Longitudinal analysis of personal networks.

The case of Argentinean migrants in Spain[*]

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Abstract

This paper discusses and illustrates various approaches for the longitudinal analysis of personal networks (multilevel analysis, regression analysis, and SIENA). We combined the different types of analyses in a study of the changing personal networks of immigrants. Data were obtained from 25 Argentineans in Spain, who were interviewed twice in a two-year interval. Qualitative interviews were used to estimate the amount of measurement error and to isolate important predictors. Quantitative analyses showed that the persistence of ties was explained by tie strength, network density, and alters' country of origin and residence. Furthermore, transitivity appeared to be an important tendency, both for acquiring new contacts and for the relationships among alters. At the network level, immigrants' networks were remarkably stable in composition and structure despite the high turnover. Clustered graphs have been used to illustrate the results. The results are discussed in light of adaptation to the host society.

Key words: personal network analysis, social networks, migration, clustered graphs.

1. Introduction

In recent years, social network analysis has shifted more and more to dynamic analysis. Networks are inherently dynamic, and a cross-sectional analysis of networks has a limited capacity to explain the processes that are responsible for the outcomes observed at one point in time. Statistical models for the longitudinal analysis of networks developed so far have been specifically designed for dealing with complete or sociocentric networks (e.g., Snijders, 2005). These models are not directly or fully applicable to personal or ego-centered networks. In this article, we explored the possibilities of longitudinal analysis of personal networks, combining qualitative and quantitative techniques.

Along with the methodological interest of our exploration, we want to show how a dynamic perspective on personal network data allows researchers to gain knowledge about the different dynamics identified and hereafter to formulate new and more powerful research questions. In our study, we have applied this perspective to the identification of patterns of change in the personal networks of 25 Argentineans living in Spain. These persons participated in a study on the changing networks of immigrants, and were interviewed twice with about two years in between.

The remainder of this article is divided in seven sections. The next two sections are devoted to a literature review of the longitudinal analysis of personal networks and statistical approaches to longitudinal personal network analysis. We illustrate these approaches with our data of the changing personal networks of Argentinean immigrants in Spain. Section 4 introduces the example context of the personal networks of immigrants, and Section 5 presents the data and the methodology developed for the two waves of structured interviews. The sixth and seventh sections describe the results of the qualitative and quantitative analyses, respectively. Last, we give a summary of the

findings and a discussion of our approach.

2. Longitudinal analysis of personal networks

One of the first studies into personal network dynamics was conducted in Toronto during several decades, first by Leighton and Wellman (in 1968) and later (1978 and 2004/'05) by Wellman and his collaborators (see Wellman, Carrington & Hall, 1988; Wellman, Wong, Tindall, & Nazer, 1997; Wellman et al., 2005). These so-called East York studies have shown how personal networks change over time and have estimated, among others, the influence of distance and communication on this evolution (Mok & Wellman, 2007; Mok, Wellman, & Carrasco, 2008). The first East York study was mainly interested in strong ties, defined on the basis of emotional closeness and frequency of contact, but the two later studies included weak ties as well.

Apart from a general interest in relationship processes, longitudinal analysis of personal networks has typically been applied in two fields of study. First, social support studies tend to use a dynamic analysis to estimate the disruptive effects of life events on the social network that surrounds an individual. The transition from high school to university (e.g., Degenne & Lebeaux, 2005), marriage (Kalmijn, 2003), divorce (e.g., Terhell, Broese Van Groenou, & Van Tilburg, 2007), childbearing, residential change, return to education in midlife (Suitor & Keeton, 1997), retirement (Van Tilburg, 1992) and widowhood (Morgan, Neal, & Carder, 2000; Guiaux, Van Tilburg, & Broese Van Groenou, 2007) have all been studied in relation to the changing personal networks of individuals. In these cases, researchers used panel studies in which the respondents were interviewed at multiple times before and after an important event. Other studies, though not focused on life events, also related personal network dynamics to changes in individual well-being (e.g., Costenbader, Astone, & Latkin, 2006).

A dynamic perspective on personal networks has also been used to illustrate social

and cultural changes in Russia (Lonkila, 1997), Eastern Germany (Völker & Flap, 1995), Hungary (Angelusz & Tardos, 2001), China (Ruan, Freeman, Dai, Pan, & Zhang, 1997), and America (McPherson, Smith-Lovin, & Brashears, 2006). The studies in post-communist societies illustrated how people used their personal networks as a resource for coping with the new market situation, either acquiring new acquaintances for taking advantage of market opportunities or deepening former relationships for obtaining products and services no longer provided by the system. For such studies into macro-level changes, researchers either used a panel or a trend analysis. In the latter case, assertions can be made at the macro-level, but not at the individual or relational level.

In this article, we concentrate on longitudinal analysis of personal networks based on panel studies, that is, studies in which respondents are interviewed at least twice. In such studies, respondents (*egos*) are typically asked to list a number of network members (*alters*) in each wave and to give information about the attributes of these network members and of the ties they have with them. This enables researchers to study how the *composition* of the personal networks, that is, the aggregated attributes of alters and ties per network (e.g., proportion of alters with a higher degree, average age of alters, proportion of kin), changes across time and to relate the changing composition to changes in outcome variables, for example respondents' well-being. In addition, data can be collected about the ties that network members have among themselves in each wave in order to study the (changing) *structure* of the ties in a personal network as well (e.g., network density, average betweenness centrality of alters, number of clusters). However, many dynamic studies do not collect data on network structure due to respondent burden (McCarty & Killworth, 2007).

3. Statistical approaches to the longitudinal study of personal networks

Researchers interested in the dynamics of personal networks have used various analytic approaches. Feld, Suitor, and Gartner Hoegh (2007) constructed a typology of the analysis of network dynamics in order to organize the variety of approaches applied to networks that do not contain data about the structure of ties among network members. They laid out a fourfold table of changes one might want to describe, depending on the level (ties or networks) and the focus of the analysis (persistence or changing contents of relationships). The first type of analysis they identified concerned the persistence of ties over time (Type 1), in other words, whether ties that were identified at a first time point still existed at a later time point. A second type of analysis concerned the changes in the contents of persistent ties across time (Type 2). At the network level, changes in the size of the network can be studied (Type 3), in other words, to what extent networks grow or shrink across time, and changes in the overall composition of the network (Type 4).

For each of the four types, changes can be described and they can be explained using covariates of the individual actors, of their network members, and of ego-alter pairs (ego-alter *dyads*). Feld et al. (2007) suggested using (logistic and multivariate linear) regression analysis for explaining changes in personal networks. They mentioned that statistical inference of such data may be problematic at the tie level due to the interdependence in the data, but argued that a sample of ties would be reasonably representative if the proportion of randomly selected individuals who account for the number of alters is large enough. Others (Snijders, Spreen, & Zwaagstra, 1995; Van Duijn, Van Busschbach, & Snijders, 1999) indicated that a regular regression analysis at the level of ties violates the statistical assumption of independent observations and therefore produces unreliable standard errors and hypothesis tests. In the case of nested observations (relationships with alters can be regarded as nested within egos), it is

appropriate to use the methodology of multilevel analysis or hierarchical linear modeling (e.g., Bryk & Raudenbush, 1992; Snijders & Bosker, 1999). Such an analysis is basically an extension of multiple linear regression analysis, but it allows researchers to decompose the variance in the criterion variable at multiple hierarchical levels. Van Duijn et al. showed that multilevel regression analysis can be fruitful for the analysis of changing tie characteristics (Type 2), where ego-alter ties (*level-2 units*, or higher-level units) are nested within the respondents (*level-1 units*, or the lower-level units). The dependent variable in such an analysis is the change in a certain characteristic of the tie (e.g., change in tie strength across time), which can be explained by characteristics of egos (e.g., gender, job situation), of alters (e.g., educational level), of dyads (e.g., gender similarity between ego and alter, duration of the relationship), and by cross-level interactions. Alternatively, an auto-correlation approach can be used, which yields the same results with respect to the effects of explanatory variables.

Similarly to the approach of Van Duijn et al. (1999) for the study of changes in tie contents, we suggest using logistic multilevel analysis for the study of changes in the persistence of ties across time (Type 1 analysis). As Feld et al. (2007) indicated, researchers interested in a Type 1 analysis tend to focus on a set of ties observed at one time point, and then describe how many of a person's ties are stable across time and explain which ties are stable and which are not. This would result in a dichotomous dependent variable (stable versus dissolved ties), and the explanatory variables can be similar as those in the former type of analysis.

For the changes indicated by Feld et al. (2007) as Types 3 and 4, the unit of analysis is the overall network, so characteristics of alters are typically aggregated to the network level (e.g., network size, average tie strength). A multiple linear regression analysis can then be used at the aggregate level, which is statistically correct as long as researchers

do not make cross-level inferences on the basis of the results. The dependent variable is the expansion or contraction of the network (Type 3), or the change in a compositional characteristic of the network (Type 4). For both types, ego and network characteristics can be used as explanatory variables. An aggregate analysis complements the Type 1 and 2 analyses. A Type 1 analysis focuses only on the persistence of ties that were observed at $t1$, but does not reveal changes in network size, as the number of new ties at later time points are not taken into account. A Type 2 analysis focuses on the change in compositional characteristics of persistent ties only, but does not show how the overall composition changes when dissolved and new ties are also taken into account. Therefore, Types 3 and 4 are not redundant given the first two types of analysis.

So far, we have concentrated our discussion on personal networks in which the research has not collected data on alter-alter ties. However, several scholars argue that it is important to consider the structure of alter-alter ties as it can modify ego-alter relationships (e.g., McCarty, 2002; Wellman, 2007). For example, the density and openness of the personal network structure shape the intensity of social control, the possibility to mobilize social support (Lin, 1999), the diversity of social capital (Flap, 2004), and the conformity of opinions and identifications in the networks (e.g., McFarland & Pals, 2005), all which can have consequences for individual well-being. If, for instance, researchers are interested in the evolution of social capital over time, they may wish to predict how alters form different clusters and how these clusters subsequently split up or merge over time. Such an analysis of the structural dynamics in a network may give a deeper insight into the underlying processes than a compositional analysis alone.

The typology of Feld et al. (2007) does not include ways to analyze dynamic network structure. Of course, structural information can be easily integrated within each

of the four types of analysis. For example, the degree to which a dyadic relationship is embedded within the larger structure of a network at one time point may be used as an explanatory variable for its persistence (Type 1) or evolution (Type 2). Similarly, structural characteristics of the networks at one time point can serve as predictors for each type of change. Last, an analysis of the change in a structural characteristic of the network is a simple extension of a Type 4 analysis. However, such an analysis may produce unsatisfactory results as it does not reveal the dyadic (alter-alter) processes underlying an aggregate result. We may find that some networks become denser over time and others less dense, without us knowing which sets of alters are particularly likely to become socially related or to end their relationships. This information may be useful in predicting the evolution of network structure. We therefore suggest a third unit of analysis in addition to those identified by Feld et al. (2007): the ties among alters. For this unit, we can in principle make the same distinction between the persistence and the changing contents of relationships over time, but as data about alters typically need to be reconstructed from the perceptions of egos, most researchers limit themselves to asking about the existence of ties and not about their contents. So, we discern one additional type of analysis (Type 5): that of the persistence and formation of relationships among alters. As the dependency structure of relationships among alters is equivalent to that of sociocentric networks, we can use methods that have originally been developed for sociocentric networks, although these tend to focus on single networks whereas personal network researchers focus on collections of networks. The most important adaptation when applying methods developed for sociocentric networks to personal networks is that the egos should be excluded from the analysis, as ego is by definition tied to each of the alters and can therefore bias the estimates strongly (cf. McCarty, 2002; McCarty & Wutich, 2005; see also Degenne & Lebeaux, 2005). In the

interpretation of results, researchers should bear this omission in mind.

For our Type 5 analysis, we propose the use of SIENA (Snijders, Steglich, Schweinberger, & Huisman, 2008; Snijders, 2005). SIENA was especially designed to model the evolution of networks through time as a function of network structure, individual attributes, and dyadic covariates, but so far it has not been applied to personal networks. When the set of alters per network is sufficiently large (say $n \geq 20$, but this also depends on the average density and the amount of change in composition), we suggest using SIENA in a two-stage multilevel procedure to analyze the networks of multiple egos simultaneously (e.g., Snijders & Baerveldt, 2003). Studies that focus on smaller sets of alters can use SIENA if it can be reasonably assumed that the networks have identical parameter values. If so, the networks can be combined in one adjacency matrix, in which pairs of alters who do not belong to the same network are given structural zeros to express that ties between these alters are impossible.

We propose that a combination of the distinct, complementary types of analysis described above gives the most complete picture of personal network dynamics. A combination of methods may seem rather fragmentary in comparison with the more integrated methods to analyze the dynamics of sociocentric networks, for which it is even possible to study how individual behavior co-evolves with the networks in a single analysis (Snijders et al., 2008). However, the complexity of personal network dynamics differs from the complexity of sociocentric network dynamics, as personal network researchers wish to relate the structure of two distinct types of dyadic relationships (ego-alter and alter-alter) to outcome variables at an analytically higher level (the ego level). Moreover, this higher-level unit of analysis has a profound impact on the compositional changes in the network, and these changes are of substantive interest, in contrast to most sociocentric networks, in which actors joining or leaving the network is

often merely seen as an exogenous event.

Whatever the type of analysis, it is important to realize that changes in (personal and sociocentric) networks can result from various sources. Leik and Chalkley (1997) distinguished four sources. First, there is unreliability due to measurement error. For example, people are not always consistent in their responses to interviews, and consequently a tie may be forgotten, even though it still exists. The second source of change is inherent instability, or spontaneous variation in personal relationships regardless of changes in external variables. No obvious explanations at the level of interpersonal relationships can be found for this type of fluctuation, and consequently this source, together with the first one, is an error source in statistical analysis. Third, there is what Leik and Chalkley called systemic change, changes in relationships that can be attributed to factors that are endogenous to the system of social relations. For example, properties of actors change across time and properties of ties tend to follow developmental curves that are reasonably predictable. Fourth, Leik and Chalkley identified external change, or disruption of the normal network dynamics by factors that are exogenous to the network. Certain life events and societal changes such as economic recession or institutional changes are examples of such external sources of network change. In a dynamic network analysis, researchers should intend to minimize the first type of change, and to search, on the basis of theories and subject matter knowledge, for explanatory variables that can model the third and fourth type of change. In our illustration, a qualitative analysis preceded the quantitative analyses for this aim. The qualitative analysis focused on the structured interviews that were held with the respondents about the reasons for the observed changes in their networks. These interviews were valuable to get an estimate of the types and amount of measurement error, to correct errors in the quantitative part, and to identify important predictors of the

network dynamics for the quantitative analyses.

4. An illustration: The case of Argentinean immigrants in Spain

Our empirical research focuses on how the personal networks of immigrants change over time as they become more adapted to their host country. International migration disrupts personal networks, as it alters the individual needs of the migrating actor and the ability of his or her network members to fulfill these needs. The process of reconstructing the network in the host country both reflects and influences the process of integration and psychological adaptation (Berry & Annis, 1974; Scott & Scott, 1989; Maya Jariego, 2006). In our earlier work (e.g., Lubbers, Molina, & McCarty, 2008), we have proposed a general model of personal network change when people move to another place of residence. We expected that in the first stage after migration, the network mainly contains kin and people living in the country of origin and that the relations among these people are dense. Relations in the country of residence are scarce and consequently, the frequency of contact is low as well. In the second stage, interaction in the new social settings (e.g., the workplace, neighborhoods, schools, sport clubs, and musical events) explains that the number of contacts in the new place of residence gradually increases. Consequently, new clusters appear (consisting of fellow migrants, the transnational community, and nationals from the country of residence) and the heterogeneity of the network increases. At the same time, we expected that the number of contacts in the country of origin decreases, as immigrants end their distant weak ties. In the third stage, people from the different clusters become interconnected. Of course, this is a hypothesized trend of change toward integration and persons or communities can show deviations from it, especially if there are barriers for people to become connected in workplaces, neighborhoods, schools, or other social settings, or if groups based on ethnicity are a source of political contest. In general, we expected that

the process of network change is especially fast during the first stages after migration, and we expected that the length of residence explains the overall process of change, although we argued that there may be episodes in which the networks show an increasing segregation (we call such changes *involution* in Section 6).

In a cross-sectional study among immigrants of various origins in Spain, we found that recent migrants had different types of networks than earlier migrants (Lubbers, Molina, & McCarty, 2008). The observed differences were largely in line with our expectations. The relation between the type of network and length of residence could also be established when controlled for possibly confounding attributes of the respondents such as ethnic origin, gender, and age. These results led us to propose that there is indeed a certain pathway of change associated with length of residence, but our cross-sectional data did not allow us to test this hypothesis. Therefore, we collected a second wave of data among a subset of the respondents of the first wave. For this article, we analyzed the changing networks of the 25 Argentinean immigrants in Spain who were interviewed twice, with the aim to test our hypothesized model of network change. More specifically, we expected increases in the proportion of Spanish network members and the average frequency of contact in the networks, and decreases in the proportions of Argentineans and kin. Also, we expected that changes in density and betweenness would depend on the length of residence.

We also wanted to explore the underlying processes of the observed network changes at the dyadic level. First, we focused on the relationships between egos and alters. Similarly to general populations (e.g., Wellman et al., 1997), we expected that (1) kinship ties, (2) strong ties, as measured by the time of knowing, emotional closeness, and frequency of contact, (3) more central ties, and (4) ties in denser networks are more likely to persist over time. Furthermore, we expected that the length of residence affects

the stability of ties of immigrants, and that ties with alters in Argentina become weaker over time while ties in the new place of residence become stronger. We also wished to explore whether the factors that influence the persistence of relationships were similar for Spanish alters as for others. We controlled for characteristics of ego such as gender, marital status, age, and employment, which may influence the formation and maintenance of ties.

Then, we investigated to what extent and how dyadic relationships among personal network members evolve through time. The more dyadic relationships exist among network members, the better embedded a respondent is in a certain environment, which has consequences for the social support he or she can mobilize. First, we wanted to know whether Spanish, fellow migrants, and originals were segregated in the personal networks. We expected that it is more likely to observe ties among alters who shared the same country of residence and country of origin than among alters of different countries. Second, we expected that the stronger the ties that two individuals had with ego, the more likely it is that those two individuals had a tie as well. Louch (2000) expressed two hypotheses about the relationships among network members that we adopted in addition: (a) a greater number of shared associates for two individuals and (b) similar group memberships with ego increases the likelihood of a tie among them.

Given the importance of the country of origin and the country of residence of the alters for integration in the host society (e.g., Lubbers, Molina, & McCarty, 2008), we distinguished four classes of network members in all analyses: those who are originally from and live in the country of origin of the respondent (*originals*), those who come from the same country of origin but live in Spain (*fellow migrants*), those who come from and live in Spain (*hosts*), and those who come from or live in other countries (*transnationals*). The proportions of alters from each of these classes and the density of

relations within and among each class gives important information about the integration of the respondent. This is illustrated by clustered graph visualizations (Brandes, Lerner, Lubbers, Molina, & McCarty, 2008; see Section 7).

5. Data

The first wave of the data for this article was collected during the years 2004-2006 for the project *Development of a Social Network Measure of Acculturation and its Application to Immigrant Populations in South Florida and Northeastern Spain,* funded by the National Science Foundation. For the Spanish part of the project, 294 immigrants in Barcelona and Girona were interviewed, among whom 81 were Argentinean. The data of the second wave were collected during the years 2007-2008 for the project *Dynamics of actors and networks across levels: individuals, groups, organizations and social settings*, funded by the European Science Foundation. For this project, 67 respondents of the first wave were re-interviewed two years after the first wave, among whom 25 were Argentinean. The present article focuses on these 25 Argentineans. We chose to focus on the Argentineans because it is a group that shows a remarkable capacity to integrate in the social structure of Spain, possibly due to their higher level of education (compared with other groups of immigrants in our sample) and for cultural reasons. All 25 respondents were first generation migrants. Sixteen of the respondents were women (64%), the average age was 32.3 ($SD = 7.8$), and the average length of residence in Spain was 4.3 years ($SD = 3.0$) at the time of the first interview - all 25 respondents were minimally two years in Spain at that time.

For the data collection, computer-assisted personal interviews were held with the software EgoNet (http://sourceforge.net/projects/egonet/), a program designed specifically for the collection, analysis, and visualization of personal network data. In both waves, the survey had four modules: (1) questions about the respondents; (2) the

question used to generate the names of network alters (or name generator). This was formulated as follows: "Please, give us the names of 45 persons you know and who know you by sight or by name, with whom you have had some contact in the past two years, either face-to-face, by phone, mail or e-mail, and whom you could still contact if you had to". The fixed-choice design was chosen to ensure that respondents not only nominated strong contacts, but also weaker contacts; (3) questions about each of those alters and the ties respondents had with them (e.g., gender, age, emotional closeness); and (4) a question about the existence of relationships among alters as perceived by the respondent, which was formulated as follows: "How likely is it that [alter X] and [alter Y] contact each other independently of you?". The response "very likely" was regarded as an indication of a relationship, whereas the responses "possible" and "not likely" were regarded as a non-relationship. After finishing the four modules, the program gives a visualization of the networks. The visualization was used as a starting point for a qualitative interview with the respondent about his or her network, which was recorded. The qualitative information allows us to contextualize the measures and to record the cognitive view of the respondent on his or her life. McCarty (2002), who introduced this methodology, showed that the reliability of the resulting sociometric nominations was quite high on a short time interval. Therefore, we assumed that the unreliability of the data as a result of measurement error was relatively limited.

The procedure for the data collection in the second wave deviated slightly from that of the first wave: (1) The interview started with the first two modules using EgoNet (the modules were identical to those in Wave 1, see above). Once the respondent had provided a list of 45 active contacts at $t2$, (2) the interviewer and the respondent compared the $t2$ list with the $t1$ list of names and identified the stable contacts present in the second wave. (3) The data collection proceeded with Modules 3 and 4 using EgoNet

(attributes of alters and ego-alter ties, mutual relationships among alters). Once the questionnaire was finished, (4) a qualitative interview was performed with the aid of the visualization of the network. The qualitative interviews in Wave 2 focused specifically on the observed changes at various levels, among others alters (e.g., why were some relationships discontinued and who were the new network members), clusters of alters, network structure and composition. The interviews were again recorded and lasted between 40 to 120 minutes, or 30 hours in total.

6. Qualitative analysis of the reasons of change

6.1 Methodology

The qualitative interviews in the second wave were heard while reproducing the same visualizations that respondents commented upon plus the clustered graphs of the two waves (see Part II for an explanation), so the pattern of change could be assessed in the process. The reasons for change as given by the respondents were classified in the following way. First, each reason was classified into one of four sources of change following Leik and Chalkley (1997): measurement error, inherent instability, endogenous change, and exogenous change. Then, for each reason, we identified whether it regarded a change that followed a trend toward larger integration in the host society (we call those changes *evolution*), a change that followed the opposite direction (*involution*) or a change that showed *stability* (in composition, not necessarily with the same alters). Reasons that were given by just a few (one to three) respondents or that had a small impact on the networks were marked with *; reasons that were given by four to nine respondents or that had a medium impact on the networks were marked with **; reasons that were given by ten or more respondents or that had a large impact on the networks were marked with *** .

6.2 Results

Comparing the sources and the direction of change, we found that endogenous changes explained most of the involution and evolution phenomena in the personal networks (see Table 1). We now discuss each of the cells of Table 1 for which we identified at least a low impact.

6.2.1 Error – Involution, Stability, and Evolution

Six respondents reported *small errors** in the data, such as erroneously reported relationships between two alters. These errors were subsequently corrected. Furthermore, five respondents reported that the *limitation to 45 alters*** underestimated the stability in their networks. In two cases, this problem pertained to only one or two alters; in the others, it involved multiple alters. Third, one respondent told us that in the first interview he had understood that he could only nominate people living in Spain, so the involution process shown by his data (see Figure 2 on Row 4, Column 2) is not reliable. However, the interviewer noted that the respondent had a highly critical attitude toward Argentineans at t1 and suspected that the respondent felt he needed to justify the absence of Argentineans in the first network when asked why Argentinean contacts were observed in the second but not in the first wave. We decided to maintain the respondent in the quantitative analyses, as the number of Argentineans who were added was relatively small.

6.2.2 Instability – Involution

In the first stages of the migration process, migrants often suffer from psychological problems (e.g., Walsh, Shulman, & Maurer, 2008). One of the respondents indicated that he had suffered a *psychological crisis** at the time of the first interview, during which he did not maintain active relationships with his family. In the second wave, the relationships with his family were restored. Apart from this case (see the visualization of Figure 2 on Row 6, Column 2), six respondents indicated that they had *traveled to*

Argentina** shortly before the second interview, and that these trips had (temporarily) reactivated former contacts and family ties.

6.2.3 Endogenous – Involution

A few respondents reported changes in the personal networks that could be classified as endogenous and that went in the opposite direction of the expected model of change, i.e., knowing less Spanish people and more Argentineans over time. The main reasons given by the respondents are the following:

- *Marrying an Argentinean***. This implies meeting new people (the family-in-law living in Argentina or Spain and the partner's friends), and reactivating relationships in one's own family.

- *Starting to work in / setting up a family business***. This does not only increase the job-related relationships with fellow Argentineans, but it also has an impact on other social arrangements such as sharing leisure activities and housing.

- *Cousins growing up**. The life cycle normally involves a reactivation of family ties. We also found this true for migrants.

- *Amateur soccer club or other activities shared with fellow migrants**. Playing soccer, exercising capoeira, assisting tango classes or a poetry club have small but interesting effects in obtaining contacts with other Argentineans in Spain.

6.2.4 Endogenous – Stability

A few cases showed a remarkable stability. According to the respondents, stable marriage could explain this fact. Among the endogenous reasons for acquiring new contacts or loosing old ones without changing the proportions of Spanish, fellow migrants, alters in the country of origin, and transnationals, the most important were:

- *Transitivity ("befriending one's friends")****, which substituted former acquaintances with the same role. Ten respondents indicated that partners, family

members, or friends of friends became their own network members over time.

- *Life cycle related ceremonies, as birthday parties and funerals** can develop new contacts of a certain class.

6.2.5 Endogenous – Evolution

The reasons given by respondents for changes that can be classified as endogenous and go in the expected direction are the following:

- *Having or getting a job****. Jobs have a profound impact on the social networks of people, immigrants included. Fifteen respondents indicated that their (new) jobs (or changes in jobs) led to new contacts. In two of these cases, a change of job was also a reason for loss of contacts with Spanish people, so that these cases should be classified under stability rather than evolution.

- *Marrying a Spaniard****. As in the case of marrying an Argentinean, a marriage profoundly affects the social networks of the couple, but in this case boosting the *evolution* process of the respondent. Five respondents were introduced by their Spanish partners to a whole new set of in-laws and friends (transitivity).

- *Studying for a Master degree or taking English or Catalan classes***. Six respondents indicated that English or Catalan classes or an academic study were sources of new Spanish contacts. Also, two women indicated that prenatal classes had extended their Spanish contacts. Classes in life-long learning were another source of new contacts. Some respondents noted that the end of a course was also associated with the *loss* of contacts.

- *Music festivals – Disco***. Music festivals and discos are social scenes that allow new contacts, normally heterogeneous in country of origin, but homogeneous in age, educational level, and taste in music. These encounters affect the creation of new clusters.

- *Sharing a flat***. The high costs of accommodation imply that people are forced to share apartments, frequently without formerly being acquainted. Along with this domestic living, friends and acquaintances of flatmates are an additional source of contacts.

- *Children playing sports or musical activities (parents meeting)***. Migrants who have children indicated that they met new Spanish contacts at the activities of their children, which is another source of change related with the life cycle.

- *Change of residence***. Changes of residence also affect the composition of social networks, even with the existing means of traveling and communication.

For the dissolution of ties with Argentineans living in Argentina, the main reason given by the respondents was the *distance**** (13 cases).

6.2.6 Exogenous – Evolution

We could identify external sources of change for a few cases (the *death of a family member***, *alters who remigrated to Argentina**, and occasionally *getting a Visa** and the *loss of a cellular phone**), which could explain part of the change observed in the evolution trend. Although it concerned only a few alters, the death of a family member was coded as a medium impact as it often affected other family ties as well, especially if the deceased occupied a central position in the kinship relations of the respondent.

7. Quantitative analyses of change

7.1 Measures

For the quantitative analyses, we used the following measures:

Characteristics of ego at t1

In the first wave, we asked the respondents about their *age* (in years), whether they were *employed* (1) or not (0), their *length of residence* in Spain (in years), their *marital status*, and we encoded their *gender* (1 for males and 0 for females). For length of

residence, seven and more years were recoded as seven, to avoid that outliers had a large impact. For marital status, we created a dichotomous variable that indicated whether the respondent was married at the time of the interview (1) or not (0).

Change characteristics of ego t1-t2

On the basis of the qualitative analyses, we decided to construct the following four dichotomous characteristics based on the data of the two waves: Whether ego visited Argentina in the past year (*visits to Argentina*), and whether ego changed in marital status (*marital status changed*), work situation (*job situation changed*), and place of residence (*place of residence changed*). For each variable, yes is coded 1, and no 0.

Structural characteristics of the network at t1 and t2

Network density. This measure gives the density of the perceived alter-alter network, which is the proportion of pairs of alters for whom the respondent indicated that they were very likely to have contact with each other independently of the respondent. The variable can range theoretically from 0 (if none of the alters knows any of the others) to 1 (if every alter knows every other alter).

Betweenness centralization. This measure gives the betweenness centralization of the perceived alter-alter network and ranges theoretically from 0 (in a network where everyone is directly connected to everyone else) to 100 (in a star network, where one network member is tied to all other network members, and other network members do not have social ties among them). In personal networks, the betweenness centralization is underestimated because each pair of alters is in fact also connected with a two-path, via the invisible ego, who is excluded from the network. However, the betweenness centrality can be regarded as an indication of the structure of the network. Networks with a high betweenness indicate that some individuals play a central role in the social lives of the respondents, as they (like the respondent) connect different subgroups.

Characteristics of ego-alter dyads and alters

Frequency of contact [3]. For each alter, respondents were asked how often they had contact with this person. Responses could be made in 7 categories: 'every day' (recoded category 7), 'twice a week' (6), 'once a week' (5), 'twice a month' (4), 'once a month' (3), 'twice a year' (2), 'once a year' (1). At the aggregate (i.e., network) level, the measure *average frequency of contact* averages the responses over the 45 alters and indicates the average amount of contact that ego has with his or her alters.

Closeness. For each alter, respondents were asked how close they felt with this person. Responses categories were: 'I don't feel close at all' (1), 'I don't feel very close' (2), 'I feel reasonably close' (3), 'I feel close' (4), and 'I feel very close' (5). At the aggregate level, the measure *average closeness* averages the responses over the 45 alters and indicates how close ego feels on average with his or her network members.

Time of knowing. Respondents were asked for how many years they knew each of the alters. As this variable was highly skewed and as some "round" categories (e.g., 25) were more often chosen than their neighboring categories, we decided to recode the variable as follows: (1) 1 year, (2) 2 years, (3) 3 or 4 years, (4) 5 to 10 years, (5) 11 to 20 years, (6) 21 to 30 years, and (7) 31 or more years. At the aggregate level, the measure *average time of knowing* averages these responses over the 45 alters.

Family. Respondents were asked in which way he or she knew each of the alters. Responses could be made in 13 nominal categories, three of which were '[Person X] is my spouse or partner', 'direct family', and 'in-laws'. The dichotomous variable *family* indicates whether the alter belonged to one of these categories (1) or not (0). At the aggregate level, the proportion of alters who belonged to one of these three categories constitutes the variable *proportion of family*.

Alters' country of origin and country of residence. On the basis of the country of

origin and the country of residence, four classes of alters were distinguished, in line with Brandes et al. (2008): Alters who were originally Spanish and lived in Spain ('hosts'); alters who were originally Argentinean but lived in Spain ('fellows'), alters who were originally Argentinean and lived in Argentina ('originals'), and others ('transnationals'). For the multilevel analyses, a set of three dummies was used to differentiate the base category (*origin*) with the *hosts* (dummy 1), *fellows* (dummy 2) and *transnationals* (dummy 3). At the aggregate level, the *number of alters* in each category was used.

Structural position of the alter at t1

Degree centrality of alters. The degree centrality of each alter was measured as the number of ties the alter had with other alters in the network at *t*1. The variable ranges theoretically from 0 (i.e., alter is an isolate in ego's network) to 44 (i.e., alter is connected to all other alters in the network).

Characteristics of alter-alter dyads

The dyadic covariates that were used in the SIENA analyses were constructed from the individual characteristics. *Tie strength alter 1 × alter 2* indicated the interaction between the strength of the ties that two alters had with ego. Positive effects indicate that the stronger the ties are between the two alters and ego, the more likely it is that the two alters have a social relation. *Same group membership* indicated whether the two alters shared the same group membership with ego (i.e., kin, coworkers, neighbors, members of an association, or childhood friends) or not. *Same country of origin and residence* indicated whether the two alters belonged to the same origin and residence class (i.e., hosts, fellows, originals, and transnationals) or not. Apart from these characteristics, we estimated the effect of *transitive triplets*, which indicated whether alters are more likely to have a social relation when they are indirectly connected via

multiple two-paths. The basic structural effects of *degree*, which indicates a tendency to relate with others, and *rate of change*, which indicates the rate at which relationships are changed, are included by default.

7.2 Methods

As indicated above, we used multilevel logistic regression analysis for the Type 1 analysis, in which the respondents formed the level 1 units ($N = 25$) and their relationships with alters the level 2 units ($N = 1,125$). The persistence of a tie was the dependent variable, and characteristics of ego at $t1$, change characteristics of ego, dyadic characteristics at $t1$, and structural characteristics at $t1$ were used as predictors (see Measures).

For the analysis of how persistent ties changed across time (Type 2), we used multilevel regression analysis. Stable dyadic relationships with alters ($N = 583$) were nested within respondents ($N = 25$). We used an auto-correlation approach, so that the characteristics of ties at $t2$ were the dependent variables, and the $t1$ measure of the characteristic was used as a covariate. The same set of predictors was used as in the Type 1 analysis.

The fixed number of nominations in our data implied that the size of the networks did not change across time, so we did not perform a Type 3 analysis. For the analysis of how the overall network changes across time (Type 4), we used a multivariate regression analysis, where the network was the unit of analysis ($N = 25$). The dependent variables were compositional and structural characteristics of the networks at $t2$, and we used the first observation of the dependent variable as a covariate.

We further used a method that visually summarizes networks for which nodes can be categorized in a small set of classes. For this method, Brandes et al. (2008) proposed a clustered graph approach in which individual nodes in a graph are replaced by node

classes. In our case, alters can be partitioned into four classes: hosts, fellow migrants, originals, and transnationals (see Measures). Figure 2 shows the positions of these four classes in the visualization. Individual variations in network composition and structure regarding the classes are then expressed as follows. First, Brandes et al. proposed to vary the size of the nodes to represent the proportion of actors in each class, so larger nodes represent the predominant classes in the network. If a personal network did not contain alters of a certain class (e.g., if the immigrant did not know any Spaniard), this class does not appear in the graph. Second, the authors proposed to vary the node color to represent the density of the intra-class relations. Node colors theoretically range from white, representing classes of actors who are not interconnected at all, via increasing grades of grey to black, representing classes of actors who are all interconnected. Last, the tie weight was varied to represent the density of the relations among two classes. So, wider ties represent higher proportions of relations between the actors of the two classes connected by the tie. An absent tie between two classes implies that no relations were observed between the actors of the two classes. The clustered graphs give a quick visual summary of the composition and structure of a personal network with regard to a variable of interest (in our case, the country of origin and country of residence of the alters) and permits an easy comparison between networks.

Clustered graphs can also be used to represent the average of a collection of networks (Brandes et al., 2008). The node size, node color, and tie weight then express the average tendencies in the collection of networks. The standard deviation of (1) the class size, (2) the density of the intra-class ties, and (3) the density of the inter-class ties can also be represented, respectively by (1) drawing a segment in the lower part of the node proportional to two standard deviations (to represent the average plus or minus the standard deviation), (2) coloring two wedges in the upper part of the nodes in the grey

shades corresponding to the average plus and minus the standard deviation, and (3) drawing a small part in the tie proportional to two standard deviations,.

Finally, the analysis of the changes in relationships among alters (Type 5) was performed using SIENA (Snijders et al., 2008), a method for analyzing the dynamics of a single social network. The method assumes that changes in a network are actor-driven and that they take place in continuous time, even though networks are observed at discrete time points. In other words, it is assumed that from time to time (between two observations), actors start new relationships or end existing relationships with other actors in the network, and that these changes are guided by certain tendencies (e.g., reciprocity, or gender similarity). In our case, we expected that network changes were driven by a tendency toward transitivity, a tendency for ego's stronger contacts to become socially related, by homophily in country of residence and origin, and by shared group memberships (see Measures). The tendencies that are expected to guide the network change are expressed in a random utility model, which is implemented as a simulation model. This model and the network as observed at the first time point form the starting point for a simulation. The outcomes of the simulation are compared with the consecutive observations, and this comparison forms the basis for parameter estimation and testing (see for further details Snijders, 2005).

As we had networks of multiple egos, we used a two-stage procedure. First, we analyzed each network separately with SIENA, and then ran a meta-analysis (using the module SIENA 8) to summarize the findings over the networks (see Snijders & Baerveldt, 2003). In our case, data were non-directed, so we assumed that one alter takes the initiative of a change and imposes this change on the other (in SIENA, this is called the *forcing model*). Also, we had compositional changes in the networks (actors leaving and joining the networks between the two observations). As we had no

information about the exact times at which alters left or joined, we assumed that the compositional change took place in the middle of the time interval.

7.3 Results

7.3.1 Persistence of ties with alters across time (Type 1)

First, we analyzed the persistence of ego-alter ties over time. Fifty-two percent of the 1,125 alters who were nominated at $t1$ were again nominated at $t2$ ($N = 583$), whereas 48% of the nominations was not repeated ($N = 542$). So, the stability of immigrants' networks over a two-year time period was about 50%.

As the first column (Model 1) of Table 2 shows, none of the ego characteristics age, sex, employment, marital status, length of residence in Spain, and the change characteristics predicted the persistence of a tie over time. So, in contrary to what we expected, respondents who migrated more recently did not have less stable ties. Also, married people did not have more stable relationships than single respondents, as was suggested in the qualitative part. At the ego / network level, only network density appeared to be important for the stability of ties. This implies that individual relationships with alters were more stable when embedded in denser networks at $t1$.

Relational characteristics were better predictors of the persistence of ties, as the second column (Model 2) of Table 2 shows. First, as expected, alters whom respondents contacted more frequently, with whom they felt closer, and who occupied a more central position in the $t1$ network had significantly higher probabilities to persist. The time of knowing did not explain any additional variance when included simultaneously with these variables. Closeness, frequency of contact, and degree can all be seen as indicators of tie strength, but it is interesting that these indicators were unequally distributed over the four origin and residence classes. That is, respondents felt closest with alters in their country of origin, had most frequent contact with Spaniards, and

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fellow migrants occupied the most central positions in their personal networks.

Second, relationships with Spanish, fellow migrants, and transnationals were less likely to be continued than relationships with Argentineans in Argentina, when controlled for tie strength and family ties. When we introduced an interaction effect between length of residence and the alter being Spanish (see Table 2) however, it turned out to be significant. This effect, together with its main effects, indicated that recent migrants had more stable relationships with their Spanish alters as compared to Argentinean alters, whereas less recent migrants had more stable relationships with their Argentinean contacts. It seems that Argentinean migrants hung on to their Spanish contacts more strongly in a first phase of migration than in later phases.

When we ran the analysis separately for Spaniards, fellow migrants, originals, and transnationals (not in table), the results remained largely the same. Closeness, frequency of contact, and centrality in the network affected the persistence of each type of tie. Additionally, for fellow migrants, the probability that a tie continued increased dramatically when the alter was a family member (coefficient 2.644, *SE* 0.712, $p < .01$).

In a final, parsimonious model, we combined the significant ego and alter-level predictors of the two former models. We also included length of residence as it was a main variable of the significant interaction, and we maintained the set of dummy variables for nationality/residence as one of these had a significant effect. As Model 3 in Table 2 shows, all effects that were significant in the two former models maintained their significance. Surprisingly though, the density effect changed its direction when controlled for closeness and frequency of contact. As density was correlated with average closeness ($r = .45$, $p < .05$) and with average frequency of contact ($r = .43$, $p < .05$), density was probably a proxy for these variables. Once the individual closeness and frequency of contact were controlled, the density had a negative influence, which

implies that contacts with equal tie strength were more likely to disappear in dense networks than in less dense networks.

7.3.2 Differences between dissolved and new ties (Additional analysis)

As we indicated before, 542 of the ties that were mentioned at $t1$ were broken at $t2$, and consequently 542 new ties were given at $t2$. An intermediate question in our analysis was whether these two groups of ties differed in strength. Table 3 shows that the alters whom the respondents did not nominate again at $t2$ were somewhat less close and slightly less frequently contacted than the newly nominated alters at $t2$. There was also a significant difference in the time respondents knew the alters, but the difference was surprisingly small. At closer inspection, it appeared that only 48% of the newly nominated alters ($N = 261$) were persons whom ego did not know yet in the first interview. The other newly nominated alters were persons whom the respondents already knew for more than two years. The percentage of dissolved ties younger than two years was 34% ($N = 186$).

It can be expected that the alters who were first nominated at $t2$ but already known to the respondents at $t1$ were either sleeping ties that had increased in importance or indirect ties that had become direct ties over time. Indeed, looking at how respondents met these alters, we found that they were primarily family members (23%) – sleeping ties on the earlier occasion –, people known in "other ways" (than family members, childhood friends, neighbors, colleagues, school mates, people of the same club or religious association, or people known via third persons; 23%), and people known via third persons (19%). The newly nominated alters whom respondents had met between the two interviews were most often known via third persons (32%), in "other ways" (29%), or at the workplace (21%). In particular, the workplace was a setting where respondents met new Spanish contacts (32% of their new Spanish contacts were met at

work) and it was much less important for meeting fellow migrants, originals, and transnationals.

7.3.3 Changes in characteristics of persistent ties across time (Type 2)

On average, the stable ties (N = 583) hardly increased (although significantly so) in closeness (M_{t1} = 3.75, SD = 1.10; M_{t2} = 3.88, SD = 1.06; t = -3.128, df = 582, p < .01) and they decreased somewhat in frequency of contact (M_{t1} = 4.65, SD = 1.78; M_{t2} = 4.09, SD = 1.88; t = 9.193, df = 582, p < .001).

For the changes in frequency of contact and closeness, we used the same predictors as those listed in Table 2. Table 4 shows the final results of these analyses in a parsimonious model. Not surprisingly, hardly any characteristic of the respondents and of the dyads could predict changes in closeness over time. The change in closeness could only be related to whether the alter was a family member or not (see Column 1 in Table 4). That is, respondents felt closer with their family members at $t2$, given their closeness at $t1$, than with other network members. The model fit improved significantly when the variable *family* was introduced (χ^2 = 17.23, df = 1, p < .01), and this single variable explained 2.5% of the remaining variance (i.e., the unexplained variance that remained after controlling for closeness at $t1$).

Changes in the frequency of contact were predicted by several characteristics (see Column 2 of Table 4). First, respondents who moved to another place of residence within Spain tended to decrease their contact with stable network members, compared to those who did not move. From an additional analysis, it appeared that only the contact with Spanish stable members was less frequent when the respondent changed residence. Second, the contact frequency with Spanish members, fellow migrants, and transnational members tended to increase more than the contact frequency with network members who lived in Argentina, which is most likely due to the geographical distance.

Third, the contact frequency with family members was higher, given the contact frequency at $t1$, than the contact with other network members. Last, respondents increased their frequency of contact more with alters who were more central in the $t1$ network as compared to less central alters. Together, the predictors explained 15% of the remaining variance and the goodness of fit improved significantly ($\chi^2 = 89.15$, $df = 6$, $p < .01$).

7.3.4 Changes in overall network characteristics across time (Type 4)

As indicated before, the average stability of ego-alter relationships was 53%, but analyses at the aggregate level indicated that the stability varied considerably between respondents: between 29% and 76% ($SD = 13.6$). Overall, the network characteristics of the respondents hardly changed over time (see Table 5). The only characteristic that differed significantly between the first and the second wave was average closeness, which increased slightly over the years. Betweenness also seemed to increase, and showed a relatively low correlation over time, but with the present sample size, the difference between the two waves was not significant. Other characteristics hardly changed. For example, the networks, which consisted of 45 network members, had gained on average only one or two Spanish network members, and had lost one fellow migrant and one Argentinean in Argentina.

Figure 2 illustrates the individual variations in the proportions of Spanish, fellow migrants, originals, and transnationals in the networks of the 25 Argentineans. As the figure shows, the individual variation in the proportions of the nationality and residence classes at $t1$ was quite large (see Figure 1 for the interpretation of the node positions). Some networks were mostly based on ties with originals (such as the network visualized in Row 1, Column 1), whereas others were mostly based on ties with Spanish people (such as the network in Row 2, Column 1) or fellow migrants. Also, Spanish alters and

fellow migrants were strongly connected in some networks, whereas they formed separate clusters in others. Figure 2 further shows that the changes of the networks from *t*1 to *t*2 showed much less variation. If we consider an increasing size of the host category and a decreasing size of the original category as evolution, and vice versa as involution, then we may conclude that some respondents had a clear trend toward evolution (e.g., the network in Row 3, Column 2) and others toward involution (e.g., the network in Row 1, Column 3), but on the whole, the changes between *t*1 and *t*2 were very small. This can be concluded both for respondents who had many Spaniards in their networks and for respondents who hardly knew Spanish people. Figure 3 illustrates that, when averaging the networks of the respondents, there were hardly any changes in the proportions of the nationality/residence classes (see also the paired *t*-test scores in Table 5) and only small changes in the intra- and inter-class relations between *t*1 and *t*2.

From a multivariate analysis, it appeared that individual characteristics (age, sex, employment status, marital status, length of residence, and change characteristics) could not explain the changes. To better understand why some persons increased in a compositional characteristic and others decreased (e.g., why some persons had on average more contact with their network members in the second than in the first wave and others less), we computed correlations between the differences in the compositional variables and the compositional variables at *t*1 (see Table 6). First, we observed a tendency of regression to the mean. That is, those who had high values at a compositional variable at *t*1 tended to decrease, whereas those who had low initial values tended to increase. Second, the changes that took place in composition appeared to be interrelated to some extent. More specifically, those who obtained a larger proportion of Spanish people in the network increased in the average frequency of contact, whereas those who obtained more Argentineans in Argentina in their networks

decreased in contact frequency. Also, higher proportions of family were associated with increasing density. Last, the networks that increased in betweenness also showed a higher frequency of contact over time.

7.3.5 Persistence of ties among alters across time (Type 5)

Last, we analyzed the factors that guided the change in ties among alters across time. Eighty-seven percent of the ties that were observed among the alters at $t1$ were durable, but this stability varied considerably among networks (from 50% to 100%). The model had a good convergence for the majority of the networks ($N = 21$); four networks did not converge. The estimation of the average rate of change in the meta-analysis was based on 14 networks, as 7 networks had standard errors larger than 5.

Table 7 summarizes the results of our multilevel SIENA analysis. With respect to the basic structural tendencies, we found a significant negative effect of degree, which reflects the low density of the networks. As expected, we observed a tendency toward transitivity, which was significant in all but two networks. So, alters who knew each other via multiple others were more likely to get a social relationship over time than alters who were only connected via ego. Second, we expected that the stronger the ties that two alters had with ego, the more likely it would be that those two alters had a social relationship. This was not the case. Only in five networks, a significant effect was found, which was positive in all cases. On the aggregate level, the effect was not significant. Third, we expected that alters who shared similar group memberships with ego (e.g., kin, colleagues, neighbors) would more likely have a social relationship. Indeed, similarity in group membership had a significant overall effect, caused by its significance in two-thirds of the networks. Last, we expected that the personal networks would be segregated along the country of residence and the country of origin. Indeed, this was the case, as the significant average effect of the variable *same residence and*

origin shows. The effect was significant in two-thirds of the networks, and positive in all but one network. The *Q* statistic of all effects was significant, which means that the effect size differed considerably among networks.

8. Discussion

In this article, we discussed various approaches to the longitudinal analysis of personal networks and applied them to the changing networks of 25 Argentinean immigrants in Spain. We argued that the changes in the personal networks of immigrants reflect their process of adaptation to and integration in the host society, and we expected to find a trend toward a larger integration, that is, of more Spanish contacts and less Argentineans in the networks, a higher frequency of contact and a larger interconnectedness among alters. We started with a qualitative investigation of the reasons that respondents gave for the observed changes. For the quantitative part, we proposed that a combination of analyses at three distinct levels (ego-alter dyads, alter-alter dyads, and networks) gives the most complete understanding of personal network dynamics.

In our qualitative study, it appeared that most respondents were easily able to explain the changes observed in their networks. Among the reasons that were given for the changes, measurement error was only a minor source. A few respondents indicated that the fixed number of nominations (45) explained why they had not mentioned certain members again, which implies that the stability of especially weaker ties may be underestimated in our study. Endogenous processes were the most important in explaining network dynamics, especially changes in job and residence. Along with this, transitivity ("befriending the friends of friends") and the life cycle (getting married, having children) were also influential. Given the importance that the respondents attached to visits to Argentina and to changes in jobs, place of residence, and marital

status, we decided to add four variables to the quantitative analyses indicating whether the respondents had experienced a change in each of these aspects in the last two years.

The quantitative analyses were performed at three different levels. At the *ego-alter level*, it appeared that on average, about half of the relationships that respondents had with their network members was persistent, but there was considerable variation in this stability among respondents. Nevertheless, the stability of ties could not be explained by ego characteristics, such as length of residence, age, gender, and marital status, and neither was it explained by the change variables that were added on the basis of the qualitative interviews. Relational characteristics appeared to be better predictors. First, stronger ties, as measured by ego's feelings of closeness to alter, their frequency of contact, and the centrality of alter in the personal network, were more persistent. This is a quite general finding (e.g., Wellman, Wong, Tindall, & Nazer, 1997), but it was interesting that for this immigrant population, these three indicators of tie strength were unequally distributed over the alter classes (and consequently, they were only moderately correlated): Respondents felt closest with alters in their country of origin, had most contact with Spaniards, and fellow migrants occupied the most central positions in their networks. A somewhat surprising finding was that at equal tie strength, relationships were more likely to disappear in denser networks. This was contrary to our expectations, as it has been suggested that structurally embedded relationships are maintained more easily (e.g., Burt, 2000). Given the correlation between density and average tie strength, our result may imply that stronger ties are more valued in networks of weak ties than in relatively strong networks. Apart from tie strength and density, it appeared that recent migrants tended to hang on more strongly to their Spanish alters in comparison to Argentineans, whereas the opposite was true for migrants who had a longer residence in Spain.

We also investigated whether new ties differed from dissolved ties in strength. Indeed, new alters at $t2$ were slightly closer and more frequently contacted than alters who were not nominated again at $t2$. Surprisingly, about half of the contacts who were new at $t2$ were in fact not unknown to the respondent on the earlier measurement. Many of these people were either family members or indirect tie partners who had become direct partners. The real new members were most frequently met via third persons, underlining the importance of transitivity in acquiring new contacts as indicated in the qualitative analyses, and at the workplace – especially Spanish contacts were obtained at work. So, although having or getting a job does not affect the stability of existing ties, it does stimulate the creation of new ties with members of the host society.

The persistent ties increased only very slightly in closeness but decreased in frequency of contact over time. The decreases in frequency of contact were more pronounced for Argentineans, yet less pronounced for family members and members who were more central in the network at $t1$.

At the level of *relationships among network members,* there was a considerable stability over time, although this varied again substantially among networks. The SIENA analyses indicated that the alters who knew multiple other network members in common, alters who belonged to the same groups (e.g. kin, neighbors, coworkers), and alters who belonged to the same country of origin and residence had a higher probability to become socially related over time. The importance of these variables indicates that new relationships among alters were primarily formed within already established clusters in the personal networks, and that they were rather homogeneous. It was less common that new relationships appeared between alters who previously belonged to different clusters, so it seems that the different segments in personal networks did not become more embedded over time. It is likely that similar results can

be found in non-immigrant samples, but so far, dynamic analyses have not been performed on the ties among network members in non-immigrant personal networks.

At the *network level*, the composition and structure of immigrants' networks hardly changed over time. For example, networks hardly gained more Spanish members over time, and they became only slightly stronger in terms of closeness. It is remarkable that a high turnover in ego's relationships can be associated with a considerable stability in overall composition and structure of the network. Apparently, although network members come and go, people tend to keep the same type of networks. Earlier research (Kalish & Robins, 2006) has demonstrated that personality affects the way in which people structure their social relationships by seeking network closure or structural holes, which could partially explain why personal network structures are rather stable in daily life even when the turnover in network members is high. However, research on the effects of life events and societal changes indicated that this presumed stability is disrupted by exogenous events, and migration is clearly such an event. Therefore, we expected a certain evolution in the networks, yet the network composition and structure of Argentinean migrants appeared to be quite stable over time. The individual variation in the amount of change could hardly be explained by individual characteristics, but this may be due to the small sample size at the ego level. For the present sample, we can therefore not confirm our model of network change for immigrants. Overall, the network dynamics that we observed seem to be comparable with those observed in non-immigrant samples. Several reasons may be responsible for this. As indicated before, all respondents were at least two years in Spain at the moment of the first interview, and Argentineans tend to integrate rapidly in the Spanish society. It is likely that their networks had already stabilized considerably. We might find more compositional and structural changes among more recent migrants and among collectives of immigrants

who face larger cultural differences, language problems, and allocation to the bottom jobs in a segmented labor market. We are currently investigating this in samples of Moroccans, Senegalese and Gambians, Bulgarians, and Dominicans. Furthermore, we did not investigate whether the respondents had intentions to remigrate. Six of the 34 persons whom we initially contacted for a second interview had already remigrated, and it is likely that a part of the 25 respondents included in this study also considered remigration on a shorter or longer term. Such intentions clearly affect one's efforts to integrate in the host society.

Empirically, our illustration of the dynamic analysis of personal networks has several limitations. First, our analyses were guided by the expectation that we would find an overall tendency toward larger integration, but we ignored individual variation in patterns of adaptation. Growing integration into the middle class of the host society is only one way of incorporating in the host society, others include moving into ethnic niches or in the host society's underclass (e.g., Portes & Zhou, 1993). Moreover, it is likely that some migrants have networks that are quite stable in composition and structure. Future research would benefit from including other indicators of immigrant adaptation, so that network dynamics can be related to specific patterns of adaptation. Moreover, other variables may be added in future research to refine the results. For example, as mentioned before, Kalish and Robin (2006) found that personality affects the way in which people structure their networks, so it is likely that personality moderates the successful integration in a host society. Consequently, it may be of interest to study whether personality affects the evolution of personal networks after migration. Furthermore, as indicated before, our sample was small at the level of egos and limited to one group of immigrants. In order to generalize the findings toward larger populations of immigrants, larger and more diverse samples are necessary.

The present paper served primarily as an illustration of the analysis of dynamic personal networks. The combination of qualitative and various quantitative methods enabled us to approach network dynamics from different angles and thus to increase our understanding of the changes. Qualitative research contributed to this study by exploring the interpretations that individual actors had about the changes observed in their networks. Qualitative research is especially valuable in areas in which relatively little research has been done, such as the emergence of new ties in personal networks. For the quantitative analyses, we combined multilevel and regression analyses and SIENA. The SIENA model, which had not been applied to personal network data before, converged smoothly on the majority of the networks and the results were largely in line with our expectations, which gives us confidence in the use of SIENA for personal networks. However, SIENA is specifically designed for sociocentric networks, and it does not address questions that are more typical for personal networks. First, SIENA enables researchers to study the co-evolution of networks and the behavior of its members. In the case of personal networks, a more interesting question would be how the network structure influences personal choices of *ego* and how ego's personal choices modify the structure. Such an analysis would require that two types of dyadic relationships (between egos and alters, and among alters) are related to outcomes at an analytically higher level (ego). Also, compositional changes (i.e., actors who leave or join the networks between observations) are regarded as exogenous in SIENA, and this assumption is to some extent reasonable at the level of alters, because it is ego who decides whether he or she nominates a certain alter or not. Nevertheless, the changing composition is of substantive interest for a dynamic personal network analysis, and it would be interesting to study how the network structure affects compositional changes, for example, whether new ties are added through existing ties, which ties generate new

contacts, and whether balance effects can be distinguished in ego's choices to end a relationship. Apart from a different method of analysis, this requires a different empirical design, in which personal networks, collected with snowball sampling, are combined into one personal community.

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Table 1. Classification of sources of change and direction of change in the qualitative analysis.

Source of change	Direction of change		
	Involution	Stability	Evolution
Measurement error	*	*	*
Inherent instability	**		
Endogenous change	**	**	***
Exogenous change			*

*= small impact or few cases, ** = medium impact, *** = high impact.

Table 2. Regression coefficients and standard errors (between brackets) of the binary multilevel regression model predicting persistence of ties ($N = 1,125$).

Group of predictors	Predictors	Persistence of ties		
		Model 1	Model 2	Model 3
	Constant	-.492 (.586)	-3.591 (.592)	-3.256 (.520)
Characteristics ego or network t1	Age	0.005 (0.016)		
	Sex	-0.184 (0.316)		
	Employed	0.041 (0.342)		
	Married	-0.299 (0.328)		
	Length of residence	0.009 (0.091)		0.192 (0.109)
	Network density	2.767 (1.337)*		-3.251 (1.380)*
Change characteristics of ego t1-t2	Recent visits to Argentina	0.263 (0.340)		
	Marital status changed	-0.028 (0.311)		
	Job situation changed	-0.354 (0.303)		
	Place of residence changed	-0.125 (0.378)		
Characteristics alter or dyad t1	Frequency of contact		0.321 (0.050)*	0.323 (0.048)*
	Closeness		0.508 (0.075)*	0.508 (0.073)*
	Time alter and ego know each other		-0.025 (0.072)	
	Alter is a family member		0.420 (0.217)	
	Alter is Spanish		0.874 (0.555)	0.915 (0.513)
	Alter is a fellow migrant		-0.562 (0.245)*	-0.626 (0.227)*
	Alter is transnational		-0.487 (0.263)	-0.498 (0.235)*
Structural position alter t1	Degree centrality		0.051 (0.015)*	0.073 (0.014)*
Interaction	Length of residence × alter is Spanish		-0.348 (0.125)*	-0.365 (0.122)*
	Variance at level 2	0.161 (0.071)	0.379 (0.140)	0.306 (0.119)

* $p < .05$

Table 3. Differences between dissolved ($N = 542$) and new ties ($N = 542$) in tie strength.

Variable	Dissolved ties		New ties		t	df	p
	M	SD	M	SD			
Frequency of contact	3.53	1.88	3.89	1.90	3.15	1,082	.002
Closeness	2.90	1.08	3.23	1.11	4.97	1,082	$< .001$
Time alter and ego know each other	3.30	1.68	2.96	1.82	3.19	1,082	$< .001$

Table 4. Regression coefficients and standard errors (between brackets) of the multilevel regression models predicting changes in closeness and frequency of contact in stable ties at *t2* (*N* = 583).

Group of predictors	Predictors	Closeness	Frequency of contact
		Final model	Final model
	Constant	1.815 (0.145)	0.832 (.181)
	Time 1 covariate	0.531 (0.033)*	0.516 (.037)*
Change characteristics ego t1-t2	Place of residence changed		-0.537(0.193)*
Dyadic and alter characteristics t1	Alter is a family member	0.309 (.074)*	0.451 (.130)*
	Alter is Spanish		0.888 (.157)*
	Alter is a fellow migrant		0.986 (.158)*
	Alter is transnational		0.473 (.088)*
Structural position alter t1	Degree centrality		0.034 (.008)*

* $p < .01$

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Table 5. Means and standard deviations of the compositional and structural variables of the personal networks at *t*1 and *t*2, correlations between the two waves, and *t*-test scores of paired differences between the two waves ($N = 25$).

Variable	Time 1		Time 2		*r*	*t*
	M	*SD*	*M*	*SD*		
N Spanish alters	13.60	7.33	15.20	8.34	.75*	-1.41
N fellow migrant alters	9.28	5.38	8.28	3.77	.63*	1.19
N alters in country of origin	15.44	8.63	14.80	6.81	.58*	0.44
N transnational alters	6.68	3.87	6.72	4.91	.60*	-0.05
Average closeness	3.34	0.50	3.57	0.49	.39	-2.07*
Average frequency of contact	4.11	0.73	4.00	0.72	.56*	-0.83
Proportion of family	0.23	0.13	0.24	0.09	.62*	-0.66
Density	0.20	0.11	0.22	0.08	.51*	-0.73
Betweenness centralization	24.28	12.40	29.12	12.07	.26	-1.62

* $p < .05$

Table 6. Standard deviations of the changes in composition and zero-order correlations between those changes and the same compositional variable at $t1$ and among the changes in composition ($N = 25$)

Differences between $t1$ and $t2$	Standard deviation	Correlation with $t1$ variable	Correlations among differences							
			1	2	3	4	5	6	7	8
1. Dif. N Spanish alters	5.66	-.20								
2. Dif. N fellow migrant alters	4.20	-.72*	-.17							
3. Dif. N alters in country of origin	7.25	-.64*	-.60*	-.47*						
4. Dif. N transnational alters	4.03	-.23	-.14	-.04	-.47*					
5. Dif. average closeness	0.50	-.23	.16	-.03	-.03	-.14				
6. Dif. average frequency of contact	0.80	-.50*	.49*	.11	-.57*	.22	-.07			
7. Dif. proportion of family	0.10	-.70*	.19	-.16	.21	-.46*	-.10	.11		
8. Dif. density	0.10	-.71*	.10	-.06	.05	-.15	.12	.22	.37*	
9. Dif. betweenness centralization	14.94	-.62*	.36	-.26	-.13	.01	.17	.40*	.33	.17

* $p < .05$

Table 7. Multilevel SIENA results ($N_{networks} = 21$; $N_{alters} = 1,708$)

Parameter	$\hat{\mu}_{WLS}$	(*s.e.*)	t	$\hat{\sigma}$	Q
Rate	9.617	(1.705)	5.64*	6.088	156.84*
Degree	-4.211	(0.627)	6.72*	2.244	152.91*
Transitivity	0.736	(0.156)	4.72*	0.545	506.72*
Closeness alter 1× alter 2	0.074	(0.055)	1.35	0.145	47.23*
Same group membership	1.952	(0.302)	6.46*	0.250	50.84*
Same country of origin/residence	1.217	(0.374)	3.25*	0.438	117.08*

NOTE. $\hat{\mu}_{WLS}$ = estimated average effect size, (*s.e.*) = standard error associated to estimated average effect size; t = statistic for testing whether the average effect size is zero, which has approximately a standard normal distribution; $\hat{\sigma}$ = estimated true standard deviation of the effect size between networks; Q = statistic for testing whether the variance of the effect is zero, which has a χ^2 distribution and $N - 1$ degrees of freedom; * $p < .05$.

Figure captions

Figure 1. The positions of the four node classes in a clustered graph visualization.

Figure 2. Visualizations of the clustered graphs for each of the 25 respondents at $t1$ (right-hand) and $t2$ (left-hand).

Figure 3. Visualization of the average network structure of the 25 respondents and the variation among them, at $t1$ (right-hand) and $t2$ (left-hand).