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# Behavioural Maps and GIS in Place Evaluation and Design

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Barbara Goličnik Marušić and Damjan Marušić

Additional information is available at the end of the chapter

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## 1. Introduction

This chapter addresses the subject of behavioural maps, their characteristics and significances; the ways they can be created or produced as well as their applicability in place analysis, its evaluation and design, using GIS as working and analytical milieu. It argues that data immanent to behavioural maps enable various simulations of places, exploring their characteristics and qualities, checking potentials of places for certain development, post occupancy evaluations etc., but also checking on skills of designers in their achievement towards user friendly places.

Traditionally, models and simplified symbols which match certain requirements regarding metric dimensions of places or spatial elements that form places have always been used in place planning and design. The question is how much freedom in place creation do such models actually allow? Saying with other words, how well do they reflect real situations and relations between functionality and physical characteristics of places they represent and their actual occupancies? In former times such templates were available in plastic models for layouts and cross-sections in different scales. Nowadays they are available within computer-aided design software packages. A critical eye must realise that such templates serve only as indicators for recognition of the main purposes of places and usually do not reflect actual shapes and do not respond to actual usage of places. For example, pre-designed symbols for basic elements such as furniture, and shapes of places or rooms derived from such basic elements are limited by their forms. When they are used in a place design process, the process itself and the final results are limited within the given framework as well. In such an approach a goal to create user friendly places is often overlooked. Attractive layouts and cross-sections are produced to fascinate clients. In terms of responsible planning and design, this should not be acceptable. Planners and designers must strive for more accurate and refined reading of relationships between places and their users.

The main assumption is, that behavioural maps are fairly dynamic means for place planning and design, as opposed to pre-designed models or templates; used either for single elements or the entire spatial systems such as rooms in buildings, groups of rooms in buildings or even buildings and patterns of open spaces between them in cities and towns. Beside the fact, that IT development enables the production of pre-designed elements and templates for design and therefore speeds up the production process, it limits the responsive part of the process. However, at the same time some other aspects of this same IT development bring advantages towards responsive design. It opens new possibilities in place design and decision-making. For example, usage of merely static templates and symbols can be replaced with dynamic responsive templates based on dynamic patterns of spatial occupancies. Further assumption is that such spatial templates which are based on behavioural maps can help to produce better place design and more user friendly solutions.

The aim of this chapter is to exceed schematic annotation of places. It takes a point of view that places differ from each other. Addressing places via behavioural maps seems an optimal scanning process which can lead towards successful decision-making and design. Behavioural maps are seen as direct links between users in places and physicality and functionality of places themselves.

The chapter discusses behavioural maps as means to addresses usability and the spatial capacity of places, via several examples and from different viewpoints. Firstly, it comments on selected relevant case studies where behavioural mapping was applied to as the appropriate method to address the original research question of each study. Mostly, the discussion is based on a research applied to urban squares and parks in two European cities, Edinburgh (UK) and Ljubljana (Slovenia), to reveal common patterns of behaviour that appear to be correlated with particular layouts and details (Goličnik, 2005). Furthermore, a research study addressing behavioural patterns of urban cyclists in Ljubljana (Slovenia), is commented mostly regarding questions relevant for mapping and tracing (Goličnik Marušić et al., 2010). Different types of behavioural maps are discussed. Secondly, the chapter discusses possibilities for various simulations of place assessment and design using principles of behavioural mapping. It shows how existing behavioural maps can be used to evaluate the quality of existing environments as well as the quality of environments to be developed in a desired way. Additionally, it shows how simulations of uses can be arranged for checking the quality of (new) proposals, using principles and characteristics of usage-spatial relationships learnt from previously observed places.

At the same time the chapter promotes GIS as a successful practical tool to build, develop and maintain a body of empirical knowledge gained from different types of behavioural maps. In this context, GIS database offers a transparent examination of places through different combinations of behaviour pattern attributes e.g. the type of activity, gender, age etc. (Goličnik Marušić, 2011). It enables a designer to look at places from any desired viewpoint of attribute combinations, which may most intrigue him or her. In addition to providing information about different elementary peculiarities of patterns of occupancies, GIS based behavioural maps can show the results which have arisen from deeper investigation, e.g. how often a certain activity

has happened, how intensively it has occurred per certain temporal unit, how the patterns of each certain activity were differentiated with regard to the presence of others, and so on.

## 2. How to produce a behavioural map?

Behavioural map is a product of observation and a tool for place analysis and design at the same time. It was developed by Ittelson et al. (1970) to record behaviour as it occurs in a designed setting. Accordingly, spatial features and behaviour are then linked in both time and space. There are some fundamental conditions which need to be met before any recording of behaviour can start. It is necessary to obtain an accurate scale map of the area to be observed, to clearly define the types of activities and details about behaviours to be observed, to schedule specific times and their repetitions for observation, and to provide a system of recording, coding, counting and analysing.

Chronologically, some of the most common ways are systematically writing notes and filling formatted tables. The development of photo-video techniques has influenced the latter methods, and nowadays computer-oriented and supported techniques are forthcoming. Environment-behaviour studies take as their basis the inseparable duality of the behavioural phenomenon and its environmental context, especially in the outdoor environment often recorded through photography and/or video. Both these media clearly show the evidence and temporal consequences of events within a place but they cannot directly give either very detailed micro-scale relationships or the overall synoptic situation of the place itself. However, for the purpose of this chapter, the latter objectification is especially necessary. Thus, the medium of (urban) designers and planners - the map, a physical layout of a place, is adhered to. This medium can convey basic and exhaustive information about an environment and enables the researcher to record changes, suggestions, decisions or any other movement in/about a place, too.

However, although an accurate scale map is a first pre-condition of behavioural mapping, the literature review on the application and development of this method/technique shows that it does not always serve as a recording board. It could have a role of an informative object in the whole process and can result in some general notes, while, for example, behavioural records are collected in a carefully developed table. This shows that there are different techniques available in recording observations, depending on the scale and the nature of the research problem. Typologically different manners in which the behaviour can be recorded are possible. Ittelson et al. (1970) stress that other possible ways of presentation include graphs, pictures, and combinations in which tables may be superimposed; and that floor plan, table, and any other methods of data presentation are all equivalent behavioural maps. This chapter discusses behavioural mapping matrixes, behavioural maps in a narrow sense and a type which combine both the manners. The latter is discussed in relation to GIS.

### 2.1. Behavioural mapping matrix

The literature review shows (e.g. Bechtel et al., 1987) that behavioural tables were quite often used in recording behaviour in indoor environments. Such a table usually consists of rows

representing physical locations and columns representing behaviour. An index mark at the intersection of a row and column then indicates whether the behaviour had occurred at that location. Goličnik (2005) redesigns and upgrades some sort of table for recording observations of outdoor places in Edinburgh (UK) and Ljubljana (Slovenia).

Data on the use of parks and squares in each city were collected during the month of May (May 2002 – Edinburgh; May 2003 – Ljubljana). May was chosen as the time when the weather was likely to be warm and the outdoor activity pleasant. A day observation unit represents four sections: morning (10am-12pm), early afternoon (12-2pm), afternoon (2-4pm) and late afternoon (4-7pm); during the week as well as weekend. Observations were usually conducted from one location in a setting, from where a good overview across a place was provided. As some places were too big to be observed with one overview across the entire place, they were divided into more sub-areas, usually three or four. Each spatial unit was observed for 10 minutes. Altogether two parks, six squares and one square-like street were observed in Edinburgh; and two parks, five squares and a park-like square in Ljubljana; 105 observations were made in Edinburgh and 106 in Ljubljana.

Because of the complex feature of the table and because each cell could collect more than one information, a table is addressed with the behavioural matrix. Every cell in the matrix can collect quantitative and qualitative data. The completed matrix from the field observation is exemplified in Figure 1.

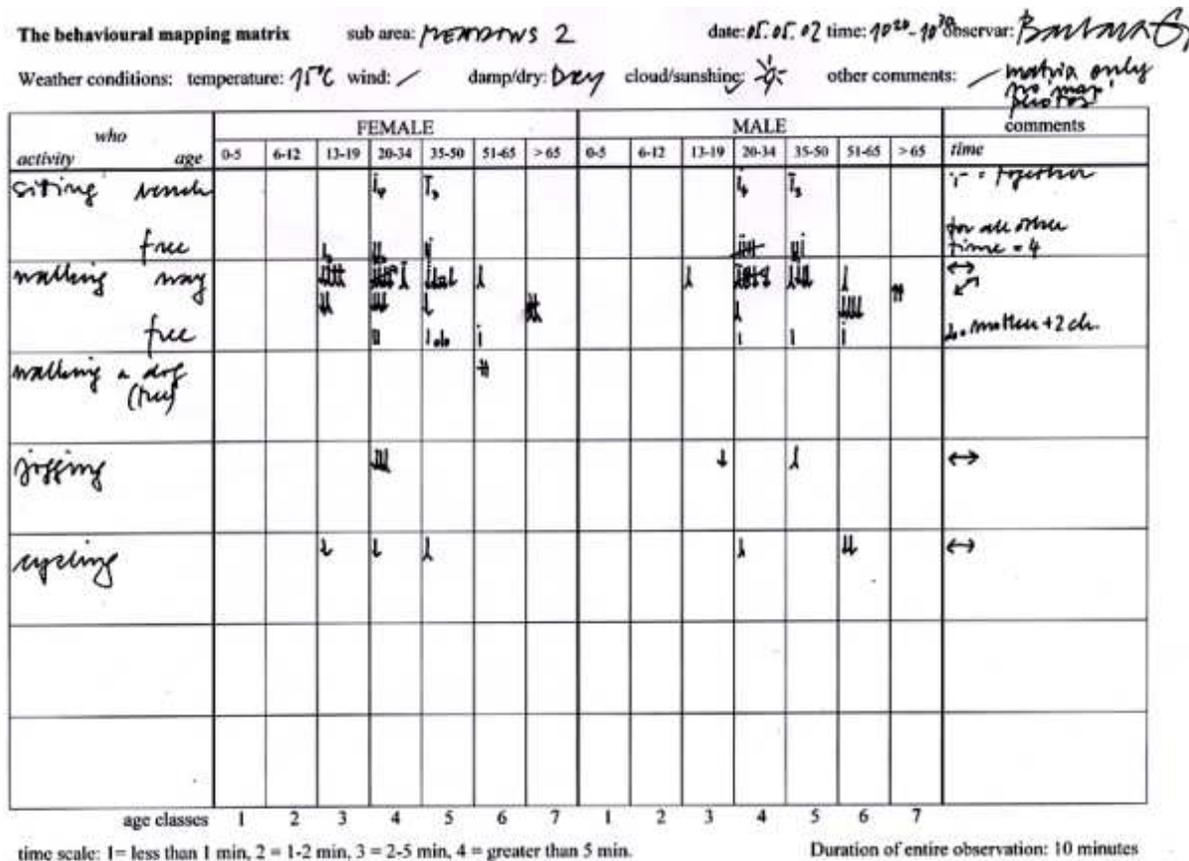


Figure 1. The behavioural matrix with the recorded data (Goličnik, 2005).

From methodological point of view Goličnik (2005) tested two types of behavioural maps: behavioural matrixes and drawn behavioural maps, so called behavioural maps in a narrow sense. The results showed that there were only a couple of situations where mapping as behavioural matrix was appropriate. This was the case for quite simple places such as square-like street with outdoor settings of tables and chairs, where beside those sitting at tables, people were only moving in transition through the place, usually alongside. In order to be able to comment on usage-spatial relationships as thoroughly as possible, drawn behavioural maps were introduced in places, where more complex situations occurred.

## **2.2. Behavioural map in a narrow sense**

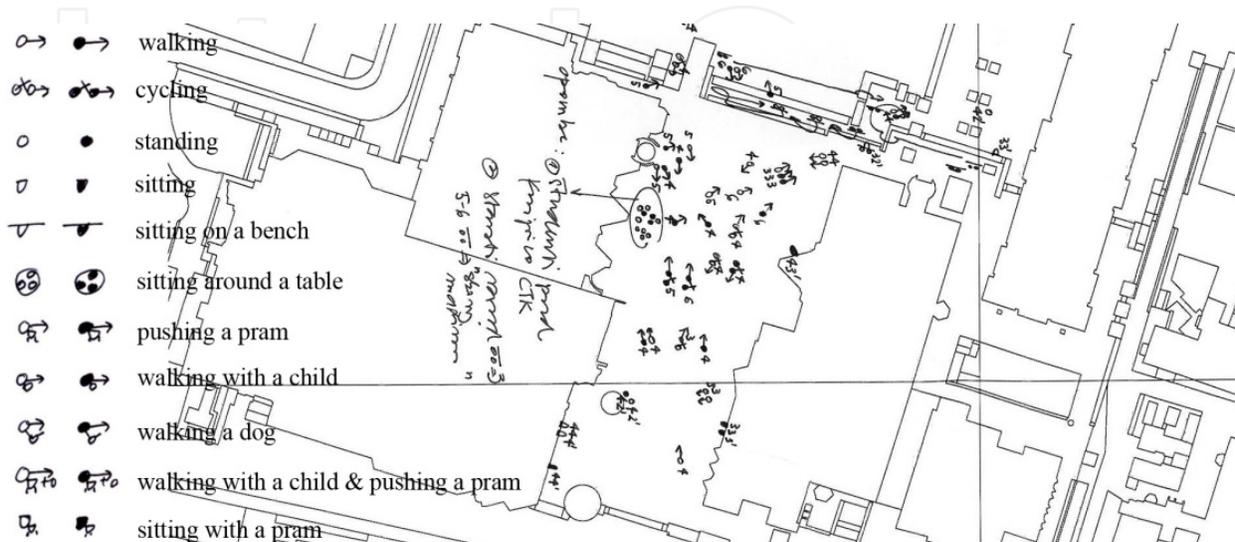
In order to create a database as informative as possible, it is important to organise the entire process of mapping very thoroughly. The process of recording behaviour itself needs to be as condensed and inclusive as possible. Accordingly, attributes such as the type of activity, the users' gender and age, duration of the activity, time of the day of occupancy, time of the week of occupancy, movement direction and weather conditions at the presence of the activity; all describe an observed activity in a place. Consequently, a coding and counting system needs to be selected before a technique's implementation is addressed. It is important that the system is designed in a way, which minimises the effort required for recording observations. Thus mapping preparation includes a list of some anticipated activities, their assigned symbols and additional coding (e.g. duration, age group). However, it is of key importance that the list of anticipated activities stays open-ended for any possible new activities to be added, and attached symbols for these unexpected or infrequent activities to be developed in the course of the observation.

Behavioural maps produced at sites were manually drawn on paper prints. The list of symbols for expected behaviours in places distinguishes symbols for male and female participants (see Figure 2). The appropriate symbols were then drawn on prepared prints of site plans. They were accompanied by some qualitative information as well; such as the duration of an activity, the estimated age of the participant (age group), the direction of movement, as well as the time and date, and the description of the weather conditions when the activity occurred. Equally the areas occupied by certain activities or behaviours were documented on a map in scale 1:1000 (see Figure 2).

## **2.3. Behavioural map in a narrow sense combined with behavioural matrix**

In principle, the usage of both behavioural matrix and behavioural map in a narrow sense combined together at the same time at the observation field is hardly ever reasonable. Practically, it is suggested to select the most appropriate technique, depending on the nature of the research problem. However, as field observation usually requires some repetition, i.e. there are always several maps produced for the observed place. If for any grounded reason the observer mixes both recording techniques for the same place during the observation period, all attributes of coding systems must be previously synchronised. It is more likely to find a combination of both types of recording when manually gathered data is digitalised

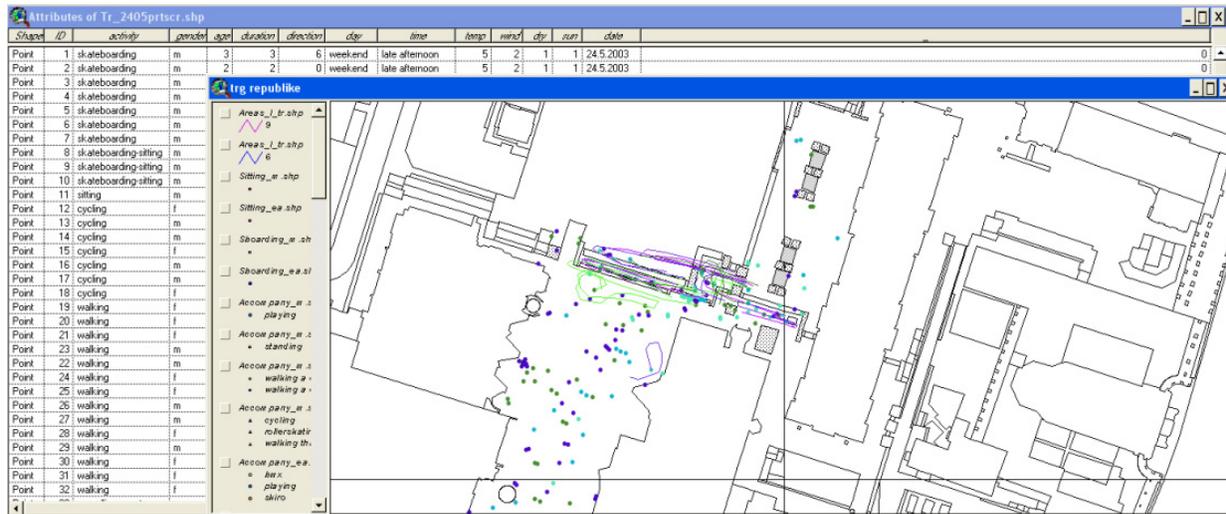
and databases are created, or when any direct recordings, e.g. GPS tracing, are introduced and data are organised into databases. Following subchapters exemplify some of such situations.



**Figure 2.** A set of activities from the entire list of expected activities including their attached symbols, specifying male and female users, used for recording activities in squares and parks of city centres of Edinburgh and Ljubljana (Goličnik, 2005), applied in Trg republike, Ljubljana within one observation session.

### 2.3.1. Digitalisation of data collected via behavioural matrixes or behavioural maps in a narrow sense

The process described at this point is relevant to the research conducted in Edinburgh and Ljubljana (Goličnik, 2005). Every symbol recorded manually was transmitted into its digital version in the same way as recorded in the original map. A map of the observed area was projected on the computer screen. The location of the re-recorded activity was identified with the cursor and clicked when the location was verified. All the attributes of each re-mapped symbol were described in the attached table under its given serial number. Following such a procedure, every database of each place consisted of information layers, based on a day-order structure. Point symbols within the layers represent single users originally recorded in the place. Properties of an activity included in symbols developed for manual behaviour mapping and the characteristics of other circumstances, such as weather conditions, time of day and day of the week, captured within symbols and matrixes of original records, were described in the table attached to those point symbols visualised on the map. So GIS behavioural map is composed of a map of geo-located activities and the attached table with detailed descriptions of these activities (see Figure 3).



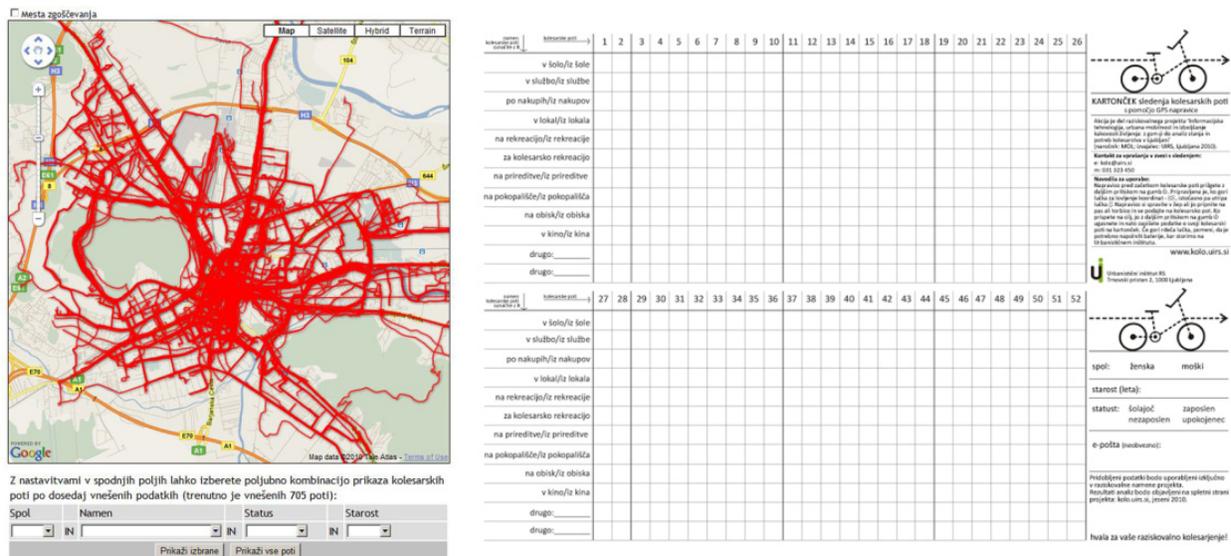
**Figure 3.** Representation of a GIS supported map transformed from a manually produced behavioural map of Trg republike, Ljubljana (Goličnik Marušić, 2011).

In some cases, where behavioural matrix technique was used to record behavioural patterns in places, re-rendering followed qualitative notifications in the matrix's cells and picked up graphical information from spatial sketches and schemes along with the original matrix.

### 2.3.2. GPS device as a data source

Usage of GPS devices is increasing in popularity in transportation studies, from traffic flow to cyclists and pedestrian tracking (e.g. Nielsen, 2005; van Schaick and van der Speck, 2007). Visualisation of collected tracks is some sort of a behavioural map, although recording process itself does not reflect all the key elements immanent to classic behavioural mapping. However, usage of tracking technologies such as GPS makes it possible to collect large datasets on human behaviour with a high level of accuracy, combining directly temporal and spatial data. The important advantage of behavioural maps conducted with the use of a GPS device is that collected information is well compatible with any GIS application. Nevertheless, the biggest disadvantage is that this approach might lead to intervention effects and inhibit natural behaviour, as users are aware of their participation in a research project. However, there are situations when usage of GPS to produce behavioural maps is credible.

Goličnik Marušić et al., (2010) studied Ljubljana cyclists' behaviour implementing several approaches, including the use of a simple GPS device. Cyclists, who were interested in participating in the research, contacted the researchers and were given a time period when a device was available. Each participant kept the device for several days and collected data of her/his journeys. Besides the GPS device, each participant collected a blank behavioural matrix designed especially for the study to collect other qualitative information relevant for each recorded trip (e.g. gender, age group, purpose of the journey etc.) (Figure 4, part 2).



**Figure 4.** Behavioural map of cyclists' tracks resulted from the use of GPS devices and two sided blank behavioural matrix where each cyclist collected other required data (Goličnik Marušić et al., 2010; <http://kolo.uirs.si/>).

Data collected from a GPS device and those recorded into a matrix were merged together to get the whole picture about users and their journeys. Monitoring and review of an emerging behavioural map was performed on Google Maps API (Figure 4, part 1). The approach combined both recoding techniques: behavioural mapping in a narrow sense was automatic; other relevant data was collected manually. Although the approach combined both recording techniques, it represents a deviation from classical behavioural mapping as spontaneity of observation is excluded and because it focuses on specific users; all users except cyclists were excluded in advance.

### 2.3.3. Behavioural mapping in a virtual environment

The study of cyclists' paths in Ljubljana (Goličnik Marušić et al., 2010) developed a web based GIS portal for production of cycling behavioural maps of Ljubljana. This web based portal offers 3D and 2D virtual environments in which cyclists digitalise their own cycle-tracks on the map (Figure 5). Beside this GIS interface, the portal <http://kolo.uirs.si/> includes user registration module and a secured online survey to assure basic descriptive information about the cyclist and the purpose of his/her journeys. Thus, it was assured that physical behavioural patterns with linked descriptive data were collected at the same time, so that finally a comprehensive behavioural map was composed.



**Figure 5.** Examples of the established GIS portal showing steps in data collection and data representation (Goličnik Marušić et al., 2010).

The example clearly shows that the accuracy of collected data may be an issue and that some corrections and adjustments of collected data must be provided before its use for further analysis (e.g. Lachance-Bernard et al., 2011).

## 2.4. Implications and limitations

Commenting on the purpose of behavioural mapping, Bechtel et al. summarise that: “it is to locate behaviour on the map itself, to identify kinds and frequencies of behaviour, and to demonstrate their association with a particular site. By associating a behaviour with a certain environment it is then possible to both ask questions and draw conclusions about the behaviour and its relationship to a place” (Bechtel et al., 1987: 23). Discussed findings in research practice show possible different manners in which behaviour can be recorded, and suggest two general principles: behavioural tables/matrixes and behavioural maps in a narrow sense.

Every technique used claims a different approach and has some advantages and disadvantages. The developed behavioural matrix enables simple and complex collection, both of quantitative and qualitative data. Observing and recording using the matrix considers especially the number of people involved, noting their age, gender and many times the duration of an activity as well. Drawing a map emphasises the particular location, certain uses and their duration. Age and gender are easily recorded variables in each approach. It seems to be most suitable to use a matrix to record the activities in which the main characteristic is movement such as walking, jogging or cycling; and to use a map technique to record more static activities such as sitting, playing within a certain area, waiting and similar. The maps were found especially appropriate for observing areas with frequent changes. Furthermore, their overlapping allowed the researcher to get a brief intermediate review.

The combined use of both recording techniques, especially in GIS supported environments and various IT related means for recordings, assures a qualitative database for further comparisons, raises new challenges and offers new possibilities in data collecting, their further use and analysis. In this way this chapter can contribute some innovations to the methodology in the practical and theoretical field of environment-behaviour studies.

To sum it up, one must be aware of limitations of literary behavioural mappings. The accuracy of recording the location of observed activities on a map may have some degrees of error, even when all researchers are trained and tested for inter-observer reliability. Recording the location of activities by the use of a GPS device might appear to offer a more accurate way of locating individuals but it may inhibit natural behaviour. However, it would derive a considerable volume of data for analysis. Therefore, such approach might have less disturbing moments if a particular type of behaviour is in focus, e.g. cyclists. GPS is also proven to be quite good to study behaviours representing transition (van Schaick and van der Speck, 2007).

However, either of the behavioural maps provides a shorthand description of the distribution of behaviours throughout a place. They are useful if sufficient repeated observation in a place is done. Examples shown compare the use of spaces on the settings by male and female users, by activities engaged, duration of the activities and their distribution. The major value of behavioural maps as a research tool, lies in the possibility of developing general principles regarding the use of space that apply in a variety of settings. Overlapping individual drawn behaviour maps can show some characteristics and changes in using spaces in terms of activities, number of people engaged, gender, and all the other variables that were explored.

### **3. Applicability of behavioural maps**

Behavioural maps record people's behaviour in real spatial settings and, by that, talk the language of research in a design manner. They offer great potential to represent behavioural patterns as visual data, and as such act towards the reconciliation between design and research in the field of planning and place design. At this point applicability of behavioural mapping and its contribution in spatial planning, place design and decision-making is addressed. Accordingly, the chapter is divided into sub-chapters discussing the roles and potentials of behavioural maps for quality of places, for refinement of designers' notions and knowledge about usage-spatial relations and their inclusion in place design, and for comprehensive simulations which enable modelling of liveable environments.

Firstly, the chapter discusses behavioural maps as scripts of the actual uses mapped in places, using repeated observation at different days, times and weather conditions. Such value of behavioural maps is represented in empirical knowledge about dimensions and spatial requirements, especially for some long-stay active uses, such as ball games in parks and skateboarding in squares, and how long-stay passive uses such as sitting, might relate to them, as well as how transitory activities relate to both long-stay engagements. In addition, it illustrates how some activities can be contiguous, while some others require 'buffer' zones between them for effective use.

Secondly, the chapter uses behavioural maps to address activities imagined in parks and squares by urban designers, using two approaches: mapping likely uses in detailed maps of selected places, and revealing a physical structure of a particular place by knowing its behavioural patterns. On this basis, the chapter examines designers' tacit knowledge about the usage-spatial relationships and highlights potential applicability, the role and value of behavioural maps and empirically gained knowledge in the design of parks and squares. This shows that designers' beliefs and awareness about uses in places, in some aspects, differ from actual use. From this point of view, the chapter reveals a need for effective design-research integration and stresses the importance of behavioural mapping as a source of empirical knowledge and its incorporation in design.

All examples are related to databases and analyses from Goličnik (2005). The data collected by mapping is reliable because of repeated observations on different days, times and weather conditions. Conditions regarding the reliability of the data collected at the workshops with urban designers were met by asking experts about places that were unfamiliar to them.

Finally, possibilities for simulations as results based from knowledge stored in behavioural maps are discussed. This sub-chapter assumes that any dynamic system can be characterised as behaviour in a space. Therefore the notion of behavioural mapping is understood as wide as possible.

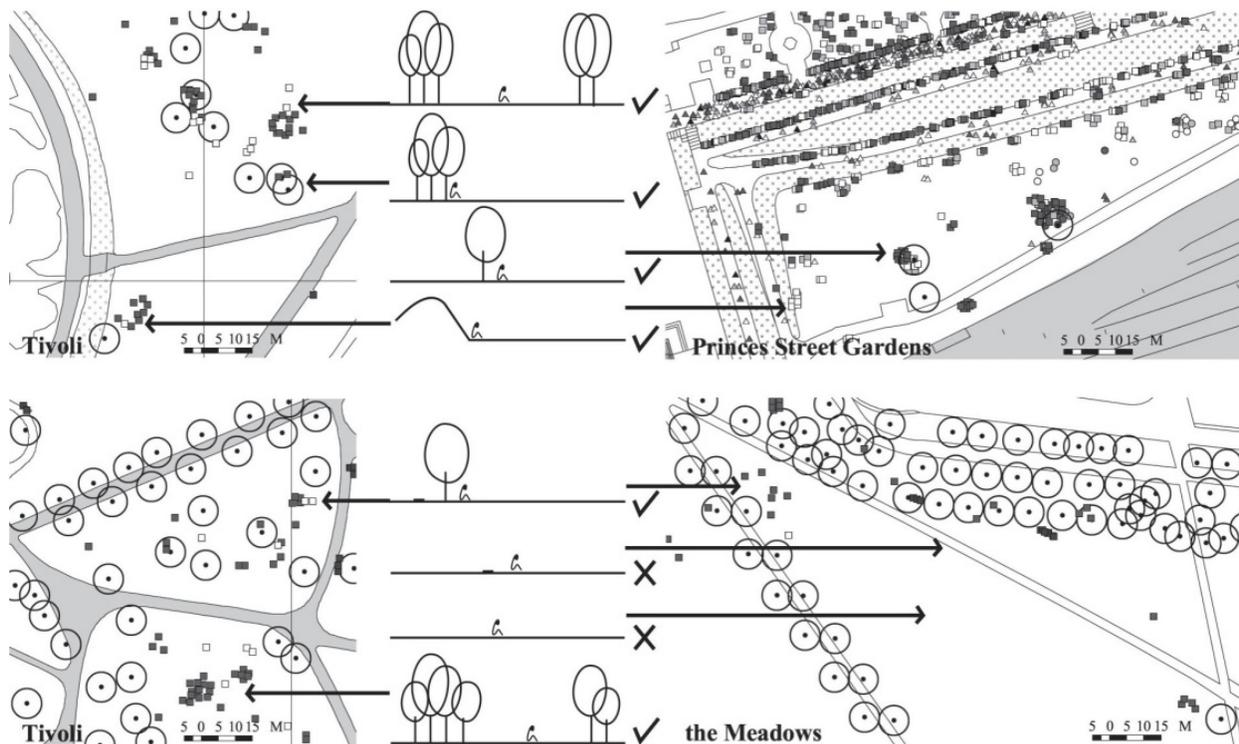
### **3.1. Behavioural map as a check-list for quality of places**

Repeated behavioural observation resulted in some common patterns of occupancies that appear to be correlated with particular spatial layouts and details. Behavioural maps analysis show actual dimensions of effective environments for one or more uses and show how design guidance can be arrived at, based on the particularities of the case study sites and cities. Here lies the potential for using information derived from behavioural maps analysis for assessment and evaluation of quality of places.

Analysis of different parks shows that a certain spatial definition such as a corner or a path with different degrees of transparency are not the ultimate clues to spatial occupancy per se. Groups of trees, some prominent single trees or any other objects can play a crucial role. What matters is a spatial articulation and a placement of uses in a place relying on a certain distance from it. It is reflected, for example, in occupancies, distanced at least 5 metres away from transparent edges such as tree lines along pathways of the patches, predominantly without trees, congregations right up against a solid edge, whether a steep slope or a bank, and in the areas of smaller groups of trees or solitaires. Figure 6 summarises and illustrates some of these situations.

Different spatial qualities of settings and their conduciveness to passive usage, such as sitting or lying down in a park, are exemplified on the basis of empirical evidence represented on the assembly behavioural maps for Tivoli, Ljubljana, Princes Street Gardens, Edinburgh and the Meadows, Edinburgh. The upper set of Figure 6 shows sitting right next

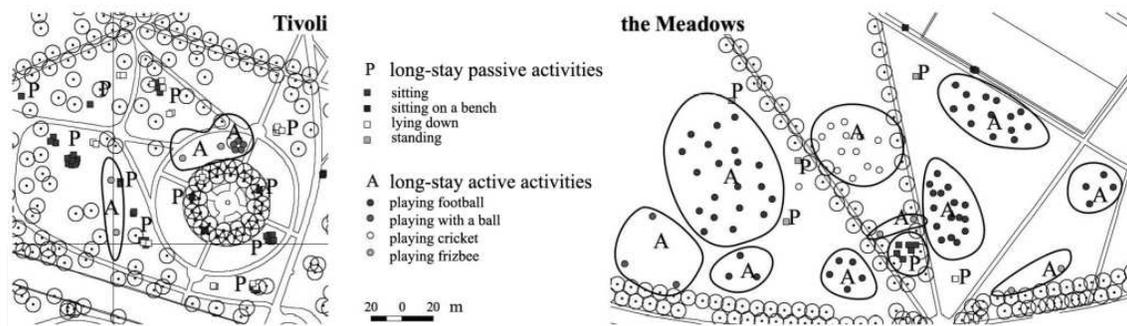
to a solid edge such as a slight slope, and people in the areas of smaller groups of trees or solitaires. The lower set exemplifies sitting further away from transparent edges, such as tree lines along pathways, especially near their intersections, and no sitting along any of the broader zones along the path with no other spatial definition.



**Figure 6.** Spatial qualities of settings and their correlations to passive usage (Goličnik, 2005).

The results also show that, even if the lawn patch is huge, if it is not articulated, unless any temporary articulation is available, uses such as sitting or lying down are less likely to occur. The importance of spatial articulation reveals, especially in places where there are not very many different elements of spatial definition, that it is not only physical spatial definitions that might direct uses in a certain spatial occupancy, but also that the presence of other uses, to a certain degree, can perform this function as well. Mainly larger groups of active participants can articulate places and, in doing so, create room for themselves and for others (see A and P in Figure 7). Goličnik (2005) has found that the size and the shape of lawns in parks are not particularly crucial for any passive occupancy; but they can be of greater importance for informal ball games, especially playing football.

Analysis of the parks showed (Goličnik and Ward Thompson, 2010) that spatial articulation is the clue to spatial occupancy. Activities, especially those significant for active group games, form patterns buffered by voids, in several quite predictable ways. There are two significant types of buffer zones that different active, long-stay users need: the buffer between an edge, whether solid or transparent, and active users (e.g. informal football); and buffers between a number of adjacent active groups occupying different territories.



**Figure 7.** Examples of a situation where, when more uses take place in a park and make new boundaries, how sitting and lying, 'move in' with regard to them (Goličnik, 2005).

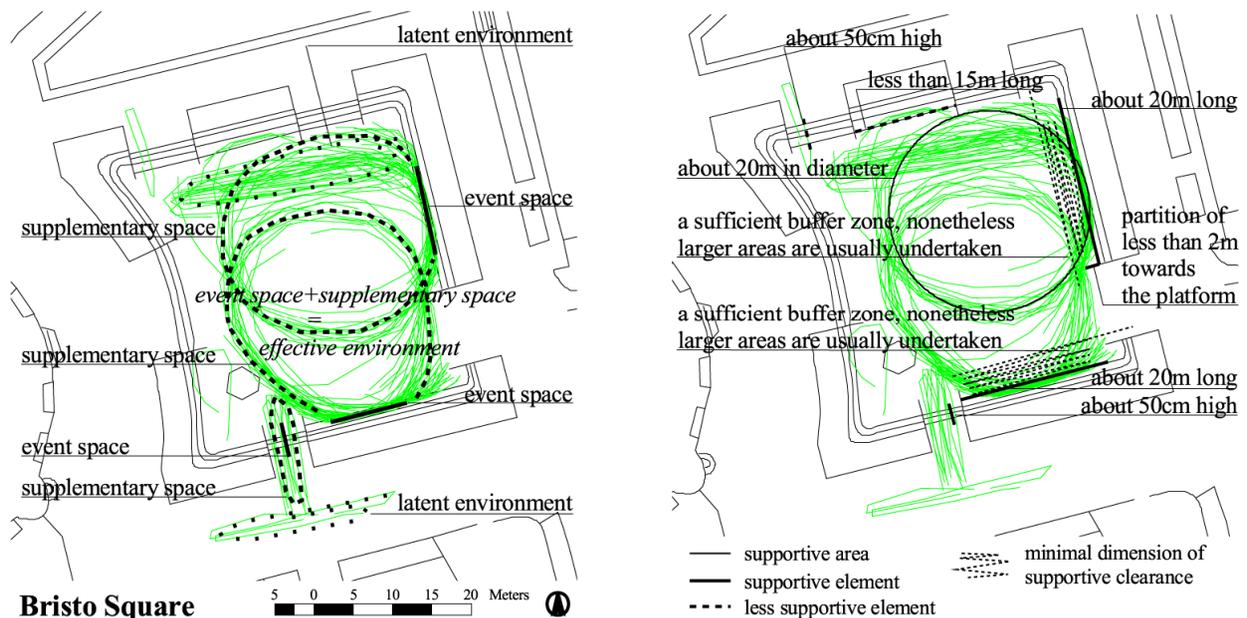


**Figure 8.** Cumulative minimum buffer zone (above) and relationships between size and shape of a patch and its occupancy by long-stay active uses based on records from a daily pattern (below) (Goličnik Marušić, 2011).

To illustrate the first type, compact groups of informal football players are likely to require a distance of at least 4m from an inner transparent edge, such as a tree-lined path. Activities forming looser and smaller groups, such as a couple of frisbee players, are likely to occupy a space closer to an inner edge, e.g., at least 2m from a path. For the second type the minimum 'common open' area between activity spaces is quite difficult to define precisely in terms of a surface area, since the activities taking place depend on the size, shape and edge qualities of a green patch. However, an abstract form which can describe the minimum activity buffer space commonly needed between groups of activities is a circle of 20m radius.

Addressing conduciveness and quality of places from the usage point of view, some observations of squares in city centres of Edinburgh and Ljubljana (Goličnik, 2005) have shown that even though none of the squares examined was planned as a skateboarders' platform, a certain articulation of those places has stimulated its users to be there and to use it for their pastime. However, this certain articulation in itself did not ensure optimal use. The size, shape and vertical articulation of the available space are of key importance.

For one of the usual skateboarder's actions, which consists of approaching an elevated spatial element such as a step, in order to jump on it, slide along, and then jump off it, the necessary full length of a step required needs to be at least 15m. The adjacent area before such a step should allow a skateboarder to approach it along a curve of a circular line of at least 20m in diameter, and to undertake virtually a jump-preparation journey on it of at least 5m. Thus, a platform at least 3m wide, attached to a long step, would allow such a minimum jump-preparation journey.

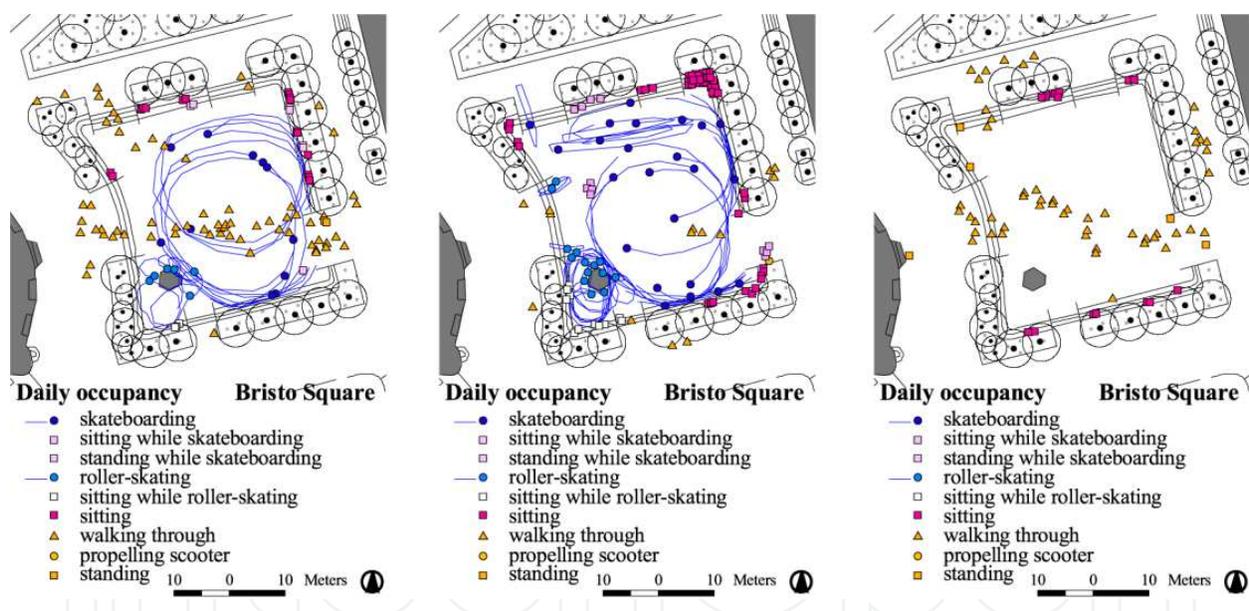


**Figure 9.** Effective environments, their structure and dimensions exemplified in Bristo Square, Edinburgh (Goličnik, 2005).

When addressing usage-spatial relationships in more detail, a spatial configuration of places becomes important. The examined cases show that steps which merge into a flat platform, are essential elements that attract skateboarders; but the merged, flat area is crucial to enable their actual use. Physical traces of actual activities, represented as graphical information on the map, elucidate the inner structure of the effective space, reflect usability and in this way, address its spatial capacity. Equipment such as boxes and some other light structures, which skateboarders brought to the stage, evokes latent environments. Bristo Square in Edinburgh and Trg republike in Ljubljana were the most illustrated examples of these skateboarders' performances (Figures 2, 3, 9,10)

Further analysis shows (Goličnik, 2005) that neither of those squares (Bristo Square, Trg republike) has any benches but participation in sitting is remarkable. Compositions of steps are attractive as sitting places as well. This examination showed also that sitters' and skateboarders' actual effective environments do not overlap. Sitters are searching for sheltered, back-covered, less exposed areas, and places with a view of either attractive landscape or actions (see figures 9 and 10).

Although the intensities in participation at Bristo Square, Edinburgh in any long-stay occupancy on a cold, windy and cloudy afternoon (first map in Figure 10), in comparison to a warm, sunny weekend afternoon (second map in Figure 10) is lower, both maps show a similar behavioural pattern of occupancy. People sitting were mostly occupying the upper steps in the parts where broad planting beds enclose the square. The distribution of uses recorded on a nice early afternoon during the week (third map in Figure 10), when there were no skateboarders around and people sitting there could have occupied any square inch of the staircases, it shows a similar pattern of passive occupancy with the other days. One may speculate that sitting along the eastern edge was not evident as the skateboarders' performance on the stage was missing.



**Figure 10.** Maps of typical occupancies in Bristo Square, Edinburgh, represent from left to right the daily occupancy on a weekday afternoon of poor weather, the daily occupancy on a weekend afternoon of very good weather, and the daily occupancy on a weekday early afternoon of good weather (Goličnik, 2005).

These examples show that, spatially speaking, optimal settings for sitting and skateboarding are different, and that Bristo Square successfully serves both activities at the same time. They also show different concerns addressing time aspects of occupancies. According to a weekly occupancy, transitory activities are more common to occur on weekdays than during the weekend. Time differences recorded for different times of the day, reflect that active

long-stay activities such as roller-skating and skateboarding, are usually participated in on an afternoon, no matter what the weather, whereas they might not be seen earlier in the day.

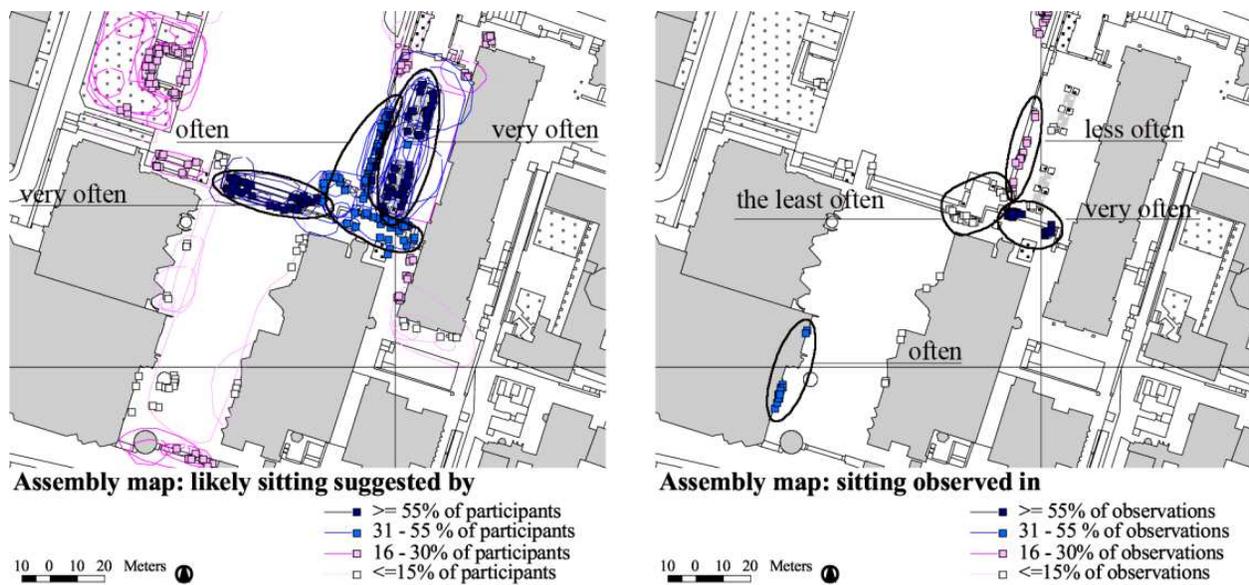
The common act of observation and behavioural mapping shows up as an effective way of searching for empirical knowledge about usage-spatial relationship. It is a comprehensive way of collecting the evidence about 'where, how and what is going on' in a place. Moreover, mapped physical dimensions of uses are seen as a potential which could inform about the design of places and could become a way of negotiating landscape forms.

### **3.2. Behavioural map as a check-list of tacit knowledge of designers**

The examination of the variety and richness of information and empirical knowledge, which may be gained from observation and GIS mapping, raises the question, what type of information about usage-spatial relationships, if any, would be most required or would be highly demanded to inform designers about better design? A search for an answer might reflect on the meaning, the value and the role that empirical knowledge may play in the design (process). In other words, what are designers' perceptions and imagination about public places and the activities that are likely to occur in them? To illustrate some of these challenges, Goličnik (2005) conducted several workshops with urban landscape designers in Edinburgh, a sample of 35 participants in total. Participants carried out the tasks individually. This inquiry was intended as a pilot study, to look for some basic insights about such issues, rather than a fully-fledged investigation.

The examination of the use of public spaces from both angles, what activities do users actually engage in, and what designers' perceptions and beliefs about them are, has shown that often there is a lack of knowledge about the nature of occupancy of one particular use or a certain combination of them. A brief conclusion showed that despite the fact that generally there had been a good recognition and listing of likely activities in specific places, concerns about the spatiality of uses and conduciveness of places to support them were not always fully considered. For example, a scrutiny of sitting, as one of the more usual activities in urban open public spaces was not sufficiently precise, especially when concerns relate to selectivity in usage's placement. Some spatial entities, which the workshop participants suggested were most likely to be used for sitting, were revealed by the observation-based evidence to be marginally in use or even unused (see Figure 11).

Further analysis of various overall assembly maps shows that, in many cases, the likely settings proposed by the designers for some activities such as skateboarding, playing or even sitting, differ in their rates and intensity of use from that recorded by surveying the actual use of settings which usually facilitate any such activity. It shows that designers were not only generous when placing certain activities such as sitting, practically everywhere possible, but also general in graphical expression using a 'bubble-diagrammatic' technique.



**Figure 11.** Locations of likely occupancy by sitting in Trg republike, Ljubljana as they resulted from the workshops and actual occupancy recorded in the entire observation period (Goličnik, 2005).

This implies that designers are not used to express their visions of places via behavioural patterns of their imagination of actual activities in places, which also indicated that they do not operate with behavioural maps. Such findings argue for the importance of getting information from empirical evidence that might inform a better understanding of the usage-spatial relationship, as well as the design itself. Accordingly, knowing about physical dimensions, spatial peculiarities of activities and their interrelations, as well as about physical conduciveness of places to occupancy, and by this recognising the potential and effective environments, is of key importance when aiming for responsible design. Behavioural maps are effective sources of such knowledge.

The examination of design proposals, which were produced by workshop participants based on known behavioural patterns of places, not only shows sometimes partly considered responses but also other characteristics of these proposals. They are reflected in solutions which, many times, are driven by a spatial context itself, a formal structural message from the area or the ideas beyond that, addressing a place's integration in a broader context. In fact, in all such cases, there was little response to a behavioural pattern as such in the first place. Goličnik (2005) reveals three categories reflecting the basic design layouts: 'quite responsive' (13 cases), 'mostly indifferent' (14 cases) and 'non-classified' (8 cases). These latter usually refer to proposals which actually do not address design as such, but which stay in a level of zoning and bubble diagram expression. Figure 12 exemplifies typical representative drawings for each category as described above. Although the examples which were classified as 'mostly indifferent' were significant for hardly responded at all, there were also examples which were overwhelmed by the design proposal. These latest are exemplified in Figure 13.



### 3.3. Behavioural map as the key input data for comprehensive spatial simulations

Behavioural maps are applicable in a variety of different scales, from the small scale of a single room, to a medium scale of a street, a square or a park to the large scale of a whole region. How behavioural maps can be created and applicable in the detailed scale of urban design has been already discussed so far. However, considering these different scales, they can for example, represent movement of individual users in particular rooms, from the living room in a house to a classroom in a school, as well as migrations in regions. In this relation it is important to consider that behavioural maps cannot be limited exclusively to individuals. Accordingly, regarding the scale and the nature of the research problem it is possible to address behaviour as a variable, which varies from a single person, group of persons or even other subjects than people relevant in spatial planning and design (Batty, 2005; Porta et al., 2009; Chaker et al., 2010). Actually, the focus on the subject depends on the viewpoint chosen and the scale preferred. When paying attention to individuals on the street, then commuters are in focus and the street represents their physical environment or context. On the other hand, when the street as a cumulative result of single commuters is in focus, its surrounding becomes recognised as the context of the studied phenomena. Both views have been addressed in a study of cyclists in Ljubljana (Goličnik Marušić et al., 2010).

Beside sliding over different scales and by this accommodating the focus on the subject to be observed, it is also possible to discuss how behavioural maps at one level or certain scale can help to interpret behaviour of subjects from another related layer. For example, behavioural patterns in squares as discussed before, can help to interpret liveability of (local) businesses in the influential area of the square. Similarly, the liveability rhythm map of such businesses is also one of the behaviours of the square; i.e. cafés open first, followed by shops, crafts and restaurants. Such mapping can be applicable on the scale of a block, a quarter, or even an entire city or a town. Via such behavioural mapping it is possible to address the capacity of places by documenting timetables of working hours, frequencies of peak occupancies, and the like, for both, spontaneous or programmed uses.

Combination of different observations in different scales and accuracies (e.g. patterns of people, rhythm of activities in businesses and services etc.) can lead to a comprehensive simulation of a place. Data or information that influences behaviour of a certain place is not always directly visible. Non-spatial data, which backgrounds a certain place, such as money flows behind the business in a place, can also be mapped and therefore spatially expressed. However, such abstract descriptions of places reflect some physical characteristics of places which can be expressed or measured by behavioural maps. The point is that the behavioural mapping approach enables us to visualise primarily non-spatial data (e.g. detailed parameters of users in places, economic efficiency, frequency of cultural events, etc.) on the maps. Thus such data are placed into the contexts of other data of spatial realities. In an urban environment for example, they may be suitable for models and simulations of revitalisation and regeneration processes. (e.g. Goličnik and Nikšič, 2009)

The discussion showed that it is possible to look at different relevant spatial parameters in similar ways. Behavioural mapping is recognised as an approach, which can be beneficial due to the way of documenting and organising data which describe the observed phenomena. However, when an approach enables different and diverse data to be gathered in compatible ways; they are more likely to be put onto a common denominator, set into a compatible database and compared between each other. Such database or network of databases can serve as a base for comprehensive spatial models. Sufficient amount of data allow also simulations of behaviour in places. Such simulations showed that by successful simulation the amount of actual observation and data collection may be reduced. And vice versa, sufficient amount of observation can offer a foundation for better design practice or simulations.

On one hand, a collection of data from comparable sites enables reliable reasoning about the site which has not been sufficiently observed, or has not been observed at all. However, checking the site (e.g. one or two observations) is required afterwards to assure reliability of the simulation. On the other hand, results gained from repeated observations such as sizes and shapes of effective environments for certain activity or more of them can be used for simulation of new places. This is not applicable only in the physical design of places. It may also be helpful in the phase of programmatic and economic efficiency planning within the entire design and decision-making process.

When using data for simulation in relevant or comparable places, it is of key importance to select a set of criteria which enable us to define compatibilities of places. For example, data collected in public open places in Edinburgh and Ljubljana was reliable because a sufficient number of repeated observations was done, but most of all as sites were proven to be comparable. Both cities are middle-sized European capital cities with a relatively small population in total (Edinburgh about 450,000 inhabitants, Ljubljana about 300,000). Both are important national and international cultural, educational, as well as political centres; in this respect, they have a similar atmosphere in terms of their daily routine. Both cities belong to the mid-latitude temperate climate zone, Edinburgh to the oceanic, Ljubljana to the continental; which causes some differences during different times of the year. In mid spring, a popular season for outdoor activities, they are quite similar, especially when conditions are dry, no matter if it is sunny or windy. By contrast, the frequency, duration, and volume of rainfall are more likely to be different. In Ljubljana's continental climate, heavy rain is usually a downfall, whereas in Edinburgh, types of downfall can vary from mist to mild showers or heavy rain. A comparable number and typology of selected places representing popular, central public open spaces of different sizes and micro-spatial contexts, were selected for study within an area of about 2 km<sup>2</sup> in each city.

Behavioural maps as scripts of behaviour of any studied spatial phenomena are especially effective within the GIS environment as it is a tool which can convey data referenced to different scales and enables organisation of data, its visualisation and analysis. These characteristics of GIS place it as a highly valuable source and environment for spatial simulations.

### 3.4. Implications and limitations

Addressing spatial characteristics of places by their usability and by reflecting from that on the conduciveness of places to occupancy, this chapter and the results of commented researches have shown in some detail the nature of effective environments and have suggested some vocabulary for their descriptions (see Figure 9). By examining the effective environments for skateboarding in more detail, it has shown that it consists of two adjacent spaces: the 'event space' and the 'supplementary space'. The event space is the actual space through which the activity is 'installed' in the place. It represents a position which a person or a group of people engaged in a particular activity occupies in a place. The supplementary space is the available space at hand to this person or a group of people, which actually enables the complete activity to happen fully. As the event space is necessary for that activity to be invited into the place, its supplementary space addresses its satisfactory staying in a place. Both spaces together form the effective space of an activity. The same is true about spaces for playing football and spaces for sitting. Therefore, it is important to understand the spatial articulation as a necessary but not sufficient condition for some kinds of use. In this respect, the examination of places through the distribution and physical dimensions of behavioural patterns in them, has enabled a discussion about what the effective environments are and how to imply their importance and relevance to design practice.

Attempts to find generalisations from findings related to dimensions of usage-spatial relationships can offer important contributions to our knowledge and understanding, even if they are still rather speculative. That is so, firstly because as the sub-chapter dedicated to designers' tacit knowledge showed, that designers' beliefs and awareness about uses in places currently often differ from actual use, and secondly, because previous theoretical stands and guidance for the built environment have now been supported by data for large open space occupancies, as well.

The discussion also showed that behavioural mapping has potential that can be used not only in studying actual patterns of occupancies of places but that the same approach can be applied to different subjects of spatial reality. However, one must bear in mind also the limitations related to this.

## 4. The role of GIS in relation to behaviour mapping and place design

The main advantage of GIS in relation to behaviour mapping is that the system can be updated practically with any information. Results showed that GIS databases can effectively serve as an inventory tool, providing basic descriptions and information about activities in places. They offer an understanding of those places by patterns of spatial occupancy with regard to their elementary characteristics, those that describe their peculiarities when being carried out. Maps, as products of visualisation, can represent the spatial data of behaviour patterns as patterns reflecting occupancies at different times of a day, or days of a week; as patterns structured by the duration, nature or type of occupancy; as patterns showing the occupancies only under pleasant weather conditions and the like.

Therefore, if the demand in practice for better designs calls for the importance of empirical knowledge, the technical possibilities performed by GIS (Jiang and Yao, 2010) can show and reflect on richness of its contents. In this chapter, the initial contents of the empirical knowledge directly reflect the information recorded through the observation. A GIS application upon it elucidates different aspects of this basic information about the usage-spatial relationship and provides a variety of different information derived further from this original collection. From this point of view, especially because the knowledge is visualised on maps, it also reveals the possibility for more effective design-research integration and stresses the effective incorporation of empirical knowledge in design.

A specific value of an empirical knowledge gained by GIS behaviour mapping lies in the notion about the effective environment, that what happens in any particular environment depends on those who use it. Hence, while urban designers might create potential environments, people create effective environments. The challenge is not only to see to what degree or how much of a potential environment can be transformed into an effective one, but also to discover its inner structure. Empirical knowledge, stored in digital interactive GIS databases and shown on maps after a selection process, can provide some insights into different dimensions of the usage-spatial relationship, such as gender or age differentiations and the like.

On the other hand GIS enables observation of hidden dimensions of subjects relevant and related to the dynamics of spaces. Qualitative descriptions of variables are immanent to such a system. Especially, as GIS (e.g. Ratti et al., 2005; Porta et al., 2005; van Schaik and van der Speck, 2008; Jiang and Yao, 2010) is a system which can be sourced in various ways, from actual data collection in the field, to data collection from a virtual environment, such as the internet. Moreover, GIS itself represents the initial platform which may offer some basic observation for a certain level of subject observed. Thus, no actual field observation is needed at all and data input is automatic. However, quality control of such data input is necessary.

#### **4.1. Implications and limitations**

This chapter found that GIS, as an analytical and evaluation tool, draws the closest approximation to meeting the challenge of 'talking about the physicality of spaces, using the language of patterns of uses'. GIS maps are recognised as an effective tool to represent and interpret behavioural patterns as visual data. They also translate recorded evidence into a body of empirical knowledge and preserve the connection of related non-spatial data to the material place. By such an association of behaviour with a certain environment, it is possible to ask questions and draw conclusions about the behaviour and its relationship to a place, and from such reasoning, move towards a reconciliation between design, decision-making and research.

Although the main advantage recognised within the topic of this chapter is openness of GIS as a system for updating the system with any relevant data, one must bear in mind that there are limitations in data collection which can significantly influence the system as such.

Quality of data depends on the quality of the observer. Generally, credibility of data can be relatively high if the observer or group of observers is trusted. Some errors may appear when data is transferred from the manual to the digital version. The accuracy in locating studied subjects is better by direct input to digital media, especially if addressing inhibition of natural behaviour; but the practical difficulties of implementing this are considerable. When using GIS web portals to collect the data of users' experiences in place usage (e.g. cycling in Ljubljana, Goličnik Marušić et al., 2010), the skills, seriousness and accuracy of person providing the information directly influence the overall quality of data provided. Besides, when using GIS web portals to collect data, another limitation must be born in mind. Although such approach can assure quite big amount of data, it does not include user groups which are not familiar with the internet and IT. When web portals are used as data sources reliability of the data itself may be questionable. Therefore, no matter the way in which data are collected, quality control must be provided by cross-checking for example, so credibility of database can be assured, including the 'smoothness' of data.

Another very important issue when using GIS either as a source of data or as an environment to produce data, is checking on compatibility and comparability of data offered within the system. For example, the socio-economic context, the functions and density of the surrounding area may vary and are certainly likely to influence the activities and level of use within a space. In this discussion, the sites chosen were roughly comparable with regard to such considerations but this potential limitation must be recognised before generalising to other parks in different (e.g. suburban) parts of other towns and cities. Well-used (and well-maintained) city parks are likely to be perceived as safe places to visit, sit on the grass, etc., but this may not be the case for emptier or poorly maintained spaces, or where there is no surrounding land use that provides informal policing of the area. However, the context of each site may also be analysed and compared with other sites using GIS.

To sum it up, when using behavioural maps of any kind, the context of the studied behaviour is always important. Various characteristics of this context are described in GIS with different levels of accuracy. Therefore it is important to develop mechanisms for detecting comparable information, and sites as GIS as a system can be quite reliable for comparative spatial studies.

## 5. Conclusion

This chapter discusses the actual uses observed in certain places to illustrate the role of behavioural mapping (based on observation and the use of GIS databases) in place design, monitoring and decision-making. The major value of the use of behavioural maps as a research tool, lies in the possibility of developing general principles regarding the use of space that apply in a variety of settings. GIS based behaviour maps extract behaviour evidence into layers of spatial information to give a better understanding of the individual and collective patterns of use that emerge in a place. The overlap of behaviour maps can

show some characteristics and changes in using places in terms of activities, number of people engaged, gender, time of day, duration of activity and similar.

The empirical knowledge gained by behaviour mapping is seen as an addition and a complement to other research approaches and tacit designers' knowledge. Such empirical knowledge brings a good template and/or a starting point for further post-occupancy evaluation analysis, as well as benefits to public participatory processes in planning and design decision-making. It is especially important when addressing user-groups such as youngsters or elderly people, even homeless people, who may not respond to participation, but whose preference and existence in a place is important, especially when talking about democratic, all-inclusive design.

Whatever technique is used or can be expected to be used as the most efficient one in future, taking into account IT development, GIS as a tool, with the ability to produce and use databases, remains of key importance. Another practical challenge in the future lies in the technical field of computer software. Having the appropriate and affordable equipment for recording digital data directly (in the field), a programme which could support a simultaneous coding of all sorts of behaviour attributes such as gender, type of activity, its duration and similar; as well as any other conditions regarding the weather, time of the day or any other relevant aspects, would be very helpful.

The combination of GIS and activity mapping provides a powerful tool to support designers with empirical evidence of the relationship between environmental design and the use of open space that is spatially explicit and therefore presented in a spatial and visual language familiar to designers. This makes it more likely to be useful and useable.

Another contribution of behavioural maps which has been brought up within this chapter is the notion that they are not necessary to be limited to the examination of behavioural patterns of activities in places. Behavioural maps and behavioural mapping can be interpreted according to various relevant aspects related to place design and research. Such viewpoints enhance the role of GIS in behavioural mapping, as GIS as a system does not serve only as a tool for visualisation and interpretation within the context of studied phenomena, but represents a common comprehensive database and works as a generator of simulations. One of the key aspects which can contribute to building such a comprehensive database is the ability of GIS to perform linkages between different scales of any data stored in such database originally may belong to. Another crucial characteristic in terms of GIS efficiency for behavioural maps is the ability to compare compatible patterns or phenomena.

## **Author details**

Barbara Goličnik Marušić

*Urban Planning Institute of the Republic of Slovenia, Slovenia*

Damjan Marušić

*The Surveying and Mapping Authority of the Republic of Slovenia, Slovenia*

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