Where do Ethnic Groups Meet? Copresence at Places of Residence, Work, and Free–time

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Abstract

This paper analyzes ethnic segregation across the whole activity space–at places of residence, work, and free time. We focus on interethnic meeting potential during free-time activities and its relationship with segregation at places of residence and work. The study is based on cellphone data for a medium-sized linguistically divided European city (Tallinn, Estonia), where the national majority (Estonian) and mainly Russian-speaking minority are of roughly equal size. The results show that places of both residence and work are similarly segregated, while free-time activities occur in a far more evenly mixed environment. Free-time segregation is only weakly associated with segregation at places of residence and work.

Keywords: ethnic segregation, spatial mobility, free-time segregation, mobile positioning, copresence

JEL codes: J70, R23

1 Introduction

Segregation research is typically focused on place of residence, the most easily observable location in daily life. The studies present a picture of persistent and high-level segregation, both for many long-term minority groups and for recent immigrants (Massey and Denton, 1993; Cutler, Glaeser, and Vigdor, 1999, 2008). The observed segregation may originate from various sorting and selection mechanisms including discriminatory practices in the housing market, and is slow to disappear (McPherson, Smith-Lovin, and Cook, 2001; Semyonov and Glikman, 2009; Harris, 1999). The nature of the social environment at a place of residence is obviously important because people spend a significant amount of time at home. However, interethnic meetings may occur elsewhere

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as well. Activity-based research distinguishes three main activity types: residence (home), business (work) and free-time activities (Arentze, Hofman, van Mourik, Timmermans, and Wets, 2000; Kitamura, 1988). Recent segregation research has increasingly focused on analyzing workplaces (Ellis, Wright, and Parks, 2004; Wang, 2010; Åslund and Skans, 2010; Hellerstein and Neumark, 2008; Strömgren, Van Ham, Marcinczak, Stjernström, and Lindgren, 2011) and activities outside the residential neighborhood and workplace in order to better understand how ethnic segregation is produced and reproduced in different parts of the activity space (McPherson, Smith-Lovin, and Cook, 2001; Shinew, Glover, and Parry, 2004; Houston, Wright, Ellis, Holloway, and Hudson, 2005).

Previous research has focused mainly on a single sphere of the activity space or, at best, on pairwise links such as those between residence and work. In contrast, we herein analyze segregation in all three main spheres—at residence, at work, and during free-time—simultaneously. We base our approach on the influential time geography tradition (Hägerstrand, 1970). We analyze movements in space-time and trace when and where people with different ethnic backgrounds can meet each other in the city. Technically, we measure copresence (being in the same place at the same time) for different ethnic groups. The focus on copresence in the activity space incorporates a new dimension—time—into the commonly used segregation indices.

Our analysis is focused on a racially homogeneous but linguistically divided European city (Tallinn, Estonia) of about 400 000 inhabitants, where Estonian-speaking majority and Russian-speaking minority populations make up almost equal shares of the total city population. It should be noted that this way we capture interethnic segregation within the same race (white). We rely on a passive mobile positioning dataset through which we observe the space-time activity pattern of cell-phone users. This allows us to establish the places of users' residence and work. We then trace where and when members of ethnic majority and minority groups have been in the same part of the city at the same time and thus may have met. We focus on the exposure dimension of segregation, in particular the homophily index (Lazarsfeld and Merton, 1954; Massey and Denton, 1988), and quantify ethnic segregation in all three places within the activity space—at place of residence, at work, and during free-time activities. We then analyze the association between free-time segregation on the one hand and residential and workplace segregation on the other hand.

2 Segregation across Full Activity Space: Background

Similar people tend to congregate. In particular, people of similar ethnic or racial background tend to live close to each other (Friedrichs and Blasius, 2003; Musterd, Andersson, Galster, and Kauppinen, 2008; Wilson, 1987; Massey and Denton, 1993). Explanations for residential segregation, which is both widespread and remarkably persistent, include various sorting and selection mechanisms, such as the preference of immigrants to live with coethnics; positive externalities, such as group-specific infrastructure; labor market and housing market structures; discrimination by the majority population; and socioeconomic characteristics such as education and salary, which restrict ethnic minority groups to certain residential environments (Lazarsfeld and Merton, 1954; McPherson, Smith-Lovin, and Cook, 2001; Semyonov and Glikman, 2009; Harris, 1999). For several reasons, data on place of residence are the easiest to obtain. This resulted in a large volume of literature that focuses on residential geography (sometimes called "sleeping population") and often ignores other important places within the activity space.

The activity-based approach relates the spatial routines of people to meaningful places within the activity space (Golledge and Stimson, 1997). It includes places of residence, work, and free-time activities (Jones, 1979; Timmermans, Arentze, and Joh, 2002). In other words, individual social relations and activities cluster in space (Rai, Balmer, Rieser, Vaze, Schönfelder, and Axhausen, 2007), with the location of place of residence shaping the geographic reach of other places that people are able to visit on a daily basis (Hägerstrand, 1970; MILLER, 1991; Neutens, Schwanen, and Witlox, 2011). To some extent, residential segregation thus affects the potential for interethnic contact at places of work and free-time activities as well.

In the case of the workplace, job search closer to home is more frequent. Firstly, long-distance commuting is subject to time and financial constraints (Ihlanfeldt and Sjoquist, 1998). Second, job creation may also be influenced by the ethnic composition of the neighborhood, for instance in relation to the provision of local services in ethnic residential neighborhoods (Wang, 2010; Wright, Ellis, and Parks, 2010). These two mechanisms link residential segregation to workplace segregation. The likelihood of workplace segregation is increased further by other mechanisms, such as discrimination at hiring or educational specialization, which leads to workplace segregation also being a persistent phenomenon (Reskin, McBrier, and Kmec, 1999). A recent study by Åslund and Skans (2010) shows an increasing trend of workplace ethnic segregation in Sweden, coupled with significant wage penalties for immigrants who work in ethnically segregated workplaces. However, the occurrence of workplace segregation is still less than that of residential segregation (Ellis, Wright, and Parks, 2004; Åslund and Skans, 2010) thanks to a number of ameliorating mechanisms that mitigate the former. These include a higher dispersal of jobs suitable for immigrants in the city, regulations promoting equal opportunities, and affirmative action (Estlund, 2003; Holzer and Neumark, 2000; Wright, Ellis, and Parks, 2010). In other words, although the two types of segregation processes are related, there is not a one-to-one overlap between residential and workplace segregation.

In addition to these two central places within the activity space, there is increasing interest in understanding interethnic contact in places where people spend their free time (McPherson, Smith-Lovin, and Cook, 2001). The current evidence for this aspect it is mixed. Several studies show that activities such as spending free time with friends, doing sport, visiting cultural and other events, could all potentially move immigrants out of ethnic networks, facilitate interethnic contact and support a general integration into the host society (Kao and Joyner, 2004; Shinew, Glover, and Parry, 2004; Boschman, 2012). Various activities performed outside of places of residence and work can bring together people with common interests irrespective of their ethnic background (Wellman, 1996; Peters and de Haan, 2011). Shinew, Glover, and Parry (2004) thus argue that "leisure settings can be ideal environments for interracial interaction to occur due to the qualities of free choice and self-determination."

On the other hand, it has also been found that leisure-time activities can be highly segregated. Physical distance still matters and the choice of places frequented during free-time is constrained by place of residence and place of work. For example, McPherson, Smith-Lovin, and Cook (2001) argue that meeting a friend living in the same or in a nearby neighborhood on a frequent basis is much more likely than meeting a friend living in a distant neighborhood. Moreover, during free time, people can choose to interact only with those with whom they share similar values and identity, which thus facilitates coethnic relations (Gobster, 2002; Shinew, Glover, and Parry, 2004). Religious activities with high levels of ethnic and racial segregation are a well-known example in this regard. The US Multiracial Congregations Project demonstrated that just eight percent of Christian religious communities are "multiracial" (Emerson and Kim, 2003). Also, US recreational wildlife areas are divided between racial groups in a way that emerges from everyday practices rather than from any specific regulation. Various other ethnic demarcation lines in leisure-time activities can be found both in the US (Shinew, Glover, and Parry, 2004) and in Europe (Peters and de Haan, 2011).

In summary, the existing literature suggests that leisure time activities and their respective places have different potentials for ethnic/racial integration. On the one hand, locations of residence and work shape the potential pool of other places people can frequent during their free time. Similar people tend to bond, and many minorities prefer to spend their free time with coethnics, also building on the existing ethnic infrastructure for their own benefit. On the other hand, free-time activities based on common interests not correlated with ethnic background may also draw people away from existing ethnic networks. In this way, free time has a high potential to enable interethnic contact (Shinew, Glover, and Parry, 2004).

3 Ethnic Segregation in Tallinn

Tallinn, the focus of our study, is the capital city and the largest urban center in Estonia. Before the World War II, the country was ethnically rather homogeneous. By far the largest group consisted of ethnic Estonians (94% of a population of about one million) with the second largest being ethnic Russians (Katus, 1990). During the turbulent years of WWII, the country was incorporated into the Soviet Union and afterward experienced mass immigration from other parts of it (mainly Russia), as a result of postwar industrialization and Russification policies (Rybakovskii, 1987; Lewis and Rowland, 1979). This process resulted in an increase of the population of the country to 1.57 million by 1989, 39% of which were ethnic minorities (Tammaru. and Kulu, 2003). Stalin's brutal regime completely destroyed any relations between Estonians and Russians, which had been quite friendly up to WWII, and the subsequent rapid increase in the Russian-speaking population, managed by an authoritarian regime, did little to improve matters.

A substantial proportion of immigrants settled in Tallinn (Tammaru and Kontuly, 2011), and by the 1970s, a linguistically divided Estonian-Russian society had emerged with residential neighborhoods, workplaces, schools and media being segregated by language (Kalmus and Pavelson, 2002; Vihalemm, 2010). The Russian-speaking population had a mixed ethnic background; besides Russians, the largest groups were Belorussians and Ukrainians. While the command of the Estonian language was poor among the minorities, most of the native population was able to speak Russian toward the end of the Soviet period in 1980s (Kulu and Tammaru, 2004). The widening use of Russian caused increasing concerns about the future of the country and the native language among ethnic Estonians (Rannut, 2008). One particular outcome of these concerns was an unwillingness to participate in mainstream Soviet society. Estonians never felt themselves to be a part of the Soviet nation, and distinguished clearly between "their own," i.e. "Estonians" and "the others," i.e. "Russians." In this way, a linguistically divided society was able to thrive, with Estonians and members of the Russian-speaking community living fairly parallel lives, which has sometimes been characterized as a silently separated society (Heidmets, 1998).

Estonia became independent again following the coup of August, 1991. The nation-building process that followed involved the two key elements of citizenship and language (Rannut, 2008). The newly elected parliament granted citizenship only to nationals of the pre-WWII republic and to their offspring (Everly, 1997). As a result, a sizeable part of the minority population does not have Estonian citizenship. Moreover, the growing importance of Estonian, now the sole official language of the country, caused a gradual deterioration of Russian language skills among Estonians, especially among the younger generation. However, most Russians are still not able to communicate in Estonian (Kulu and Tammaru, 2004). For this reason there is no universally shared language in the country today.

Such moves were widely regarded to be discriminatory by Russian speakers (Pettai, 2002). Being transformed from the majority ethnic group in the former Soviet Union into a minority in a new country also presaged a major identity crisis (Vihalemm, 2010) and an unfavorable economic position (Leping and Toomet, 2008). In this way the historic animosity between the two language groups, the high levels of segregation in many important spheres, and the lack of a *lingua franca* contributed to the low number of interethnic contacts and general lack of social integration today. While the attitudes toward the other ethnic groups have been improving through the previous decade, the number of contacts has remained low (Lauristin, Uus, and Seppel, 2011, p 48). The tensions do occasionally rise to the surface as, for instance, during the large-scale riots in Tallinn in the spring of 2007.[1]

4 Data

4.1 Study Area

Tallinn is very well suited to our analysis for two main reasons. First, the population is almost equally divided between Estonian and Russian speakers (54% and 46%, respectively, based on the 2000 census). Second, the language groups are distributed rather unequally across the city despite their similar size. This is due to sorting and selection mechanisms that differ from those in the cities of Western Europe and the US (Hess, Tammaru, and Leetmaa, 2012).

[1] The riots were caused by the relocation of a Soviet World War II monument, popularly referred to as the "Bronze Soldier", from central Tallinn to a military cemetery. From the perspective of ethnic Estonians, the monument was considered to glorify oppressive Soviet rule, while for the Russian-speaking population it was a symbol of victory over the Nazis in the "Great Patriotic War." See Schultze (2011).

The main mechanism shaping the ethnic composition of the neighborhoods in present-day Tallinn is related to historic immigration and residential construction. The city was home to 165 000 inhabitants in 1947, but this number had risen to 480 000 by the end of the Soviet period 40 years later (Tammaru, 2001). The main source of this growth was immigration, mainly from Russian-speaking regions elsewhere in the USSR. In the absence of a housing market, immigrants were usually granted flats in newly built, standardized, high-rise housing estates (Kährik and Tammaru, 2010). The estates were supplied with modern amenities, such as central heating, running water and bathrooms, which were often missing in older residential buildings. Such new apartments were rather desirable and always in short supply (Kulu, 2003). In this way, Russian-speaking newcomers in Tallinn lived at the relatively high end of the housing ladder, in sharp contrast to most of the immigrant groups in Western Europe and the US (Leetmaa, Tammaru, and Anniste, 2009). The Soviet-era housing estates still provide accommodation for about three quarters of the total population of the city, indicating that a large number of Estonian speakers live there as well nowadays. These neighborhoods are still considered rather "Russian," whereas Estonians are over-represented in pre-WWII (and also in the small post-1991) housing stock, and also in detached houses. In this way, the current ethnic composition of neighborhoods largely reflects the specific type of housing construction undertaken during different periods. Indeed, suburbanization and the fact that a substantial part of the immigrant population left after the collapse of Soviet Union (the population of Tallinn had fallen to 415 000 by 2011) has not radically changed this picture.

4.2 Passive Mobile Positioning Data

In this study we use unique cellphone usage data from the largest mobile service provider in Estonia, EMT. Approximately 96% of the adult population in the country use cellphones and, based on a 2008 survey, EMT's market share in Tallinn is 39% (Ahas, Aasa, Roose, Mark, and Silm, 2008).

The type of data we use is commonly referred to as "passive positioning data," where "passive" refers to the fact that it is extracted from the memory files held by mobile operators.[2] The passive mobile positioning database is based on Call Detail Records (CDR), where each CDR is described by the time and location of the call activities (calls, text messages and multimedia messages). Typically for the passive data, we do not observe the actual location but rather the Cell Global Identity (CGI), i.e. the network antenna which processed the outgoing call.[3] This gives us a spatial resolution of a few hundred meters in dense urban environments, and up to five kilometers in rural areas. The data include the start time of each call activity (to a precision level of 1-second) and the corresponding location (CGI). Every network user (as identified by a SIM card with a unique phone number) is assigned a random identification tag,

[2] A more precise "active" positioning requires additional steps to be taken by the network operator.

[3] In a cellular network, a "cell" roughly corresponds to an area where all the network traffic goes through a particular antenna (transceiver). Usually, several antennas are located in one transmission tower and are oriented in different directions. We know the location of the transmission towers and the direction of the antennas. Based on this information, we can construct "typical" cell boundaries; however, the actual boundaries may fluctuate due to network load, obstacles and noise.

making it possible to track the same user over time.[4] In the current analysis, we only observe outgoing call activities.

Besides the calls made, the data also include some background information about the users (SIM card owners). The most crucial variable for this study is the preferred language of the cellphone user. This information is obtained from the operator's customer database. As explained earlier, bilingualism is not universal in Tallinn, and hence the preferred language information is often collected by businesses in the service sector. Therefore, preferred language can serve as a proxy for ethnic background. This is supported by the data from the 2000 census, which shows that virtually all of those who identified themselves as ethnic Estonian also listed Estonian as their first language, while most of those from other ethnic backgrounds mainly used Russian (see also Kulu and Tammaru, 2004). The overwhelming majority of users for whom we have valid language data prefer one of these two languages. In our analysis, we omit a small number (0.3% of the total) who prefer English. The database also includes information on the gender and age of most users. In addition, based on the timing, location and regularity of the calls, we can attach a place of residence and a place of work to each cellphone (see Ahas, Silm, Järv, Saluveer, and Tiru, 2010, for details).

The data cover a one-year time span, from January 1 till December 31, 2009. We randomly selected 5 200 individuals while keeping the ethnic composition across the municipal districts equal to that of the 2000 census. We only sampled those with valid language data and whose place of residence was located within the same part of the city and within the boundaries of the municipality of Tallinn for at least eight months. Our final sample of 5 200 individuals consisted of 2 784 (54%) Estonian speakers and 2 416 (46%) Russian-speakers.

5 Method

Our approach in this study is follows: based on cellphone activity, we determine the proximity (copresence) of different individuals in space and time, both in their neighborhood of residence (home), in their neighborhood of work, and during their free time. Next, for each individual we analyze the ethnic background of those they are "together with" in all these places. Finally, our main analysis relates the ethnic composition, as measured in this way, to the characteristics of neighborhood of residence and neighborhood of work, and a number of individual descriptors.

5.1 Activity Space

Our point of departure is the framework of the space-time path in the activity space, which is widely used in time geography. Here, the central aim is to undertake a joint analysis of the spatial and temporal dimensions of individual activities (Hägerstrand, 1970). Traditionally, three types of places are distinguished in the daily activity space: those related to residence (home), those

[4] Obviously, the individuals and real phone numbers cannot be identified using the tag in our data. The collection, storage, and processing of the data obtained using the passive mobile positioning method complies with all European Union requirements regarding the protection of personal data (European Commission, 2002). Approval was also obtained from the Estonian Data Protection Inspectorate.

related to business (work), and those connected with free-time activities (Arentze, Hofman, van Mourik, Timmermans, and Wets, 2000). Our data do not provide us with readily available information about the actual activities undertaken. Instead, we use the location of neighborhoods of residence (R) and work (W) to approximate the corresponding activities (Golledge and Stimson, 1997). This is similar to previous studies that compare segregation at residential and work neighborhoods (Ellis, Wright, and Parks, 2004). We term all the other places *free-time places* (F).

When determining proximity (operationalized as *copresence*, see below) of two individuals in a certain place (R, W or F) within the activity space, we exclude all those activities performed in other places. More specifically, we only measure proximity between individuals who are both at the same time in their corresponding residential neighborhood, workplace neighborhood, or participating in free-time activities.[5] In this way, R-proximity occurs when people who live close to each other meet in the public spaces close to where they live (residential neighborhoods), such as in shops, schools and parks, and when neighbors visit each other in the same neighborhood. We expect that the ethnic composition of such meetings will reflect quite closely the population composition in the neighborhood of residence. Similarly, W-proximity describes meetings between colleagues at work, and also encounters with other people, working in the same neighborhood. Here, the ethnic background of the others is related to workplace segregation, where "workplace" must be understood in the sense of a neighborhood. This also facilitates comparison with the previous literature on segregation in residential and workplace neighborhoods (cf. Ellis, Wright, and Parks, 2004). Where individuals live and work in the same neighborhood, we are not able to distinguish between these two types of calls and therefore count them as both residence and work-related calls. Other limitations are discussed in more detail in the following section. Finally, F-proximity describes encounters during common free-time activities, and other activities not connected to the residential or workplace neighborhoods, such as shopping or visiting a doctor.

5.2 Copresence

We operationalize proximity as *copresence*. For face-to-face interaction, the persons have to meet—they must be present in the same place, both in space and time. Copresence analytically measures the potential of people seeing each other and feeling their nearness, and the possibility of such an interaction between them (Goffman, 1966; Lawrence, Payne, and Kripalani, 2006; Urry, 2003; Zhao, 2003).[6]

We calculate copresence from the passive mobile positioning data as follows. First, we aggregate both spatial and temporal data into geographic units and time intervals. In the original data, geographic resolution is provided at the network cell level and time is provided in seconds. In the main analysis below, we use a geographic resolution at city tract level. Tracts are a division of the city based on public transport catchment areas that correspond to neighborhoods as traditionally used in segregation research. There are 25 tracts in Tallinn with a typical dimension of 1km, see Figure 2 in Section 6.2. The mean tract

[5] We operationalize the neighborhood in the next section.

[6] Needless to say, we are not able to observe the actual interaction, rather we can identify that there is moderate proximity which is a necessary condition for an interaction.

size is about 15 000 residents, that is somewhat more than in typical US census tracts. Tracts are different both in terms of population size (ranging from 300 to more than 60 000) and ethnic composition (the proportion of Russian speakers ranges from 7–70%). Further details are provided in Appendix A. Although our research population resides in Tallinn, their daily mobility pattern is not restricted to within the city boundaries. Outside the city, we lower the spatial resolution to the municipality level in the metropolitan area, and to the county level elsewhere. Along the temporal dimension, we aggregate the time information into three-hour intervals. We refer to the above-defined space-time units as *timeframes*. In this way we assign a unique timeframe to every call made in the network. It is important to note that despite the complexity of operationalizing or data, the main results remain robust across different space and time resolutions, see Appendix C.

Next, based on the timeframes of cellular activities, we compute copresence in the following way. For each individual i, we denote the timeframe of their call k by c_{ik}. Let C_i be the set of all timeframes where the individual made at least one call. We define the dyadic copresence p_{ij} for individuals i and j to be the number of timeframes where both of these individuals are present. Formally,

$$p_{ij} = \sum_{k} \mathbb{1}(c_{jk} \in C_i), \tag{1}$$

where $\mathbb{1}(\cdot)$ is the indicator function. Note that we do not distinguish between making one or more calls in a given timeframe. This is because we are interested in presence, not in communication activity. In this way copresence describes the "closeness" of two individuals both in space and time; for there to be a high level of copresence requires that the individuals are repeatedly close to each other in different timeframes. Obviously, copresence does not capture the actual interaction; it is only a necessary condition for it. We refer to it as "meeting potential".

Previous literature that has analyzed the association between copresence and social ties provides us with a mixed picture of the relation. Using qualitative methods, Peters and de Haan (2011) find that multiethnic contacts in public space do not go beyond superficial interaction, in particular they do not lead to cross-ethnic bonds in the private sphere. However, even superficial contacts facilitate exposure to and a sharing of cultural values, which can create a more positive view of others. Different type of evidence stems from Parreñas (2010), who stresses that the segregation of Filipina migrant entertainers in Japan partly originates in temporal segregation, i.e., the daily schedule for workers in the nightlife industry is very different from that of the bulk of the population. Nevertheless, based on electronic data, Crandall, Backstrom, Cosley, Suri, Huttenlocher, and Kleinberg (2010) show that copresence is a strong predictor of underlying social ties. Although we have no information on actual social ties in our data, our approach (space-time copresence) is clearly a more precise measure of meeting potential, compared to data that are solely based on the spatial dimension.

However, our study does have some limitations. Therefore, before discussing our results, we now briefly discuss the most important technical limitations of our copresence measure. Intuitively, because we only observe the locations of cellphone calls, copresence is a sufficient, but not a necessary condition for being in a given timeframe. This may create a certain level of bias for groups with different cellphone usage patterns. Another point to note is that copresence is based on the binary indicators for presence in a given timeframe. We do not take into account eventual presence in neighboring tracts and hence ignore the potential "across-the-border" meetings. However, this method is substantially simpler than potentially superior methods that weight space-time distance in a continuous way. Finally, we do not take into account the duration of stay in individual timeframes. For instance, individuals driving in the city may have copresence with many others despite having little chances for interacting with them. This type of shortcoming is less of an issue if we increase the spatial and temporal resolution. Despite these limitations, our method still captures the navigation patterns in the city for all individuals, and allows us to understand the potential for interethnic interaction in an urban context.

5.3 Homophily

As stated above, our primary focus is the meeting potential between individuals from different ethnic groups—the chance to meet people with other ethnic backgrounds in everyday life. According to the classification of Massey and Denton (1988), we are interested in the exposure dimension of segregation. We select *homophily* as the basis for our analysis.[7] Homophily is a version of the isolation index that is adapted for individual observations. It measures the percentage of an individuals' own type of contacts among their complete set of contacts. We treat the copresence p_{ij} between individuals i and j as a measure of their contacts. In this way, we can analyze the isolation index in copresence.

We define homophily as follows. We observe two types of ties (copresence) for the individual i: with those who prefer the same language as i (s_i), and with those who prefer a different language (d_i). Hence the homophily for individual i can be written as:

$$h_i = \frac{s_i}{s_i + d_i}. \tag{2}$$

Intuitively, homophily is the percentage of copresence with individuals sharing the same language. In the case of random meetings, the expected value of homophily equals the relative size of the individual's own group in the population. As a relative measure, it is not affected by the daily pattern of cellphone usage, as long as it is identical for both ethnic groups; however, similar homophily figures may mask widely different numbers of actual meetings. Here, we would stress again that this study only looks at the residents of Tallinn. Copresence with people living elsewhere is not analyzed in this paper.

The simplest interpretation of homophily assumes that the probability of there being a social tie between individuals i and j is proportional to the corresponding pairwise copresence (meeting potential), and this probability is independent of language. This is a heroic assumption, but it is qualitatively similar to that which is implicitly used when interpreting the residential or workplace segregation measures. The interpretation below still remains valid if this assumption is replaced by a more relaxed one that allows the likelihood of a social tie behind the copresence to differ between same- and different-language copresence.

[7] Homophily is a commonly used measure in multi-component network analysis (see, for instance, Currarini, Jackson, and Pin, 2009, 2010). See also McPherson, Smith-Lovin, and Cook (2001) for a review.

5.4 Empirical Strategy

Our main interest is related to the relationship between the homophily in different locations (R, W and F) of the daily activity space, in particular the association between F-homophily on the one hand, and R and W homophily on the other hand. To do this, we first present the homophily distributions across all three locations separately, characterizing the daily activity space of people in the city. Second, we analyze the relationship between F-homophily and R and W-homophily using a regression approach where we also control for a number of background variables. Since choice regarding place of residence and place of work are potentially influenced by the free-time environment, the regression does not necessarily determine the causal impact of the residence and work neighborhoods (see Ellis, Wright, and Parks, 2004, for a related discussion).

We split R and W-homophily into two components, both of which are included in the regression as explanatory variables: a tract average (macro-level effect) and an individual deviation from that average (micro effect). We specify the macro effects in two ways. First, we control for the average tract homophily $\bar{h}$. This allows us to estimate the association between individual homophily and tract homophily. Second, we introduce tract fixed effects instead of $\bar{h}$. Here, we cannot identify the macro effect, but estimated micro effects may become clearer from the macro-level measurement and specification problems. Accordingly, we have the following two specifications:

$$h_i^F = \alpha_0 + \bar{\alpha}_1 \bar{h}_{R_i}^R + \alpha_1 \rho_i + \bar{\alpha}_2 \bar{h}_{W_i}^W + \alpha_2 \omega_i + \boldsymbol{\beta}' \boldsymbol{X}_i + \epsilon_i \tag{3a}$$

$$h_i^F = \alpha_0 + \bar{\boldsymbol{\alpha}}_1 \boldsymbol{R}_i + \alpha_1 \rho_i + \bar{\boldsymbol{\alpha}}_2 \boldsymbol{W}_i + \alpha_2 \omega_i + \boldsymbol{\beta}' \boldsymbol{X}_i + \epsilon_i \tag{3b}$$

Here, h_i^F is the F-homophily of individual i; $\bar{h}_{R_i}^R$ and $\bar{h}_{W_i}^W$ are the average R-homophily and W-homophily in the residence- and work tract of individual i, denoted by R_i and W_i, respectively; and ρ_i and ω_i are corresponding individual deviations from that average, respectively. In the fixed effects version of the model we introduce the fixed effect vectors $\boldsymbol{R}$ and $\boldsymbol{W}$ for residence- and work tract, respectively. $\boldsymbol{X}$ represents the individual background (control) variables (age, gender and call activity). α and $\boldsymbol{\beta}$ are estimated parameters. We choose to standardize the explanatory homophily measures ($\bar{h}^R$, $\bar{h}^W$, ρ and ω) in order to make the results easier to interpret, while we express the dependent homophily measure h^F in percent. Regarding the control variables $\boldsymbol{X}$, we introduce age groups (<20, 20–29, 30–54 and 55+), a gender dummy and call activity groups (dummies for distribution quintiles). We regard the latter as a proxy for socioeconomic status. All models are estimated separately for both language groups.

6 Results: F-Homophily

6.1 Aggregate Figures

We start with a descriptive analysis of the copresence and homophily in our data. Table 1 columns 1–4 provide a split of the different types of copresence across the three activity locations. We distinguish between meetings of two Estonian speakers (ET-ET), two Russian speakers (RU-RU) and those of an Estonian speaker with a Russian speaker (ET-RU). From the table, we can see that in terms of the number of meetings, the tract of residence clearly dominates

Table 1: Percentage of copresence across different locations and dyad types.

	1	2	3	4	5	6
Domain	Location by type (%)				Homophily (%) by location	
Dyad type:	ET-ET	ET-RU	RU-RU	Total	ET	RU
R	42.4	49.6	58.3	49.9	52.2	59.0
W	32.2	26.2	22.9	27.0	61.2	51.7
F	25.4	24.3	18.8	23.1	57.3	48.7
Total	100.0	100.0	100.0	100.0	–	–

over the other locations.[8] 42% of ET–ET, 50% of ET–RU and 58% of RU–RU meetings occur in the residence tract. However, roughly 50% of potential meetings in everyday life occur outside the home tract. Both workplace and free-time places account for roughly 25% of all encounters.

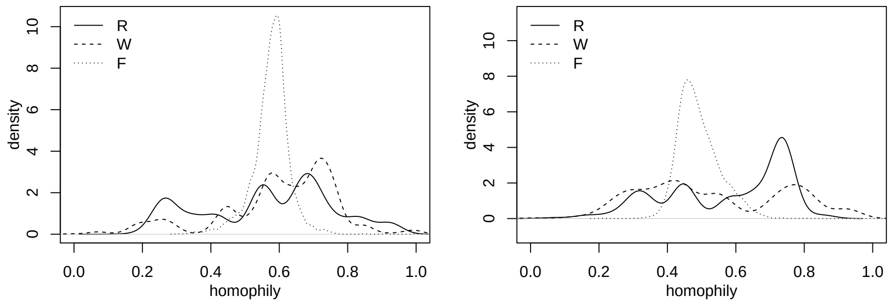
Next, we look at the average homophily values by location (columns 5 and 6 in Table 1). These figures range between approximately 50 and 60 percent. As Estonian speakers form a somewhat larger group in the population, we expect their homophily values to be slightly higher. This is indeed true for W and F, but not for R. On average, Estonians appear to be the most isolated (i.e., they show the largest homophily) at work, and the least isolated at home. In contrast, Russian speakers are most isolated at home with their homophily exceeding the value of that of the Estonian speakers. At work and in free-time places, Russians are less isolated than Estonians. In other words, it can be inferred that Russian speakers are more inclined to cluster in coethnic residential neighborhoods, but have a higher chance of meeting Estonian speakers in places of work and during free-time activities. In general, these averages are reasonably close to the expected values of 54% for Estonian and 46% for Russian speakers (reflecting the proportion of each group in the 2000 census for Tallinn). Hence the aggregate homophily is not radically different from what we would expect in case of the random meetings.[9]

6.2 Homophily Distribution in Different Locations of the Daily Activity Space

In the previous section we discussed homophily in terms of averages, but this is a global measure that potentially masks important differences in the underlying distribution. Therefore, in this section we look at the (marginal) homophily density in all three locations (Figure 1). It appears that isolation at place of residence and place of work is distributed in a broadly similar way, and this is true for both language groups. In both R and W-locations, homophily ranges roughly between 0.2 and 0.8, which reflects the population and workplace composition that varies across the city. The similarity of population composition in the residence and work tracts is further highlighted by the remarkably close

[8]Obviously, these numbers are sensitive to how the corresponding locations are defined. Using a smaller area for the place of residence and work will cause the importance of these to fall and the free-time to pick up the more-and-more of the meetings.

[9]We also test the relationship between R-homophily and composition of the corresponding tract population. As expected, this shows a very close fit and suggests that cellphone usage does not differ substantially between these two population groups.



(a) Estonian (b) Russian

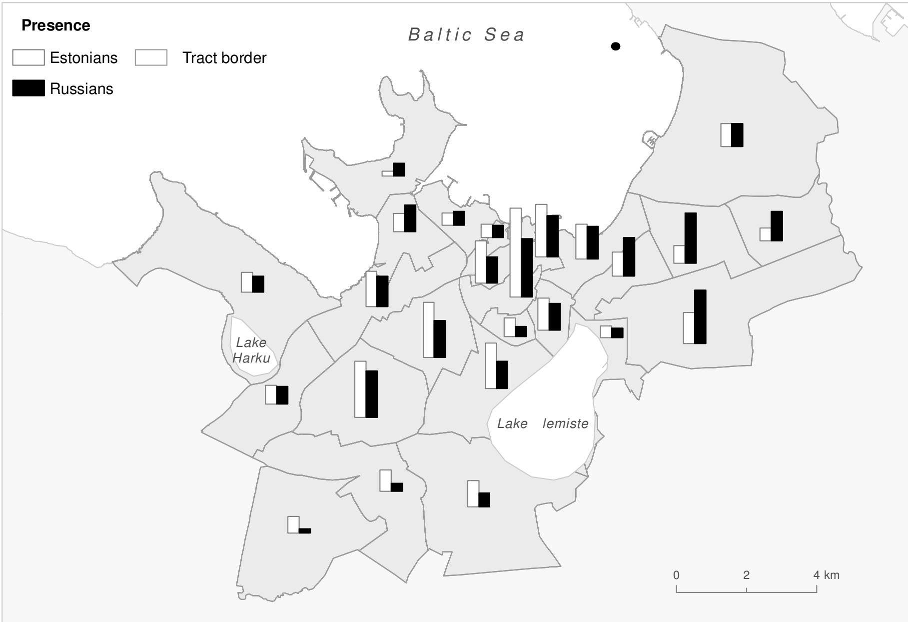
Figure 1: Kernel density estimates of the homophily distribution in R, W and F-locations for Estonian- and Russian-speaking groups.

dissimilarity indices ($D^R = 0.35$ and $D^W = 0.34$ respectively[10]). Figure 1 indicates that a number of Estonian speakers live in tracts that are densely populated by Russian speakers (where the homophily ranges between 0.2 and 0.4), while a significant fraction of Russian-speakers live in tracts that are more coethnic (homophily of around 0.7). The W-homophily distribution of Estonian speakers also has more mass at the more isolated end of the scale (homophily 0.7 and higher). This explains why the Estonians' average W-homophily exceeds their average R-homophily in Table 1 whereas for Russian-speakers, the opposite is true.

In contrast, the F-homophily is distributed rather differently, with virtually all the mass being concentrated in a narrow interval between 0.4 and 0.6. The distribution exhibits a prominent single peak for both groups, corresponding to the mean value in Table 1. Hence quite similar mean homophily indices in all three locations (table 1, columns 4 and 5) actually mask large differences in the corresponding homophily distributions. In other words, Figure 1 clearly indicates that both residential and work tracts are moderately segregated. However, free-time activities take place close to the other language group. In other words, if they are not at work or at home, the residents of Tallinn experience a significantly more mixed environment in terms of ethnic composition. The corresponding dissimilarity index $D^F = 0.18$ also indicates a substantially more even distribution in the free-time sphere.

Further detail on meeting potential between those with different ethnic backgrounds is provided by the distribution of the free-time meetings on the map (figure 2). As expected, most of the meetings occur in the central tracts and the part of downtown that is near the residential areas of both language groups. This is because Tallinn, as a typical European city, is centered on a dense and vibrant downtown, which serves both as the central business district and as the main focal point for cultural activities and entertainment, irrespective of language spoken.

[10] These figures are based on "presence," counting the number of timeframes with call activities by both Estonian- and Russian-speaking individuals throughout the whole year in the city tracts. This method also allows us to asses evenness in free-time place in a similar way. The approach commonly found in the literature, namely calculating the indices based on data about home and workplace, produces rather similar numbers: $D^R = 0.32$ and $D^W = 0.34$. All these figures include activities only inside the municipality of Tallinn.



(a) Presence (arbitrary scale)

(b) ET-RU copresence

Figure 2: Free-time distribution (upper panel) and interethnic copresence (lower panel) by city tract

6.3 How is Homophily in Different Locations Related? Regression Approach

In the previous section we described the marginal homophily distributions for the three locations (R, W and F), disregarding their possible interdependence. Those results indicated a rather different distribution for F-homophily compared to R- and W-homophily. To clarify the picture further, we perform a regression analysis in order to determine whether there is a potentially more complex relationship between these homophily dimensions when controlling for individual background characteristics. We are mainly interested in the effect of R-homophily and W-homophily on F-homophily, at both the micro and the macro level (i.e., parameters α_1 and α_2 in equations 3a and 3b).

The estimates are given in Table 2. The table is split into three pairs of columns containing a different specification each for both Estonian speakers and Russian speakers. As explained above, we choose to measure the F-homophily as a percentage, whereas both the R-homophily and the W-homophily are normalized. Hence the corresponding coefficients should be interpreted as the effect in percentage points per standard deviation of change. From the table we see that both home- and work-tract average segregation ($\bar{h}^R$, and $\bar{h}^W$) are in fact significantly related to F-homophily in all three specifications. The same is true for the individual deviation from the tract average, ϱ. The estimates of individual deviation in work tract, ω, are smaller and not significant in two of the three specifications. All these estimates are fairly stable across the specifications and similar for both Estonian and Russian speakers. However, the effects are small, as also suggested by the previous descriptive analysis. An increase of one standard deviation in R-homophily is related to an increase in F-homophily of no more than 2.2 percentage points (the coefficient for $\bar{h}^R$ for Russian speakers, specification 2). The fixed effect estimates (specification 3) show results that are almost identical to those of specification 1, indicating that the linear impact in regression model (3a) is indeed a good approximation.

The results thus confirm that R-homophily and W-homophily have limited influence on F-homophily. For instance, if we increase the isolation by one standard deviation, both in the residential and in the work location, the corresponding F-homophily increases by about 3 percentage points (for both Estonian and Russian speakers). Despite the high levels of statistical significance, these figures are unlikely to possess much social meaning.

In specification 2, we also introduce a number of additional explanatory variables in order to control for the demographic and social composition of the sample population. All of these estimates remain small (although statistically significant in a number of cases), and do not exceed that of the most important explanatory homophily variable ($\bar{h}^R$). In Appendix B we also present results for a more flexible specification, where we allow the individual background characteristics to moderate the homophily relationship. Most of the cross-effects are not statistically significant. It gives some evidence, though, that more frequent cellphone usage is associated with a weaker role of R-homophily, suggesting that more active mobile users are somewhat less constrained by their neighborhood of residence. These results are also robust with respect to uneven tract sizes (note that fixed-effect specification 3 implicitly controls for tract size).

In other words, common variables that characterize population composition have relatively little influence on shaping the potential to meet members of the

Table 2: Regression estimates of F-homophily

specification	1		2		3	
	Estonian	Russian	Estonian	Russian	Estonian	Russian
Dependent variable: h^F						
$\bar{h}^R$	1.533***	2.118***	1.666***	2.158***		
	0.392	*0.570*	*0.132*	*0.176*		
ρ	0.494***	0.323***	0.538***	0.374**	0.595***	0.333
	0.128	*0.081*	*0.154*	*0.150*	*0.143*	*0.228*
$\bar{h}^W$	0.875***	0.939***	0.861***	1.101***		
	0.117	*0.096*	*0.099*	*0.103*		
ω	0.163	-0.014	0.186	0.160	0.179*	0.213*
	0.160	*0.151*	*0.138*	*0.104*	*0.096*	*0.113*
male			-1.371***	0.589**	-1.345***	0.517**
			0.259	*0.254*	*0.226*	*0.248*
age <20			0.154	-1.876*	0.012	-1.809**
			0.725	*0.959*	*0.729*	*0.860*
age 20–29			0.784***	0.487	0.787***	0.028
			0.260	*0.329*	*0.214*	*0.319*
age 55+			-0.400	-0.393	-0.502*	-0.553**
			0.314	*0.304*	*0.258*	*0.219*
usage quintile 2			-0.488	0.187	-0.373	0.190
			0.417	*0.356*	*0.377*	*0.481*
usage quintile 3			-0.485	0.281	-0.387	0.374
			0.437	*0.424*	*0.418*	*0.415*
usage quintile 4			-0.941**	-0.033	-0.741*	-0.217
			0.389	*0.426*	*0.402*	*0.486*
usage quintile 5			-1.386***	0.359	-1.119***	0.014
			0.410	*0.407*	*0.363*	*0.320*
constant	√	√	√	√	√	√
R fix. ef.					√	√
W fix. ef.					√	√

Notes: standard errors are clustered across work and home tracts
Explanatory homophily measures ($\bar{h}^R_R$, ρ, $\bar{h}^W_W$ and ω) are standardized, h^F is expressed in percent.
*: P < 0.1
**: P < 0.05
***: P < 0.01

other ethnic group in the city. Our main results help us to understand one facet of urban ethnic geography more clearly–the probability of meeting other ethnic groups is high during free-time activities, and this appears to be true for all contexts in which people live or work, and across all observed sociodemographic characteristics.

7 Discussion and Concluding Remarks

The analysis presented here provides a clear and unambiguous picture of the extent of ethnic segregation in Tallinn. While residential (home) and work locations are fairly segregated, places where free-time activities take place are not. For various reasons, people of different ethnic origin are living and working largely in separate neighborhoods in the city. However, when they are neither at home nor at work, these individuals have a good chance of meeting each other, typically in the central districts of the city. Moreover, mixing in free-time is not conditional in any important way on the main sociodemographic characteristics. This outcome strongly suggests that spatial segregation may be a considerably smaller problem than suggested by residence-only or workplace-only data.

Also, having less economic resources, as suggested by the ethnic marginality theory (Washburne, 1978; Johnson, Bowker, English, and Worthen, 1998), or having a cultural preference for spending free time with coethnics, as suggested by the ethnicity theory (Allison, 1988; Floyd and Shinew, 1999) does not help to explain the empirical evidence on the elevated copresence of different ethnic groups during free time. So, what are the mechanisms which lead to free-time integration while both the residential and workplace neighborhoods remain segregated? One possible explanation may be related to city size. Previous studies have shown that residential segregation patterns do systematically vary with city size, with large cities being more segregated than smaller ones (Farley, 1991). Tallinn is of course rather small (400 000 inhabitants). However, both Tallinn and its transportation networks are geographically stretched due to geographic conditions, which has resulted in there being relatively large distances between many of the neighborhoods within the city. Figure 2 indicates that freetime meetings between ethnic groups largely occur in downtown Tallinn, implying that certain characteristics of the inner city attract people irrespective of their ethnic background. Although several neighborhood service centers exist in Tallinn, the free-time distribution of people indicates that the strong and well-developed downtown where the historical core is mingled with new central business district provides the preferred mix of various amenities and services. This centrality is also enhanced by the concentration of transportation networks in the city center. This enables people from all the various residential and workplace neighborhoods to access this shared consumption space, providing an important meeting place for everyone, irrespective of ethnic background. Unlike the cities in North America, the existence of a strong city center is very common in European cities.

Our results have important policy implications. First, a large number of studies, conducted since Allport (1954) proposed the influential contact theory, indicate that intergroup contacts indeed reduce prejudices under suitable conditions (Pettigrew and Tropp, 2008). It is possible that even superficial everyday meetings in public space are sufficient to lessen the interethnic or interracial divide that hampers the creation of social capital and trust (see Peters and de Haan, 2011). Moreover, the observed free-time copresence may also reflect the type of repeated and extensive contacts that can actually lead to the dismantling of interethnic barriers according to contact theory. The importance of leisure time activities is on the rise in contemporary societies, and combined with universal consumption behavior, this may also increase the number of closer relationships established through free-time activities (Ellis, Holloway, Wright, and Fowler, 2012). While programs that attempt to improve the conditions of the poor by relocation into more affluent neighborhoods, such Moving to Opportunity in Boston during 1990s, tend to show a rather weak effect, one may alternatively envision policies that directly target the environment or social institutions where interethnic contact occurs.

The second policy implication concerns the urban socio-spatial structure. If our interpretation regarding the role of a strong and diverse inner city is correct, it implies the need for stricter policies to counter urban sprawl and sociospatial fragmentation, two powerful processes in contemporary urban areas. These have traditionally been considered a major problem mainly from the environmental perspective. Possibly, spatial policies that strengthen city centers and counter urban sprawl could also counter social fragmentation and increase the opportunities to meet others with different socioeconomic background and trigger social integration in contemporary multiethnic and highly urbanized societies. This hypothesis needs to be tested in different urban contexts.

A City Tracts

Table 3 presents the population (N) and percentage of Russian speakers by city tract. We only include those who report their first language to be either Estonian or Russian or Ukrainian (counted as Russian speakers in this table). This leaves out about 20 000 inhabitants (5% of the total); the population of Tallinn was 400 378 in 2000.

Table 3: Number of inhabitants and percentage of Russian speakers by city tract.

Tract	N	percentage
Tiskre - Kakumäe - Haabersti	1 684	16.45
Mõigu	328	11.28
Väike-Õismäe - Astangu	31 124	52.18
Pelgulinn - Mustjõe	9 155	26.37
Pelguranna - Sitsi	24 312	67.49
Nõmme (Laagri - Pääsküla - Kivimäe)	15 285	14.56
Nõmme (Hiiu - Nõmme)	10 542	7.58
Mustamäe	60 575	40.71
Lilleküla	27 625	29.07
Järve - Tondi - Kitseküla	11 412	36.42
Nõmme (Männiku - Rahumäe)	11 110	29.63
Balti jaam	3 462	34.60
Vanalinn	1 957	16.45
Kesklinn	17 719	33.61
Juhkentali	5 587	35.49
Sadama	3 446	37.72
Kadriorg	7 577	23.29
Pirita	8 809	28.88
Lasnamäe (Mustakivi - Seli)	46 385	68.48
Lasnamäe tööstus (Ülemiste - Sõjamäe - Väo)	2 326	75.37
Lasnamäe (Laagna)	31 486	59.19
Lasnamäe (Sikupilli - Pae)	27 520	71.07
Kalamaja - Karjamaa	10 721	46.81
Kopli - Paljassaare	7 927	68.01
Veerenni	2 119	32.00
Total	380 193	46.00

B Heterogeneous Effects

Here, we analyze whether the interrelationship between R, W and F differs between socio-demographic groups. We amend the baseline regression specification (3a) by additional cross-effects between the homophily descriptors and individual background variables. To simplify the interpretation of the results, we introduce age and usage quintiles in linear form. The results are shown in Table 4.

Table 4: Model 2, allowing for the effect heterogeneity across gender, age, and call activity.

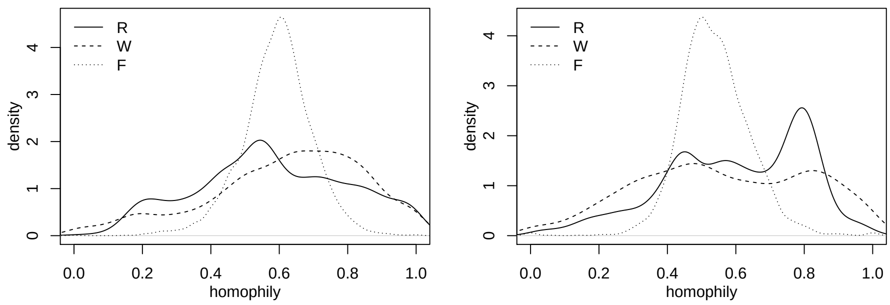
	Estonian		Russian	
Dependent variable: h^F				
constant	59.288	*0.244******	48.901	*0.438******
$\bar{h}_R^R$	2.060	*0.323******	2.778	*0.497******
ρ	0.238	*0.423*	0.749	*0.464*
$\bar{h}_W^W$	1.129	*0.258******	1.133	*0.293******
ω	0.096	*0.419*	-0.057	*0.288*
male	-1.426	*0.247******	0.636	*0.255*****
age	-0.249	*0.082******	-0.161	*0.086****
usage quintile	-0.329	*0.075******	0.048	*0.102*
$\bar{h}_R^R\times$male	0.164	*0.261*	0.106	*0.324*
$\bar{h}_R^R\times$age	0.047	*0.117*	-0.157	*0.051******
$\bar{h}_R^R\times$usage quintile	-0.157	*0.071*****	-0.205	*0.090*****
$\rho\times$male	0.277	*0.292*	-0.179	*0.242*
$\rho\times$age	-0.248	*0.116*****	-0.050	*0.109*
$\rho\times$usage quintile	0.074	*0.122*	-0.091	*0.117*
$\bar{h}_W^W\times$male	-0.107	*0.282*	-0.261	*0.286*
$\bar{h}_W^W\times$age	0.072	*0.083*	0.088	*0.098*
$\bar{h}_W^W\times$usage quintile	-0.092	*0.076*	0.015	*0.104*
$\omega\times$male	0.058	*0.268*	-0.397	*0.236****
$\omega\times$age	0.003	*0.107*	0.170	*0.096****
$\omega\times$usage quintile	0.025	*0.092*	0.153	*0.069*****
# obs	1996		1670	
R^2	0.2022		0.2156	

Note: standard errors (in italics) are clustered across home and work regions. *age* is introduced as (age in years − 40)/10.

C Robustness Analysis

In this section we repeat the analysis of Section 6 using a finer-grained resolution and show that the main results remain mostly unaffected. We choose the highest spatial resolution we have access to, that of the network cells. We also substantially shorten the temporal span of the timeframe, down to one hour. These adjustments radically lower the amount of copresence we observe in our data because the chances of being together in the same network cell in a one-hour time span are much lower than in a city tract over a period of three hours. However, we still define the home and work locations as corresponding city tracts in order to prevent activities just outside of the home cell from being treated as belonging to free-time or work.

First, we present the density estimates (Figure 3) which are analogous to those in Figure 1. We can easily see that, as in the main analysis above, the home and workplace homophily distribution is spread out much more widely than that of free-time. Note also that, because the number of observations in each cell is small compared to that in the city tracts, overall we see more spread along the horizontal axis. However, the main conclusion remains the same: during free-time activities, people act in an ethnically rather balanced environment. The corresponding dissimilarity indices are $D^R = 0.41$, $D^W = 0.46$ and $D^F = 0.24$ suggesting that the workplace is slightly more segregated than the place of residence, while spatial segregation outside of both of these locations is much lower. As expected, at the lower level of aggregation the spatial distributions of the language groups are less similar, especially at the place of work.



(a) Estonian (b) Russian

Figure 3: Kernel density estimates of homophily distribution in R, W and F for Estonian- and Russian-speaking groups.

Next, we repeat the regression analysis of section 6.3. The results are given in Table 5. For brevity, we only list the estimates of homophily-related coefficients, using variables standardized in a similar way as in the baseline analysis. The table indicates that the coefficients are up to twice as large as in the case of city tracts. However, numerically, the figures are still small. For instance, were we to increase the homophily by one standard error both in the cell of residence and the cell of work, the corresponding F-homophily would only grow by about 4–5 percentage points. This figure is probably too small to carry much social meaning. However, the larger estimates at a finer-grained level make it tempting to claim that the city may be even more segregated at an even smaller spatial

Table 5: Regression estimates of F-homophily

	1		2		3	
	Estonian	Russian	Estonian	Russian	Estonian	Russian
Dependent variable: h^F						
$\bar{h}_R^R$	2.854***	2.871***	2.999***	2.901***		
	0.256	*0.343*	*0.207*	*0.217*		
ρ	0.495***	0.359**	0.448***	0.229	0.639**	0.588**
	0.154	*0.176*	*0.172*	*0.209*	*0.268*	*0.263*
$\bar{h}_W^W$	1.742***	1.551***	1.660***	1.669***		
	0.199	*0.197*	*0.212*	*0.237*		
ω	0.222	0.458***	0.030	0.261	0.195	0.324
	0.181	*0.173*	*0.228*	*0.195*	*0.237*	*0.219*
# obs	2575	2214	1947	1648	2575	2214
R^2	0.1474	0.1465	0.1729	0.1592	0.5886	0.5835
constant	√	√	√	√	√	√
indiv charact.			√	√		
R fix. ef.					√	√
W fix. ef.					√	√

Note: standard errors are clustered across work and home regions.

level. Unfortunately, the current data do not allow us to assess this claim. Note also that network cells are already substantially smaller than typical census tracts.

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