Chapter 4
Beyond Space (As We Knew It): Toward Temporally Integrated Geographies of Segregation, Health, and Accessibility

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4.1 Introduction

Geographers and scholars in cognate disciplines have long recognized the importance of time and mobility for understanding a wide range of human experiences (e.g., de Certeau 1984; Giddens 1986; Rowe and Wolch 1990; Valentine 1993; Chai et al. 2002; Lefebvre 2004; Cresswell 2006; Urry 2007). Yet many notions in geographic and social science research still tend to be conceptualized largely in static spatial terms, ignoring how our understanding of the issues we study can be greatly enriched through the lenses of time and human mobility. For instance, accessibility still tends to be understood largely in spatial terms (e.g., in terms of the distance or travel cost between facilities and the people they serve). Past research also tends to ignore various facets of time – such as rhythm, duration, and subjective experiences of time – that shape people's spatiotemporal experiences of marginalization, discrimination, and social isolation (however, see May and Thrift 2001; Valentine 2008; Dijst 2009; McQuoid and Dijst 2012; Merriman 2012; Schwanen and Kwan 2012; Schwanen et al. 2012; Rogaly and Thieme 2012; Valentine and Sadgrove 2012).

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As recent research suggests, three geographic notions conceived largely in static spatial terms to date will benefit enormously from integrating time as a critical dimension (e.g., Delafontaine et al. 2011; Kwan 2012b). These three notions are racial and ethnic segregation, environmental exposure, and accessibility. They together address a wide range of social issues of interest to geographers and social scientists (e.g., social inequality, social isolation, environmental justice, environmental health, and access to social services and health care facilities). This article revisits these notions and argues that expanding our analytical focus beyond space to include time and human mobility will considerably enrich our understanding of how individuals of different social groups experience racial and ethnic segregation, exposure to environmental influences, and access to social facilities. For instance, although racial segregation is conceived as the extent to which members of one racial group live apart from those of other racial groups, people's segregation experiences are also affected by how much time they spend in areas outside of their residential neighborhoods and how much social contact they have with other racial groups there (Ellis et al. 2004; Wong and Shaw 2011). Examining segregation, environmental exposure, and accessibility in terms of residential space or location alone will only yield a partial understanding of human spatiotemporal experiences.

This article elucidates how temporally integrated geographies of segregation, environmental health, and accessibility can shed new light on many issues geographers and social scientists have been examining for decades. It suggests that new insights can be gained when commonly used spatial concepts take into account human mobility and incorporate various facets of time as integral elements. Informed by recent work on human mobility and geographies of encounter (e.g., Sheller and Urry 2006; Valentine 2008; Adey 2010), the article emphasizes that people's spatiotemporal experiences are influenced not only by where they live but also by other places they visit, when they visit these places, how much time they spend there, what they experience as they travel between these places, and who they interact with while at those places. It argues that by going beyond static residential space and examining how individuals reach relevant social opportunities or come into contact with other people or social/environmental influences as their lives unfold over space and time, our understanding of the effects of social difference on racial/ethnic segregation, health outcomes, quality of life, and many other critical social issues will be deeply enriched.

4.2 Racial and Ethnic Segregation

Geographers and social scientists have examined racial/ethnic segregation, social exclusion, and social isolation for decades (e.g., Massey and Denton 1988; Wong 1993; Darden and Kamel 2000; Schnell and Yoav 2001). Research on the segregation of different racial or ethnic groups in urban areas have been conducted largely with a focus on people's residential location (e.g., Brown and Chung 2006; Johnston et al. 2007). In these studies, segregation was examined in terms of the extent to

which members of different racial or ethnic groups live apart from each other (Ellis et al. 2004). Based on the geographic clustering or concentration of different racial groups and using census data to compute summary measures of segregation, these studies examined segregation at various spatial scales based on static population distribution in the residential space (Wong and Shaw 2011).

Yet people experience segregation or social exclusion not only in their residential neighborhoods but also in other spaces as their daily lives unfold, including their workplaces and sites for social and recreational activities (Lee et al. 2008; Skans and Åslund 2010; Lee and Kwan 2011; McQuoid and Dijst 2012; Schwanen et al. 2012; Wang et al. 2012; Palmer 2013). Ignoring the time people spend outside of their residential neighborhoods and their interactions with other social groups there omits a considerable part of their everyday experiences, which may reinforce or mitigate the segregation they experience in their residential spaces and lead to erroneous conclusions about their overall segregation experiences (Wong and Shaw 2011; Jones and Pebley 2014; Kwan 2012b; Palmer et al. 2013; Krivo et al. 2013). It can also create a misleading impression of a city's racialized spaces as fixed (Kwan 2002; Ellis, Wright and Parks 2004). Considering people's daily mobility and including other spaces (e.g., school, work, or leisure spaces) in segregation studies will allow us to more accurately assess people's experience of segregation (Wong and Shaw 2011).[1]

Further, examining segregation or social isolation based on where individuals of different racial groups live ignores how the presence of others who work or undertake other activities in those residential neighborhoods influence people's segregation experience (Ellis et al. 2004; Jones and Pebley 2014). For instance, the study by Ellis et al. (2004) on the Los Angeles metropolitan area observed that segregation examined by work locations is considerably lower than by residential neighborhoods, indicating that there may be more intergroup interaction during working hours than at home. But the picture seems much more complex when other activity spaces are included, as indicated by two recent studies using the Los Angeles Family and Neighborhood Survey (L.A. FANS) dataset. Jones and Pebley (2014), for instance, found that most people experience substantial racial segregation across the range of spaces in their daily lives, not just in their residential neighborhoods (e.g., both Latinos and African Americans have activity spaces with relatively low proportion of whites). Considering a range of neighborhoods where individuals undertake their daily routines (e.g., shopping, working, seeing a

[1]However, it is important to note that living or working in less segregated environments (e.g., racially mixed residential neighborhoods, workplaces or schools) do not necessarily mean higher exposure to social advantage or more positive experience for racial minorities. As many past studies have shown, it may instead mean more intense exposure to racism and various intersectional discriminatory practices or oppressive encounters (e.g., Tatum 1987, 1997; Lim and Herrera-Sobek 2000; Li and Beckett 2006; Valentine 2007, 2010). To fully understand people's spatiotemporal experiences of marginalization, discrimination and social isolation, we need to go beyond spatial proximity of social groups to examine how oppressive power relations pervade micro spaces (and times) of everyday encounters.

doctor), Krivo et al. (2013) observed that African Americans and Latinos experience additional penalties in social isolation in where they conduct routine activities and in association with their movement in the city when compared to Whites who live in economically similar neighborhoods. These studies clearly showed that focusing only on the time people spend at home or in their residential neighborhoods can lead to misleading results.

Interestingly, urban studies scholars Atkinson and Flint (2004, 876) have provided some of the earliest arguments for expanding the focus of segregation studies to a greater consideration of "the dynamic flows of everyday life both within and outside the field of residential interaction and lived experience." They suggested that segregation needs to be considered with regard to both how people's everyday lives unfold dynamically over time (daily dynamism) and their static residential manifestations. While their study focused on how gated communities represent spaces of self-exclusion created for avoiding unwanted social contact by "elite" social groups, they argued that each of these spaces segregates its occupants from social contact with different social groups through what they called "time-space trajectories of segregation" (Atkinson and Flint 2004, 877).

Recent studies strongly corroborate this insight and the need for new perspectives on racial segregation that take time and the dynamic flows of everyday life into account. With a focus on where, when and with whom people spend their time, Lee and Kwan (2011) showed that the spatiotemporal experiences of social isolation of Korean immigrants in the U.S. can be effectively revealed through examining their daily space-time trajectories and patterns of social contacts in space-time. In another study, Wang et al. (2012) observed sociospatial segregation among residents of different types of neighborhoods in Beijing, China based on the spatiotemporal configuration of their activity spaces. Using GPS and cell phone data to examine where subjects spend time and how they move around, Palmer et al. (2013) found that for a quarter of the participants, exposures to whites when they are in and outside their residential neighborhoods are different (higher for white participants but lower for blacks and Latinos). The study concludes that time spent outside the residential neighborhood can either attenuate or intensify segregation, depending on the social group one is examining. These studies cogently illuminate the need for going beyond people's residential spaces (and times) in research on racial/ethnic segregation or social exclusion to consider how and where different social groups spend their time in their daily lives.

4.3 Environmental Exposure and Geographic Context

Geographic context is an important notion in environmental health and neighborhood effects research (e.g., Kawachi and Berkman 2003; Diez Roux and Mair 2010). It is the conceptual foundation of various methods for assessing people's exposure to contextual or environmental influences. An essential task in this kind of studies is to identify the appropriate geographic area or contextual unit for

deriving exposure measures. Exposure measures in most studies to date, however, tend to ignore the critical role of time and human mobility in people's exposures to contextual or environmental influences (Kwan 2012a, b).[2] They are largely based on notions of context, neighborhood or place that conceive them as static administrative areas, often operationalized as the home census tract or block group (or other homogeneous zones constructed based on census units). These conventional notions assume that the residential neighborhood is the most relevant area affecting health outcomes or environmental exposures and neighborhood effects operate only through interactions among those who live in the same residential area.

Although these conventional exposure measures are widely used, their static conceptualizations of geographic context and ignorance of time is problematic in several respects. First, most people move around to undertake their daily activities and rarely stay at only one place (e.g., home) throughout the day. They often traverse the boundaries of several neighborhoods in the course of a day and come under the influence of many different neighborhood contexts outside of their home neighborhoods (Matthews 2008, 2011; Kwan 2009, 2012a, b). Much of the contextual or environmental influence they experience and most of the physical and social resources they utilize may be located outside or far from their home neighborhoods (Matthews et al. 2005). Residential location is thus only one of the places where people spend their time. The residential neighborhood may not include many of their daily activity locations. Recent studies that collected GPS data from participants have repeatedly shown that people spend a considerable amount of time in their daily lives outside of what has conventionally been defined as geographic context or neighborhood (e.g., Wiehe et al. 2008; Basta et al. 2010; Palmer et al. 2013).

Further, besides moving around to undertake their daily activities, people also move around over time. They may change their residence in the same city or move to another. As a result, people's exposure to environmental influences may also change considerably over time and thus studies on people's exposures to health risk factors (e.g., carcinogenic substances) also need to consider their residential history (Löytönen 1998). Contextual influences may vary over space and time in a highly complex manner. They may vary with different temporal patterns or time frames. For instance, as people move through the changing pollution field over time during the day, their exposure to traffic-related air pollution also changes (Gulliver and Briggs 2005).

Recent studies have shown that ignoring time and human mobility in environmental health and neighborhood effects research may lead to erroneous results.[3]

[2]There are exceptions to this, especially in research on individual exposures to traffic-related air pollution (e.g., Gulliver and Briggs 2005; Eleanor et al. 2010). See also Fang and Lu (2012) for a helpful review of recent studies that implemented various methods for personal real-time air pollution exposure assessment. There are also important advances in research on the role of human mobility in disease transmission (e.g., Bian et al. 2012; Wesolowski et al. 2012; Qi and Du 2013).

[3]Also see Kwan (2012b) for a discussion on the inferential errors this may cause.

For instance, Inagami et al. (2007) found that for subjects in a Los Angeles survey, greater exposure to less disadvantaged non-residential neighborhoods where subjects worked, shopped, and undertook other daily activities is associated with better self-rated health. Kwan et al. (2012b) observed that neighborhood effects based on people's residential neighborhoods tend to overestimate their actual exposure to social disadvantage for certain gender and racial groups. Both studies highlights the fact that characteristics of the non-residential neighborhoods people visit in their everyday lives may mitigate (or in other cases, exacerbate) the disadvantage they experience in their residential neighborhood. More importantly, Wiehe et al. (2013) observed using GPS data that contextual influences on adolescents' health behaviors vary by time of day, within participants' residential neighborhoods at the micro-geographic level (e.g., spending time on the front porch, street corners, or other places without adult supervision), and at various distances from home (e.g., area immediately surrounding the home versus areas farther away from home but are normally considered part of their residential neighborhood). Findings from these study clearly indicate that accurate assessment of people's exposure to contextual or environmental influences needs to be based on dynamic notions of context that take both time and human mobility into account (Kwan 2012a, b).

4.4 Accessibility: From Locational Proximity to Space-Time Feasibility

Accessibility is a widely used analytical construct in geography, urban studies, and transportation research. It helps us understand how the built environment and individual attributes affect people's access to social opportunities important to their quality of life and well-being, including jobs, social services, and health care facilities (e.g., Weber 2003; Horner 2004; Parks 2004; Casas 2007; Wang et al. 2010; Hawthorne and Kwan 2012; Shi et al. 2012; Wang 2012; Weber and Sultana 2013). However, most empirical studies to date tend to conceptualize accessibility mainly in terms of locational proximity or some closely related derivatives such as gravity-based measures. In these conceptualizations, distances or travel costs between facilities and the people they serve play an important role in determining accessibility. Although conventional accessibility measures are valuable as indicators of the relative distribution of people and the facilities that serve them (place accessibility), their ignorance of time and human mobility poses several difficulties for understanding people's experiences of access (Kwan and Weber 2003). For instance, these measures do not take into account people's need to be at certain locations at certain times of the day (e.g., chauffeuring children to or from schools and childcare providers), the amount of time they have for reaching activity locations and undertaking activities there, and facility opening hours that may render many facilities temporally unavailable and thus inaccessible (Weber and Kwan 2002, 2008; Schwanen 2007; Neutens et al. 2010; Delafontaine et al. 2011).

They also ignore the fact that people move around to undertake their daily routines and as a result may be presented with various opportunities for accessing needed material and emotional resources and improving their quality of life (Takahashi et al. 2001).

In many senses, time is a fundamental dimension that shapes people's access to and use of urban opportunities. Individuals have different space-time constraints and temporal rhythms of activities throughout the day (Kwan 1998, 1999; Dijst and Vidakovic 2000; Schwanen et al. 2008; Farber et al. 2013). These constraints and temporal rhythms may also vary considerably from day to day (Neutens et al. 2010). Facilities and services have specific temporal schedules or opening hours that render them unavailable in certain hours of the day, and individual accessibility of people with different personal and household attributes can be affected differently by changes in these opening hours (Neutens et al. 2010; Delafontaine et al. 2011). Further, not all opportunities are relevant unless the time one can spend at the activity site exceeds the threshold requires for meaningful participation in that activity (Kim and Kwan 2003). Various types of delays people encountered during their travel, such as traffic congestion or changes in transit schedules in different hours of the day, also affect the extent to which facilities can be accessed or used (Weber and Kwan 2002).

Simply put, locational proximity does not necessarily mean better access for many people. For instance, a government office is not necessarily very accessible even if it is located right next to a person's residence if the person's space-time constraints (e.g., work schedule) make it difficult to visit the office during its opening hours. Public transit is not necessarily accessible even if one lives right next to a bus stop if the bus schedule does not entail frequent service at the time it is most needed. Ignoring people's space-time constraints and the temporal schedules of facilities or services can lead to serious overestimation of the level of access people actually experience.

While only a few studies to date have compared results obtained from including and ignoring the temporal dimension in accessibility research, they provide strong evidence about the possibility of erroneous conclusions when time is ignored. For instance, Kwan (1998) compares 18 conventional accessibility measures with 12 space-time measures that take into account people's space-time constraints and the sequential unfolding of their activities over time. The study found considerable gender differences in the geographic patterns of accessibility when using space-time measures, while no such differences were observed when using conventional measures. This result means that accessibility measures that do not take time and human mobility into account may not reveal the effects of social difference (e.g., gender, race, class, age, and disability) on individual accessibility because they are not sensitive to people's space-time constraints.

More recently, Ren et al. (2014) compare the geographic patterns of demand for service generated with three conventional location-based demand measures and eight demand measures that take into account people's space-time accessibility. The study found that ignoring the temporal dimension of accessibility in demand modeling may underestimate potential demand for service in most situations and

can lead to distorted demand patterns and facility location that is far from the best for clients. Studies like these have shown that ignoring time and human mobility in accessibility research can often obfuscate what people actually experience in their everyday lives and lead to erroneous conclusions. Because people with different attributes (e.g., gender, race, sexual orientation, age, and disability) face different space-time constraints, the effects of the same physical environment on accessibility, even for individuals who live at the same physical location (e.g., members of the same household), can be very different. Conceptualizing accessibility as space-time feasibility will thus have significant implications for our understanding of many important social issues.

4.5 Toward Temporally Integrated Geographies

This article argued that critical insight can be gained when commonly used spatial concepts of segregation, environmental exposure, and accessibility take time and human mobility into account. Temporally integrated human geographies have considerable potential for shedding new light on many important issues geographers and social scientists have examined for decades. The article, however, did not argue that space is no longer important. It aimed mainly to expand our analytical focus from static residential spaces to other relevant places and times in people's everyday lives: where and when people work, eat, play, shop, and socialize. Mobility is an essential element of people's spatiotemporal experiences, and these complex experiences cannot be fully understood by just looking at where people live.

While this article treated segregation, environmental exposure, and accessibility as separate notions, they are nonetheless analytically interlinked. They all focus on where and when individuals come into contact with or under the influence of other people or social/physical conditions (e.g., environmental risk factors or social opportunities) as their daily lives unfold. The places people can reach and at what time they can reach them (individual accessibility) are important determinants of their exposures to various social or environmental influences (Gulliver and Briggs 2005; Kwan 2012b). Racial or ethnic segregation not only may limit people's access to jobs and social facilities but also can expose them to higher levels of environmental risk (Chakraborty 2012; Grady and Darden 2012). There are some recent attempts to bridge these three notions and to develop new hybrid analytical constructs. For instance, Wong and Shaw (2011), Farber et al. (2012), and Palmer et al. (2013) conceptualize racial segregation as exposure to different racial groups via people's daily activity spaces. Exploring the analytical links among segregation, environmental exposure, and accessibility through some unifying notions seems a fruitful direction for the future development of temporally integrated geographies. As many social scientists are also interested in studying these three themes, interdisciplinary research along this line may have a broad impact on many disciplines beyond geography.

Moving beyond the conventional focus on static residential spaces and toward temporally integrated perspectives, however, poses many challenges. While it is now possible to collect high resolution space-time data on people's daily activities and trips using location-aware devices like global positioning systems (GPS) and mobile phones (Ahas et al. 2010; Shoval et al. 2011; Almanza et al. 2012; Rodríguez et al. 2012; Richardson et al. 2013; Wiehe et al. 2013), high quality data are still costly and time consuming to collect. Further, reliably linking the space-time data of people's movement to other relevant attributes (e.g., activity type, real-time sociogeographic context) is fraught with difficulties. There are few widely available methods for analyzing the complex relationships among human space-time trajectories, racial segregation, environmental exposure, and accessibility. Taking into account certain facets of time (e.g., people's subjective experiences of time) remains difficult. Modeling human movements and incorporating time also faces complex issues of uncertainty. Recent studies, however, have begun to address some of these difficulties. For instance, recent studies have attempted to model human mobility and travel in probabilistic terms (e.g., Ettema and Timmermans 2007; González et al. 2008; Kuijpers and Othman 2009). Qualitative approaches also provide promising alternatives for grappling with people's complex spatiotemporal experiences (e.g., Kwan and Ding 2008; Valentine and Sadgrove 2012). To fully address the challenges of temporally integrated geographies, much remains to be done in future research.

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