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UrbanDiary - A Tracking Project: Capturing the beat and rhythm of the city: Using GPS devices to visualise individual and collective routines within Central London.

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Abstract
This paper investigates aspects of time in an urban environment, specifically the cycles and routines that constitute everyday life in the inner city. As part of the UrbanDiary project (urbantick.blogspot.com), a preliminary study was undertaken that utilised GPS wristwatch devices to record the individual journeys and spatial habits of twenty volunteers, in order to capture and trace their lived experiences of the city. The data collected included time and location, which enabled each trip by an individual to be plotted on a base map of the city and visualised as a 'personal track'. The tracks were then compared with a series of statements by the individuals that described how they 'used' and experienced the city. The tracks made by individuals were superimposed upon one another to build up a composite picture of their daily, weekly and monthly movement routines. Individuals' composite pictures could even be aggregated, to distinguish 'collective' from 'personal arteries' within the inner city. In this paper, the main intent has been to explore the context of the UrbanDiary project, as well as to examine the methodological and technical aspects of tracking, focusing on a comparison of the different visualisation techniques used. The paper concludes by presenting examples of the most promising approaches to data visualisation and suggesting that, by taking account of the aspect of time, the city can be understood in a new way as a collective, constantly renewed space.

Keywords: time, urban space, GPS tracking, visualisation, individual trips, personal routines, collective experience,

1. Introduction

Traditionally the city is mapped as a network of streets, buildings and blocks that form the space within, where this given space is generally taken as universal and objective similar to a box populated with objects. Within this box-like construction of space-time, movement and change are treated as placed attributes. Movement and change are not employed in the construction of the box because they, unlike the physical elements of the city, have not one state but many. The UrbanDiary (UD) project aims to address this problem of “many states at the same time” by examining techniques and methodologies to observe and map the change of movement and time directly. The viewpoint adopted is from within the given and generally understood concept of space, but insofar as this project combines aspects of process into the overall description of urban space by tracking activities, the paper aims to generate new perspectives on how to define and interpret the city as a collective product of patterns in time.

Unlike many studies in the field of traffic and movement surveillance, which deal solely with data on the spatial locations of activities, this study is specifically looking at the route chosen between locations and the pattern of repetition occurring through rhythmic schedules over varying periods of time. At the first stage of data collection, a number of volunteers were equipped with a GPS device that allowed their journeys through the city to be tracked. Over a period of at least two months, participants recorded their personal spatial diary, mapping the extension of their personal everyday life in space-time. In-depth interviews and contextual information focusing on individual routines and habits was recorded. The resulting data set allows for a space and time relation to be constructed and linked to a collection of habits and routines. The expressions 'everyday', 'everyday life' and 'routine' in this context are used in the sense of de Certaux (1984). The data collected and the scope of routines used are very much on an individual level, but combined as a collective map, this represents a spatial diary of events taking place in the urban environment and ultimately captures aspects of the rhythm of the city that we seek to explore.

2. Context

The research focuses on cycles and rhythms in the urban environment. Day and night, the rush hour, weekends, train timetables, paydays or a yearly celebration day are examples of repetitive patterns occurring in the city. Such patterns could theoretically be the result of spatial and social configurations, and they are seen here as based around the organisation of the urban environment. In ”The Social Logic of Space” Hillier and Hanson (1984) collect a large set of examples demonstrating the connection between social configuration and morphology of the built form as a static setting.

Figure 1 - Garmin Forerunner 405 : The gadget use for tracking

As the hypothesis of this research, cycles as repetitive activities are believed to be a third dynamic element within the system of objects (the first element) and their interrelationships (the second element). In any urban setting, these repetitive patterns are the main source of identity, provide orientation and are a main creator of memory. Barry Curtis even regards memory as “one of the key ingredients in the creation of place” (quoted in Borden 2001, p.63) and he reflects on this by adding “Memory is rarely without contradictions, and it must be compromised in order to function”. The UD project is an explorative project led by two main research questions: firstly, do cycles participate in the shaping of cities, especially on the level of urban form, and secondly, how can cycles be incorporated as a tool in the urban design and planning process? Distinguishing between three main

groups of cycles, natural, activity and material cycles, the focus will lie on the activity group, daily rhythms and routines of individuals, living in the city and how these habits are manifested in space (Neuhaus 2010). With both a theoretical and practical context, the UD project examines the spatial extension of an individual's routines in urban environments.

3. Methodology

GPS technology has become widely available with relatively accurate devices. For this study, the participants wore a watch-like GPS device on their wrist, which is illustrated in Figure 1. The specific technology and accuracy of GPS systems is explored further later in the paper. Wearing the device on a daily basis ensured that personal routines were captured at the required level of detail over the duration of the study, which lasted two months to ensure that monthly and weekly, as well as daily, patterns were included. The data record contains location and time information, which can be mapped using a variety of methods and tools. Participants were not specifically selected, but they were all adults of different ages with a mix of female and male candidates from different backgrounds, family and work statuses. Each participant was met weekly or biweekly to download the data. This ensured a close contact between researcher and participant and allowed for informal discussions about the collected data and personal routines. Towards the end of the recording period, a formal interview was carried out, allowing the presence of routines or habits to be recorded that may not be identifiable in the GPS data.

4**. Technology**

For the study, GPS was used to track participants as they move around the city going about their everyday business. In this section the technology behind this approach will be discussed in more detail, to create a context for the data collected and the nature of the findings. GPS stands for Global Positioning System and is a global navigation satellite system. Based on a signal sent from satellites orbiting the earth, a specialised receiver device can accurately define its location in the framework of the Cartesian system. “Current generation navigation systems … determine the user terminal position through the time of arrival. In general, this kind of ranging technique is based on the measurement of the time interval employed by a signal transmitted by an emitter (e.g. satellite, radio beacon) at a known location to arrive at the user receiver” (Prasad 2005, p.15). For pinpointing a location, theoretically three satellites (reference points) would be needed to triangulate the position. However, due to a constant unknown bias, usually differences in clock time, for an accurate location, the signal from at least four satellites is necessary (Tsui 2005, p.9), where the fourth one is used for time correction. Accuracy can be up to a few metres depending on the quality of the satellite signal. Each location is determined as a latitude-longitude pair of coordinates and, together with the time information, is stored as a location point on the device's internal memory. With the time information, this data can, as a sequence, produce a track as a line of movement.

Initially developed for military use, the technology has, in the last few years, become very popular in everyday culture. Today a large variety of digital gadgets are equipped with a GPS receiver, ranging from in-car navigation systems to mobile phones and cameras. This was initiated by the former president Bill Clinton's decision to lift the imposed selective availability (SA) restriction in 2000 (Prasad 2005, p.7). The SA was initially imposed to prevent enemies from using the system in military action against the United States. Following the SA removal, civil and commercial GPS accuracy increased from around 100m to somewhere between 3m and 15m (Pendleton 2002 as cited in Spencer 2003, p.56).

Geocaching or geotagging of images are just two examples of the use of GPS in everyday life. Unfortunately, a large number of location-based service applications under development are mainly led by the idea of sourcing new areas for advertisement. A key player is Google, with its location-based information services that developed from Google Maps. The main technological problem for the GPS devices is battery life. Most mobile phones cannot support the energy-consuming GPS receiver together with the energy-consuming communication to cell phone towers, over a longer period of time or even a day. Specialised GPS devices currently perform much better, and can last for days depending on the settings. The latest handheld devices can be the size of a watch. For these reasons, a specialised GPS device was used for this study.

The signal strength is dependent on a number of environmental factors, such as the weather and the nature of the physical environment. Errors can be on the satellite side, such as ephemeris errors related to incorrectly transmitted position or time. Even though each satellite is based on four atomic clocks, errors occur due to instability, and a deviation of 10^{-8} seconds results in around a 3.5 m error on the ground (Parkinson 1996b as cited in Spencer 2003, p.52). The atmosphere also creates errors as the signal passes through, resulting in 2m to 6m errors. The largest impact on errors, however, is called position dilution of precision (PDP) and describes the signal quality as a result of satellite positions, relative to one another. A good signal is received if the four necessary satellites are distributed at the same height in the sky, whereas a low quality signal results from clustered satellite positions or satellites being very low on the horizon (Spencer 2003, p.28). With the help of the corrected satellite position, published some time after the event by the GPS Master Control Stations (MCS), a correction filter for the data can be calculated. Similarly the location for a survey can be pre-checked, if the time is known, regarding the satellite signal, and especially if the PDP takes into account the quality of signal that can be expected.

On the ground the radio signal can be reflected by hard surfaces, resulting in multi-path interference. Buildings or trees can, through this, have a significant impact on signal quality. Here, the resulting errors can vary between 2m to 15m from large, highly reflective surfaces such as water bodies. This is significant in the urban setting of the UD project, as it is located largely in a dense urban environment. The combination of narrow streets and high buildings, plus a large amount of street furniture and signage, can make it difficult for the receiver to establish and maintain the satellite

signal. An additional implication for the quality of the satellite signal is the mode of transport. In the context of London, the underground and the bus play a significant role in the daily journeys of citizens. Underground on the tube, no satellite signal can be recorded. Similarly on the bus or on the train, it can be difficult for the device to register a proper signal. A window seat is notably better that an aisle seat, and the further away the device is from the building facades towards the road centre, the more this will also improve the signal quality.

As we have already mentioned, in the UD study, a Garmin Foretrex 201 was used. It is a simple handheld GPS device that can be worn around the wrist, like a watch. When it is turned on, it starts automatically to search for satellite signals and if the position is determined, starts recording. Approximately every two days, the participants are required to recharge the device overnight. Reception of satellite signals on this device is quite good, but it can be affected by errors as previously described, due to the setting. Nevertheless, results have been determined as satisfactory so far.

The data collected by the participant is stored locally on the device and downloaded manually by the researcher, usually on a weekly basis. For the older 201 models, some data cleaning is required due to random location points saved when the device either loses signal or has a weak signal. A database stores the location points together with contextual and anonymised personal information. For visualisation purposes, the data can be output in various table formats and processed further, for example as an individual diary map or as a collective diary map for London (Figures 2a and 2b).

Figure 2a (left) UrbanDiary map showing twenty participants tracked over a period of two months and Figure 2b (right) showing only the records of an individual participant.

5 Mental Maps

One of the most cited studies using mental maps is “The Image of the City” by Kevin Lynch. The study was carried out over five years and summarised in his 1960 book. Lynch states: “*Every citizen has had long associations with some parts of his city, and his image is soaked in memories and meanings*” (Lynch 1960, p.1). It is a fairly romantic description, with a lot of implicit hints to how environments may be understood socially, but it also expresses the view that there is some knowledge and meaning residing in each one of us about the environment we live in and navigate through. This is not about orientation, exact distance measurements or overarching, objective descriptions. Rather, it is about personal experience, judgment and what is physically and psychically important to the subject. Lynch states, “*Most often our perception of the city is not sustained, but rather partial, fragmentary, mixed with other concerns. Nearly every sense is in operation, and the image is the composite of them all*” (Lynch 1960).

Lynch was not the first to express these views. As noted by Gould and White (1974, p.28), as early as 1913 the pioneer of mental maps, Charles Trowbridge, commented on how people have different senses of orientation. He concluded that there were two groups of navigators. Some people have imaginary maps in their heads centered upon the location of their homes. They are able to navigate a certain distance on familiar ground, but they would lose orientation in unfamiliar ground. The other group was described as more “egocentric“ and orientated to their own position at the moment, with a better ability to navigate in unfamiliar territory.

The map is just one form of expression of these personal memories and descriptions. Although it is called a map, it has two fundamental differences from a conventional cartographer's map. It has no scale and no objective direction assigned to it, so that the drawing of its elements may only stand in this personal context, e.g. there is no assumed north point unless the author of the map assigns it. Nevertheless, some features of a map may be borrowed from conventional maps by the participant, such as a top down view, symbols and so on. Other methods can be a description in words, both as a text or an interview. The business building block system Lego Serious Play is another creative way of expressing memories and perception in a hands-on sort of way. David Gauntlett from Westminster University is a researcher working with this method. He explains in his presentation clip “Representing Identities” on YouTube (Gauntlett 2008) that using these creative methods will encourage the brain to work in a different way. He argues that individuals each have an embodied experience, and that this experience is more easily accessible through body gestures.

The instructions to draw a mental map are intentionally simple. The focus lies on the content and not the beauty of the sketch; there is no right or wrong. The key is that the sketch is not copied from a map or image, but rather it is drawn from memory. Lynch introduces the mental map to the participants as follows: “We would like you to make a quick map of ... Make it just as if you were making a rapid description of the city to a stranger, covering all the main features. We don't expect an accurate drawing - just a rough sketch” (Lynch 1960, p.141). It is a quick exercise that does not

require a lot of planning and thinking. However, based on the experience of using them on this project, there appear to be three distinct phases to the creation of a mental map. The first is the skeleton phase, during which most of the important information, objects, direction, names and paths is set down. The second phase increases detail by linking between memories with information and description. This will often trigger some more memories and makes the map rich and representative. The third and last phase is the beautification process, where no more important information is added, but rather the sketch is adjusted and critiqued.

Mental maps have been used in a variety of spatial research. On one hand, there are studies such as Lynch's with a focus on the physical environment. On the other hand, there are studies that focus on the quality of the perceived environment, as recorded through feelings like desire, stress, fear or happiness. Such a study has been carried out by David Ley in Philadelphia and presented in "The black inner city as frontier outpost: images and behaviour of a Philadelphia neighbourhood" (Ley 1972), where participants' responses have been processed to create an intensity topography. Sorin A. Matei is currently undertaking a similar project on fear in Los Angeles, which can be viewed on www.mentalmap.info (Matei 2003). From participants' responses, he was able to create a three-dimensional digital surface to represent the amount of fear in the Los Angeles region. The colours red and green are used to highlight areas of lesser or greater amounts of fear.

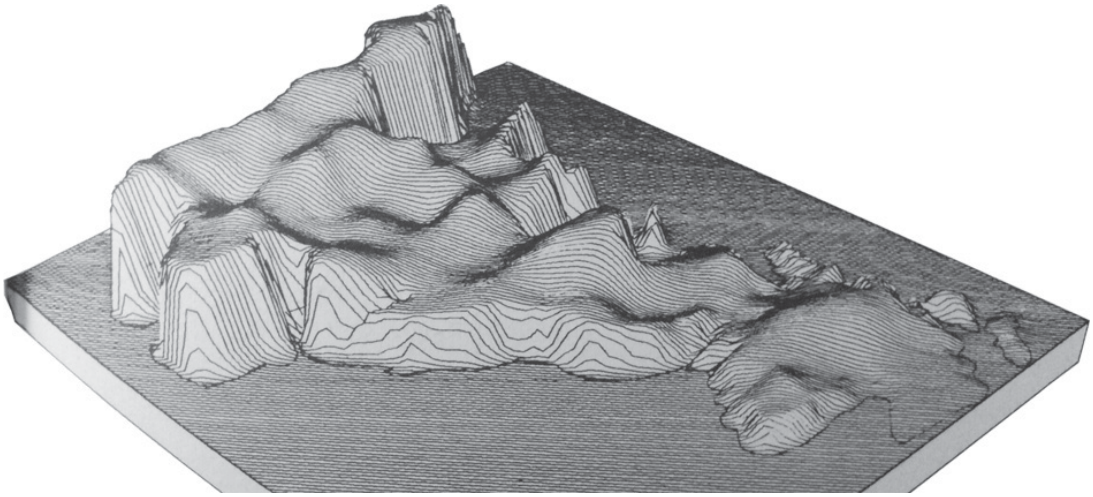

Figure 3 - A mental map of the desired locations of residency in the UK. Image by Peter Gould and Rodney White taken from Gould & White 1974

Peter Gould and Rodney White (1974) summarise an investigation into people's desires using mental maps in the book of the same name. They posed the following research question: "Suppose you were suddenly given the chance to choose where you would like to live - an entirely free choice that you could make quite independently of the usual constraints of income or job availability. Where would you choose to go?" (Gould & White 1974, p.15). From the responses, they generated a surface of desire for different areas in the world. In these early days, surfaces were visualised through contour maps, with each contour representing a change in value. In a very early 3D computer rendering of the data, they detail the UK by plotting the desired location of residents, as illustrated in Figure

4. Unsurprisingly, the taller peaks are in the southern part of the island. These approaches do not actually work with mental maps as sketched by the participants, but they use participants' responses to specific questions to generate them into a mental map that could be called collective.

During the UD interview, the participants were asked to sketch a mental map to allow participants to express how they navigate the space of the city. In addition to the technical GPS record, this personal view focuses on the participants' perceptions of space based on memory, experience, circumstances and current concerns. Through the comparison of the two different maps, new insights into people's motivations for choosing a route, and individual methods of orientation, can be explored. For the drawing of the maps no graphical restrictions on how to represent elements were imposed; the only rule was not to copy it from a street map or image. In addition, they were asked to comment on what they had drawn, to record in-depth information on perception and important factors beyond the sketch. Figure 4 is an illustrative example showing the mental map drawn by the participant whose objective 'tracks' were shown earlier in Figure 2b, together with an analysis of the drawings.

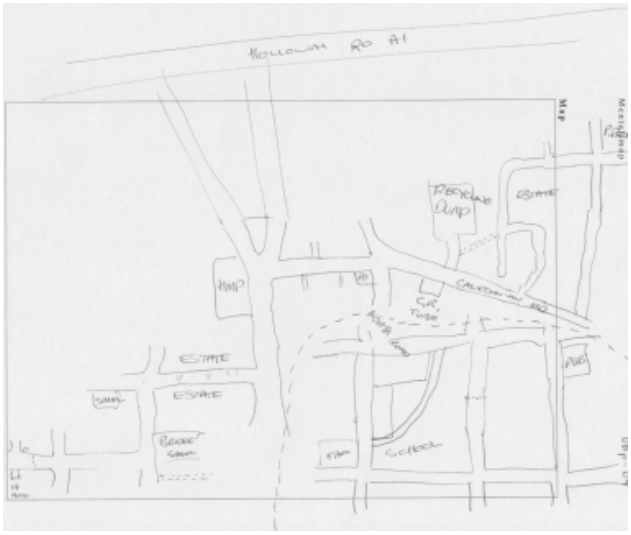

Figure 4 - A mental map of the routine commute from home to work and back home by one of the participants of the UrbanDiary project.

A great deal of information is contained within the mental maps on how people perceive space, use space and ultimately how people create their space. As a very abstract concept, it could be compared to the technical creation of space in the virtual world as an orbit around the subject in time and space. The engine only renders a certain area or distance in a game scene and not the world, city or house as a whole. In a similar manner, the temporary space people create in the real world could be described as a bubble. Space, as in social space or individual space, is probably not the same as Euclidean space, which is the way we think about space generally. If we describe space from personal perception and a temporal point of view, the concept of space might be something very different from the space-in-a-box concept. The creation of space could be something very personal that, through mental maps, can be accessed and recorded as a very dynamic concept of temporal perception based on mood, concerns and circumstances.

6. Participants

This project is, by definition, looking at the urban area, so the research participants are all located within the Greater London Region. A secondary criterion for participants is that they are over the age of eighteen. To date, twenty different people's data has been collected through the UD project. While this is a small sample and not statistically representative, partly due to limitations in the availably of GPS units, it nevertheless allows several different types of characteristics to be represented. The study contained nine female and eleven male participants. Nine participants, of whom six have dependent children, co-habit with a partner, and eleven are currently single or live in a distant relationship. Looking at their occupation, ten are classed as students, nine are employed and one is self-employed. All except one student and one employed participant work full-time.

The GPS devices record participants' movements automatically, and they are not required to keep a manual diary. For detailed trip information, participants are interviewed at a later stage of their data collection. The interview was designed as a semi-structured interview with the main topics based on their personal schedule, transport and movement, experience of the city, orientation and memory. They were asked to undertake two additional tasks which were firstly, to write down a rough personal schedule on a daily, weekly and yearly basis and secondly, the drawing of the mental map described earlier. The schedule helps with the interpretation of the data regarding patterns that are not synchronised with the individual's normal routine. It is also interesting to learn more about an individual's organisation, both in time and space. The mental map on the other hand is directly related to space, and visualises an individual perspective of the city. Both elements are regarded as important to the spatial narrative of everyday life in the city. In addition, this information is believed to be essential to understand the GPS information. The contact between researcher and participant during the two-month period is relatively close. Meetings take place on a weekly or biweekly basis, ostensibly so that the researcher can download the collected data from the device. However, these regular meetings also allow for informal chats. As mentioned earlier, the personal routines and habits are the main topic of these discussions. Very often participants suddenly become aware of a number of routines they follow without having noticed them beforehand.

Usually participants have a different perception of their spatial habits, and will describe them at the beginning of the tracking as diverse and spread over a large area of the city. The first few times they see the collected data, it can be disappointing for them to see a rather strong routine. Routine seems to be negatively perceived and participants often would describe themselves as active, flexible and spontaneous, implying a widely spread range of activities with a diverse movement pattern. Of course, one does not necessarily exclude the other, but the usual interpretation of a strong pattern tends to be this way. This phenomenon might have its origin in the modernist ideal conceptualisation of space and movement. It could be a late descendent of the illusion of the automatic and autonomous freedom that played an important part in modernist spatial concepts and en-

capsulated by positive feelings about the beauty of the machine and the associated freedom newly-inherited by the middle class. As Alistair Bonnett puts it “Thus 'ordinariness' and 'everydayness' are maintained as the provinces of the working class, …” (Bonnett, 2000, p.28).

To describe their personal routine, participants often refer to someone else whom they think of as very flexible or very inflexible; just to provide an example for comparison. It appears to be more convenient to define routine in terms of metaphor or other characters. It seems to be a personal subject where people prefer to make assumptions and live with stereotypes. The aim of the interview is to collect information on how the participants actually perceive their activities and how they would describe these routines. From the GPS data, a schedule can be generated, but this might not reflect the intended plans of the individual.

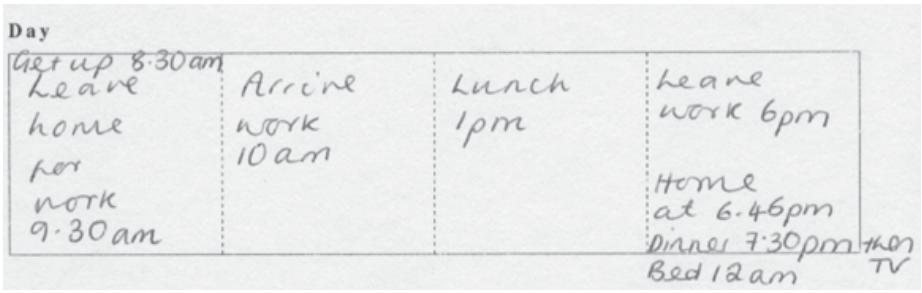

Figure 5 - Participant's schedule for a day

The participants were then asked to write down details about their schedule, focusing on important structuring events. Three scales were of interest, the day, the week and the year. It turned out that discussing participants' individual schedules is the longest and most complicated part of the interview. It seems to be not as simple a matter as to explain one's daily schedule. There are a lot of 'ifs, ands, ors' together with 'thens and woulds'. In short, it is presented as a dynamic string of decisions with numerous dependencies. Nevertheless, there are strong elements of direction (structure?)within this pool (flux?) of fluent decision-making. Again, the major element is the working week versus the weekend, and then there are the clear western standards for a daily structure both on weekdays, illustrated in Figure 5 and weekends as illustrated in Figure 6. The focus does represent the personal situation. There are big differences, though, between participants who have dependent children and those who have none.

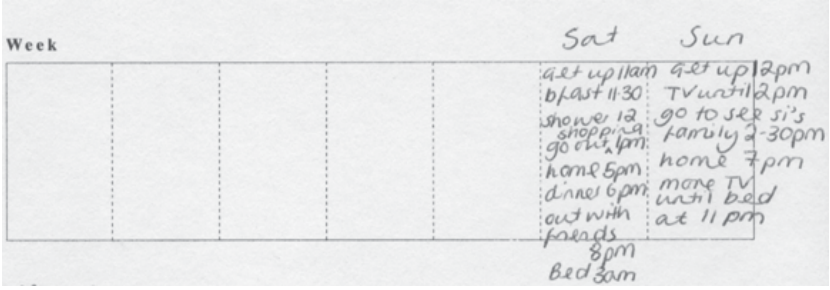

Figure 6 - The same participant's schedule for a typical weekend.

Taking the two time frames together, these can be regarded as representing the participant's "mind map" of weekly activities. Regarding the information, one might expect large gaps between plans and activities; however, the two are largely similar. The "mental picture" of our routines is strong, and comparing this to participants' perceptions of their spatial activities, this can be surprising as, in spatial terms, people often think their activities are much more flexible and they are traveling more than they actually are, as explained above.

While working with these schedules an unexpected finding emerged that the time spent interacting with the urban morphology, for example, by moving about in the city, is rather restricted. There are clearly defined timeframes for each individual, of course, but generally time spent in the city is limited and certainly not random. From the examples in Figures 5 and Figure 6, activity that involves spatial interaction on weekdays is basically during the rush hour in the morning and the evening. Other than this there is little activity. The weekend pattern is different, in that there is afternoon and evening activity, with Saturday being the more active day.

The information about yearly events did not generate much valid data, as for most of the participants, this category was too broad. It seems not to be a unit that people plan or even live in, even though in professional life, this is definitely an important time frame. In terms of personal activity, few have had planned activities other than the expected Christmas and Easter breaks. Birthdays and holiday were among the other named activities on a yearly scale. Regarding the city and its spatial morphology, longer timeframes are of course interesting, but the connections have probably to be found elsewhere.

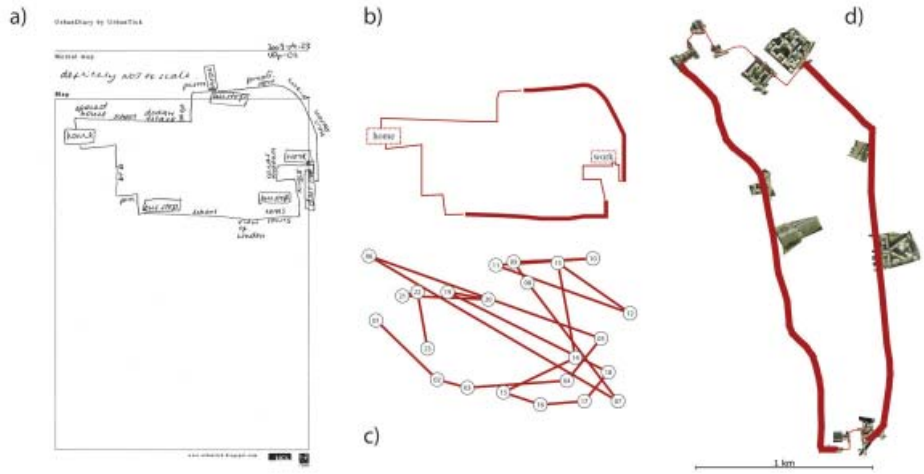

Figure 7 - UDp-02 mental map a) compared to GPS record d).

The topics of 'space' and 'movement' look into how participants use city space on a daily basis, and how it is perceived in connection to their everyday routines. It is therefore of interest to see if and how individuals are able to connect the spaces they frequently visit within their mental map. This is especially noteworthy in the context of London because, for example, travelling by tube might leave the traveller unable to connect the start and end location of the trip spatially. Movement, on the

other hand, is directed towards how participants travel and how this becomes part of the routine. Again, it is interesting to hear from the participants how they see themselves in this respect and how much they think they travel. Most of the participants have clear preferences regarding their mode of transport. Some mainly travel by tube, because it is easier to navigate with clear destinations, whereas others would only very reluctantly go into the tube, because it is narrow, underground, or busy. Instead, they prefer the buses and describe them as flexible and close to their destination.

To explore the topics 'spatial experience' and 'memory', the participants were asked to draw the mental map of one journey as described earlier in the section on mental maps. For this setting, the focus was specifically on the daily commute, the journey from home to work and back. To draw the map, participants are asked to include not only the direction in which they travel, but also additional elements, things they use for navigation, orientation or simply as reminders. These can be street names, buildings or urban settings, and even views or atmospheres can play an important role here. The paper for the mental map is prepared with a frame/box to further limit the space for drawing on, as experience has shown that this additional boundary line helps “inexperienced sketchers” to navigate on the “white paper”. Participants tend to draw towards the edge, and then they realise that there is no more space left on which to draw the second half of the journey. The additional space outside the frame can accommodate some of this information, which is otherwise lost or drawn in a disconnected way. In the example illustrated in Figure 7a, only the very top of the sheet was used. Participants are asked to comment on what they draw and the transcript of this helps to interpret the drawing later, for example regarding the sequence (in which the events were drawn, or in which the illustrated journey was undertaken, or both?). Individuals' comments about their feelings in connection with a certain element or configuration within their trip can also be traced back. A frequent phrase, for example, is “This is not to scale”, pointing out that there is an uncertainty about actual metric distances.

In the example pictured, Figure 7a, contains the mental map as drawn by the participant where Figure 7d, is a reference map generated from the same participant's GPS record. In the middle, the two analysis diagrams look at the relationship of the map to the mode of transport used on the journey (Figure 7b) and as the sequence of the map's creation (Figure 7c) represented as a dot-to-dot doodle. Both are based on the participant's mental map.

Modes of transport in this example are bus journeys (bold lines) and walking (thin lines) to and from the bus stop. Comparing the length of both modes to the GPS record, it is clearly visible that the length of the bus journey is different in the mental map and the GPS reference. Similarly, the walked part is represented in more detail in the mental map than the bus journey. This suggests that the perception of space changes with time, mode of transport and especially with speed. Less detail is registered by some commuters on the bus as they “know” the route and focus on the destination. Some of the participants have explicitly stated in the interview that on the bus they ignore the route

and concentrate on a book, the music playing through their headphones or simply just look out the window without registering anything. This leaves them with little knowledge that could be retrieved later and used to describe the journey.

During the interview, aspects of daily activities come up that are of note, where the participants' seem to feel that an explanation is required. Many participants feel the need to explain their activities and make an excuse for them. This seems to be related to the amount of movement, flexibility or distance. Generally, routine is viewed as negative, whereas flexibility and independence is deemed positive. This experiment has been insightful in this respect, as the recorded movement unveiled routines that seemed to be much stronger than the participants have so far realised.

7. Visualisaion and Findings

The GPS tracks have been used to map the participants' activities. The data recorded by the device is in effect only locations, as a series of points. The trajectory map results from connecting these points with lines. These trajectory lines represent what is assumed to be the line of movement. If the recorded points are close together; that is, recorded at frequent intervals, this is believed to provide an accurate representation of the participant's movement.

Figure 8 - London as drawn from the twenty participants' movement path. Same data as in Figure 2 but zoomed in on the centre of London and showing one individual track record in colour. The visible main features are Regents Park in the top left corner, Oxford Street in the middle to the left.

Over the period of the tracking, the map that was being built up started to show patterns, which mainly represent the repetition that occurred in the participant's behaviour. Thick lines start to accumulate on the daily routes and draw out the very personal arteries of the city. Most of the participants rely on the public transport network and therefore are channelled into the routes simultaneously used by thousands of fellow travellers. These personal arteries become collective arteries, and start to

represent transport corridors. The major overall pattern that starts to show up from early on is the very London-like characteristic of a centralised radial structure [Figure 8]. The trajectory map starts to look like a star, with the majority of the traces drawn from an peripheral location into the centre and back out again. Based on the Transport for London zone plan, most participants lived in zone two or three, but travelled into zone one for work. This travelling is generally in a predominantly straight line pointing at a virtual centre. The radial pattern that emerges from collective activity is therefore directly related to the structure of the London infrastructure layout. Compared to records of other cities [Figure 9], this characteristic may be individual to each city and is determined mainly by the morphology, transport network and citizen behaviour.

Although the raw data is only point information, for visualisation, mainly 2D mapping purposes, the recorded location points are used to render a line representing the movement. The reason for this is the better sense of continuity and sequence this provides. There are cases where the device has lost signal over a longer period due to environmental factors as explained above in the technology section. Lost signals are, however, generally picked up at a later time. This is the case if participants are traveling underground, using the tube. In this case the tube station is the point of disappearance and another tube station the point of reappearance. In Figure 10 we represent these as dotted lines to give an idea of how movement and places are connected. This allows an observer to make sense of a number of islands of activities, by tying them back into the overall picture. Currently no data is added to the journey data, e.g. tube lines.

Figure 9 - Track structure comparison between Basel Ch (left), London UK (middle) and Plymouth UK (right)

Depending on the participant's transport preferences, the emerging pattern of activity either draws a continuous track or starts to build up isolated and spatially disconnected areas, as Figure 10 shows. One major factor to influence this pattern of detached locations is the individual's chosen mode of transport, which in the case of London may involve using the tube. However, as mentioned before, not all patterns end up as a collection of disconnected locations. There is another group of participants that maintains a record of continuous traces of movement. Two of the participants happen to be a couple, and their individual movement patterns are each representative of one group. She mainly uses the bus, whereas he mainly uses the tube, as shown in Figure 10. Their records strongly illustrate the characteristics of each mode.

Guy Debord examined and defined the phenomenon of the city islands as isolated and spatially disconnected areas in his Naked City text (1959) and challenged traditional ideas of mapping with the map of the same name (Sadler 1999, p.60), by dramatically departing from the grid and

introducing a fragmented, subjective and temporal perspective. This view and description of space as a personal perception and experience is summarized the term phsychogeography. However, the experience of the UrbanDiary project suggests that the emergent pattern is also connected to people's personal preferences. Some of the participants would never use the tube for personal reasons and others would always use the tube for the same reasons. Often the argument is about the sense of orientation that participants associate with the particular mode of transport, e.g. the 'simplicity' of the London tube map or the 'simplicity' of the surface bus route, respectively.

Figure 10 - City islands, the impact of mode of transport on personal psychogeography of the city

The aspect of time in this kind of mapping is not represented as such. To visualise this part of the information, other techniques have to be used. One method is to apply colours according to the time. This method has its limitation as the colours are more often used to distinguish between different individuals, but it was successfully tested in a single participant environment, as Figure 11 illustrates.

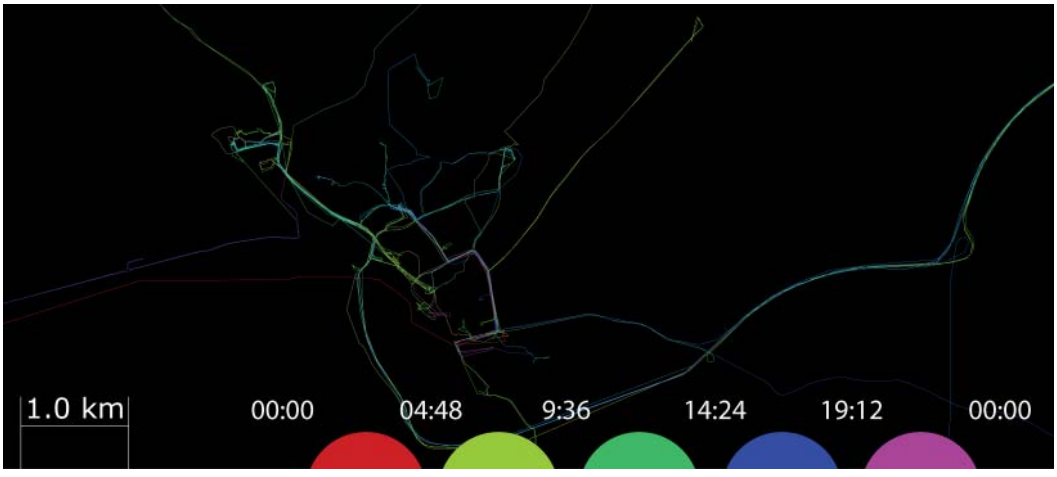

Figure 11 Showing a GPS track colour coded according to time, starting with red at midnight fading into yellow, green, blue over the day and turning into purple at night.

Another method to represent time and location simultaneously was developed in the 1970's by Torsten Hagerstrand (1978). The model produces a 3D visualisation of the data, using the x- and y-dimensions to refer to the spatial location of events and the vertical z-dimension to plot the passage of time. This space-time 'aquarium' (Carlstein et al. 2001) comfortably merges the two different types of information. Hagerstrand originally used the term 'prism' to describe this phenomenon, but the metaphor of an 'aquarium' perhaps captures more accurately the internalised, situated experience of the participant. The approach was also implemented successfully in work done by Kwan, summarised in GIS Methods In Time-Geographic Research (2004). Although the readability of the object can be tricky, it works well in an interactive 3D environment but can be confusing when used as a static 2D print with a lot of contextual information. Patterns of repeated activities do emerge as obvious with this method, as is illustrated in Figure 12.

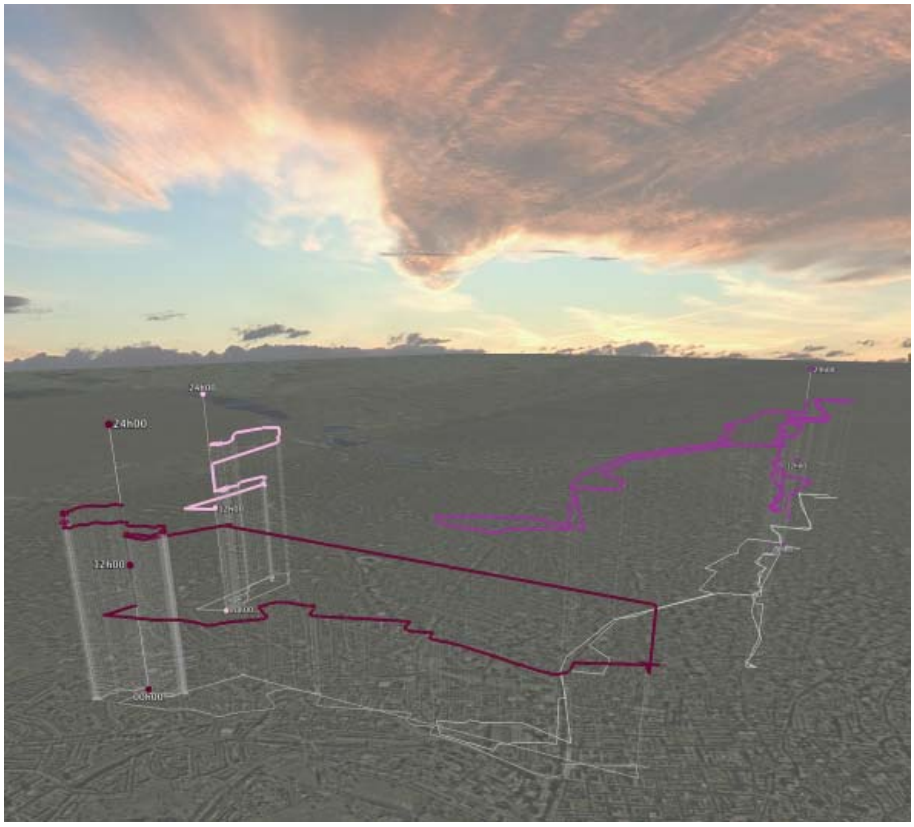

Figure 12 - Space-time aquarium (after Hagerstrand) plotting three participants in the UrbanDiary data

GeoTime has turned this method of representation into a functioning software programme including a user interface (Kapler & Wright 2004). From a point data set, it can build the space-time aquarium and offers a set of tools for analysis. During all processes, the software keeps the representation of the aquarium flexible and the representation can be altered at any time. This maintains a very welcome flexibility and helps with the reading of the data. GeoTime has been used to run analysis on the UD data set. Specifically the “Meeting Finder” proved very interesting. With this tool, points can be identified where personal trajectories of movement intersect with one another in terms of the criteria of distance and time, It turned out that participants on the project have been in the same location at the same time, of course without knowing each other, suggesting that London is perceptually not so big after all.

A further method to map time-based information is by employing animation techniques. With this method, the passage of time can be represented through sequential frames, see Figure 13. A number of clips have been produced and continuously updated as the UD data log grows. Usually Google Earth has been used as the visualisation platform. The built-in functionality to replay time tagged location information is simple to use and powerful. To achieve more clarity in pattern representation, the recording period was usually compressed and represented as a single day. This means superimposing all the days onto a 24-hour period. Reoccurring events show up as accumulated activities, whereas one-off activities are represented as single lines. The Virtual London Model, developed by Michael Batty and Andrew Hudson-Smith at CASA (Batty & Hudson-Smith 2005), has been used to set the recorded locations into a spatial context. This setting is regarded as a first step to combine the time-based information with the morphological space of the city.

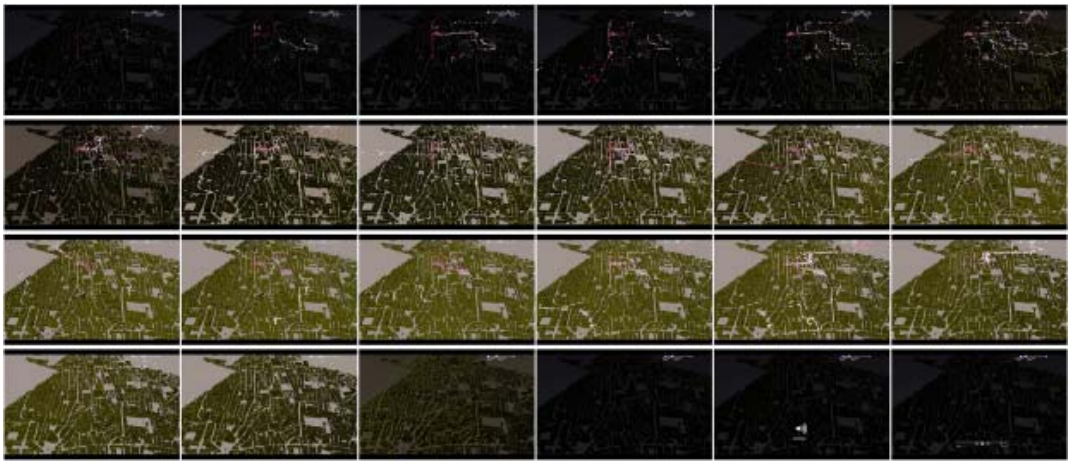

Figure 13 Shows 24 animation stills taken from a 24 hour day GPS trace visualization. Shown is a central London area with the brightness giving an indication of the time of day.

Graph visualisation focuses on the quantitative aspect of the data. The idea is to look at the schedule of information contained in the record. This is of interest as the project aims to enhance knowledge about personal, spatial routines. The graphs are visualising the amount of activity over a specific time period. The periods are one day, one week and one month. Using these units of general time frames helps to establish an appropriate framework for the data. Participants are all understood to use these time frames. More specific units could relate to religion, culture, job or specific responsibility. These will be represented later when an individual level of data analysis is undertaken. In the graphs shown here, the x-axis represents time whereas the y-axis refers to amount of activity drawn directly from the GPS log; this is measured by the number of log points the GPS device has stored for the time period in question. The graphs do not provide information about time spent in one location for they solely focus on travel time between destinations.

If we look more closely at the graph illustrated in Figure 14 or also Figure 15, the following can be observed. One month analysed both by day and by participant shows the weekly pattern, with four peaks over four weekends. They generally do match, although one peak has slightly moved into week three. This was the UK school midterm week, a holiday break. Participants who have children

or work in a school have spent more time travelling during the normal weekdays. Surprisingly, activity levels over the Sunday at the start of this mid term week is very low. All of the participants have recorded little activity. This may have been due to inclement weather conditions, resulting in the participants being more likely to stay indoors.

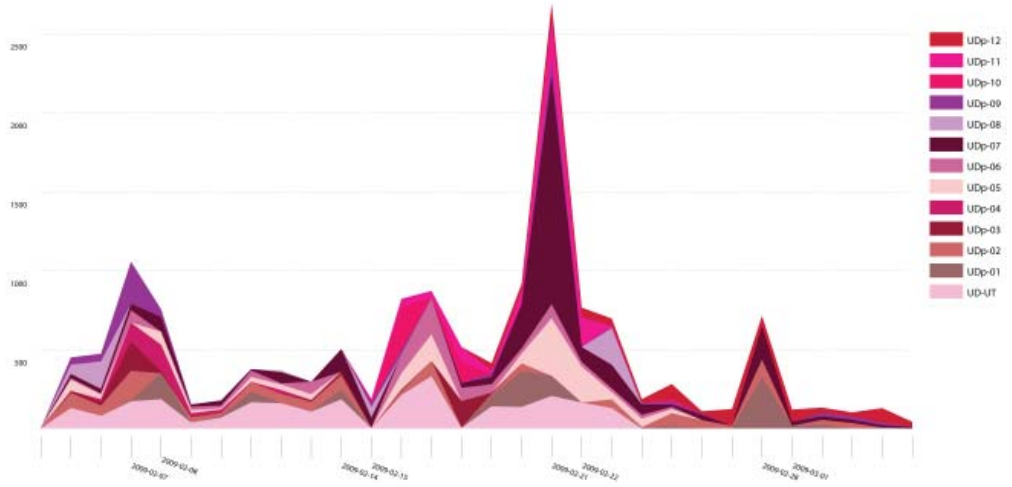

Figure 14 - Diary graph over the period of two months.

By contrast, one Saturday stands out intensively. One of the participants had an intensive outdoor sports day, during which he generated a large number of points. Activities seem to accumulate on Saturdays. This shows up in particular in the week's graph. Saturday has more than double the amount of points over other days of the week. Not only is there one participant who is doing intense sports activity on Saturday, but also all of the participants tend to have significantly more activity on Saturdays. Other than that, the weekdays are fairly even in terms of activity, with a tendency to lower activity midweek.

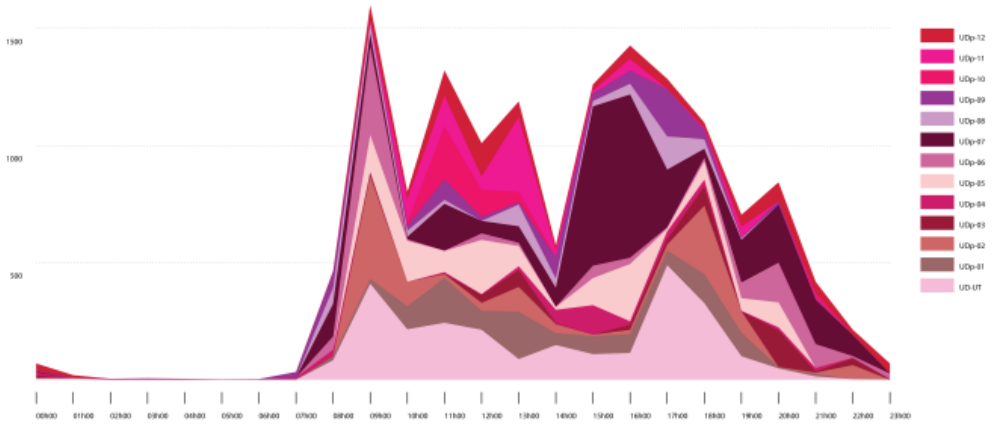

Figure 15 - Graph plotting GPS records of sixteen participants superimposed on to 24 hours - one day

Compared to the regularity of the week, the 24-hour graph, illustrated in Figure 15, details a number of peaks. The graph starts at midnight with an expected flat portion representing few activities. In the first hours of the day, there is some activity but it reduces to virtually zero in the early hours of the morning. The day then starts with a first peak during the morning rush hour. After seven o'clock, participants start leaving the house, but the recorded activity takes off from eight, peaking around nine and coming to a first low point at around ten. By looking closely at the participants involved in these first two peaks, one can see that actually there are two groups, one generating the first "rush hour peak" and the second group creating a second, similar peak about one hour later. The second peak of the day has a 'twin peak' with a first high point around 10h00 and a second one just before lunch around 13h00. This second group turns out to be mainly participants with small children, not yet of school age, who undertake morning activities. After lunch, around 14h00, there is the low point of the day with the least activity during this 24-hour period apart from the early morning hours.

After the lunch break, there is a notable afternoon / evening peak. This is the result of a combination of weekend and weekday activities such as work and outdoor sports mentioned above. Included in this peak are a first evening rush hour high point between 17h00 and 18h00 and a smaller second peak around 20h00, possibly pointing to visits made to the pub after work. Generally this resembles the expected daily routine pattern of a western city. More surprising is the accuracy the pattern shows, rather than any unexpected results. Although the sample is not representative, it was not expected that such regularity would be found.

8. Conclusion

Through the above visualisation of the data, some preliminary findings can be drawn. There are two main levels of interest; one is at the level of the individual, in the context of personal routine and activity. The other is at the collective level, looking at overall patterns and rhythms that point towards a spatial society and urban morphology. The first one is ultimately present for the participants as individuals who experience the city, where the findings mainly reflect the context each perceives themselves to be in. The second, collective, level is something that can be constructed from the individual activities. The present research was particularly designed to capture individual data and not collective data, to gain insight into the routine of the basic unit. This will help to understand how the two levels interact.

Timewise there are big differences between work time and personal time. The pattern of this almost universal division is an extreme determent of what all participants do. In addition, there is the pattern of the week, with its weekdays and weekends, that structures the time over this longer period. The workdays are represented as a back and forth movement between the locations of home and work place. The London morphological characteristic here loosely resembles a star shape; as discussed above, people live outside and travel linearly into the centre and back out again. To some extent, this might depend on the data sample and the pattern observed here might not apply for all

configurations. However, the routine in movement between a few fixed destinations shows up clearly throughout. Over time each routine-defined location builds up a sub local area. Depending on the activity and the time spent in this location, the area grows denser as the creating individual becomes more familiar with the location.

The way the different destinations are connected spatially depends on the mode of transport and personal preferences. For some participants, the workweek tracks are two islands on the map, as most of the travelling happens underground, whereas other participants travel to work by means of overground transport and the map shows an intense, continuous collection of tracks. The weekend travel pattern, on the other hand, is mainly focused around the home location or tends to be directed outwards, away from the city. Very often this is directed by the location of friends and family, also the location of shops and amenities such as markets, parks or playgrounds play a major role as attractors.

By looking at the neighbourhood area where participants live, the local pattern becomes more obvious. The weekend pattern shows activities within the neighbourhood and local streets rather than the main routes. The localised activity of participants with dependent children is not only greater, but more intense. Local amenities and activities play a major role in their weekend planning. Especially if the weather is poor, the local activities are popular. For all the participants, visiting friends and family is another major activity undertaken during the weekend days. Their home location creates another set of destinations with clear directions.

Figure 16 - What shape are you? Track records show distinct individual pattern of four participants over the same time period and represented at the same scale.

It emerged from the recorded data that each participant has their own unique trail pattern, which is illustrated in Figure 16. Almost like an individual fingerprint, the shape created by daily movement is unique. The shape is determined by a number of factors such as the spatial relationship of destinations, the physical distances travelled, the amount of travel and the intensity of repetition. The first factor, the relationship of destinations, makes for the overall shape and the last factor, the intensity of repetition, makes for the character of the shape.

This preliminary study, to trace citizens' spatial habits, has provided the study with a great deal of valuable data and a number of possibilities for mapping the data have been explored. Findings so far have shown that people in the city seem to live according to rhythms that appear to be largely congruent, more so than might be expected. Admittedly, the small sample of twenty participants is not

representative, but it is enough to show that there are emergent patterns at the level of collective activity. The sample will need to be carefully chosen once the study grows, to include a larger set of observations.

In terms of technology, GPS tracking has been successful and has proved to be a good method for collecting data about individual movement. The involvement of participants by wearing a special device and "being in charge" of the collection could in this respect be regarded as positive. This will be further explored in the next stage of semi-structured interviews with the participants. Having said that, there will be further steps of investigation with the UD project. This will continue on the individual level and will consist in interviews directed towards understanding the individual participants' perceptions and memory using mental maps.

The analysis of the project data so far has been personal and individual. Another step will be to look at ways to combine the data, to move towards the analysis of the collective level. This will be closely connected to the body, both of the participants but also the city, looking at morphology as a product of rhythmic processes.

In the sense of the cycle and the routine the pattern as explored here in the urban context demonstrates how close the ties are between the urban fabric, the chosen route and the resulting personal trails and how this consistency builds up and remains over a longer period. This demonstrated the productive process and visualises, how the city can be understood as an emerging result of the activity culture inhabiting it.

We all agree that different locations in cities have different economic values, which influence such things as property prices and rents. And even though markets react on exactly such values and there is a whole industry trying to analyse them, the specifically spatial preconditions are difficult to capture, especially on the detailed scale we are referring to here. The analytical techniques above then seem most interesting as a means to develop more precise tools for such evaluations, especially when it comes to predicting how new urban projects will create new location-values as well as redistribute already present ones. Obviously, there are other values at work here, such as the value of what is actually built, but the theory of spatial capital specifically aims at the evasive value of urban form.

This concerns the *exchange-value* of spatial capital, suggesting how the value of urban form literally can be translated into economical capital. But just as important is the *use-value* of spatial capital, the value urban form represents in a multitude of ways for everyday urban life - socially, culturally, and environmentally. Although not all needs require high spatial capital, on the most fundamental level this seems to be what cities offer: the support of the generic need for people and societies to *access differences* as a means for social, cultural, and economical development. In the end, we here seem to see the major reason behind the accelerating growth of our cities - for people poor in economical, social, or cultural capital, cities offer spatial capital, for people rich in economical, social, or cultural capital, spatial capital enhances its value.

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