example due to increasing impairment. Older adults may become more dependent on others, lacking the ability to perform certain tasks themselves. The existing balance in their relationships may be disrupted, introducing strain and discomfort. Furthermore, a decline in health may impose restrictions upon older adults' capacities to engage in interaction with others. Hearing and memory problems can limit conversational exchanges. Reduced physical mobility can limit participation in shared activities. [*See* HEARING; MEMORY.]

It can be concluded that differences in the personal networks of older people are related to differences in situational and personal characteristics. A network is

the result of macrosocial trends that create individual opportunities to maintain a personal network, but it also reflects individual transitions, relationship standards and personal characteristics. In studying the networks of elderly people, it is recommended to relate network features to situational as well as personal characteristics of the elderly.

II. PERSONAL NETWORK DELINEATION

A. Methods for Network Delineation

A personal network is defined in general as the group of persons (network members) with whom a focal individual (anchor) has a direct relationship. There are various methods to delineate the social network. Some methods are based on the content of the relationships, some on the affective value of the ties, and other methods use the formal role relationship as criterion for network membership. Research interests determine which method is used and which part of the larger social network will be identified.

With respect to the identification of networks of the aged, the following five major methods can be used: (1) the affective method, (2) the role relation method, (3) the exchange method, (4) the interactive method, and (5) the domain contact method. The 5 methods are conceptually unique and map different parts of the personal network. A general overview of these methods to delineate personal networks is provided below. Table I provides a summary of the main features of the 5 methods.

1. The Affective Method

a. Conceptual Framework The affective method identifies members who are of affective value to the focal individual, in other words, significant others or intimates. The underlying assumption is that these network members are potentially important sources of support for the focal individual. The method is commonly used by researchers who are interested in the "psychological network" defined by (among others) Milardo and Surra as "those persons to whom the focal person is committed emotionally and psychologically."

b. Name Generator Basically this type of network is identified by asking one question: "Who do you feel close to?" or "Who are the persons who are important to you?" Some researchers set limits to the number of names to be mentioned, others apply a time frame (e.g., within the past 6 months). Sometimes a distinction is drawn in the degree of importance or the level of closeness of the network members.

c. Network Features Typical of the affective network is a small size (about 5 to 9 members), a large proportion of (close) kin (about 50 to 80%), a large number of long-standing relationships, and many supportive exchanges within the ties. The stability of this type of network is high, mostly because relationships that are stable, as with close relatives and best friends, are cited.

d. Evaluation Crucial to this method is the subjective nature of the name generator. People are asked to evaluate relationships in terms of importance or closeness. This evaluation may be shaded by norms and obligations to mention relationships supposed to be important, for example with the spouse and children. One is less inclined to mention relationships that are potentially supportive but not very important to the individual, for example, with neighbors or colleagues. In addition, it need not be necessary to include persons with whom one interacts on a regular basis. As a result, this type of network cannot be used to indicate the degree of social participation or integration of the focal individual. This type of network is positively related to the degree of well-being and negatively to feelings of loneliness of the central person. The major advantage of this method is that it has proven to be a robust method by yielding similar types of networks in different samples.

2. The Role Relation Method

a. Conceptual Framework The role relation method defines network membership purely on the basis of the formal role relationship one maintains with the focal individual. Role relationships are derived from status variables such as marital status, employment status, type of living arrangements, friendship, and family status. The network accordingly includes the partner, children, co-workers, friends, and members of the household. The underlying assumption is that the formal role relationship reflects norms and obligations with respect to the con-

Table I Overview of Network Delineation Methods

	Affective[a]	Role relation[b]	Exchange[c]	Interactive	Domain contact[d]
Conceptual definition	Network of significant others (affect based)	Network of formal role relations (role based)	Network of relations in which significant interactions occur (content based)	Network of persons with whom social interaction exists (contact based)	Network of socially active and important relations (contact and affect based)
Name generator(s) (examples)	"Who do you feel close to?"	"Name your spouse, children, neighbors, colleagues, friends."	"Who do you discuss personal problems with?" and "Who helps you with daily chores?"	"Name the persons you have contacted today for at least 10 minutes."	For each role relation (e.g., children, neighbors): "Who do you have regular contact with and who is also important to you?"
Number of questions asked	1 or 2	Depending on the roles of interest: 5–7	3 to 20	1 (repeated every day for a certain period of time)	One for each role relation of interest (about 7)
Limits on period of time	No	No	Yes (past 6 months, past year)	Yes (2 weeks, one month etc)	No
Network size	Small (about 3–9)	Depends on the number of roles of interest	Large (10–22)	Large (16–26)	Medium (13–15)
Proportion of kin	Large (50–78%)	Depends on the roles of interest	Low (19–48%)	Low	Medium to large (66%)

[a]Kahn, R. L., & Antonucci, T. C. (1980). Convoys over the life course: Attachment, roles and social support. *In* P. B. Baltes & O. Brim (Eds.), *Life-span development and behavior* (pp. 253–286). New York: Academic Press.

Morgan, D. L., Schuster, T. L., & Butler, E. W. (1991). Role reversals in the exchange of social support. *Journal of Gerontology, 46,* 278.

Wellman, B., & Hall, A. (1986). Social networks and social support: Implications for later life. *In* V. W. Marshall (Ed.), *Later life: The psychology of aging* (pp. 191–232). London: Sage.

[b]Berkman, L. F., & Syme, S. L. (1979). Social networks, host resistance and mortality: A nine-year follow-up study of Alameda County residents. *American Journal of Epidemiology, 109,* 186.

Litwak, E., & Szelenyi, I. (1969). Primary groups structures and their functions: Kin, neighbours, and friends. *American Sociological Review, 34,* 465.

[c]Kendig, H. L. (1986). *Ageing and families: A social networks perspective.* Sydney: Allen and Unwin.

Tilburg, T. G. van. (1992). Support networks before and after retirement. *Journal of Social and Personal Relationships, 9,* 433.

Wenger, G. C. (1990). Change and adaptation in informal support networks of elderly people in Wales 1979–1987. *Journal of Aging Studies, 4,* 375.

[d]Tilburg, T. G. van. (1995). Delineation of the social network and differences in network size. *In* C. P. M. Knipscheer, J. de Jong Gierveld, T. G. van Tilburg & P. A. Dykstra (Eds.), *Living arrangements and social networks of older adults* (pp. 83–96). Amsterdam: VU University Press.

tent of the relationship. The mere existence of relationships is expected to protect one from social isolation, illness, and loneliness. There is very little focus on the content of the relationships.

b. Name Generator Researchers using this method do not always use a name generator. Inquiring after marital status, parental status, or job status will suffice if one is interested in the availability of a spouse, children, or co-workers. Researchers interested in the additional features of the role relationships have to use name generators. Examples include "Who is your partner?" "Who is your best friend?" or "Could you name two of your neighbors/colleagues/fellow members of organizations etc?" The type of role relationship that is identified depends on the research objectives. Sometimes limits are set to the number of names to be mentioned.

c. Network Features The size as well as other features of the network are completely dependent on the name generators used. The stability of the role network is high, because formal role relationships are not likely to change over a short period of time.

d. Evaluation The advantages of this method are that it is very easy to administer and it uses an objective measure for the identification of network members. Researchers interested in the social integration of individuals will be able to use this method successfully. One disadvantage is that relationships that have no formal role but may nevertheless be important or supportive might be overlooked. Its use in studies on support networks may therefore be limited.

3. The Exchange Method

a. Conceptual Framework The exchange method assumes that the relationships in which significant interaction occurs with network members are among the most important ones. Within this significant interaction, a regular exchange of emotional support, instrumental assistance, and material goods takes place. This interaction is considered to be of a supportive nature. By asking about a large range of significant interactions, a broad and varied network is expected to be identified.

b. Name Generator The exchange method uses several questions (usually 6–10) to identify members with whom significant interaction occurs. Examples include "Who do you talk about personal problems with?" "Who do you discuss problems at work with?" "Who helps you with daily chores around the house?' "Who takes care of you if you are ill?" Often a limit is set to the number of names to be identified in response to each question. The number of questions asked is related to the number of persons to be identified, but there is a certain limit. It has been noted that asking 5 questions on different types of support (emotional and instrumental support and companionship) identified about 80–85% of the persons who are mapped with 10 questions. Some researchers distinguish between questions indicating the receipt of support ("Who helps you with daily chores?") and questions indicating the provision of support ("Who do you help with daily chores?"). This results in a larger number of identified persons compared to nondirective questioning about exchange relations.

c. Network Features The typical exchange network is rather large, varying from about 10 to 20 names. The proportion of kin within the network is rather low, varying from 35–50%. In general, the exchange network contains many relationships that are socially active at the time of measurement. A relatively large proportion of more superficial relationships are identified, based on a (temporary) sharing of the same workplace, organization membership, neighborhood, and so on. The stability of the exchange network is relatively low compared to the affective and role relation network, because many unstable nonkin relationships are identified.

d. Evaluation The exchange method is easy to administer and of a rather objective nature. The interactions are specific and not multi-interpretable. The exchange method can map different parts of the network. In contrary to the affective method, nonkin relationships are more likely to be identified. One disadvantage is that ties that are potentially supportive but not actually supportive at the moment are overlooked. In addition, persons one is socially involved with but with whom no significant interactions are exchanged (e.g., more distant relatives) are also excluded from this network. It is crucial to this method that it focuses on the content of a tie rather than the formal role relationship or the degree of contact frequency.

4. The Interaction Method

a. Conceptual Framework The interactive method identifies the persons one engages in social interaction within a given period of time (e.g., 2 weeks, 1 month). The assumption is that the interactive network indicates the degree of social participation. It is found to be unrelated to support or well-being.

b. Name Generator The interactive method requires a systematic recording of who one has contact with on a daily basis. Usually this is done by having respondents maintain a diary or by contacting them daily by telephone. Respondents have to indicate who they interacted with that day for at least 10 minutes.

c. Network Features The size of the interactive network depends on the period used for monitoring social interaction. The longer the period, the more different persons are identified. The interactive network

may contain a large proportion of nonkin relationships, depending on the living situation of the respondent (married, employed, with children and so on). The interaction network is apt to be sensitive to changes in daily contacts. Many superficial contacts that are part of the interaction network in a given period may not be included in another period of time.

d. Evaluation The interactive network is a good indicator of the degree of social participation, because it records daily social interaction. Comparing this method to other methods reveals a very small overlap between the networks. The affective and exchange networks are far more psychological, and their members usually do not meet every day. However, enlarging the monitoring period of the interactive network will eventually decrease the differences with the exchange network. A major advantage of daily monitoring is that it provides a reliable picture of the social interaction of the respondents.

5. The Domain Contact Method

a. Conceptual Framework The domain contact method combines the different roles an individual performs with the frequency of contact and the importance of the relationships as criteria for the identification of network members. The main objective of this method is to identify the socially active relationships in the larger network. A central assumption is that this type of network constitutes the structural vehicle for the ties in which various types of support can be exchanged. In this line of reasoning, the potential or actual support exchanged is not a criteria for delineation, but an object of research on the delineation of the personal network.

b. Name Generator Network members are identified in various domains of the network, for example, household members (including the spouse), children and their partners, other relatives, neighbors, school or job acquaintances (including voluntary jobs), members of organizations (sport, church, political parties), and others (friends, acquaintances). All the household members are included in the network. As to the other domains, the respondents are asked: "Name the persons (e.g., in your neighborhood) you have frequent contact with and who are also important to you." No limits are set on the number of names to be mentioned.

c. Network Features The domain contact network is medium to large (an average of 13 members, ranging from 0–75), with about two-thirds of the relationships being with relatives. Because that contact frequency is used as a criterion for identification, the average contact frequency with these network members is relatively high, between about once every 2 weeks and weekly.

d. Evaluation Using several criteria for network membership leads to a medium-sized network (compared to the smaller affective network and the larger exchange network) that contains a large range of role relationships. The method combines objective (role relationship and contact frequency) and subjective criteria (importance) for the delineation of network relationships. As a result, the domain contact network indicates the actual degree of social participation as well as the availability of potentially supportive relationships.

B. Choices in Network Research

The examination of the personal networks of older adults requires several choices to be made by the researcher beforehand. The first choice concerns the type of method to be used for network delineation. This necessitates a clear description of the research objective. Usually two types of research objectives can be distinguished: (a) the network has to indicate the degree of social participation of older adults, and (b) the network has to reflect the actual support reservoir of older adults. The first type of objective requires the use of the role relation method, the interactive method or the domain contact method in the delineation of the network. The affective method and the exchange method are more appropriate if one has the second type of objective in mind.

The second choice within network research focuses on how many network members and relationships additional information will be collected on. In most network research (particularly large surveys), there is no time to collect information on *all* the network members who are identified. Some researchers have solved this time problem by setting limits to the number of names to be identified by the name generator. It is put forward here that limits of this kind distort the identification of the network because they leave uncertainty about the true size of the personal net-

work. Because network size is crucial for the calculation of other structural and functional network features (e.g., proportion of kin), it is strongly recommended to set no limits on the number of persons to be identified. A better solution is to add an extra objective criterion such as contact frequency or traveling distance to the identification procedures. If interview time is of the essence, additional information can be asked about a selection of the network members. The selection criterion can either be objective (e.g., the 10 persons contacted most frequently) or subjective (e.g., the 6 persons who are the most important). The subjective option has the disadvantage that respondents have to choose between certain network members, which may be a difficult task.

The third choice in network research pertains to the type of information to be collected on some or all of the identified network members. Again this choice is guided by the research objectives. Yet, there seems to be a general consensus among network researchers that it is advisable to collect information on the type of relationship and sex of as many network members as possible. Researchers interested in the degree of social participation also inquire about the contact frequency with each network member, whereas support researchers are more interested in the support exchanged within the relationship.

A final choice the network researcher has to make involves who is to serve as a respondent in the study. Usually the information on network members and relationships is only obtained from the focal individual, the anchor of the network. The identified network is then called a star network, and information is only available on the ties between the anchor and his or her network members (Figure 1). Yet, it is also possible to include network members as respondents and ask them about the tie characteristics with the anchor and with the other identified members of the network. If members of a personal network report about identified ties with other network members, data are available on a full network (Figure 2). The following two sections will elaborate on the characteristics of the star and the full network.

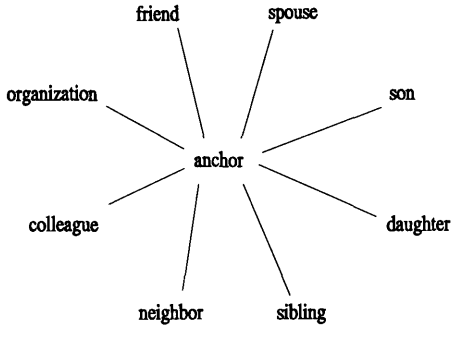

Figure 1 Example of a star network. Information is only available on the relationship between the focal individual (anchor) and other members of the network.

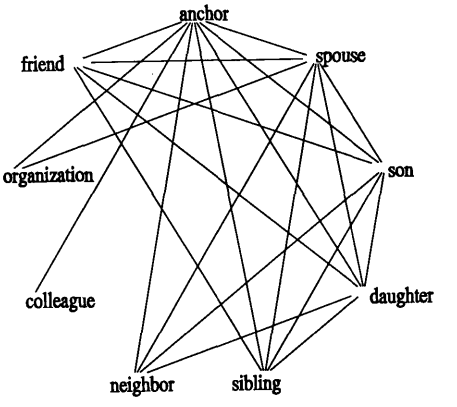

Figure 2 Example of a full network. Along with the focal individual, network members are included as respondents. Data become available on identified ties between all network members.

III. FEATURES OF THE PERSONAL NETWORK

In a star network, the older adult is the focal person, the anchor. All the features of the network and the relationships can be linked with his or her behavior and state of mind. An overview is provided below of features of the network structure and content that are associated with aging. As people age, these aspects of the network are subject to changes and are therefore relevant to the study of the networks of older adults. Tables II and III give examples of network structure and content based on information about relationship features.

A. Network Structure

The *size* of the network indicates how many relationships one is involved in, whether affect-based, role-based, or contact-based. Involvement in a larger network is associated with a larger degree of social participation and a greater exchange of support and

Table II Features of Network Structure

Network structure	Operationalization at the network level	Information on the dyad	Information on the network member
Size	Total number of identified network members	—	—
Composition	e.g., number of children, friends; proportion of kin	role or type of relationship	
Homogeneity	e.g., total number of females in the network; percentage of members within the same age category	Similarity between characteristics of anchor and nework member: e.g., same-sex or cross-sex	e.g., sex, age, race, partner status, employment status
Density	Total number of pairs who know each other of the total number of available pairs	—	How many of the other network members are known
Stability	Average years of network membership	Duration of the relationship	
Role complexity	Number of multiplex relationships	Number of different roles shared with the network member	
Geographical dispersion	e.g., number of persons living within 15 min; mean traveling time	Traveling time from anchor to network member	

well-being. A large network is considered a social resource. Older adults who want to reorganize their social life after retirement are better off with a large network, because it increases their chances of getting acquainted with new people. Network size varies widely among elderly people of different ages, types of living arrangements, and marital or parental status. Younger elderly people who live with a spouse and have children available usually have the largest networks, regardless of the delineation method used.

The network *composition* indicates the available proportions of kin and nonkin. The distinction between kin and nonkin is often too global, and it is wise to differentiate between relationships with a spouse, children, other kin, neighbors, friends, and other nonkin. The impact of aging on the network composition is far larger in the other kin and other nonkin network sections, and smaller in the children, neighbors, and friends sections. Other kin are likely to be of the same generation (siblings, cousins) or of an older generation (parents, uncles, aunts) and become less available. Other nonkin are recruited from job sites, organizations, and so on, and participation in these social fields is greatly reduced in the oldest age groups. The composition of the network is strongly associated with marital and parental status. Elderly people who

Table III Features of the Network Content

Network content	Operationalization at the network level	Information on the dyad
Interaction	e.g., proportion of network members contacted at least weekly; mean frequency	Frequency of contact
Support intensity	e.g., total amount of emotional support received and given; proportion of ties with large social support intensity	Receiving and giving support (emotional, instrumental, social, material goods)
Support complexity	e.g., total number of multiplex relationships	Exchange of one versus more types of support
Reciprocity	e.g., average number of reciprocal relationships; proportion of unbalanced ties; ratio of given and received support	Balance between giving and receiving of support

have never been married or had children may have established bonds early in life with relatives (siblings or cousins) as well as neighbors and friends. These groups are used to recruit their contacts outside the home and benefit from these relationships until old age. Older women and men differ with respect to the composition of their network. Women are generally more involved with kin, neighbors, and friends, whereas men are more involved with other nonkin relationships.

If information on the personal characteristics of the network members is available, it is possible to compute the *homogeneity* of the network with respect to sex, age, parental status, and so forth. It has often been reported that individuals like to associate with people who have similar backgrounds and are assumed to have similar life experiences. In particular, nonkin network members are expected to exhibit marked similarities in sex, age, and level of education with the focal individual, resulting in a large homogeneous nonkin network. Relatives, however, are likely to be dissimilar with respect to sex, age, and parental status. Because of the increasing chance of the loss of a partner in old age and women living longer than men, the networks of the elderly will be relatively homogeneous with respect to sex and partner status, especially where intergenerational contacts are concerned.

The *density* of the network refers to the interconnectedness between network members. Large networks usually have a low overall density, meaning that fewer network members interact with each other without the anchor being present. Yet, large networks may also contain specific parts that are very high in density (neighbors or close relatives). Networks that are low in density are generally found with younger persons who are highly educated and participate in various social organizations, which are only loosely connected to each other, if at all. Small networks usually have a high density, and are generally more prevalent among elderly people with a relatively low level of education. Within dense networks, people often share the same norms and values. Being embedded in a dense network can be comforting for people who have recently lost a spouse. Yet, a dense network can also limit the widow or widower's capacity to rebuild and expand the network, which is a necessary step in adjusting to widowhood. Dense networks are generally composed of persons who have been interacting for many years, indicating a high *stability* within the network. This stability may vary among different types of relationships. Relatives will have been around for a lifetime, while the widowed neighbor down the street may have entered the network only recently.

Network members may have more than one formal role relationship with the focal person. A neighbor may also be a friend, and a second-degree relative may also be a member of the same bridge club. At the network level, *role complexity* is indicated by the number of uniplex (one formal role) or multiplex relationships. Networks with a high role complexity are usually also small and densely knit.

The *geographical dispersion* within the network indicates the extent to which network members live in the same neighborhood or region by the proportion of network members who live less than half an hour's drive away. Networks of elderly people are generally largely locally based, although children and other relatives might live far away. How close network members live is of particular importance to elderly people who are in need of instrumental support. The geographical dispersion of the network may therefore be used to demonstrate the availability of potential supporters in the vicinity of the older adult.

B. Content of the Network

The overall *interaction* of the older adult with the network members is often used as a token of social participation. Network interaction may vary among different parts of the network. Interaction is higher with the spouse, children, and neighbors than it is with distant relatives and acquaintances. The more frequent one interacts with network members, the more likely the exchange of support.

The *support intensity* of the network refers to the exchange of support between all the network members and the focal person. Various types of support can be distinguished: emotional support, instrumental support, social support (companionship), material support, and so on. Furthermore, a distinction can be drawn between giving and receiving support. In general, elderly people are thought to be on the receiving end of support, in particular as they grow older, less mobile, or less healthy. Yet, they are also capable of giving support, specifically emotional support and financial support to their children. The types of sup-

port vary among the types of relationships, and among older men and women. Men are known to exchange instrumental support, whereas women are known to give and receive emotional support to an old age.

The exchange of two or more types of support within the network relationships indicates the *support complexity* of the network. Some network members provide emotional as well as instrumental support, whereas others only exchange material goods.

Lastly, the balance between the overall provision and receipt of support indicates the *support reciprocity* within the network. In general, elderly people receive more support than they provide. This is particularly the case after when they pass the age of 75 and there is a strong decline in their physical capacities. Giving and receiving support is usually more balanced for women than men. An unbalanced support network has a negative impact on the well-being of the elderly. The imbalance created by being in debt to many network members may lead to feelings of guilt, whereas providing support to many relatives and friends without receiving much in return can lead to feelings of being exploited.

IV. FULL NETWORKS

A. Advantages of Full Network above Star Network Data

In star networks, the elderly person occupies a central position as anchor of the network. This is why we focus completely on the world this one particular elderly person lives in, and explain, for example, his or her well-being on the basis of the features of the network as viewed by this elderly person. If one wants to gain insight into the structure and processes of the separate relationships and of the network as a whole, one can examine the relationships in which both of the persons within the relationship have been interviewed and collect data on both parties, and one can examine full networks, collecting data from all the network members on their relationships with each other.

In star networks, only the data of the elderly person are collected. Data on each relationship, such as the support exchanges within it, are then solely viewed from the perspective of the elderly person. Studies in which relationships are examined from both sides have shown that the perception of the network member regarding the relationships frequently differs from the perception of the elderly person. This holds particularly true of more subjective information, for example, on giving and receiving emotional support. Differences in perception regarding the extent to which support is exchanged can be an important factor in the continuation of the support exchange.

If data are only collected from the elderly person, there is virtually no insight into the circumstances and attitudes of the network members. The support received by elderly people is not only influenced by the need and presumed need for support on the part of the elderly person, but also by how willing and able the network members are to give support. The poorer the health is of a network member, the less able he or she is to give instrumental support. It is possible to ask the elderly person to assess the health of the network members, though the validity of the data is questionable. The extent to which network members are willing to give support, particularly lengthy support, to an older person is not something the older person can easily be asked. Data on the circumstances and attitudes of network members should thus be gathered from the network members themselves.

In a full network, the relationships between the various network members are also addressed. The more support network members exchange with each other, the more likely they are to give support to an elderly person and the more organized it is apt to be. This is far less the case if the network members barely have any contact with each other. In the personal networks of older people, three of the structural aspects of the full network are important. *Support density* indicates the extent to which relationships are mutually supportive and serves as a supplement to the overall density. *Cliques* are indicative of the existence of subnetworks within which a great deal of contact and support is exchanged, and between which barely any contact or support at all is exchanged. *Network reciprocity* indicates the extent to which the total network is characterized by support reciprocity. In connection with this concept, patterns of exchange are distinguished within triads. The data from a star network might show that the anchor gives support to B, and C gives support to the anchor. The totality of the anchor's relationships are thus reciprocal even though the network need not be reciprocal. In the full network, the triad of the anchor, B, and C can be

examined. Depending on whether B gives support to C, C giving support to the anchor can be viewed as the act that puts the equilibrium between giving and receiving support back into balance in the entire network. Network reciprocity touches upon the concept of generalized reciprocity, which indicates that the total balance within a network is more important than the balance within the relationships with one person, as they can be determined within the star network.

B. Data Collection on Full Networks

The data collection starts with the delineation of the network, as is explained in section II. The network members and their relationships with each other are the subject of the data collection. Because the number of network members and the number of relationships (maximum $N \times (N-1)/2$) can be large, in many cases a selection will have to be made from the network members. The network members are then asked about their features (demographic data and data relevant to the specific study, such as attitudes) and about the features of their relationships with each other. Together with the data collected from the anchor, these data constitute the data set.

If a limited number of elderly people's networks are examined, the data can be collected in face-to-face interviews and dealt with in the usual case study manner. Studies of this kind have been conducted at various times. It has also proved possible to conduct large-scale studies on full networks. In a Dutch study, the networks of 500 elderly people were delineated in face-to-face interviews; the elderly people and 3,500 of their network members were then approached with mailed questionnaires. Because each network member was asked about his or her relationships with a unique set of other network members, the questionnaires were personalized; the study focused on a total of approximately 9000 relationships. As preparation for the production of the written questionnaires, in the face-to-face interviews with the elderly people with extent to which the network members had contact with each other was inventoried by way of a density matrix. This made it possible for the written questionnaires to only ask the network members questions about other network members whom they had contact with.

Collecting data on full networks requires a great deal of work. The advantage however is that the analysis can take place from three angles, the perspectives of the older person, the network member, and the structure of the network. Each of these angles is unique and supplements the other two.

V. METHODS OF NETWORK ANALYSIS

A. Data Storage

Network data is hierarchically constructed. There are two levels of star network data. The elderly person as the anchor of the network is the higher level with such characteristics as sex, age, network size, and well-being. Inside of it, characteristics of the network members, such as sex, and of their relationships with each other, such as traveling time and support received by the elderly person, are on the lower level. There are three levels of full network data: the network as a whole, for example its size, the characteristics of the network members including the elderly person, and the features of their relationships with each other. The data are stored in accordance with this hierarchic structure. They can either be stored in a hierarchic database or in different files for each level. If they are stored in different files, the levels can be linked to each other by giving each case in the files unique and shared identifiers. In the case of star networks, let us say the number 123 is attributed to the case of a certain elderly person and numbers 12301 to 12399 are attributed to this particular elderly person's 99 network members and his or her relationships with them. In the number 12301, the first three figures are the shared identifier and the last two figures are the unique identifier.

B. Analysis of Data of Star Networks

The data of star networks and the relationships within them can be analyzed on their own level. On the level of the elderly person, there is only one nonaggregated feature (i.e., the network size). The structural and functional features of the network referred to in section III are based upon the features of the separate relationships. The network size can serve as an explanatory variable for differences in the well-being of

elderly people. In addition, the data can be analyzed on the level of the separate network members and the separate relationships with them. One can thus see whether there is any correlation between traveling time and the intensity of the support exchanges. One disadvantage of this analysis is that it violates an assumption of many analysis techniques, namely that the data of different cases are independent of each other, because the data on the relationships of an elderly person are all collected from and linked to the characteristics of one and the same elderly person. One way to study the correlation between traveling time and support without violating this assumption would be by randomly selecting one relationship of each elderly person. The procedure could be repeated for the remaining relationships.

One of the attractive things about being able to have network data at ones disposal is that data on different levels can be linked to each other. There are three methods for simultaneously analyzing the data on both levels: aggregation, disaggregation, and multilevel.

In aggregation, data from the lower level of the separate network members and/or relationships are transferred to the higher level of the elderly person. For each elderly person, one can take the mean of the contact frequency within his or her relationships and introduce the average contact frequency as variable in an analysis to explain the differences in the well-being of elderly people. In an aggregation of this kind, differences in the contact frequency between the network members of the elderly person are overlooked; if one wants to include them in the analysis, one can also calculate the variance in the contact frequency between the elderly person and his or her network members and include it in the analysis. A variant on the aggregation as the average frequency of contact across relationships would be to count the number of network members with whom there is contact at least once a week. Statistical software such as SPSS (Statistical Package for the Social Sciences) has capacities for aggregation of this kind. In aggregation, elderly people who have no network members are not given a score on the aggregated variable. One thus has to *decide on substantive grounds whether these elderly* people should be excluded from the analysis or what score should be attributed on the aggregated variable.

In disaggregation, data from the higher level of the elderly person are transferred to the lower level of the separate network members and/or relationships. To find out whether more support is exchanged in same-sex relationships than in cross-sex relationships, one adds a variable to the relationship data file that indicates for each relationship whether it is with an older man or woman. Using statistical software such as SPSS, this procedure is easy to implement. Then one can combine the sex of the elderly person and the network member in one variable and analyze whether the support differs for the values of this combined variable. In disaggregation it is also true that data from different cases are not independent of each other, so that one is violating an assumption of many analysis techniques.

An alternative for disaggregation is multilevel analysis. In this analysis technique, a linear regression equation is formulated for explaining variance in a variable on the lower level from the perspective of other variables on the lower level. The support received by an elderly person is then predicted on the basis of, for example, the age of the network member and the traveling time. A crucial aspect is that the magnitude of the effect of explanatory variables may differ between respondents. Therefore, the intercept as well as the slopes of the different independent variables in this equation are then explained with different regression equations from the perspective of independent variables on the higher level, such as the age and health of the elderly person. Multilevel analysis techniques are available as specific software (HLM, ML3, VARCL).

C. Analysis of Data of Full Networks

In star networks, it is possible to make data from different networks ready for analysis in one step. Techniques for the analysis of full networks analyze the data of one network at a time. To analyze the data of more than one network, the analysis has to be repeated. Then one collects the results of the analyses and includes them as network features in an analysis on the level of the elderly person. For a sample of *elderly people, one can thus compare the network* reciprocity of the full network with the anchor reciprocity as an aggregated feature of the star network. The UCINET program, which provides techniques

for determining a wide range of network structural features, is available for analyzing full network data.

VI. SUMMARY AND CONCLUSIONS

This article provides an overview of network analysis with respect to elderly people. The article starts by describing the importance of the personal network for elderly people. The personal network is considered a social resource and is important for daily functioning, coping with life events, and maintaining well-being. The impact of aging on the personal network becomes evident in the changes within the structure as well as the content of the network. The personal network of the elderly can be studied from different perspectives. The focus can be on the content of the network (e.g., the relation between support and well-being), or on structural aspects of the network (e.g., the relation of marital status to its size, composition, and density). In every network study, several methodological choices are made beforehand: which network delineation method is to be used, whether additional information is to be collected on some or all of the identified network members, which information is to be collected, and who will provide this information (only the older adult or all the members of the network). With respect to the last choice, data will be available on either a star network or a full network. Five methods for personal network delineation are described, varying from affect-based, role-based, exchange-based, and interaction-based to domain contact-based. These methods are conceptually unique and map different parts of the personal network. Features of the network structure and content that are usually examined within star networks are described and related to features of the older population. Attention is devoted to the reasons for and methods of studying full networks. Finally, methods for storing and analyzing network data are described.

BIBLIOGRAPHY

Antonucci, T. C. (1990). Social supports and social relationships. In R. H. Binstock & L. K. George (Eds.), *Handbook of Aging and the Social Sciences* (pp. 205–226). San Diego: Academic Press.

Dykstra, P. A. (1990). *Next of (non)kin: The importance of primary relationships for older adults' well-being.* Lisse, The Netherlands: Swets and Zeitlinger.

Kendig, H. L. (1986). *Ageing and families: A social networks perspective.* Sydney: Allen and Unwin.

Knipscheer, C. P. M., & Antonucci, T. C. (Eds.). (1990). *Social network research: Substantive issues and methodological questions.* Lisse, The Netherlands: Swets and Zeitlinger.

Milardo, R. M., & Wellman, B. (Eds.). (1992). Social networks. *Journal of Social and Personal Relationships* (special issue), 9.

Sarason, I. G., Sarason, B. R., & Pierce, G. R. (1994). Social support: Global and relationship-based levels of analysis. *Journal of Social and Personal Relationships, 11,* 295.

Snijders, T. A. B., Spreen, M., & Zwaagstra, R. (1995). The use of multilevel modeling for analysing personal networks: Networks of cocaine users in an urban area. *Journal of Quantitative Anthropology, 5,* 85.

Starker, J. E., Morgan, D. L., & March, S. (1993). Analyzing change in networks of personal relationships. In D. Perlman & W. H. Jones, Eds., *Advances in personal relationships, vol. 4: A research annual* (pp. 229–260). London: Jessica Kingsley.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications.* New York: Cambridge University Press.

Wasserman, S., & Galaskiewicz, J. (Eds.). (1993). Advances in sociology from social network analysis. *Sociological Methods and Research* (special issue), 22.

Wenger, G. C., & St. Leger, F. (1992). Community structure and support network variations. *Ageing and Society, 12,* 213.