Journal of Transport Geography 53 (2016) 61–73

Contents lists available at ScienceDirect

Journal of Transport Geography

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

Investigating the interactions between travellers' familiar areas and their multi-day activity locations

Wen Zhang *, Yusak O. Susilo, Nursitihazlin Ahmad Termida

Department of Transport Science, KTH Royal Institute of Technology, Teknikringen 10, 100 44 Stockholm, Sweden

ARTICLE INFO

Article history:
Received 6 September 2015
Received in revised form 11 April 2016
Accepted 26 April 2016
Available online xxxx

Keywords:
Mental map
Familiar area
Activity space
Activity travel pattern
Stockholm

ABSTRACT

A mental map is considered a representation of an individual's spatial cognition. It defines an individual's choice set of plausible activity locations and influences his/her daily activity-travel patterns. Despite its importance, how individuals' activity travel patterns interact with their mental maps on a daily basis is largely unknown, mainly due to data, operation, and measurement issues. The aim of this study is to address this. A total of 57 individuals in Stockholm were asked to record a two-week travel diary and draw their familiar areas in the specified maps. The familiar areas, which in this study are considered as representative of individual mental maps, were manually drawn and transferred from graph to ASCII code in ArcGIS for modelling purposes. The recently visited activity locations were used to construct the individuals' activity spaces. The crucial determinants that related to these activity spaces and familiar areas were investigated. The marginal effect of each key variable was calculated in order to understand the magnitude of influence of each variable to the individuals' activity spaces and familiar areas. The results show that an individual's activity space is partially or completely located within the individual's familiar areas and they are strongly correlated to each other. Large activity centres, such as Stockholm's central areas and areas of Huvudsta have higher probabilities to be included in both individuals' familiar areas and activity spaces than other areas that are closer to home.

1. Introduction

The image of a space in one's mind is the result of a two-way process between the observer and his or her environment. The observer selects, comprehends, absorbs and learns from the environment based on his or her own needs (Lynch, 1960). The end product of this psychological transformation with respect to the everyday spatial environment is called a cognitive map, sometimes known as a mental map (Downs and Stea, 1973). A mental map is, therefore, one's unique perception of the environment one is experiencing.

The study of mental maps has always been a topic of interest in human geography, urban planning, environmental psychology, and travel behaviour. People learn from the environment through travelling, whilst at the same time they continuously update their mental map, and make their travel decisions based on it (Hannes et al., 2006). To study the role of mental maps in travel decisions, the concept of "activity space" is needed, which can be defined as the area containing all locations that an individual visited during a period of time as the result of his or her daily activities (Golledge and Stimson, 1997). Since people tend to exhibit habitual behaviour and their activities are mostly limited to a certain geographic scope due to the constraints of space and time, looking at people's actual or potential activity space is considered to be a good approach to approximating people's daily activities in a geographic context (Kwan, 1999). Furthermore, the actual activity space, or part or all of the potential activity space are very likely to be in one's perceived activity space (Dijst, 1999a). Hannes et al. (2006) have stated that '*once formed, the mental map becomes the foundation of decision making. It reflects the internal knowledge of potential activity spaces and their accessibility by different modes and routes.*' Based on the cognitive learning model, individuals will continuously update their mental map based on observations made during the implementation of activities and trips, and these further affect their travel choices (Cenani et al., 2012).

Therefore, the inclusion of mental maps in transport models can help city planners to understand people's internal spatial knowledge, as well as their travel behaviour and their travel choice sets more accurately. Chorus and Timmermans (2009) suggested a non-linear relationship between the physical world and travel behaviour, in which mental maps play an important role. One of the main reasons for this is that the objective accessibility measured by the transport network is not the same one that is perceived by travellers, because mental maps introduce biases with respect to travel time in the travellers' minds, and thus affects their choice sets. Arentze and Timmermans (2005) investigated the effect of mental maps on locational choices for leisure activities, and they found that people tend to choose locations with better accessibility and that are a shorter distance away than

* Corresponding author.
E-mail addresses: wenzha@kth.se (W. Zhang), yusak.susilo@abe.kth.se (Y.O. Susilo), nursitihazlin.termida@abe.kth.se (N. Ahmad Termida).

http://dx.doi.org/10.1016/j.jtrangeo.2016.04.012
0966-6923/

other locations. They also noted that travellers will update their cognitive maps and reduce their feelings of uncertainty as long as enough information has been conveyed to them (Dziekan and Dicke-Ogenia, 2010), which will help to support the improvement of public transport. For these reasons, mental maps are of importance to understanding a person's travel behaviour, both theoretically and empirically.

However, our understanding of a person's mental map is still very limited, due to measurement, operation, and data availability issues (Hannes et al., 2006). Chorus and Timmermans (2010) conducted a survey on students in Eindhoven and tried to examine the quality of the stated and revealed mental maps. They found that travel mode choice is a key determinant of mental map quality, and also that there is a strong correspondence between stated and revealed mental maps among men, architecture students, and local residents. Al-Zoabi (2001) used hand-drawn maps as a way to portray children's mental maps. He mentioned three disadvantages with respect to the study after translating the maps: (1) the scale of the hand-drawn maps was not fixed, (2) the ability of people placing objects on the map with the right proportion may not be reliable, and (3) the respondents were not experienced enough to draw mental maps explicitly. The data processing was also considered as a hindrance due to its complexity and the time required to register and analyse the land parcel units.

There have been a lot of efforts made to understand the influence and the importance of mental maps and activity spaces towards individuals' travel patterns. Less, however, has been done to investigate the determinants that constitute these two abstract concepts and their interactions in a systematic way. Most of the previous studies address the problem from explorative and descriptive points of view. There is no specific mathematical model that can be used to understand the formation of mental maps and activity spaces, and their relationship with individuals' socio-demographic and build environment characteristics. Therefore, to contribute to this research gap, this study aims to answer the following four questions. First, how can mental maps be presented in a tangible way? Second, how do people express their mental maps? Third, which attributes or factors are important to the formation of mental maps? Fourth, how does a person's mental map interact with his or her activity space?

In this paper, mental maps were obtained through self-reported respondents' spatial knowledge of their familiar areas within a given boundary. Potential activity spaces were derived from all the locations that the respondent reported in his or her travel diary during a two-week time period. The concentration of daily activities in the same geographic area as the familiar area was used as a simplified measure for presenting the activity space. All data were processed in ArcGIS, and then transferred to ASCII code for modelling purposes, so as to identify any link between an individual's calculated activity space and his/her self-reported familiar area. A logistic regression model was used to systematically identify the determinants that constitute the spatial areas of an individual's familiar area and activity space. Marginal effects were then calculated for the purposes of explaining the results with respect to different locations' degree of attractiveness. These are the original contributions that are offered in this study.

In the next section, the data set used for this study will be described. This is followed by a section that describes the different steps of the analysis and data processing. The model formulation and interpretation are then discussed; next, the inferences of cumulative marginal effects are presented; the paper ends with a conclusion.

2. Data

In order to achieve the research objective, a panel data of two-week travel diaries and the familiar areas of 57 individuals in Stockholm, Sweden were collected. The data collection took place in Solna, Sundbyberg, and Alvik, sub-urban areas in which the new extension line of the tram service was introduced on the 28th of October 2013. The intention was to observe possible changes in individuals' travel behaviour on account of the new extension line of the tram service, which is connects to and lies within these areas. Further description of the data collection can be found at (Ahmad Termida et al., 2016). Fig. 1 shows the geographic location of this new tram extension. The original data set was comprised of a four-wave panel dataset, which was collected consecutively, on four occasions over the course of one year. In this paper, however, only the Wave 1 data is used as the data set. (See Fig. 2.)

Individuals who live close to the new tram extension were recruited for data collection. The term 'live close' refers to individuals living within approximately 500 m of the new tramline's stations. Therefore, the respondents should have similar characteristics to the study area in terms of the land-use and the built environment. At first, 130 participants were recruited through street interviews (random) and a panel email lists from a survey firm, in order to anticipate and take into consideration the dropout level during the survey period. However, only 67 individuals participated with respect to all the questions from Wave 1 until Wave 4. In addition, after reviewing their mental map-related questionnaire answers, it became clear that only 57 individuals completed the mental map questionnaires for all four waves. Therefore, these 57 respondents become the sample data for this paper. Fig. 3 shows the home locations for these 57 respondents. More detailed description of the data collection can be found at (Ahmad Termida et al., 2016).

As shown in Table 1, a comparison was made between the travel characteristics of respondents in Wave 1 and the Swedish National Transport Survey (NTS) for Solna municipality in the year 2011. The major differences between the data set used in this study compared with the NTS 2011 is in the distance travelled, the purpose of the trips, and user type. The differences may have emerged because of the use of different travel survey forms (activity diaries vs trip diaries) and different survey approaches (paper and pencil approach vs telephone interview) in collecting travel information, and as a result, there may exist non-reporting trips in this two-week travel diary (Ahmad Termida et al., 2016).

In general, the sample size in this study is not representative of the population. Therefore, the conclusions drawn in this paper can only provide some insights regarding how individuals' familiar areas interact with their activity spaces, which could be interesting for future research with more comprehensive data. Meanwhile, further use of the result discussion in this study should be carefully treated due to this sample limitation.

The two-week travel diary each respondent was asked to fill out was a self-reported travel diary, requiring a pen and pencil approach, and was mailed to each respondent. The diaries were used to record information on the origin and destination of every trip, mode choice details, purpose of the trip, departure and arrival time, estimated travel distance, estimated travel time, travel companion detailed, and estimated travel cost. Meanwhile, the psychologically related questions were distributed via an online survey approach, meant to capture the respondents' beliefs and opinions about the new tram services. Note that the results from this particular set of questions have not been included in this study analysis. The mental map-related questionnaire (also requiring pen and pencil approach), which was mailed together with the travel diaries, aims at exploring the changes in the respondents' mental maps over the course of the four waves of the survey period. The boundary of the geographic area was fixed and pre-defined, covering Central Stockholm (see Fig. 3 for the map questionnaire boundary in shapefile[1] format).

Respondents were asked to draw a polygon on their familiar areas by using the grid given as a guide (A sample of the mental map questionnaire can be seen in Figs. 4–6). The question asked was: "*Think about the area(s) that you are familiar with*; *now draw a polygon(s) around*

[1] A popular geospatial vector data format for geographic information system (GIS) software (ESRI, 2015).