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Article

Analysing Personal Networks in Geographical Space Beyond the Question of Distance

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Abstract
Recent literature recognises the importance of situating social networks in spatial context. Yet, the spatial analysis of personal networks has often been limited to examining residential distances between actors. While distance is a central characteristic of social relationships, it is a poor indicator for understanding the intricacies of the geographical space, places and personal networks. This study develops an original approach for mapping and analysing personal networks based on their geographical scope and the distribution of the residential locations of network members in relevant geographical areas. We perform a factor and cluster analysis to identify the major geographical patterns of personal networks using two samples of egocentric networks from France and Switzerland. We validate the approach first by interpreting the patterns both quantitatively and qualitatively, and second by examining how these patterns relate to important social characteristics of respondents and their personal networks. We conclude by discussing the significance of this approach for integrating geographical information into the analysis of personal networks and for rethinking networks and the geographical space as co-constituted.

Keywords
distance; geographical space; mixed methods; personal networks; place; social network analysis

Issue
This article is part of the issue "On the Role of Space, Place, and Social Networks in Social Participation" edited by Gil Viry (University of Edinburgh), Christoph van Dülmen (Thünen Institute of Rural Studies), Marion Maisonobe (CNRS), and Andreas Klärner (Thünen Institute of Rural Studies).

1. Introduction

Social relationships and networks develop in and across the geographical space. The network literature has shown that migrants, families, scientists, friends, etc., can develop their personal relationships and networks over large distances while places and spatial proximity continue to strongly structure personal networks, even in the age of the Internet (Mok et al., 2010; Small & Adler, 2019; Spiro et al., 2016). Yet, social network research has not fully taken up issues of space and place. The role of space in extending and sustaining personal networks has often been examined through the lens of physical distance—usually as something "from the outside" to overcome—rather than as an inherent characteristic of relationships (e.g., cross-border or long-distance relationships), networks (e.g., transnational families, mobile friendship groups), and spatial environments (e.g., metropolitan areas). In turn, urban and mobility studies have often focused on specific places of interest (e.g., poor neighbourhoods) or populations (e.g., international migrants, kinetic elite), and have largely ignored the intermediate level of personal networks when examining the impact of spatial or mobility-related aspects on

individual behaviours and outcomes. A recent network literature has analysed migrants' transnational networks (Herz, 2015; Lubbers et al., 2021; Vacca et al., 2018), the links between spatial mobility behaviours, and network spatial dispersion (Puura et al., 2022; Viry, 2012), or the influence of urban contexts and physical space on personal networks (Huszti et al., 2021; Tulin et al., 2019; Vanhoutte & Hooghe, 2012). However, approaches for analysing personal networks within geographical space beyond the notion of distance and Euclidean space need further development.

Our starting hypothesis is that personal networks that spread across multiple places are different from networks clustered in one or two places at equivalent distances (Barrat et al., 2013). Networks in multiple places often bear the traces of people and groups' mobility experiences (relocations, study and work periods, holidays), and resilience to physical separation. Individuals have therefore a particular history of their social relationships and networks that is intimately intertwined with the link these relationships have to places and spatial mobility (for a relational approach to space see, e.g., Massey, 2005). While individuals do not necessarily develop a bodily and sensory experience of the places where their network members live (e.g., by visiting them), being connected to various places through network members reflects adaptation skills and is likely to increase awareness of and access to these places and their social, cultural, economic, etc., specificities. This spatial diversity may therefore contribute to expanding people's horizons and social world, which may also be turned into opportunities and resources over the life course. In Granovetter's (1973) terms, these resources can be derived from both weak and strong ties. By their location in different places, people can act as bridges to novel resources and information, but can also be long-standing, emotionally close relationships (e.g., relatives, old school friends) that are less dependent on physical proximity and frequent in-person contact to be sustained (Rutten et al., 2010).

A better understanding of the geography of personal networks is an important issue for social inclusion in a globalising world. Maintaining social relationships in different places is valuable, but often requires substantial resources of time, effort, access, emotion, and planning that are unevenly distributed across regions and social groups, and therefore an important source of social inequality (Urry, 2012). It is also critical for research on social inclusion to examine how network and geographical contexts relate to each other and other risk factors of social exclusion (e.g., lack of mobility, discrimination, area- and individual-level deprivation).

By combining the disciplines of sociology and human geography, this study aims to develop a novel approach that accounts for the complexity inherent in the geographical patterns of personal networks and that can be replicated in diverse settings. As such, this framework can be used to set a new research agenda in spatial sociology and social geography. Our research question is: How to approach the geography of personal networks beyond the residential distance between network members? We argue for an approach that considers the distribution of the residential locations of network members in functional spatial units, mainly employment areas. We also argue that this approach can be applied to a wide variety of personal network data using basic geographical information. In this study, we apply our approach to two different datasets from France and Switzerland. We identify the main geographical patterns of personal networks and interpret them using both qualitative and quantitative network analysis. We further validate the approach by examining how these patterns relate to important social characteristics of the individuals and networks. In using two different datasets, our intention is not to compare the geography of networks across both settings; rather we aim to demonstrate that our approach can be applied to diverse types of networks and different spatial contexts.

Instead of measuring the spatial dispersion of personal networks based on residential distances (e.g., great circle distance, confidence ellipse; see, e.g., Frei & Axhausen, 2007), we examine the personal networks of respondents (named *ego*) based on their geographical scope and the distribution of the residential locations of network members (named *alters*). To capture the diversity of distribution patterns, we develop a classification of personal networks in geographical space, using the employment areas of a country as the main geographical unit. The employment areas are defined as areas where most of the workforce both lives and works. Their delimitation is statistically based on commuting flows and not on administrative divisions (e.g., French departments, Swiss cantons). For example, the employment area of Zurich—the largest city and a major economic hub of Switzerland—extends far beyond the canton of Zurich by including large parts of several other cantons, in which the majority of the employed population works in the Zurich area. This functional unit is sociologically relevant because most activities of daily living (e.g., visiting, commuting, consuming) occur within their boundaries. We use network indices to examine both the extent to which alters live in the same area as ego, and the extent to which their residential locations are clustered into the same area or, conversely, scattered across different areas. We approach the geographical scope of personal networks, by considering the national regions, countries, and continents in which the areas are distributed. By geographical space, we refer to the complex and social system formed by places, networks, and flows between these places (for a definition see Gadal, 2012, p. 30). This conceptualisation goes beyond a definition of space as only a physical and neutral phenomenon (Euclidean space).

In the following sections, we review the relevant literature on the geography of personal networks and the links between their social and spatial dimensions.

We then present our approach, including how the classifications of personal networks are performed. Using the most typical networks of each class as examples, we enter the individuals' socio-spatial histories to better understand the classes identified. We conclude the analytical part by showing how these classes relate to some key social characteristics of the egos and personal networks. The final discussion centres on the relevance and replicability of this approach for further exploring the intricacies of space, places, and personal networks.

2. Space and Personal Networks

Social network analysis (SNA) has an ambivalent relationship with space. In its early days, SNA focused on restricted and relatively closed spaces, such as reform and residential schools for the social psychologist Moreno (1934), or an island for the anthropologist Barnes (1954). Early examples also include the work of Festinger and colleagues showing that small differences in the spatial environment (e.g., configuration of the housing unit) influenced friendship formation (Festinger et al., 1950). The Chicago School rooted sociology in urban contexts, from which it later sought to "abstract" networks (Hannerz, 1980, p. 219). The Manchester School of Anthropology was also interested in how place experiences relate to personal networks, in particular when migration generates "contradictions" between the multiple social structures individuals belong to. A classic example is the study by Mayer (1962) on rural migrants in Southern African towns.

In sociology, the important development of SNA in the 1990s focused attention on formal or structural explanations, which contributed to detach networks from their social, cultural, and geographical contexts, and therefore also from the subjective meanings actors attach to places or culture (Eve, 2002). The notion of networks was used as an alternative to the notions of territory or community. However, some studies such as those by Wellman (1979) or Fischer (1982) were more concerned with examining how personal networks vary in different geographical settings (e.g., neighbourhoods, urban/rural areas).

This development contributed to maintaining a gap between mainstream SNA that is largely placeless and the spatial analysis of networks in geography and cognate fields, such as economic geography, transport and communication research. A number of transport studies have incorporated personal networks into the analysis of travel behaviours and destination choice (for a review see Kim et al., 2018). Strongly related to research in physics, recent literature on the spatial dimension of complex networks has also emerged in geography, but this research remains fragmented (Andris, 2016; Ducruet & Beauguitte, 2014). Personal relationships are also considered in the literature on neighbourhood effects (Hägerstrand, 1970; Tulin et al., 2019; Vallée et al., 2015). These studies share common objectives with network scholars in sociology in analysing and mapping everyday activity spaces.

The importance of space in personal network research has also largely been studied through the lens of cross-border migration and its effect on network composition, often in terms of the countries of origin and destination, but also in relation to the ethnic diversity of the residential place (Huszti et al., 2021; Vanhoutte & Hooghe, 2012). The research questions often revolve around whether distance matters in the formation, duration, and quality of migrants' relationships and how migration affects personal networks.

Despite repeated argument that mobile and internet-based technologies will reduce the "friction" of distance, evidence still shows that spatial proximity and place sharing facilitate social interactions and that social networks remain strongly shaped by linguistic, institutional and national borders (Mok et al., 2010; Spiro et al., 2016; Wang et al., 2015). But the literature on transnational networks also shows that people can maintain strong relationships and sustain a sense of being emotionally close with others living far away, especially parents, adult children, and close friends (Herz, 2015; Lubbers et al., 2021; Vacca et al., 2018). Some evidence suggests that transitive relationships (e.g., a friend of a friend) survive greater distances (Viry, 2012). The rare longitudinal personal network studies show a high turnover in relationships over time and after migration, but the overall composition, size, and structure of networks are remarkably stable (Lubbers et al., 2021; Mollenhorst et al., 2014). Physical distance also does not affect everyone equally, with evidence that high-status individuals show more spatial dispersion in their networks. Finally, personal networks with many network members living in a different place than ego tend to be structured around clusters of long-distance relationships concentrated in a few places rather than being composed of many far-flung network members living in different places (Frei & Axhausen, 2007).

While this literature has demonstrated the significance of spatial proximity and spatial mobility for personal networks, it is often influenced by a traditional notion of space as fixed and containing networks, whose "impact" on networks is limited to a Euclidean distance between network members. In geographical and sociological debates, a process has started by which SNA must better incorporate spatial context and rethink the places where people turn to others beyond propinquity (Blokland et al., 2021). The geographical space affects the opportunities for social actors to develop and maintain specific network patterns through other mechanisms than distance (Farber & Li, 2013; Small & Adler, 2019; Tóth et al., 2021). In turn, individuals are producing networked spaces by interlacing places through their personal relationships. Personal networks bear the traces of the successive places, groups, and contexts through which individuals navigate and in which they have woven ties that remain active today. Whether the

groups remain as network clusters or only isolated individuals remain, the network structure (size, density, clustering, etc.) reveals the history of the contexts, places and activities that ego shares with others (Bidart et al., 2020). Some family and friends move, other people are met far from home (e.g., holiday or work travel), and new residential places appear in the network. Egos may not have visited some of these places but are connected to them through their personal relationships and realise that these places are within their reach. The geography of personal networks can therefore be examined in relation to the members' places of residence, the relationship ego has with these places (e.g., current or former places of residence, places of visit), and the flows between these places.

3. Data and Methods

We used two different egocentric network datasets to illustrate our approach to the geography of personal networks. The first one is the Caen Panel, a qualitative follow-up study based on social activity-focused name generators capturing large networks (mean size of 37 alters) of 87 young people who were aged 17–23 and lived in the city of Caen (Normandy, France) at the time of the first interview. Participants were interviewed five times between 1995 and 2015 (all waves are pooled here). In a wide range of life contexts (school, family, friends, neighbourhood, work, leisure, and voluntary activities), young people were asked to name "people whom they know a little better, with whom they talk a little bit more" (see https://panelcaen.hypotheses.org/methodologie#english). The second dataset comes from the nationally representative 2013 MOSAiCH survey including the family networks of 670 adults (18+) living in Switzerland. Personal networks were based on a unique name generator asking respondents to self-define their meaningful family members (mean size of 6.25 alters; see https://forscenter.ch/projects/mosaich).

A critical issue for studying the geography of personal networks is to determine the relevant geographical areas. Using a micro-geographical scale, such as GPS coordinates, streets, or blocks, has proved to be a useful method in neighbourhood research, architecture, and urban planning for investigating how spaces are routinely used for diverse activities (see, e.g., Andersson & Musterd, 2010). It is however deemed too fine-scaled for determining the residential patterns of alters because people with whom ego has developed long-term and cross-context personal relationships often live beyond the borders of ego's neighbourhood. Using large national regions (typically NUTS 2 areas in the Eurostat classification, such as national provinces) would, conversely, be too coarse for capturing differences in the residential contexts of alters within these areas.

We considered the employment areas of a country as an appropriate geographical unit in which most residents live and work. Contrary to agglomerations, these functional areas are not necessarily associated with large urban centres and their surface significantly varies depending on the density of population. This statistically-defined unit also has the advantage of facilitating comparisons, while administrative divisions (e.g., municipalities, counties) are extremely heterogeneous in their delineation and their definition varies across regions and countries. Finally, employment areas (and associated statistics) are available in many developed countries. Our approach thus offers a straightforward way of characterising the geographical patterns of personal networks across one or several usual places. In Switzerland, we used the 16 large employment areas based on commuting flows of the employed population in 2014 (https://www.bfs.admin.ch/hub/api/dam/assets/8948839/master). In France, we used the 2010 delineations of 322 labour market areas (*zones d'emploi*) based here again on commuting flows of the employed population using the 2006 census (https://www.insee.fr/fr/information/2571258). Because only the country information was available for alters living abroad in the MOSAiCH sample, we used the country of residence as the area for these alters in both datasets.

To characterise the geography of personal networks, we used seven network indices:

1. Number of alters cited (network size): While large networks are more likely to be dispersed across many areas than small networks, it is important for our purpose to distinguish small networks with high dispersion and large locally-based networks.
2. Number of areas: The number of different employment areas where alters live is a key element to measure the geographical dispersion of personal networks.
3. Index of qualitative variation (IQV) of areas: The IQV index measures the extent to which alters are evenly distributed in areas, regardless of the number of alters and number of areas (Agresti & Agresti, 1978; Crossley et al., 2015). Suppose we have r different areas and P_i is the proportion of alters living in area i, then the IQV index is defined as:

$$\text{IQV} = \frac{1 - P_1^2 - P_2^2 - P_3^2 - \cdots - P_r^2}{1 - \frac{1}{r}}$$

   The index ranges between 0 and 1, with 0 meaning that all alters live in a single area and 1 meaning that the residences are evenly distributed in the different areas. We applied a log transformation $\log(1 + x)/\log(2)$ that keeps the index between 0 and 1 but weighs up small (non-null) scores. This indicator is useful to analyse whether egos have multiple geographical poles of importance in their networks or, conversely, most of their alters clustered in the same residential area.
4. Ego-alter geographical similarity using EI index: This ego-alter similarity index measures the extent

to which alters live in the same area as ego (Krackhardt & Stern, 1988). If E stands for the number of alters living in different areas than ego's and I stands for the number of alters living in the same area as ego, then the EI index is:

$$EI = \frac{E - I}{E + I}$$

The index ranges between −1 and 1, with −1 (perfect similarity) meaning that all the alters live in the same area as ego and 1 (perfect heterogeneity) meaning that all the alters live in different areas than ego's.

The three infographics in Figure 1 illustrate extreme cases of IQV and EI indices.

The last three indices measure the geographical scope of the network:

5. The proportion of alters living in a different region than ego within the same country (national scope). We used the 18 administrative regions for France and the three linguistic regions for Switzerland. The use of this meso-geographical level is to determine whether alters live in the same country as ego but in a region with a different language for multilingual Switzerland and different administrative and transport structures (e.g., the regional train system TER) for France. Similar national divisions could be used for other countries (e.g., states in the USA or NUTS 2 areas in the Eurostat classification).
6. The proportion of alters living in a different country in Europe (European scope). We used the United Nations geoscheme to define the European continent. However, the MOSAiCH sample includes some alters living in ex-Soviet countries of Europe (e.g., Russia, Moldova, Ukraine) and because transportation costs are relatively high between Switzerland and these countries, we decided to classify them in the "World" category.
7. The proportion of alters living outside Europe (world scope).

The proportion of alters living in the same region within the same country as ego can be deduced from these three proportions and is therefore not included here.

4. Classifications of Personal Networks Based on Their Geography

Table 1 reports some descriptive statistics of the seven indices for both datasets. A majority of alters live in the same employment area as ego, with a negative mean

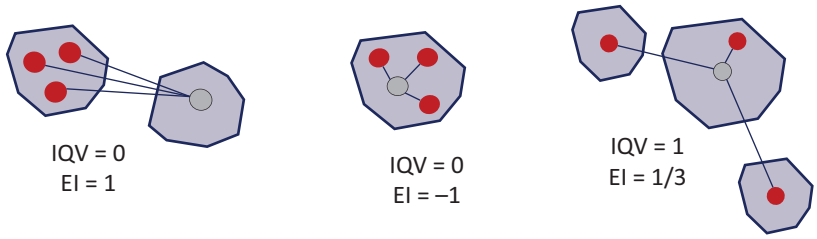


Figure 1. Examples of extreme cases for IQV and EI indices.

Table 1. Descriptive statistics of the indices.

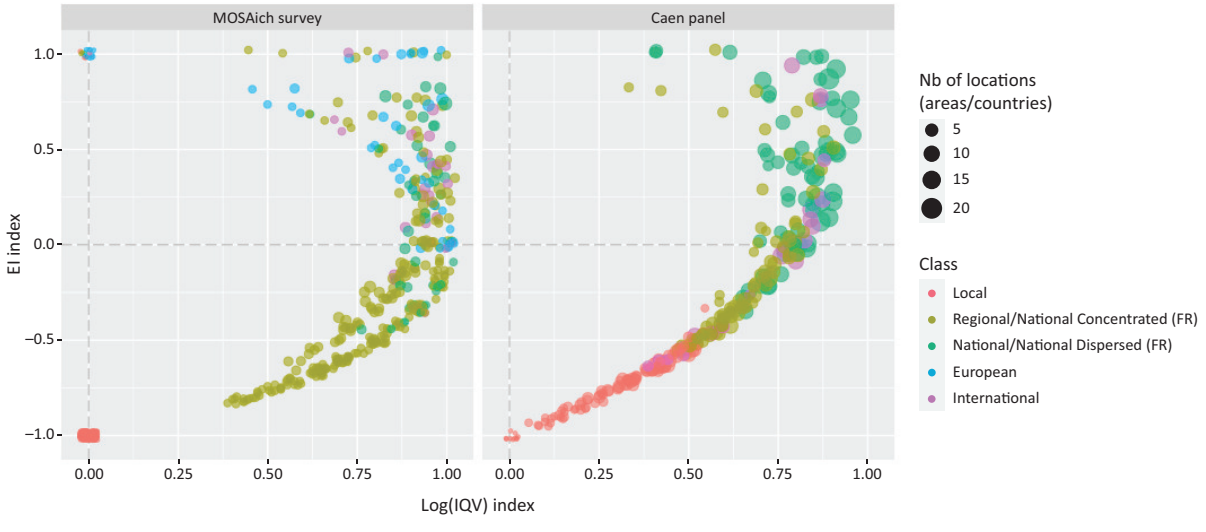
	Mean	SD	Median	Min	Max
MOSAiCH (N = 670)					
Size	6.25	2.95	6	1	11
#Areas	1.89	1.03	2	1	7
IQV	0.45	0.42	0.58	0	1
EI	−0.45	0.63	−0.67	−1	1
% Different region	0.04	0.13	0	0	1
% Different country—Europe	0.09	0.20	0	0	1
% Different country—World	0.03	0.11	0	0	1
CAEN PANEL (N = 281)					
Size	38.08	18.03	36	6	131
#Areas	6.84	4.08	6	1	23
IQV	0.56	0.25	0.58	0	0.94
EI	−0.23	0.55	−0.36	−1	1
% Different region	0.23	0.22	0.15	0	1
% Different country—Europe	0.01	0.03	0	0	0.19
% Different country—World	0.004	0.01	0	0	0.09

EI index. When considering the geographical scope of the personal networks, 84% of alters in the MOSAiCH sample live in the same linguistic region of Switzerland as ego. Among the remaining 16 %, a majority live abroad. In the Caen Panel, personal networks are more national in scope, with 23% of alters living in a different region in France (note that egos who moved abroad were excluded from the sample in this study). This last difference between the two datasets highlights the important influence of sharing the same language on sociability.

Figure 2 shows how the IQV and EI scores relate to each other for each dataset. Each point represents a network and its size is set according to the number of areas (colours represent the classes described below). In both datasets, the networks dispersed across many areas are logically associated with high IQV and EI scores. We find a positive relationship between IQV and EI indices for negative EI values (lower half of the plot). This means that when many alters live in the same area as ego, an additional alter living outside ego's area tends to increase the dispersion. When many alters live outside ego's area (positive EI scores, upper half of the plot), an additional alter living outside ego's area does not significantly change the IQV score for large networks (the IQV score is already close to 1) and tends to be associated with lower IQV scores for small networks. The latter corresponds to situations where the few alters named are clustered in a few areas (sometimes only one for MOSAiCH) that are not the area where ego lives.

Using the library FactoMineR in R (Lê et al., 2008; R Core Team, 2022), we ran a principal component analysis (PCA) using the seven indices presented above. We then performed a hierarchical ascendant cluster analysis using the factor scores to group networks into classes representing typical geographical patterns. We chose a 5-class solution for MOSAiCH and a 4-class solution for the Caen Panel based on inertia gains (the solutions also suggested by FactoMineR).

Tables 2 and 3 summarise the classes for each dataset based on the mean scores of the seven indices used. In MOSAiCH, the first "Small-Local" class represents almost half of the sample. These individuals have a small family network, in which all alters live in the same area as ego. In Class 2, the second-largest class, individuals have larger family networks. A majority of alters live in the same area as ego, although a substantial share does not (EI = −0.27). On average, they live in 2.48 areas, across which they are relatively equally dispersed (IQV = 0.77). Most alters live in the same linguistic region of Switzerland as ego, so we named this class the "Regional" class. Class 3 is a smaller class with networks that are "National" in scope with about half of the alters living in a different linguistic region of Switzerland. Alters are evenly distributed in areas (three on average) with a mean IQV score of 0.90. The "European" Class 4 corresponds to personal networks with an average proportion of 70% of alters living in another European country. Many alters do not live in the same area as ego (EI = 0.60)—a typical network pattern of recent immigrants who have maintained many relationships with relatives in the country of origin. Finally, the fifth class, named "International," is composed of networks with about half of the alters who live beyond Europe. These networks are the largest, most dispersed personal networks, with an average number of 3.07 areas. The average distribution of alters in areas is almost as high as in Class 3 of national networks (IQV = 0.89). Although smaller than in the previous group, a relatively large proportion of these alters do not live in the same area as ego.



Relationship between the IQV scores and EI scores for MOSAiCH and Caen datasets

Figure 2. EI scores by IQV scores for the MOSAiCH survey and the Caen Panel. Note: Because many points overlapped each other for the small networks of the MOSAiCH sample, we added a small amount of random noise to each point to better identify where the mass of the data is.

Table 2. Description of groups by the indices (MOSAiCH, N = 670).

	1 Small-Local	2 Regional	3 National	4 European	5 International
N	287	259	46	48	30
% Sample	43	39	7	7	4
Size (mean)	4.80	7.54	6.72	6.48	7.87
#Areas (mean)	1	2.48	3.02	2.21	3.07
IQV (mean)	0	0.77	0.90	0.69	0.89
EI (mean)	−0.98	−0.27	0.19	0.60	0.30
% Another region (mean)	0	0.02	0.46	0.01	0.01
% Europe (mean)	0	0.08	0.03	0.70	0.10
% World (mean)	0	0.01	0.01	0.01	0.46

In the Caen Panel, we chose a classification in four classes. The individuals of the first "Local" class have a middle-sized personal network where most alters live in the same area as ego (EI = −0.74). In the second "National-Concentrated" class, alters live in 6.27 areas, on average, mostly in the same region as ego, although 24% live in a different region of France. The distribution of alters' residential locations in these areas is average compared with the other classes and the mean network size is the lowest of the sample. The third "National-Dispersed'' class is characterised by networks that have about half of the alters living in a different region of France, on average. The network size is the highest of all classes. Alters' residences are evenly dispersed in many areas (11.60 areas, IQV = 0.79), with an important proportion of alters who live in a different area than ego (EI = 0.37). The fourth "International" class corresponds to networks with an average proportion of alters not living in France of 9%. The number of areas and distribution of alters in these areas is slightly more important than in Class 2 but lower than in Class 3. There is also an equal proportion of alters living and not living in the same area as ego (EI = −0.07).

5. Paragons as Illustrative Cases of the Classes

To give some flesh to the geographical patterns identified in the previous section and better understand their specificities, we now illustrate these classes by investigating the paragon of each class. Paragons are the individuals closest to the gravity centre (or centroid) of their class (the most "typical" case). In other words, they are the best representatives of their class in terms of their scores on the seven indices examined. The network diagrams and geographical mappings of these paragons are presented in Figures 3 and 4 for each dataset. Edges on network diagrams represent emotional support relationships for MOSAiCH (directed ties) and knowledge ties for the Caen Panel (undirected ties). Geographical locations of alters' residence (in relation to ego's) are represented by colours.

The paragon of the first "Small-Local" class in MOSAiCH is Sylvia, 34, a single woman who lives alone in Luzern (central Switzerland) where she is employed as a production planner in the electronics industry. In her family network, Sylvia named her two parents, her uncle and aunt, who all live in the suburbs of Luzern where she also grew up, and her younger sister who lives in a village in the canton, about 20 km away. The paragon of the second "Regional" class is Christian, 53, who lives with his partner and her two children from a previous marriage in a small town in the canton of Aargau (northern Switzerland). Christian also named his brother, his brother's wife, their child and Christian's goddaughter, who all live in a village in the Swiss Eastern Alps, about one and a half hours away by car. Christian grew up in a village close to the lake of Constance (north-eastern Switzerland) and works in Zurich city, 45 min drive from home, as an investigating officer. The paragon of the third "National" class is Daniela, 44, who lives alone

Table 3. Description of groups by the indices (Caen Panel, N = 281).

	1 Local	2 National Concentrated	3 National Dispersed	4 International
N	106	85	68	22
% Sample	38	30	24	8
Size (mean)	34	30	54	38
#Areas (mean)	3.77	6.27	11.60	9.09
IQV (mean)	0.29	0.65	0.79	0.68
EI (mean)	−0.74	−0.11	0.37	−0.07
% Another region (mean)	0.07	0.24	0.48	0.20
% Europe (mean)	0.003	0.006	0.018	0.041
% World (mean)	0.0004	0.0007	0.003	0.05

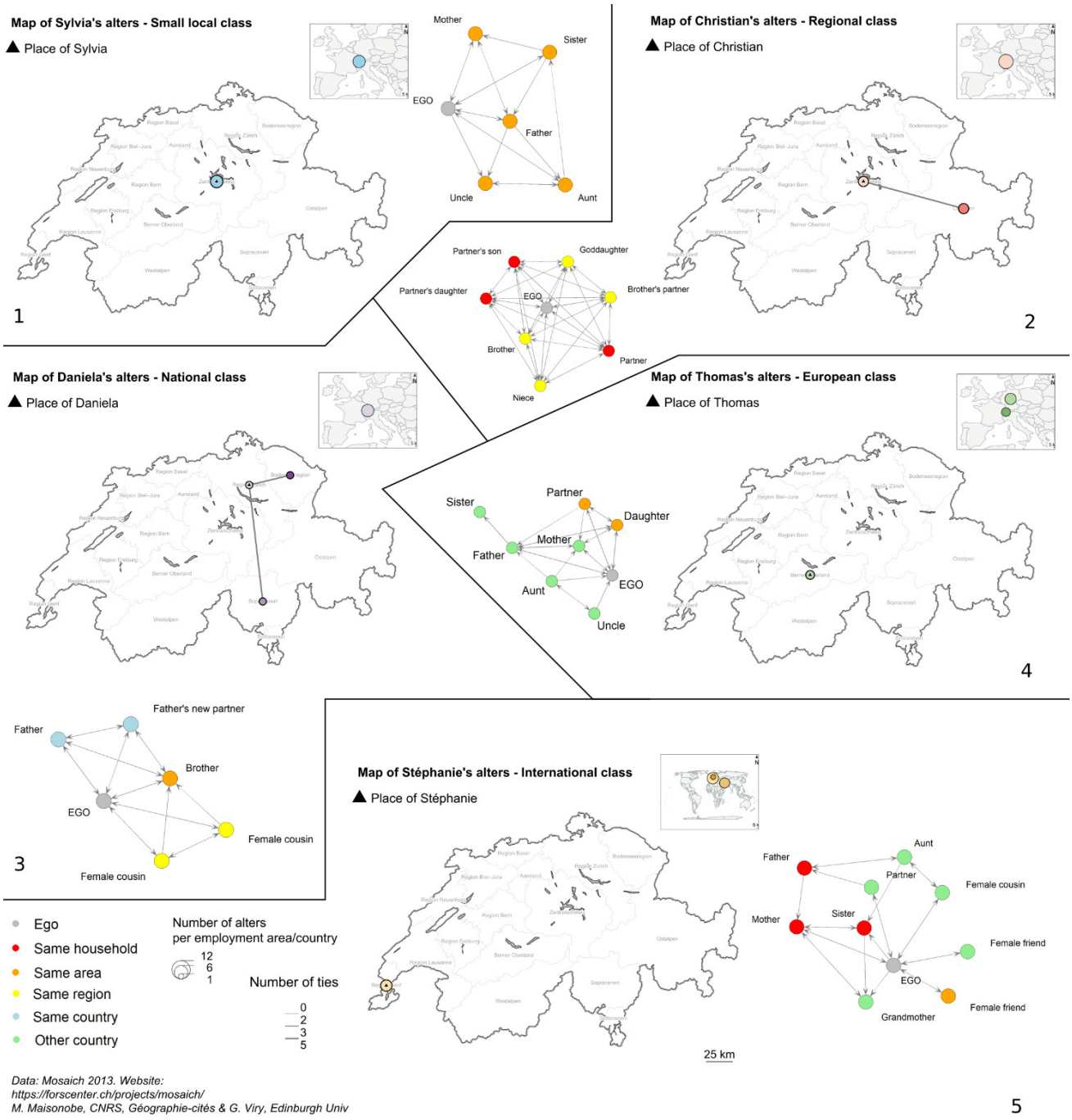


Figure 3. Network diagrams and geographical mappings of the paragons of the MOSAiCH classes.

in the region of Zurich, in a village, 20 minutes drive from the city. She works in the outskirts of the city as a safety inspector. In her family network, she named her older brother who lives in a nearby locality in the suburbs of Zurich where Daniela grew up. She also named two female cousins who live in the lake of Constance region, as well as her father and his partner who live in the Italian-speaking region of southern Switzerland, close to Locarno, about a three-hour drive from Daniela's home. The paragon of the fourth "European" class is Thomas, 37, who was born in Germany and lives in the Bernese Alps. He is an IT consultant for a company based in Zurich. Thomas lives alone but has a partner and a daughter who live in the same area. Thomas also named his two parents, an uncle, aunt and sister who all live in Germany. Finally, the paragon of the fifth "International" class is Stephanie, 22, who lives with her parents and her younger sister in the suburbs of Geneva, close to where she grew up. Stephanie has a university degree and has never been employed. Her father was born in Iran and her mother in Germany. In addition to her household members, Stephanie named her partner, an aunt, a female cousin, and a female friend (considered a family member) who all live in Iran, another female friend who lives near her home and her mother's mother who lives in Germany.

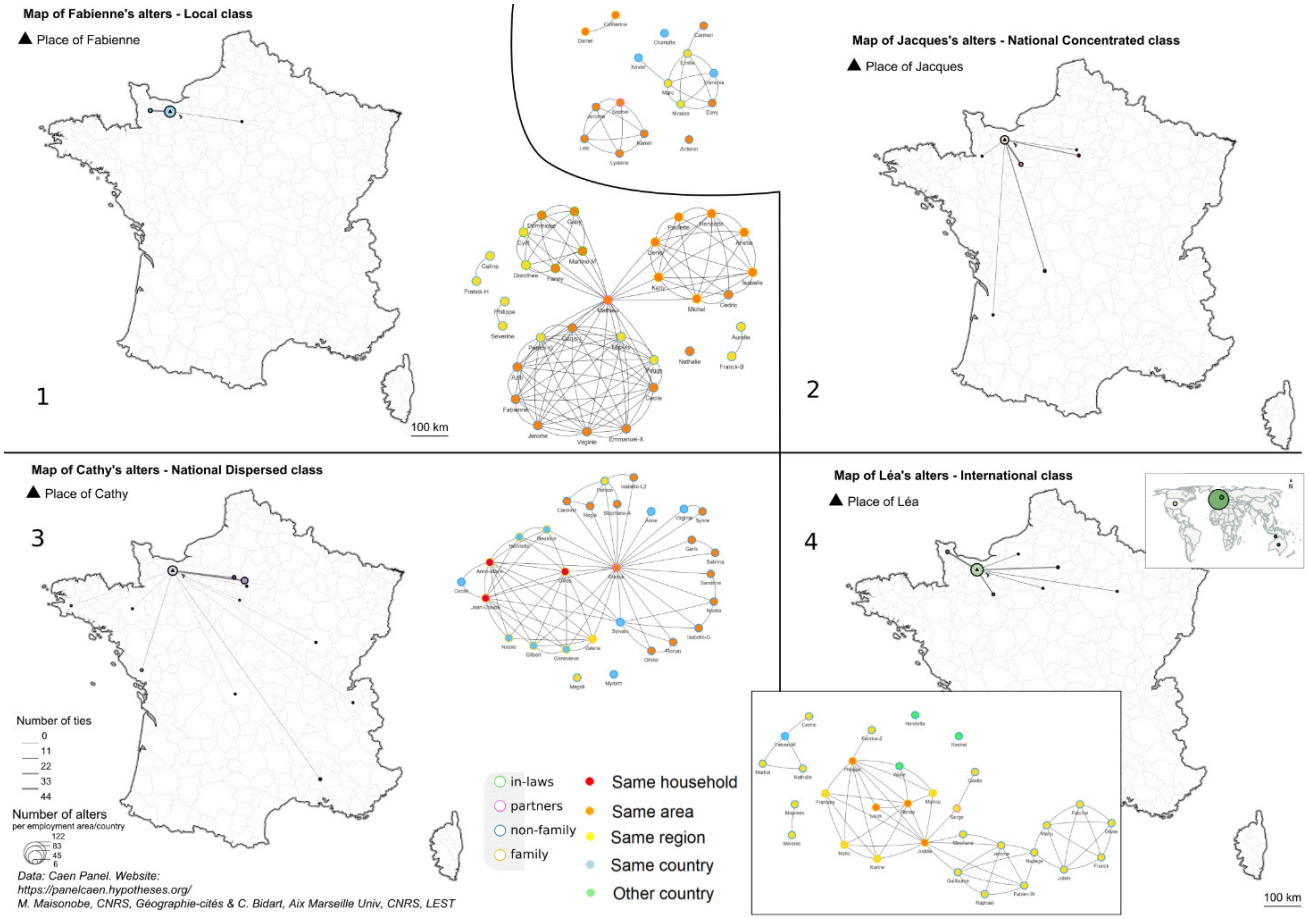


Figure 4. Network diagrams and geographical mappings of the paragons of the Caen Panel classes.

As the Caen Panel has a strong qualitative dimension, we can describe in more depth the situation of the paragons to gain insight into how life events, family backgrounds and institutions shape the geography of personal networks. In Figure 4, roles (family, non-family, partner, in-laws) are represented by coloured rings.

Fabienne as the paragon of the "Local" class was born in Caen, where her whole family lives. She worked for three years as a supermarket sales assistant in Saint Lô, a small town about an hour's drive away from Caen. She still has friends there, two couples (Séverine and Philippe, Aurélie and Franck), and some members of her biker gang, which makes up most of her friends. She also has a weak tie with Frédéric, who now lives in Paris (he appears on the map but not on the network diagram, which only depicts strong ties). The networks of this class show a typical network structure segmented into very dense components and cliques. In some cases, like Fabienne's, only the ego and partner connect the components, forming a star-shaped structure. Both density and clustering are high. These networks are typical of working-class non-mobile trajectories. Some rare long-distance relationships are usually related to the move of alters, except when ego experienced short periods of study or work, like Fabienne.

Jacques as the paragon of the "National Concentrated" class is a shopkeeper who lives in the suburbs of Caen and has never lived elsewhere. But his network includes several alters in other cities of France. His core group of childhood friends (Marc, Nicolas, François) moved after school, but they remained close friends despite the spatial dispersion. Individuals in this class have the smallest networks in the sample. They show network structures particularly fragmented into small parts. Life stories show commitments in groups (music bands, school gangs) that have eventually dispersed geographically due to family or job-related reasons, but people have remained tied together. In general, there is no partner to bridge these groups but ego.

Cathy as the paragon of the "National Dispersed" class is training to be a secretary in Caen. She lived previously in the suburbs of Paris where her family stayed. Her mobility experiences explain the dispersion of her network. Some of her high school friends also moved away to other cities for their studies, but they still meet in couples or small groups in Normandy or the Paris region. For example, Sylvain lives close to Paris, but his parents have a holiday house in Cathy's village where he regularly meets the local group of friends. In this class, both the ego and alters were mobile. Non-local family and in-laws contribute to the geographical dispersion. The proximity of the coastline also increases holiday travel and the seasonal reactivation of relationships.

The network structure is mostly segmented, sometimes in a star-shaped structure around ego and the partner. The high spatial dispersion is explained by the combination of factors that contribute to forming small, dispersed groups.

Léa as the paragon of the "International" class completed her high school and lives with her parents. She never moved further than 30 km but included in her network people living in foreign countries who were met in student exchanges organised by secondary and high schools. This is how young people from working-class backgrounds like Léa (her father is a security guard and her mother is a nurse) had the opportunity to travel and develop international relationships. In an interview, she said: "I went to England with Nadège. I went to Germany last year, I stayed in touch with my pen pal, Wolle, who came to visit me this summer and invited me to Hanover. I went to the United States with the school. I stayed in contact with the family at Henrietta's house. And before that, the school hosted an American girl who came to France, Rachel." In this class, some egos never travelled abroad but stayed in touch with people who did, such as French alumni of prestigious schools who eventually moved to different countries. Here, institutions like schools and Erasmus programmes play an important role in the international scope of the network. The networks of this class are composed of both local and long-distance relationships. Their structure is in star or pearl-collar shape with a high diameter: different alters connect different components.

6. Assessing the Validity of the Classifications: Relationship to Socio-Demographic and Structural Variables

We used different strategies to assess the validity of the classifications obtained. First, in an exploratory way, we evaluated different indices and different methods of factor analysis (PCA or factor analysis of mixed data) and assessed the quality of the classifications based on clarity, internal consistency, and parsimony. Second, we validated the classifications based on the stories and visual inspection of the geographical mapping of the paragons. Finally, using bivariate analyses, we measured the association between the classes and some social characteristics of the individuals as well as structural properties of the personal networks. Because of size limitations, we only present here the results of the analysis for four characteristics: ego's social class, living arrangement, residential mobility, and network density at both the inter-individual and inter-area levels.

6.1. Social Class

We used the social class scheme of Oesch (2006) where occupations are classified into five classes based on employment and work conditions. For the Caen Panel, we added the category of "Students and non-employed people" since they represent an important proportion of the studied population. Figure 5 shows a strong association between the geography of personal networks and ego's social class for both samples. Those in the service class tend to have a personal network that is dispersed at the National or European (for Switzerland) levels, and to some extent, at the international level. Conversely, skilled and unskilled workers, students and non-employed people are over-represented among those having local networks in both datasets and national-concentrated networks in the Caen Panel. Despite some differences between both datasets largely explained by the differences in the composition of the two populations, the analysis reveals a greater propensity to have a spatially dispersed personal network among people in service occupations.

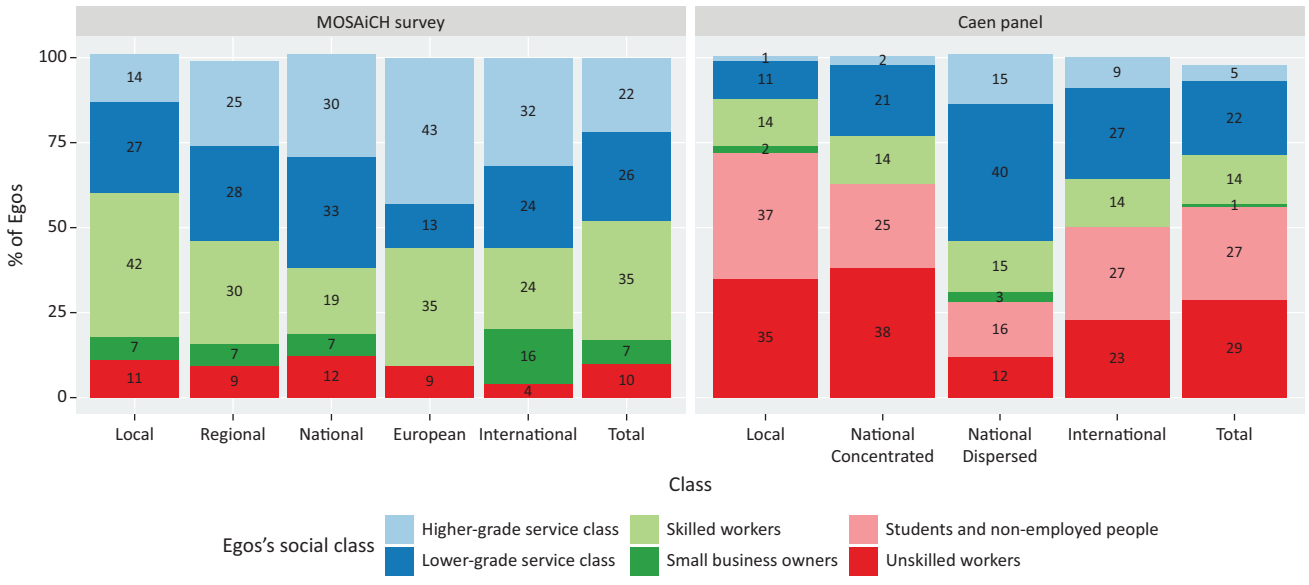


Figure 5. Classes by ego's social class.

6.2. Living Arrangement

We also observe clear differences by ego's living arrangement (Figure 6). In both samples, those having a local personal network often live with parents or with a partner and children. People having a regional, national, or European network are more likely to live alone than those having a local network. Individuals living with a partner without children are overrepresented among those having a national and dispersed network. Finally, we observe that people with an international network differ in their living arrangements across the two samples: They often live with a partner and children in MOSAiCH while they often live with parents in the Caen Panel.

6.3. Residential Mobility

In the MOSAiCH sample, ego's residential mobility was measured based on the place where ego lived at the age of 14. For both samples, we grouped respondents into four categories: (a) those who live in the same employment area as the one at 14; (b) those who live in the same linguistic region of Switzerland for MOSAiCH/in the same administrative region of France for the Caen Panel as the one at 14; (c) those who live in a different linguistic region of Switzerland/administrative region of France from the one at 14; and (d) those who lived abroad at the age of 14. For the Caen Panel, this last category concerns one respondent only.

We see a strong correspondence between residential mobility and the geography of personal networks (Figure 7). In MOSAiCH, those who grew up in a foreign country are more likely to have a European or world-wide personal network. The effect of mobility is also strong among those who grew up in Switzerland. Those who moved from a different linguistic region of Switzerland are more likely to have a national network. By contrast, egos who developed a small-local network or a regional network are more likely to live close to or in the same area where they grew up.

In the Caen Panel, those with a national and dispersed network are more likely to live in a different area than the one where they lived at 14. By contrast, those who live in the same area as where they grew up are overrepresented among the local and international class (this latter being probably due to the student population and exchange programmes). As shown in the previous analysis on living arrangements, individuals in the international class of the Caen Panel significantly differ in their sociodemographics from their counterpart in MOSAiCH. The latter group in Switzerland are mostly employed people, some of whom have immigrated for work.

6.4. Network Density

Network density is defined as the number of existing relationships between network members divided by the maximum number of possible relationships. Scores range between 0 and 1, with 1 meaning that all members are interconnected and 0 meaning that no one is connected to anyone else in the network. We calculated the inter-individual network density based on the directed emotional support relationships in MOSAiCH and knowledge relationships in the Caen Panel. For the latter, egos were excluded from the calculation, since by definition they know everyone in their personal networks. We also computed the "inter-area" density according to the proportion of existing relationships between alters located in different areas (considering only strong ties in the Caen Panel).

For both samples, we observe that the classes are strongly associated with network density, both at the inter-individual and inter-area levels (Figure 8). The more

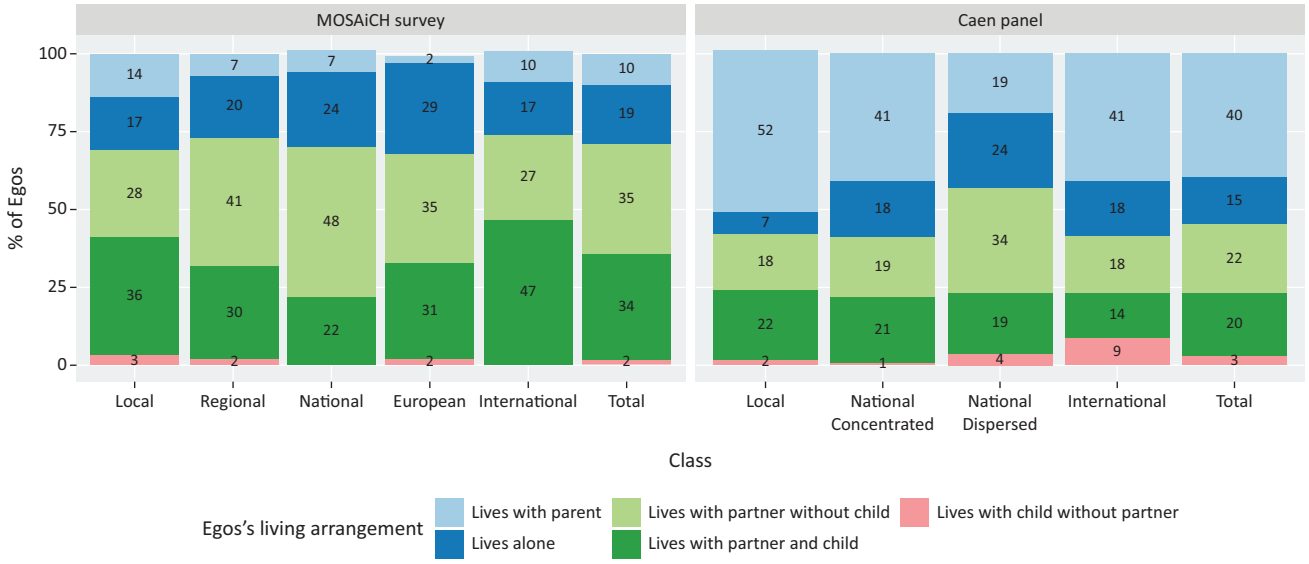


Figure 6. Classes by ego's living arrangement.

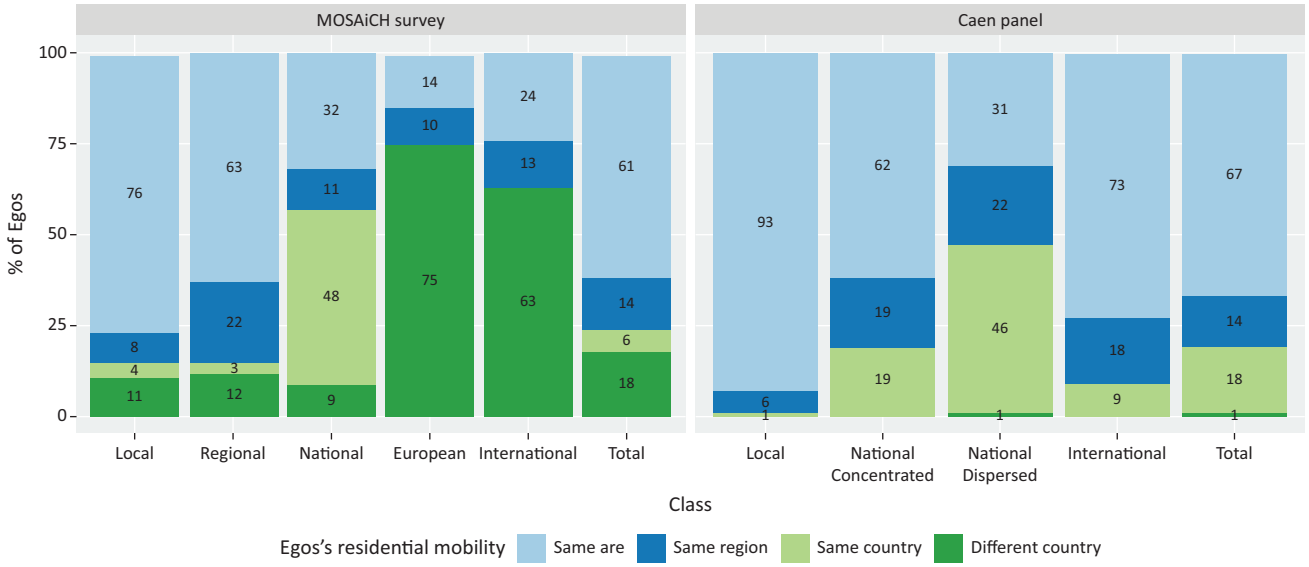


Figure 7. Classes by ego's residential mobility.

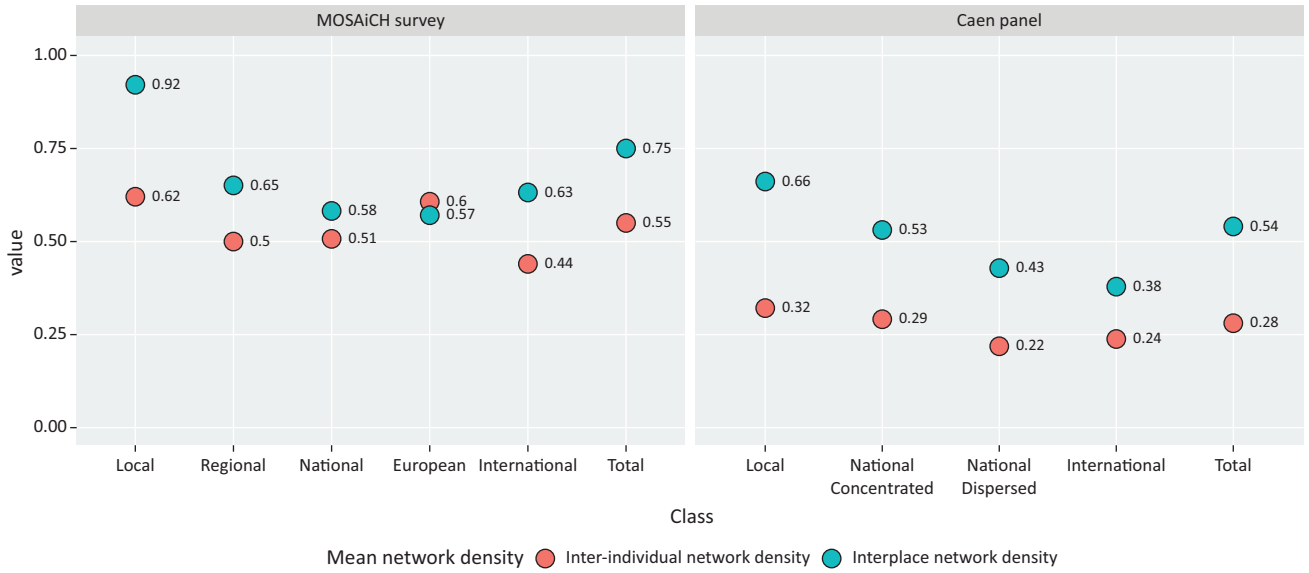


Figure 8. Mean density of ego's inter-individual and inter-area networks.

spatially dispersed networks are, the lower the density. Local networks are particularly dense, but these networks tend to be smaller in size, especially for the MOSAiCH dataset, as density is generally inversely proportional to network size. The only exception concerns the European networks in MOSAiCH, which are characterised by a high inter-individual density. In this class, networks are relatively small and egos named a relatively high proportion of relatives who live in the country of origin and are tightly connected.

7. Conclusions

The approach proposed in this study has proved to be effective for analysing the geography of personal networks. We grouped network members' residential locations by employment areas and analysed the aggregate structure (networks of places). Our results based on two samples of egocentric networks suggest that the approach is applicable to a wide range of geographical settings and types of personal network data. Our approach further demonstrates the added value of using relevant geographical areas rather than residential distance information. The geographical patterns identified are more meaningful and better capture the complexity of geographical patterns than distance-based descriptors. The main geographical unit of analysis used, the employment area, is a functional statistical unit whose delimitation is provided by national statistical offices and is based on local commuting flows. The network indices considered (IQV, IE, number of areas, etc.) are appropriate to examine the dispersion of personal

networks across employment areas and the propensity of egos to have alters living in the same area as them. In addition, the geographical scope of personal networks is based on structuring geographical divisions: linguistic, administrative, and national borders, rather than a continuous and linear variable, such as a mean distance. Another important advantage of the proposed approach is that characteristics of these areas (e.g., economic activity, deprivation, demography evolution) can easily be integrated into the analysis as environmental factors for better understanding personal networks in their geographical context. The proposed approach also has the advantage of capturing the geography, not as an attribute of network members, but as a higher structural level, with the potential to analyse the links between the composition, structure and geography of personal networks. Researchers could use alternative indices, units and divisions depending on the research questions addressed. For example, the geographical scope of networks could be measured using categorical indicators either based on the "farthest alter" or the category in which the highest number of alters falls. Using cross-national employment areas would also be useful to overcome methodological nationalism.

In addition to statistical analysis, the analysis of the paragons—the statistically most typical networks of each class—proved to be an efficient way of illustrating and characterising the geographical patterns identified. When the data are available, qualitative analysis of personal stories of the paragons gives further insight into how life events, social backgrounds, and institutions shape the geography of personal networks. In this study, the key factors that appear to be relevant are the location of the family and in-laws, ego's mobility experiences, divorce and remarriage, having met friends in another place who stayed there, or having friends who moved and remain connected, temporary jobs and studies in other places, leisure activities that tie together people living in different places, secondary residences in tourist places, and institutional exchange programmes. All may contribute to the spatial dispersion and geographical scope of personal networks. The classifications were further validated by the strong statistical associations with egos' socio-demographics and network characteristics.

We see three promising extensions of this approach. One is incorporating area characteristics (e.g., transport networks, population density, socio-economic deprivation) into the analysis to examine the influence of environmental factors on the geography of personal networks. Statistical models could also include both the geography of personal networks and area characteristics to estimate their respective effects on individual-level outcomes (e.g., social exclusion). A second extension is studying the geographical distribution of the different classes to highlight local and regional specificities in the geography of personal networks. This is particularly relevant when using nationally representative samples like MOSAiCH. When using panel data like the Caen Panel, a third promising extension of this approach is to analyse intra-individual changes in class across survey waves to dynamically analyse the geography of personal networks over the life course. In all these research directions, the use of our approach by other network researchers seems to us particularly desirable to examine personal networks in geographical context.

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Conflict of Interests

The authors declare no conflict of interests.

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