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Thesis Preparation
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September 30, 2022

Annotated Bibliography –

The activity space approach is being increasingly utilized in spatial segregation research to broaden the scope of research away from residential neighborhoods and into other socio-spatial contexts. Socio-spatial contexts are defined as environments where individuals or groups live their everyday lives. Given that residential spaces are not the only contexts that people exist in, and that significant amount of time is spent outside of residential spaces in what are defined as activity spaces it is important to understand how segregation manifests. This annotate bibliography will refer to research that has captured segregation beyond residential neighborhoods, across individuals, multiple activity locations, and mobility broadly as activity space segregation.

A review of activity space segregation research identifies approaches, methods, and data sources that can be applied to conducting this form of research. Initial review has highlighted that the activity space approach allows for segregation to be studied from the perspective of people, places, and mobility flows. It has also illustrated that traditional data sources and novel data sources – such as social media – are valuable to this form of research. Additionally, review has highlighted a three-step methodology for analysis that should be replicated in future research.
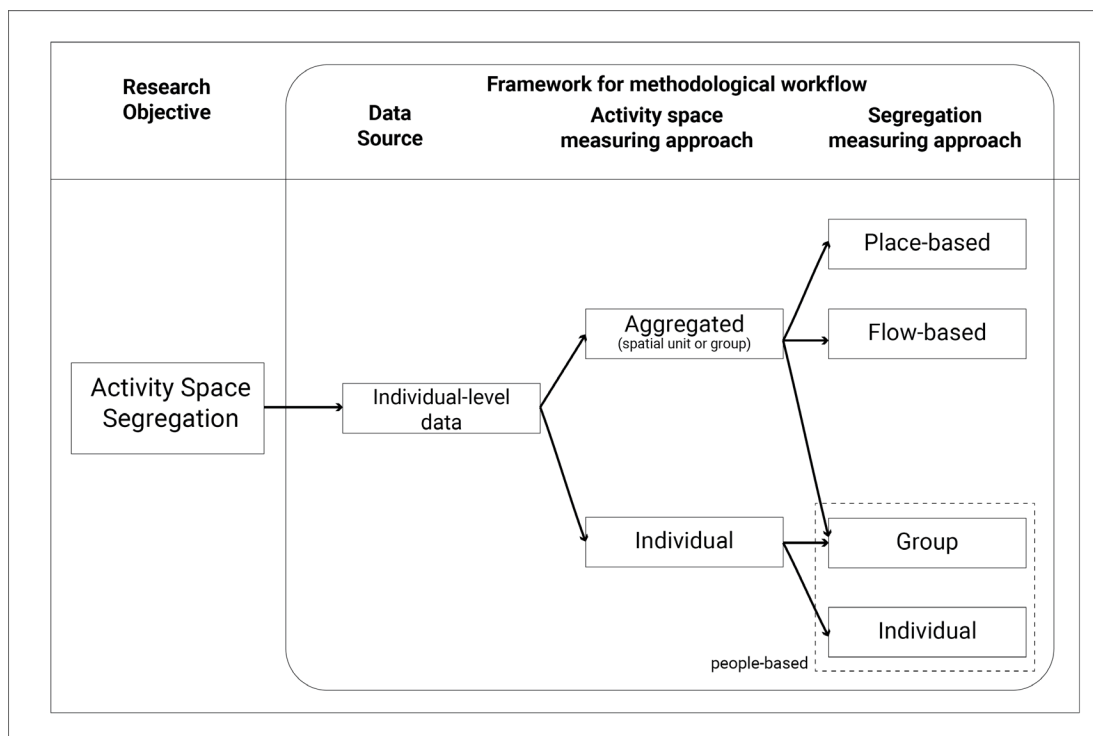
As stated earlier, preliminary review has identified that activity space segregation can be studied from the perspective of people, places, and mobility flows. *This research addresses the question of whether tract-based isolation indices suggest less or greater isolation than those based on transit route service areas.* I will examine isolation in terms of race, poverty, and nativity. Geography of analysis will be defined by placing half-mile walkshed around bus lines. Analysis of these transit service areas address one slice of what is defined as activity space. Analysis will be conducted in the largest cities in each Census Bureau Division. Further review of existing research will help to narrow how isolation indices will be calculated.

Initial hypothesis: tract-based isolation indices will suggest greater isolation than those within the established transit route service areas.

This realm of research must work to turn abstract concepts into measurable observations. Throughout this review it will become apparent that there are several methods and measures that have been proposed, tested, and developed. A review of the effectiveness of these strategies would be beneficial, however, that is beyond the scope of this work.

It is important that future research should ensure that activity space segregation research contains strong links to segregation theory. In future research there are three central perspectives that can be addressed when examining segregation – place, people, and movement flows. Central questions to address these themes are – "how segregated are neighborhoods?", "how segregated are individuals activity spaces?", and "how segregated are mobility flow patterns between activity locations?" Future research should bring place- and people-based methods together as well as flow-based perspectives, which has received minimal attention. This thesis will tackle segregation across place and movement flows, which among other things reflects and reinforces mobility injustice.

Context:

Golledge, R. G., and Stimson, R. J. (1997). *Spatial Behavior: A Geographic Perspective.* New York, NY: Guilford Press.

Palmer, J. R. B. (2013). *Activity-Space Segregation: Understanding Social Divisions in Space and Time*. PhD Dissertation. Princeton, NJ: Princeton University.

Wong, D. W. S., and Shaw, S.-L. (2011). Measuring segregation: an activity space approach. *J. Geogr. Syst.* 13, 127–145. doi: 10.1007/s10109-010-0112-x

Yao, J., Wong, D. W. S., Bailey, N., and Minton, J. (2019). Spatial segregation measures: a methodological review. *Tijdsch. Voor Econ. Soc. Geogr.* 110, 235–250. doi: 10.1111/tesg.12305

The activity space approach to segregation (Wong and Shaw, 2011; Palmer, 2013) that builds on the concept of activity spaces (Golledge and Stimson, 1997) proposes that segregation is produced and reproduced across all locations that a person visits and routes and areas the person travels through. This highlights the importance of both activity locations and spatial mobility in shaping people's segregation experiences. Mobility is crucial for understanding the intersection between segregation in residential neighborhoods, schools, workplaces, and leisure time.

Preliminary literature review has underscored two key concepts: segregation and activity space. Segregation is defined as spatially uneven distributions and relationships – spatial arrangements and patterning and/or spatial interactions – between people belonging to different populations (Yao et al., 2019). Activity spaces are defined with reference to Golledge and Stimson (1997) as geographic space that captures an individual's activity locations and mobility over a period of time.

Data Sources & Social Dimension:

Jones, M., and Pebley, A. R. (2014). Redefining neighborhoods using common destinations: social characteristics of activity spaces and home census tracts compared. *Demography* 51, 727–752. doi: 10.1007/s13524-014-0283-z

Li, F., and Wang, D. (2017). Measuring urban segregation based on individuals' daily activity patterns: a multidimensional approach. *Environ. Plan. A* 49, 467–486. doi: 10.1177/0308518X16673213

Scheiner, J. (2000). Activity spaces in the Western and Eastern part of Berlin: Socio-spatial integration or ongoing division? *Die Erde* 131, 143–160.

Silm, S., Ahas, R., and Mooses, V. (2018). Are younger age groups less segregated? Measuring ethnic segregation in activity spaces using mobile phone data. *J. Ethnic Migr. Stud.* 44, 1797–1817. doi: 10.1080/1369183X.2017.1400425

Wang, D., Li, F., and Chai, Y. (2012). Activity spaces and sociospatial segregation in Beijing. *Urban Geogr.* 33, 256–277. doi: 10.2747/0272-3638.33.2.256

Wang, Q., Phillips, N. E., Small, M. L., and Sampson, R. J. (2018). Urban mobility and neighborhood isolation in America's 50 largest cities. *Proc. Nat. Acad. Sci.* 115, 7735–7740. doi: 10.1073/pnas.1802537115

Research on activity space segregation is relatively young compared to the longer history of residential segregation, meaning research in this field has developed in tandem with the accessibility of big data sources and can include big data to supplement traditional data (Wang et al., 2018). Activity research have used various data sources to analyze individuals' mobility and activity locations quantitatively. Early studies relied on small-scale surveys of self-reported

data or automatically collected data. (Scheiner, 2000). Activity space segregation studies incorporate other quantitative data to contextualize location data, such census data to obtain specific characteristics to examine individuals' exposure to different socio-economic contexts (Jones and Pebley, 2014; Li and Wang, 2017).

Activity space segregation studies, like residential segregation research, focus mainly on socioeconomic, and ethnic, racial, etc., data. Most studies have taken the perspective of one social dimension. Lessons can be learned from international study design and contexts. In China, studies focused on income groups (Zhou et al., 2015), and people that reside in a range of housing types (Li and Wang, 2017) or neighborhoods (Wang et al., 2012). Some studies have formed population groups by intersecting background characteristics age and language (Silm et al., 2018), and race and income level (Wang et al., 2018).

Measurement of Activity Spaces:

Lathia, N., Quercia, D., and Crowcroft, J. (2012). "The hidden image of the city: sensing community well-being from urban mobility," in *Pervasive Computing, Volume 7319*, eds J. Kay, P. Lukowicz, H. Tokuda, P. Olivier, and A. Krüger (Berlin: Springer), 91–98.

Li, F., and Wang, D. (2017). Measuring urban segregation based on individuals' daily activity patterns: a multidimensional approach. *Environ. Plan. A* 49, 467–486. doi: 10.1177/0308518X16673213

Mooses, V., Silm, S., and Ahas, R. (2016). Ethnic segregation during public and national holidays: a study using mobile phone data. *Geografiska Ann. Ser. B Human Geogr.* 98, 205–219. doi: 10.1111/geob.12100

Netto, V. M., Meirelles, J. V., Pinheiro, M., and Lorea, H. (2018). A temporal geography of encounters. *Cybergeo* 43, 28985. doi: 10.4000/cybergeo.28985

Schnell, I., Diab, A. A. B., and Benenson, I. (2015). A global index for measuring socio-spatial segregation versus integration. *Appl. Geogr.* 58, 179–188. doi: 10.1016/j.apgeog.2015.01.008

Silm, S., Ahas, R., and Mooses, V. (2018). Are younger age groups less segregated? Measuring ethnic segregation in activity spaces using mobile phone data. *J. Ethnic Migr. Stud.* 44, 1797–1817. doi: 10.1080/1369183X.2017.1400425

Wang, D., and Li, F. (2016). Daily activity space and exposure: a comparative study of Hong Kong's public and private housing residents' segregation in daily life. *Cities* 59, 148–155. doi: 10.1016/j.cities.2015.09.010

Activity spaces are calculated at the individual level or the aggregate level – measured by social group, spatial unit, or flows between locations. Schnell et al. (2015) and Li and Wang (2017)

measured activity spaces solely at the individual level, while Wang and Li (2016) and Silm et al. (2018) examine activity spaces at both the individual and the aggregate level. In terms of aggregate level activity space measure, which appears to be the most salient methodology will for this this thesis, two metrics stand out. Locations visited were aggregated to predefined spatial units such as municipalities or districts within a city (Mooses et al., 2016), or census areas (Lathia et al., 2012). Furthermore, movement of people between activity locations was aggregated to a physical network (Netto et al., 2018) or to an origin-destination matrix (Shen, 2019). Aggregation to spatial units often will utilize big data sources, and aggregation to movement flows often relies on census data or other statistical data.

Segregation Measurement:

Farber, S., O'Kelly, M., Miller, H. J., and Neutens, T. (2015). Measuring segregation using patterns of daily travel behavior: a social interaction based model of exposure. *J. Transp. Geogr.* 49, 26–38. doi: 10.1016/j.jtrangeo.2015.10.009

Greenberg Raanan, M., and Shoval, N. (2014). Mental maps compared to actual spatial behavior using GPS data: a new method for investigating segregation in cities. *Cities* 36, 28–40. doi: 10.1016/j.cities.2013.09.003

Järv, O., Müürisepp, K., Ahas, R., Derudder, B., and Witlox, F. (2015). Ethnic differences in activity spaces as a characteristic of segregation: a study based on mobile phone usage in Tallinn, Estonia. *Urban Stud.* 52, 2680–2698. doi: 10.1177/0042098014550459

Li, F., and Wang, D. (2017). Measuring urban segregation based on individuals' daily activity patterns: a multidimensional approach. *Environ. Plan. A* 49, 467–486. doi: 10.1177/0308518X16673213

Östh, J., Shuttleworth, I., and Niedomysl, T. (2018). Spatial and temporal patterns of economic segregation in Sweden's metropolitan areas: a mobility approach. *Environ. Plan. A Econ. Space* 50, 809–825. doi: 10.1177/0308518X18763167

Schnell, I., and Yoav, B. (2001). The sociospatial isolation of agents in everyday life spaces as an aspect of segregation. *Ann. Assoc. Am. Geogr.* 91, 622–636. doi: 10.1111/0004-5608.00262

Shen, Y. (2019). Segregation through space: a scope of the flow-based spatial interaction model. *J. Transp. Geogr.* 76, 10–23. doi: 10.1016/j.jtrangeo.2019.02.007

Silm, S., Ahas, R., and Mooses, V. (2018). Are younger age groups less segregated? Measuring ethnic segregation in activity spaces using mobile phone data. *J. Ethnic Migr. Stud.* 44, 1797–1817. doi: 10.1080/1369183X.2017.1400425

Wong, D. W. S., and Shaw, S.-L. (2011). Measuring segregation: an activity space approach. *J. Geogr. Syst.* 13, 127–145. doi: 10.1007/s10109-010-0112-x

Activity space segregation can be calculated for a spatial unit (place-based), a movement flow (flow-based), an individual's or group's activity space (people-based), or a mixed approach (combined measure). One methodology is to calculated individual-level segregation indices (Schell, 2001), some researchers used statistical regression measurements (Li and Wang, 2017), and others apply a geovisual map comparison method (Greenberg, Raanan, and Shoval, 2014). Researchers will often aggregate data on individual activity spaces into predefined spatial units. One strategy identified is to calculate a dissimilarity index based on the distribution of activity locations across study districts (Silm et al., 2018), others will apply a social interaction potential metric to identify and map spatial patterns in social contact opportunities (Farber et al., 2015), and some will used a co-presence metric to examine and compare exposure to poverty and wealth in different urban areas at different times (Östh et al., 2018).

One study used a flow-based segregation metric, where a segregation indicator was calculated for each movement flow between two spatial units (Shen, 2019), while others employ a combination of people-based and place-based, and flow-based and place-based approaches (Jarv et al., 2015; Wong and Shaw, 2011). Further methodological review of each of the methods identified will reveal which method or mix of methods should be used for this thesis.