Combining Gps & survey data improves understanding of visitor behaviour

Abstract

Visitor tracking is frequently used in tourism planning for large sites, but is far less common at individual attractions, despite a body of literature examining the detrimental impact of crowding on visitor experience. This study used handheld geographic positioning system (GPS) units to track 931 groups of visitors around a single tourist attraction to determine where they went and how long they dwelt at particular locations. The tracking data were combined with survey data to discover whether different types of visitors behaved differently when exploring the attraction. The majority of visitors followed similar routes revealing a strong ‘main path inertia’ with over half missing exhibits away from the perceived main route. Different group types varied in how long they dwelt at different locations and in how long they spent at the attraction altogether.

# Introduction

## Visitor tracking

Movement of people has been widely used by recreation planners at large, usually outdoor, tourist locations to manage transitory populations and ensure facilities are placed optimally (Cooper 1981; Pearce 1988). Understanding of tourist movement and behaviour can aid in targeted marketing (Chancellor and Cole 2008), help manage impacts associated with overuse or crowding (Russo 2002; Hallo *et al.* 2004), guide adjustments to transport systems (Shoval and Isaacson 2007; Edwards and Griffin 2013) and aid understanding of the visitor experience (Pettersson and Zillinger 2011; Sorensen and Sundbo 2014). Studies utilising visitor tracking at individual visitor attractions such as zoos, however, are few, and those that do exist focus on behaviour and movement around specific exhibits (Marcellini and Jenssen 1988; Ridgway *et al.* 2005; Francis *et al.* 2007). The complexities and labour intensive nature of following individual visitors, or groups of visitors, means little work has been done on visitor movement around these types of attraction as a whole.

The benefits of gaining a better understanding of visitor movements within an individual attraction include: evaluating effectiveness of exhibit design (Francis *et al.* 2007); examining circulation patterns for potential problems (Falk *et al.* 1985; Bitgood and Cota 1995); assessing visitors' needs, for example, for rest or sustenance (Davey 2006b); and to determine whether location specific information could enhance the visitor experience (O'Hara *et al.* 2007). A modern zoo exhibit, for example, is likely to have several view points and many interpretation features. When evaluating the effectiveness of the design it is important to know if all are being used by similar numbers of people for the same amount of time or if some are favoured over others (Serrell 1998; Francis *et al.* 2007). The length of time a visitor spends at a single location (dwell time) is a key factor in their enjoyment of, and learning from, exhibits as it takes time to absorb information and relate it to what is being observed (Moss *et al.* 2008). Extending dwell time at exhibits and slowing movement, therefore, enhances the overall visitor experience (Davey *et al.* 2005; Ross and Lukas 2005; Gutwill and Allen 2010).

Visitor crowding occurs when the number of people in a location exceeds the visitor's expectations and restricts them from achieving their goals, whether that is observing the exhibit, relaxing with friends or taking in information (McManus 1998). Russo (2002) highlighted the importance of managing access to the key locations that attract visitors to a tourist location and how understanding the spatial behaviour of visitors is essential to managing crowds at those locations. Local crowding at key exhibits can have a significant effect on a visitor's enjoyment and their perception of the carrying capacity of the attraction (McCool and Lime 2001; Manning *et al.* 2010). If all the visitors were concentrated at a small number of exhibits or at catering outlets the visitor's perception of crowding is likely to be very different than if the same number of people were spread evenly over a variety of locations (McManus 1998). Within a zoo environment, crowding at animal enclosures is also likely to create stress for the animals as well as visitors (Carder and Semple 2008; Fernandez *et al.* 2009) and discourage people from stopping to observe the animals or take in information. Managing crowding is therefore essential, in the case of zoos to minimise stress to animals, and more widely for all attractions, to encourage visitors to spend longer at exhibits, allowing more time for observation and to absorb information provided. Bireboim *et al*.(2013) emphasised the importance of understanding the variation in temporal activity of visitors, as well as their spatial movement, to gain a better understanding of how behaviour varied over the duration of their visit. With a better understanding of visitor circulation the institution can take steps to spread visitors to less well used areas through better way-marking, elimination of bottle-necks or pinch-points and by providing more activities and facilities in popular areas (Fyall and Garrod 1998; O'Connor *et al.* 2005; Davey 2006b). Enhancing the visitor experience in this way should therefore lead to an enhanced day out, allow greater opportunities for learning and hopefully enhanced reputation, increased repeat visits and a greater number of personal recommendations (Santana-Jimenez and Hernandez 2011).

Traditional methods of studying visitor movements relied on post-visit questionnaires, recall maps or movement diaries (Potter and Manning 1984; Lew 1988; Pearce 1988; Hallo *et al.* 2004). These methods rely on the accurate recall of activity, time and positioning by the participants and hence are a relatively crude measure with wide margins of error (Lew and McKercher 2006; Shoval and Isaacson 2007; Beeco *et al.* 2012). Real-time travel diaries that participants complete throughout the duration of their visit, remove the error from poor recall (Pearce 1988; Fennell 1996) but may introduce a significant element of deliberate or subconscious bias on the part of the participant, who clearly knows they are being observed. They also require considerable attention and effort on behalf of the participant which could detract from their enjoyment and hence influence their behaviour (Shoval and Isaacson 2007). Direct observational studies have also been used, where participants are followed or observed from a distance, but the labour-intensive requirement of these means the sample sizes are inevitably small (Hartmann 1988). Geographic Information System (GIS) visualisation and analysis of data from visitor movement studies can be a very powerful tool (Chancellor and Cole 2008) but it relies on accurate positioning data to really come into its own (Pettersson and Zillinger 2011; Beeco *et al.* 2012). In recent years the continual reduction in price and increasing accuracy of hand-held geographic positioning system (GPS) units makes them a viable method of gathering accurate spatial and temporal positioning data on individuals at large, outdoor attractions (Hallo *et al.* 2012). Several studies have used GPS to assess visitor movements within very large areas, such as national parks or tourist-orientated towns (Thornton *et al.* 1997b; Modsching *et al.* 2009; Pettersson and Zillinger 2011; Edwards and Griffin 2013) but the use of GPS to examine visitor movements within a single attraction, covering a relatively small area is less well documented. In their comparison of different digital tracking methods, Shoval and Isaacson (2007) determined that the high resolution of modern GPS unit should be good enough to work in locations such as theme parks, but the need for continued sight of the sky may hinder observations. Recently studies in large attractions such as theme parks (Birenboim *et al.* 2013) and safari parks (Sorensen and Sundbo 2014) have shown that GPS is viable in these situations but highlight the difficulties in gaining a large sample size.

## Visitor segmentation

In studying how visitors use an attraction, an understanding of the different types of visitor is required (Birney 1988; Davey 2005). Various attempts have been made to categorise visitors to an area or attraction based on personality types (Debbage 1991), the activities they are interested in (Fennell 1996), on the amount of structure they place on their day (Beeco *et al.* 2012) and on their motivations for visiting (Falk and Storksdieck 2005; Falk 2006). Motivations for visiting may vary with the type of group a person is with as well between individuals, so a visitor with a group of friends may have a different experience than they would have had if they had visited with family and children (Crompton 1981; McManus 1987; McManus 1988; Thornton *et al.* 1997a). Parents visiting with children may be looking for an educational experience for their children, they may want to have some social time together as a family or they may simply be looking to take them out for fresh air and exercise. Their behaviour may also vary with the number of times a visitor has been to a particular attraction in the past (Kemperman *et al.* 2004) and their familiarity with what is on offer (Fallon and Schofield 2003). In particular, first time visitors will tend to wander more and visit all the main or 'signature' attractions of a location while repeat visitors will spend more time in supplemental activities such as retail or catering (Lau and McKercher 2004; McKercher *et al.* 2012).

Zoos tend to be very popular with families with younger children (OceanConsulting 2007; BIAZA 2014) and children will have a significant influence on both the destination chosen and group behaviour once at a destination (Turley 2001; Wang *et al.* 2004; Carr 2006). Visitors may be looking for formal learning opportunities for children, such as talks or presentations, they may be engaged by open learning opportunities from interactive activities (Falk *et al.* 2008) or they may simply be looking for an entertaining day out (Tofield *et al.* 2003). Where learning is a desired outcome of the institution exhibit designs and their spatial positioning within the attraction needs to reflect these different motivations to engage different sections of the audience in different ways and maximise the learning opportunities.

Demographic variations may also affect visitor behaviour. Cooper (1981) found that the spatial behaviour of tourists varied with both socio-economic status and age. Lower income groups were thought to explore less in order to spend more time at fewer high reward locations and maximise the experience reward rather than visiting many sites with lesser experiences for a short time each. Lower income groups could therefore be expected to spend longer at an attraction than higher income groups in order to maximise the return from their day out.

The purpose of this study was fourfold:

* To evaluate the effectiveness of handheld GPS as a means to track visitor groups around individual tourist attractions
* To evaluate visitor movements within an individual tourist attraction, examine the routes taken and determine if different areas of the attraction were used more or less than others
* To determine the influence group make up had on visitor behaviour, locations visited and routes taken
* To examine how visitor movements varied across the day and where crowding may occur

# Case study : Marwell Zoo

Marwell Zoo is a large (57 ha) parkland zoo in Hampshire, UK. The size and layout of the zoo is comparable with other ‘out of town’ zoos in the UK without being so large as to require driving around. No previous work had been undertaken to understand visitor behaviour at this location

The layout of Marwell consists of a single large perimeter path with smaller paths crossing the central area (Figure 1). Many of the enclosures that Marwell staff consider to be the most popular are located along this perimeter path, while the inner areas are thought to be comparatively underutilised. A 'road train' travels around the main perimeter path, shown as a thick line in Figure 1. A narrow gauge rail train ride runs alongside the paths on the southern side of the park.

1 Car Park

2 Entrance

3 Survey Point

4 Gift Shop

5 Penguins

6 Anteater

7 Capybara

8 Grey Kangaroo

9 Giraffe

10 Cheetah

11 Pygmy Hippo

12 Amur Leopard

13 Snow Leopard

14 Large, indoor cafe

15 Meerkat

16 Amur Tiger

17 Tropical World

18 Lemurs

19 Okapi

20 Back lawn / gardens

21 Large playground

22 Otter and Gibbons

23 Coati

24 Kiosk cafe & playground

Paths

Narrow gauge rail ride

Park boundary

Figure 1 Marwell Zoo layout showing key locations

## Survey design

The survey incorporated both demographic and motivational factors to characterise visitors (Rentschler 1998; Packer and Ballantyne 2002; Packer 2004; Falk 2006; Horn 2006; Dawson and Jensen 2011; Falk 2011). Demographic questions included: age, gender, household income, education, pet ownership and whether they belonged to Marwell's membership scheme. Group type was categorised into one of eight categories based on staff expectations and internal surveys (OceanConsulting 2007). These were: parents with children; larger family group; family and friends; grandparents with grandchildren; couples; groups of friends; carers or childminders and solo visitors. The number of individuals and age range of individuals in a group was also recorded.

## Survey method

The surveys were conducted on 51 days between April 5th 2010 and October 30th 2010 with days stratified between peak days (school holidays, 44% of expected annual visitors) and intermediate days (term time April - Oct, 38% of expected annual visitors) according to expected visitor number variation throughout the year provided by the marketing department. No samples were taken during the off peak period (November - March, 18% of expected annual visitors) due to time constraints and unpredictable weather conditions. During term time the majority of visitors visit at weekends so preference was given to weekend days during these periods. During school holidays there is less variation between weekend and weekday visitor numbers so a more even split of days was chosen.

The majority of visitors arrive between 10am and 1pm at which point arrivals tail off. On busy days this tail can be long, but even on these busy days 80% of visitors will have arrived by 12:30pm. Surveys were therefore spread evenly from 10am - 12:30pm by sampling at approximately 5 - 10 minute intervals from opening time at 10am.

Visitors were selected at random at a survey station approximately 50m inside the park. One participant from each group was asked to both complete the survey and to take the GPS tracker so that the same person was answering questions and being tracked in case a group split up during their day. The GPS units were set to record their positions at two second intervals. Participants brought the GPS units back as they exited the park. A random sample was obtained by preparing the survey form and GPS unit then selecting the next group to pass a preselected point (litter bin) approximately 15m in front of the survey point and then approaching them as they passed the survey point. If this group declined to take part, the next group passing the selection point was approached. As many groups passed by while waiting for the selected group to arrive, this method was considered to produce a sufficiently random sample, however self selection bias on the part of the participants could not be ruled out. The composition of the groups declining to take part was estimated visually and was found to contain a higher percentage of parents with children than the survey group (62% vs 47%) so although parents with children were the largest group taking part in the survey, these may in fact have been underrepresented compared to the total population.

## Data handling and analytical approach

A total of 1005 groups took part in the survey and 635 declined.

GPS data was analysed using ArcGIS. Data from the GPS units was downloaded at the end of each day and converted to shapefiles to project the points onto the park map (Figure 2). There were some reliability issues with the GPS units resulting in no track being recorded for individual units on some days. In total 999 GPS tracks were recorded from the 51 days. Of these, a further 57 showed some form of data inconsistency such as gaps in data where satellite signal was lost or data collection stopping before the visitor returned to the start / finish point. These incomplete tracks were also removed from the data set. On analysis of the surveys it was found there were only 10 participants in the category of Career / childminder and 1 in the solo category. This resulted in very high variance for these small samples, so tracks and survey data for these groups were also removed from the analysis, leaving 931 complete tracks and survey data for further analysis.

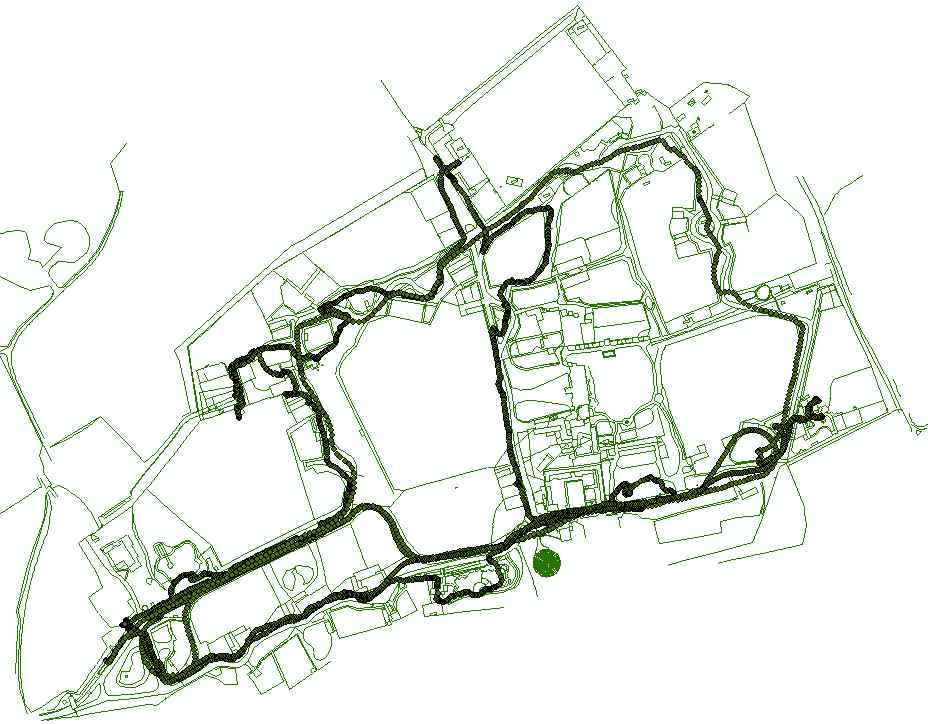


Figure 2. Example of a GPS track overlain on park map showing data points recorded at 2 second intervals

The accuracy of the GPS units was affected by the buildings that participants entered and by dense tree cover. Accuracy in the more open areas of the park was typically ± 5m whereas adjacent to the woodland accuracy was in the region of ± 8 to 10m. This resulted in many of the tracks appearing to be off the footpaths. Usually it was possible to recognise which path the participants were on due to the large separation of footpaths which in all areas is much greater than 10m. The positioning error meant that it was not always possible to tell if a participant was at a specific enclosure or the adjacent one. In those cases where the participants could not definitively be said to be at a particular location, that location was not included in the cumulative animal enclosure location analysis. For the bulk of the park, where spacing of enclosures was sufficient to allow distinction between them, capture polygons were drawn larger than the enclosure, using kernel density maps as a guide, to ensure all participants passing any particular area were included.

A category termed ‘linking pathways’ was used to capture all locations where it was not possible to determine where the participant was with sufficient accuracy or where the participant was walking between enclosures. The results for time spent at animals will therefore be lower than was actually the case. This error should be the same for all groups and hence should not negate the differences in behaviour found, but the reduction in resolution means differences may exist which are not found. This type II (false negative) error is considered preferable to including the doubtful areas in the animal area count and risking a type I (false positive) error.

Intersection and frequency analysis was performed for each GPS track and the polygons for animal enclosures, non-animal attractions (catering, play, picnic and retail) and linking pathways. The counts of points at each location were then converted to time at each location by multiplying number of points by two seconds, resulting in a list of times at each location for each track. Many of the animal enclosures at Marwell are large, with a viewing area spread along the side of the path. Traditionally in visitor tracking studies, the visitor is recorded as viewing an exhibit when they have been stationary and facing the exhibit for two or more seconds (Serrell 1998). Serrell used the sweep rate index (SRI) to relate dwell time to exhibit area and thus allow for comparison between exhibits. Whilst this is effective for indoor exhibits with an easily defined area, it is less effective with larger outdoor exhibits where the exhibit area is not so easily defined and a good view of an animal or exhibit could be had without a stationary period. An alternative measure of interaction or 'attending to' was therefore used which allows for the participant slowing their pace to look, but without necessarily stopping (Yalowitz and Bronnenkant 2009). This measure excluded those passing by both on foot without slowing and those travelling past on the road or rail train rides. To gain a measure of the time taken to pass each exhibit without slowing to look, visitors were observed and timed walking past each enclosure without slowing or stopping to look. This 'walking past' time was subtracted from the dwell time at each location, as recorded by GPS point counts, to produce a table of ‘attending to’ interaction times which give an indication of the time spent specifically interacting with a particular exhibit (Table 1). All negative times resulting from this calculation, due to a participant passing by more quickly, including on the trains, were rounded up to zero.

Birenboim *et al* (2013) advocated the use of functional descriptors to categorise locations and allow comparison between different tourist attractions containing similar functional elements. They divide their functional elements into tangible products (in their case rides and shows) and augmented products (catering, retail, customer service) using Kotler (1997) as a guide. In this study interaction times were examined both at individual animal exhibits and at five types of aggregated functional locations: tangible product locations (animal exhibits) and augmented product locations (catering, picnic, play and gift shop). This time at location data was combined with the survey and weather data for analysis of statistical significance of differences seen. The total distance covered was also recorded from the GPS tracks and combined with the survey data for analysis.

### 2.3.1 Statistical tests

The time spent at specific locations and cumulative time spent in aggregated locations did not show either a normal distribution or homogeneity of variance hence the non parametric Mann-Whitney U test was used to analyse the relationship between visiting specific locations and time spent in the park.

Variants of generalized linear models (GLM & GLMM) were initially considered for a fuller analysis to examine the variation in dwell time with demographic differences and group type. Exploratory analysis, however, showed that the responses were neither simple, linear nor interaction-free and the various assumptions could not be met for the wide range variables assessed. A model using boosted regression trees, a modern robust method from machine learning that makes very few assumptions about the data (Hastie *et al.* 2009) was therefore used instead. This machine learning technique fits many decision tree models and combines the most appropriate to arrive at the best predictive model possible from the data available. The specific model used here was a Gaussian boosted regression tree (BRT) model, fitted using the R package gbm 2.1.1 (Ridgeway 2015) and the extra routines supplied by Elith *et al.* (2008). The maximum number of trees was set to 10,000, bag fraction = .5, tree complexity 5 and learning rate 0.001. Ten-fold cross-validation optimisation of the model was performed using Elith *et al.’s* (2008) step.gbm routine.

The boosted regression tree model was constructed with a total of 33 factors: 21 describing the participant and their party taken from the survey data; 5 relating to the day of their visit (day of the week, closing time, holiday or term time, in park events and external events happening that day) and 7 describing the weather conditions on that day.

The point shape files were merged into a single file consisting of circa 7,500,000 points with each point matched with the survey responses given by the relevant participant for analysis of variations in locations visited with the survey responses. With points recorded at two second intervals, a high point count equates to high dwell times at that location.

Kernel density analysis was used to highlight the variation in time spent in particular areas of the park for all visitors and for specific groups of visitors. The kernel density maps were produced using an output raster cell size of 5x5m and a search radius of 40m. Effectively the GIS software fits a smooth curved surface over each point and then counts how many of the points fall within the search radius based on that curved surface. A point falling within the output cell counts as one point, a point falling outside of the cell, but within the search radius, is counted as a fraction of a point depending on the fitted curved surface and the distance away from the output cell. The resultant map shows areas with high point counts showing up as increasingly darker patches with increasing point counts.

Kernel density analysis was also used to compare the behaviour of different categories of visitor, as defined by their demographic and group type categorisation. Comparison between different combinations of groups of visitors was achieved by normalising the kernel density maps for each group to a scale of 0 – 1 and then subtracting the density map of one group from another. The resulting density difference maps have a midpoint of zero, which represents no difference in dwell time between the two groups under analysis, and is coloured grey on the maps. Differences in dwell time between the groups being assessed show up as shading variation away from the grey midpoint. If the first group dwells longer in a particular location than the second group, that location will show up brighter / whiter than the area of no difference. Conversely if the second group dwells longer than the first, the area will show up darker / blacker than the surrounding area of no difference.

## Results

#### 2.4.1 Variation in locations visited and time in the park for all visitors.

Kernel density analysis of all points revealed the most popular areas of the park (Figure 3).

1 Penguins

2 Capybara

3 Cheetah

4 Warthog

5 Giraffe

6 Amur leopard

7 Meerkat

8 Tiger

9 Okapi

10 Serval

11 Coati

12 Lemurs

13 Tropical House

14 Pygmy Hippo

15 Grey Kangaroo

16 Giant Anteater

17 Gift Shop

18 Large indoor Cafe

19 Large playground

20 Kiosk cafe & playground

Figure 3. Kernel density analysis of all visitors showing areas of longest stay as darker shading

The majority of the time for all visitors was spent around the perimeter path with fewer people venturing along the smaller paths in the centre of the park. All of the top 12 most visited locations were on the main perimeter pathway, while exhibits such as the Meerkat and Okapi in the central areas were missed by over 50% of visitors (Table 1). The large, indoor cafe was the most visited non-animal location, closely followed by the gift shop and playgrounds.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Location | No of visitors | Percentage of visitors | Mean dwell time (min) | SD |
| Penguin | 920 | 98% | 9.76 | 6.93 |
| Amur Leopard | 916 | 97% | 4.12 | 3.14 |
| Cheetah | 900 | 96% | 4.31 | 3.60 |
| Giraffe | 874 | 93% | 4.17 | 4.21 |
| Giant Anteater | 850 | 90% | 1.53 | 1.59 |
| Grey Kangaroo | 839 | 89% | 1.04 | 1.19 |
| Pygmy Hippo | 774 | 82% | 2.87 | 2.88 |
| Capybara | 744 | 79% | 0.59 | 0.76 |
| Coati | 744 | 79% | 2.63 | 2.65 |
| Serval | 734 | 78% | 1.46 | 1.48 |
| Amur Tiger | 725 | 77% | 9.31 | 10.14 |
| Warthog | 721 | 77% | 1.06 | 0.89 |
| Tropical house | 568 | 60% | 7.26 | 4.42 |
| Large, indoor cafe | 539 | 57% | 26.20 | 19.16 |
| Gift shop | 525 | 56% | 7.16 | 8.15 |
| Lemurs | 508 | 54% | 11.08 | 7.22 |
| Large playground | 487 | 52% | 14.72 | 12.76 |
| Meerkats | 442 | 47% | 3.82 | 3.55 |
| Kiosk cafe & playground | 424 | 45% | 22.40 | 18.60 |
| Okapi | 250 | 27% | 3.54 | 2.36 |

Table 1. Proportion of participants visiting key locations and the mean dwell time for all visitors at each

The tendency of the majority of visitors to follow the same route around the park resulted in large concentrations of visitors in different areas of the zoo at different times of the day (Figure 4) with the areas visited in the morning almost empty by early afternoon. For example over 80% of the visitors who went to the Giraffe exhibit did so before 1pm (Figure 5). Throughout the day, however, the density of visitors to the central areas of the zoo remained low (Figure 3 & Figure 4). Those visitors who did visit the animals in this central area, such as the Meerkat or the Okapi, were those who spent more time in the park overall and spent more time looking at animals (Table 2).

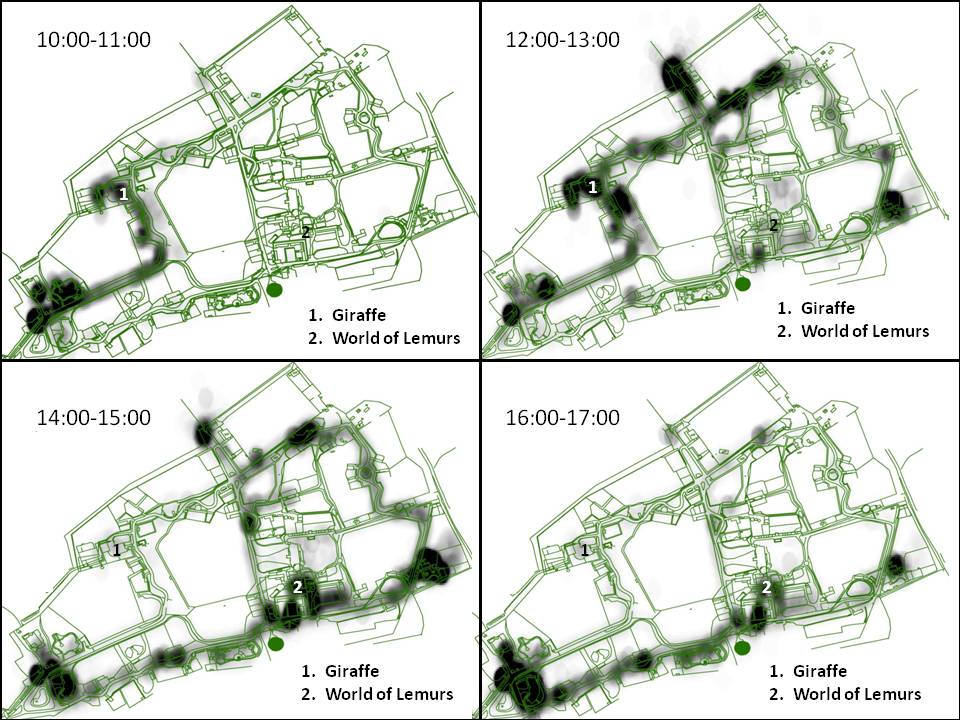


Figure 4. Density maps showing concentrations of visitors during four 1 hour time periods throughout the day

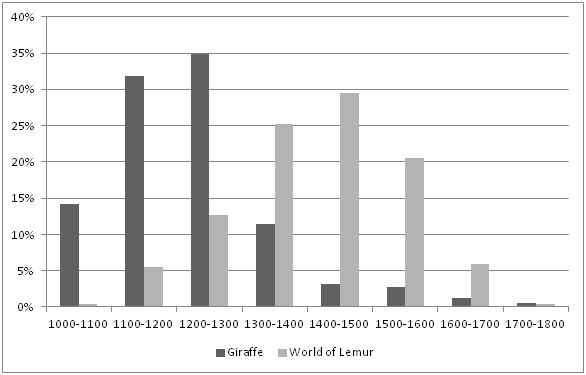


Figure 5. Percentage of visitors to Giraffe and World of Lemur for each hour of the day

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Animal location | Visited location  (time in minutes) | |  | Didn't visit location  (time in minutes) | |  | Mann Whitney U | | |
| Median | IQR |  | Median | IQR |  | z | p | r |
| Meerkat | n = 440 | |  | n = 491 | |  |  |  |  |
| Total time in park | 254 | 100 |  | 225 | 103 |  | 5.804 | < 0.001 | 0.19 |
| Time spent at animals | 88 | 55 |  | 65 | 43 |  | 9.311 | < 0.001 | 0.31 |
| Okapi | n = 247 | |  | n = 684 | |  |  |  |  |
| Total time in park | 257 | 98 |  | 235 | 99 |  | 3.719 | < 0.001 | 0.12 |
| Time spent at animals | 93 | 53 |  | 68 | 46 |  | 8.424 | < 0.001 | 0.28 |
|  |  |  |  |  |  |  |  |  |  |

Table 2. Comparison of time spent in park for those who did, and did not, visit key animals off the main path (IQR = interquartile range).

Significant variations in total time spent at the zoo and distance travelled around the zoo were found. The mean time spent in the park for all visitors was 238 minutes (SD 71) and the mean distance covered was 5,516m (SD 1,728). The shortest time spent in the park was by a family of four with two children under the age of 3 who were zoo members and who stayed for only 55 minutes and covered 1,387m. The longest time spent in the park was by a group of four people in the category 'family and friends' who stayed for 461 minutes and covered 9,586m while the longest distance covered was 14,117m, also by a group of four in the 'family and friends' category, who stayed for 419 minutes.

2.4.2 Variation in locations visited with demographic variation.

Group type, travel distance, number of previous visits and group size were the major factors in determining how long people stayed in the park () with the larger groups spending more time in the park than smaller ones.

Figure . Partial dependence plots for the top four variables affecting variation in total time in park with 95% CI. Relative contribution is given in parenthesis.

Overall the larger groups consisting of large families or family and friends spent the longest in the park while the most frequent visitors (>3 visit per year) spent the least amount of time. The larger groups account for nearly a third of all visitors while the most frequent visitors account for a quarter of all visitors to Marwell Zoo each year ().

Total time in the park was shortest for those with the shortest distance to travel. This increased rapidly as distance increased and reached a plateau between 50 and 120 km travel distance before reducing again (although the latter is within the 95% confidence interval for distances less than 120 km). The total time model explained 45.9% of the deviance using the training data (explanation of observed data) and 25.6% of the deviance using the cross validation (CV) data (prediction of left-out or test data).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group type | Parents with children | Larger family group | Family and Friends | Grandparents with Grandchildren | Couple | Friends |
| No. of responses | 472 | 178 | 118 | 78 | 121 | 26 |
| Percentage | 47% | 18% | 12% | 8% | 12% | 3% |
| Previous visit | Never | Many years ago | Once within 3 years | More than once before | Regular < 3 times per year | Regular > 3 times per year |
| No. of responses | 190 | 151 | 60 | 246 | 101 | 255 |
| Percentage | 19% | 15% | 6% | 24% | 10% | 25% |

Table . Number of participants categorized by group type (excluding solo visitors and careers/childminders) and by number of previous visits

The number of previous visits, travel distance, membership and household income had the largest affect on how long participants spent interacting with animals (Figure 7).

The most frequent visitors and members spent the least amount of time attending to animals. There was a positive correlation (Spearman's rho = 0.713, p < 0.01) between membership and frequency of visits and a negative correlation (Spearman's rho = -0.416, p < 0.01) between membership and distance travelled to reach the zoo (i.e. members were the most frequent visitors and lived closer to the zoo).

Several of these key variables were found to overlap. Household income had a low negative correlation (Spearman's rho = -0.103, p < 0.01) with the length of time spent attending to animals (Figure 7) with those in the higher income groups spending less time attending to animals. There was a low correlation between income and number of previous visits with those in lower income brackets visiting the zoo less often (Spearman's rho = 0.093, p < 0.01) and between income and membership (Spearman's rho = 0.105, p < 0.01) with those in lower income brackets less likely to be members.

Figure . Partial dependence plots for the top four variables affecting variation in time spent attending to animals with 95% CI. Relative contribution is given in parenthesis.

The animal time model explained 38.0% of the deviance in time attending to animals using the training data (explanation of observed data) and 19.8% of the deviance using the cross validation (CV) data (prediction of left-out or test data).

The amount of time spent at the augmented product locations was particularly influenced by the presence of children under the age of 12 in the group, with household income, education level and distance travelled having a lesser effect (Figure 8).

Figure . Partial dependence plots for the top four variables affecting variation in time spent at augmented product locations with 95% CI. Relative contribution is given in parenthesis.

The augmented product time model explained 43.5% of the deviance in the time at augmented product locations using the training data (explanation of observed data) and 20.1% of the deviance using the cross validation (CV) data (prediction of left-out or test data).

Time spent ‘attending to’ the animals amounted to approximately a third of the total time in the park with a further third spent at non-animal, augmented product locations, and the remainder walking between exhibits and at the exhibits that could not be resolved. This ratio is comparable with other studies, for example Birenboim *et al* (2013) who found only 40% of visitor time was spent at identifiable locations, but still leaves a significant proportion of the visitors day unaccounted for.

Kernel density analysis highlighted the variations in behaviour between the differing group types and at which locations different group types spend their time. Figure 9, for example, shows the variation in dwell time across the zoo comparing the groups which did not include children (couples or groups of friends) with the other groups, all of which include children within their parties. Locations where those groups not including children dwelt for longer are shown as lighter coloured areas and locations where those including children dwelt for longer are shown as darker coloured areas. The light coloured areas are predominantly animal locations while the dark coloured areas are predominantly the augmented product areas (picnic, catering and playgrounds). Those groups that did not include children spent a larger proportion of their day attending to animals (mean 46%, SD 10% ) than the other group types which all included children (mean 32%, SD 12%) (Figure 10). Conversely the groups with children spent a larger proportion of their day at the augmented product sites than those without. The BRT analysis found that the number of children under the age of 12 was the most important factor in the proportion of total time spent at the augmented product sites accounting for 31% of the variation in this variable. The small family groups consisting of parents with children or grandparents with children are a significant audience for Marwell making up over half of all visitors in this study and over 85% of all visitor groups include children ().

1 Penguin

2 Giraffe

3 Picnic area

4 Large indoor cafe

5 Large playground

6 Tiger and Meerkat

7 Kiosk cafe & playground8 Lemurs

9 Tropical World

10 Otter and Gibbons

11 Snow Leopard



Figure 9. Variation in dwell time between groups that include children and those that did not.

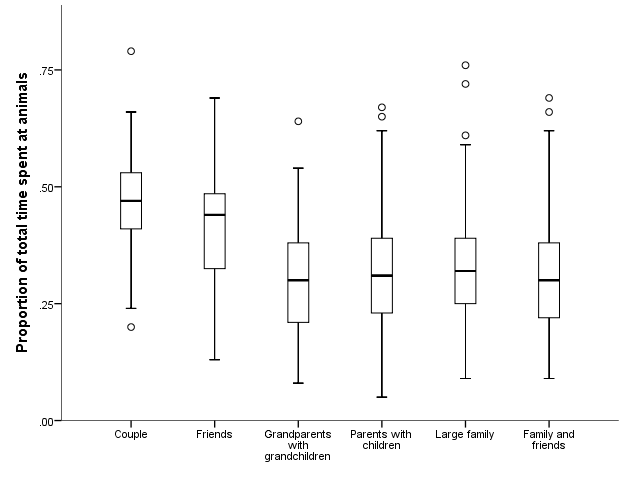


Figure . Box plot of the proportion of total time spent attending to animals by group type

## Discussion

2.5.1 Common routes followed and locations visited

Visitors were consistent in the park areas they visited with the most visited locations found along the perimeter path. As with Deans et al. (1987, as reported in Bitgood (2006)) and Davey (2006b) visitors tended to stick to what they perceived as the main path and less than half ventured into the centre of the park. Bitgood (2006) applied a general value principle model to visitor movements and suggested the inclination to stick to a main path, rather than deviate onto smaller paths, is an aspect of inertia and cost / benefit analysis. The uncertain benefits of venturing off the main path, to a destination that may not be visible, do not compensate for the additional cost of walking farther. In the absence of an incentive to deviate, the visitor will continue on the same path in the same direction.

The tendency for the majority of guests to follow the same route around the park resulted in a bunching effect with the majority of visitors arriving at key exhibits in relatively narrow time windows rather than being spread out across the day. and Figure 5 show that the majority of visitors at the Giraffe and Lemur areas visit these popular locations within a small time window. This bunching and peaking in visitor numbers can be of benefit to the institution as it allows visitor presentations to be timed to coincide with the peak in visitor numbers at a given location, for example the Giraffe talks is at 11:30am, and thus reach the largest number of visitors possible. Conversely, however, there is also a risk that these areas become overcrowded, stressing more sensitive animals and discouraging some visitors from stopping. This study did not examine visitor behaviour directly at these locations during peak times but this would be a worthwhile exercise in order to gauge the affects of these peaks in visitor flows.

The catering team at Marwell were aware of this common route affect to some extent and have been able to utilise this information in the positioning of outlets. A burger outlet near the Giraffe was closed in 2014 as visitors were arriving at it too early in their day and it did not do enough business to justify retaining this option. The large indoor cafe conversely, which visitors encounter after about 2 hours at the zoo, was frequently overcrowded on busy days. A seasonal takeaway burger outlet was therefore opened adjacent to the cafe which did considerably better business than the outlet near the Giraffe had done and relieved pressure on the indoor cafe.

The low level of visitors seen at animals such as Meerkat and Okapi, which were only visited by 47% and 27% of participants respectively, confirms the institution's concern that the central areas of the park were underutilised. Meerkats could reasonably be expected to be popular due to their entertaining nature and high media profile in the UK, but their position off the main path appears to result in their being missed by over half of visitors. The dwell time of those who did visit the Meerkats was above average (mean 3.82 minutes, SD 3.55), despite the relatively small enclosure, suggesting these visitors were rewarded for their efforts to explore more. The Okapi exhibit is much larger, consisting of two buildings and four paddocks, but was missed by nearly 75% of visitors. Those who did visit this location also stayed for above average dwell time (mean 3.54 minutes, SD 2.36) again suggesting these visitors were rewarded for their additional effort.

It could have been hypothesised that visitors only have a certain capacity for viewing animals and therefore that those who took the time to find the central animals did so at the expense of other exhibits. The results from this study, however, indicate that those visitors who spent time at these central locations did so in addition to the time spent at the main path animals most commonly visited by the majority of visitors. This suggests that action should be taken to allow more visitors to gain the same level of reward.

Dierking *et al.* (2004) found that animal activity levels did not influence dwell time when viewed at complex exhibits with many features to see and interact with. Conversely, where other activities are not available, the number and activity of the animals is a strong indicator of dwell time (Ridgway *et al.* 2005). The Okapi exhibit was an example of the former with a greater number and variation in interpretation items but the animals themselves are shy and elusive whereas the Meerkat enclosure, at the time of this study, was an example of the latter: a simple enclosure with animals that were almost always active and visible. This finding also conforms with that of Davey (2006a) who found visitors were willing to spend the time to look for animals at more complex exhibits and gained a level of satisfaction from the search. Since this study was conducted, the Meerkat enclosure has been relocated to a more prominent position on the perimeter path and work is underway to divert more visitors through the Okapi area on their way to a new exhibit. Anecdotally the relocation of the Meerkat enclosure to the main path has resulted in significantly larger numbers of visitors viewing these animals, although no formal visitor counts had been carried out at the time of writing.

Visitors who were found not to have ventured to the animal enclosures in the interior of the park spent less time interacting with animals, less time in the park overall and covered a shorter distance. This reduced contact time gives the zoo less opportunity to engage with visitors and risks compromising the visitor experience (Fernandez *et al.* 2009; Santana-Jimenez and Hernandez 2011).

Dierking *et al.* (2004) also found that the animal locations with the longest dwell times were those with more than one viewing location or with a path to follow within the exhibit with a variety of things to see along the way. In this study, the Penguin and Tiger exhibits are examples of the former while the Tropical house and World of Lemur are examples of the latter and all are among those with the longest dwell times. Tropical house and World of Lemur, however, were only visited by just over half of all visitors (Table 1). These are both examples of larger, immersive exhibits which represent considerable investments in space, energy and manpower on the part of the zoo and which should offer many opportunities to engage with visitors. There are a number of possible reasons for the low visitor numbers to these areas within the context of the zoo. They are generally encountered towards the end of the day when visitors may be getting tired and less inclined to look (Falk *et al.* 1985); the entrance to the tropical house in particular tends to be congested which may discourage people from entering (Ridgway *et al.* 2005; Fernandez *et al.* 2009); and the World of Lemur entrance is somewhat hidden meaning it is not obvious how much there is to see from the main path and hence what there is to gain from the additional effort of diverting from the main path (Bitgood *et al.* 2006). As with the Meerkat and Okapi exhibits, more work is needed in these locations to highlight the opportunities on offer to the visitors at these indoor exhibits.

2.5.2 Variation in visitor type affects dwell time at specific locations*.*

Group type, distance travelled and visit frequency were found to have a large effect on how much time visitors spent within the park and at specific locations. Groups with children spent less time attending to the animals and more time at non-animal locations than those without. The greater input children had in deciding where these groups dwelt longest may reflect the differing expectations and limitations in attention span of children and adults (Bitgood 2002; Ridgway *et al.* 2005; Ross and Lukas 2005). The difference in time spent at non-animal locations also supports the findings of other authors who have found that visitors see zoos as social destinations as much as, or more than, places of learning (Clayton *et al.* 2009) and that social interaction can have a significant effect on dwell time at exhibits (Ridgway *et al.* 2005). The large family and family and friends groups spent the longest time in the park. These group types may see each other less often than immediate family so the social aspect of their visit will play a larger part in how they spend their day (Garrett 2013). While they may have come with the intention of engaging their children with nature and animals, they will also have other requirements for an enjoyable day out such as play and refreshment. Although the lowest income groups did not spend any longer in the park overall than other groups they did spend longer attending to the animals which agrees with Cooper (1981) that these groups make the most of their less frequent visits.

The GPS tracking exercise indicates that many visitors, and particularly repeat visitors, to zoos spend significant portions of their day moving and engaging in non-animal related activity rather than engaging with the animals. Less frequent and first time visitors are prepared to spend longer engaging with animals and hence may have a different learning experience to the frequent visitor. Future development should provide more opportunities to slow down, stop and look at 'experience points’ in order to engage a greater proportion of visitors. It is at these locations where learning is most likely to happen (Serrell 1998; Davey *et al.* 2005) and a visit can be enhanced by greater interaction with animals and the exhibits (Gutwill and Allen 2010). Conversely, for those frequent visitors who prefer a shorter visit, 'quick facts' that are easily read and understood and can potentially be changed regularly may help to keep these visitors engaged and develop their understanding and awareness over a number of visits.

# Conclusion

This paper set out to determine if GPS units could be used to accurately track visitors at an individual tourist attraction, to examine the spatial and temporal behaviour of those visitors within the environs of that attraction, and to investigate what demographic or group factors affected that behaviour. Understanding how visitors move around large attractions and what influences the choice of route can make a significant contribution to spatial planning for many institutions.

The GPS tool was effective at determining where visitors went and combining this data with the survey data was partially successful in differentiating between the behaviours of different group types. The tracking exercise was able to resolve visitor movements spatially across the park and temporally throughout the day. The technique was also able to distinguish behaviours of broad visitor groups such as those with and without children. The reluctance of visitors to stray from what they perceive to be the main path suggests more than simple way marking is needed to encourage visitors to explore locations away from the main exhibits. A country house and garden, for example, may need to do more than use signage to encourage visitors to walk to a distant lake and boathouse exhibit if it is out of sight of the main house, despite its potential aesthetic or historic interest. In the case examined here, simply signposting the World of Lemur or Okapi exhibits may not be enough to persuade visitors to visit these locations. Inviting entrances with bold images and themes may be necessary to highlight the rewards on offer for diverting into these exhibits.

To use visitor tracking most effectively as an evaluation tool it would help to know not only which locations were visited, but also which elements were popular within those locations. For example, the dwell time at various animal enclosures at Marwell Zoo showed a large amount of variation between groups. This may have been due to local factors such as activity level of the animals; poor vantage points for small children or to group factors such as low attention span of smaller children or grandparents wanting a rest. If attractions wish groups to spend more time at key locations like these, they will need to consider how they cater for the differing group types and their individual needs. More seating or more interactive elements might persuade different groups to dwell longer and experience more.

The boosted regression trees model used here had only moderate predictive power suggesting factors not tested here are also having an effect. Many variables can affect dwell time that it was not possible to include in this study but which could be investigated in future work. More detailed discussion with participants may reveal personal animal preferences or external factors affecting dwell time while observations around the zoo could highlight location specific issues of crowding, animal activity or spontaneous keeper interactions.

The resolution of the GPS units was not always high enough to distinguish between viewpoints and provides no insight into the reasons for choosing one location over another. For the larger exhibits at the case study location, some distinction was possible, for example between the front of penguin pool and rear lookout station. Elsewhere it would be difficult to say with any certainty whether the visitor was looking at one enclosure or the adjacent one. For example, was a participant on the back lawn looking at the monkeys or just picnicking in that area? Direct observation of visitors would be needed to resolve these more detailed issues. Using the methods described here it would not be possible to evaluate the effectiveness of an exhibit by separating which specific elements of an exhibit an individual is looking at such as Francis *et al.* (2007) did. This current limitation in accuracy suggests that GPS tracking is useful as a location-wide planning tool but that alternative, more precise methods are needed for exhibit design evaluations.

Combining GPS tracking with other methods may, however, improve the level of detail in key locations to allow exhibit evaluation. O'Connor *et al.* (2005) used small tracking tags of the type used for tracking and timing runners in large public races. These do not record location continuously but instead they use radio frequency identification tags (RFID) technology to communicate with receivers placed in key locations to record time of arrival at that point. While less detailed overall, the short range of the receivers means this method has the advantage of being very precise to a specific location. This technology could work well in the zoo environment where receivers could be placed at the entrance and exit to exhibits, particularly indoor exhibits where GPS reception is poor, to accurately record arrival and departure times. Alternatively, Chrysanthi *et al.* (2012) combined GPS tracking with photographs taken by participants as they toured an archaeological site. This was able to give a good idea of what interested the participants in their small study (36 GPS tracks, 644 images) but could quickly become unwieldy in a larger study of the kind attempted here.

Providing accurate position information indoors is developing rapidly for large indoor retail outlets using high level cameras and smart phones (Clifford and Hardy 2013). Costs of CCTV cameras continue to fall and many attractions provide public Wi-Fi in large parts of their parks so these methods of tracking have the potential to allow a far greater range of tracking studies to be undertaken. Combinations of park-wide GPS tracking and more detailed methods at locations of specific interest may therefore benefit from the advantages of both types of data gathering and compensate for the limitations of each. GPS receivers are now common in mobile devices hence many attractions now provide navigation and information apps which couple location data with pop-up information triggered by Wi-Fi or Bluetooth 'ibeacons'. These apps provide the opportunity to gather much greater detail on a visitor’s movement and interaction but privacy concerns will need to be addressed before detailed visitor tracking becomes widespread to avoid risking alienating visitors.

This study combined an entrance survey to categorise visitors with GPS tracking to examine the behaviour of those visitors. Using one or more of the methods described above to improve the positional accuracy of the tracking and combining this with an exit survey could provide valuable insight into the effectiveness of exhibit design in delivering learning opportunities or providing an entertaining and enjoyable day out.

Encouraging visitors to explore fully and maximise their time at an attraction maximises both their learning opportunity and their chances of satiation from their day out. Whether their visit was for learning, or for an opportunity to spend time together as a family or group of friends, providing a full day out will maximise the visitors opportunity to achieve those objectives, providing they are kept entertained and engaged throughout.

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