Journal of Transport Geography 66 (2018) 300–308

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

The limitations of using activity space measurements for representing the mobilities of individuals with visual impairment: A mixed methods case study in the San Francisco Bay Area

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ARTICLE INFO

Keywords:
Activity space
Visual impairment
Mobility
Accessibility
Travel behavior
GIS

ABSTRACT

Activity space measures are often utilized to quantify the physical spaces that individuals travel through and have access to over the course of their daily activities. To date, these measures have rarely been used to investigate the mobility of people with disabilities, who often experience difficulties accessing transportation and navigating the built environment. Additionally, researchers have yet to compare results from activity space measures to people's perceived accessibility as a means of method validation. This paper contributes to the existing literature by (1) evaluating the activity spaces of individuals with visual impairment (VI) in the San Francisco Bay Area and (2) comparing the activity space results to qualitative information about individuals' travel behaviors and their perceptions about the accessibility of their environments. This mixed quantitative and qualitative methods project models individuals' activity spaces from travel diaries and analyzes participants' travel behaviors and perceptions from interviews. Three activity space measures are considered: standard deviational ellipse, network buffer, and potential path area. The results demonstrate significant shortcomings in activity space measures for representing the experiences of people with visual impairment and identify how existing methods can be improved for future research on environmental accessibility.

1. Introduction

People with disabilities face considerable transportation challenges that impede their mobility and access to places (Graham et al., 2014; Lubin and Deka, 2012). For many, transportation options are inaccessible, expensive, or unavailable. Limited access to transportation makes commuting to work and competing in the labor market more difficult (Gillies, 2012; McDonnall, 2011; O'Day, 1999). It also makes travel to health care facilities a challenge, leading to lower health care utilization and to a greater risk of unmet health care needs (Iezzoni et al., 2006; McDoom et al., 2012; van Rooy et al., 2012). This kind of transport disadvantage can significantly curtail individuals' access to places, resources, and opportunities, and diminish their quality of life. This paper focuses on the mobility experiences of individuals with visual impairment (VI), a subgroup of people with impairment who encounter distinct travel challenges related to their vision loss.

In transportation geography, many scholars seek to understand the impact of transport disadvantage on vulnerable populations (Hernandez and Titheridge, 2016; Maia et al., 2016), often through the development and application of different measures of accessibility (Casas et al., 2009; Pyrialakou et al., 2016; van Wee, 2016). Activity spaces are increasingly used to quantify and summarize individuals' potential accessibility, or the spatial extent of where they can travel given constraints related to daily activities, time, and transportation mode (Kamruzzaman et al., 2011; Li and Tong, 2016; Patterson and Farber, 2015). However, the vast majority of activity space research focuses on able-bodied populations. With notable exceptions (Casas, 2007; Townley et al., 2009), the activity spaces of people with disabilities continue to be understudied despite recognition that they are much more likely to experience transport disadvantage than the general population. There are consequently few research efforts to quantify areas that are inaccessible to people with disabilities and to understand the kinds of transport disadvantage that they face.

This paper has two interrelated objectives. First, it evaluates the accuracy and appropriateness of three activity space measures when applied to the travels of individuals with VI. The activity space measures are standard deviational ellipse (SDE), network buffer (NB), and potential path area (PPA). Then the activity space results are compared to individuals' perceptions of travel opportunities and barriers and the accessibility of their environments. The main contribution of this paper

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https://doi.org/10.1016/j.jtrangeo.2017.12.004
Received 16 July 2017; Received in revised form 13 November 2017; Accepted 12 December 2017
Available online 07 January 2018
0966-6923/

is to assess the applicability of well-established activity space measures for the mobilities of individuals with VI. This research also seeks to address a literature gap identified by Patterson and Farber (2015) – that few scholars have made explicit comparisons of different activity space measures and compared the quantitative outcomes with perceived accessibility. In comparing quantitative and qualitative results, this article draws attention to the distinct accessibility issues of people with VI.

In the sections that follow, I begin with a brief overview of visual impairment and the travel challenges faced by people with VI. This is followed by a review of accessibility methods and activity space measures used in research on transport disadvantage. Next, the activity space measures and qualitative analysis of interviews are discussed. Finally, the results are summarized and future recommendations are provided for improving existing methods.

2. Background

2.1. Visual impairment & transportation challenges

Visual impairment refers to a spectrum of sight loss ranging from moderate and severe vision loss to total blindness with no light perception (World Health Organization, 2014). Many people with VI have partial sight and may experience loss of peripheral or central vision, light sensitivity, blurry vision, and night blindness (American Optometric Association, 2016). Approximately 7.3 million people (2.5%) in the U.S. (National Federation of the Blind, 2016) and 285 million people in the world (less than 4%) have a visual disability (World Health Organization, 2014). Their travel experiences depend partly on the type of vision loss they have (Casey et al., 2013) and the age of onset of visual impairment (Hersh, 2015).

Recent improvements to the built environment and increased access to assistive technologies have greatly facilitated the mobility of individuals with VI (Casey et al., 2013). However, despite these advancements, having a visual impairment still amplifies travel constraints and challenges. Transportation choices are often inaccessible, unaffordable, or unavailable (Crudden et al., 2005; Gold and Simson, 2005; McDonnall, 2011; O'Day, 1999). With rare exceptions, people with VI are unable to drive and therefore rely on public transit, walking, or on someone else to drive them (Gallagher et al., 2011). Some experience travel challenges due to a lack of spatial information about their routes and destinations (Casey et al., 2013; Golledge, 1993; Marston et al., 1997). Another issue is difficulty navigating busy traffic intersections, construction areas, and crowded public events (Kaminsky et al., 2014).

Apart from a couple of studies (Casas, 2007; Townley et al., 2009), there is little research on the activity spaces of people with disabilities as they relate to issues of transport disadvantage and mobility. Utilizing accessibility methods to measure people's mobility and access to opportunities, Casas (2007) finds that people with disabilities experience greater transport disadvantage than individuals with no disabilities. Using activity spaces to represent the mobility of individuals with serious mental illness, Townley et al. (2009) find larger activity spaces to be positively associated with more optimistic life assessments. In these studies, findings from activity spaces reveal how living with a disability can influence individual mobility and access to resources and amenities.

No studies have used activity spaces to analyze the mobilities of individuals with VI, who have unique travel experiences and views about the accessibility of their environments. Bridging the work of behavioral, time, and transport geography (Casas et al., 2009; Charleux, 2015a; Golledge, 1993; Hägerstrand, 1970; Kwan, 1998; Marston et al., 1997; Miller, 1991; Patterson and Farber, 2015) and that of disability geography (Gleeson, 1999; Imrie, 2013; Macpherson, 2008; Pow, 2000; Worth, 2013), this paper evaluates three types of activity space measures using the daily travel diaries of 31 individuals with visual impairment. The modeled activity spaces are compared with individuals' perceptions to identify the method that best represents their everyday experiences. This paper's key contribution is assessing the applicability of activity space measures for characterizing the mobility and accessibility experiences of people with VI.

2.2. Accessibility & activity space measures

In recent decades, transportation researchers have developed and utilized accessibility measures that can be categorized as either place-based or people-based (Charleux, 2015a; Kwan, 1998; Miller, 2007; Neutens et al., 2010). Place-based methods generally assess the geographic proximity of opportunities from a reference location, such as an individual's home or workplace. They include indices based on: (1) calculating the number or ratio of opportunities that can be reached from a reference location within a given time, distance, or geographic area (Black et al., 1982; Handy and Niemeier, 1997; Hanson and Schwab, 1987), (2) determining supply-to-demand ratios within floating catchments (Wang, 2012), or (3) using gravity-based measures in which the attractiveness of opportunities decreases with increased distance, time, or transport costs (Hansen, 1959; Guy, 1983; Linneker and Spence, 1992). While place-based measures are useful for evaluating and comparing the accessibility of different places, they are critiqued for ignoring individual space-time constraints that affect people's ability to access locations when and where needed (Kwan, 1998; Miller, 2007; Neutens et al., 2010). A significant limitation is that all individuals are attributed the same level of access to opportunities (Kwan, 1998), when in reality different groups experience variations in access. Given that place-based measures use reference locations as proxies for individuals (Kwan, 1998; Miller, 2007), individuals' unique traits and behaviors are not considered and the issue of differential access is ignored.

To address the limitations of place-based accessibility measures, scholars have increasingly turned to people-based methods that explicitly consider individuals' travel behaviors. Computational advancements coupled with the development of accessible software tools have driven the application of people-based methods, particularly those focusing on activity spaces (Patterson and Farber, 2015). Introduced by behavioral geographers, activity spaces (AS) are defined as the physical spaces within which people travel in the course of their daily activities (Golledge and Stimson, 1997). In theory, AS refers to an individual's actual mobility – the spaces they access daily. However, in practice, AS is typically used to summarize an individual's potential mobility – the spaces they are able to reach given the fixed time-space constraints of everyday life (Patterson and Farber, 2015). Activity spaces are utilized in transport geography and demography, and health researchers are increasingly using the methods to model health service access and environmental health effects (Kamruzzaman et al., 2011; Li and Tong, 2016; Matthews and Yang, 2013; Patterson and Farber, 2015; Townley et al., 2009; Zenk et al., 2011). However, the activity spaces of socially vulnerable populations such as people with disabilities have been overlooked by transport scholars, along with their perceived accessibility to opportunities and places (Patterson and Farber, 2015; van Wee, 2016).

Diverse activity space measures have been developed and applied in understanding travel behavior. Widely-used methods such as the network buffer and standard deviational ellipse are easy to compute in a GIS, whereas other methods are more computationally intensive (Patterson and Farber, 2015; Perchoux et al., 2013; Sherman et al., 2005). In many applications, researchers choose an AS method based on access and computational considerations, while giving less weight to the appropriateness of the method for the population and study area of interest.

Patterson and Farber (2015) identify a shortage of research that explicitly compares AS measures. Previous studies compare place-based accessibility measures with people-based ones (Casas et al., 2009; Kwan, 1998; Neutens et al., 2010), providing evidence that people-