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Measuring the outcomes from active transport interventions for children

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ABSTRACT

In this paper, some of the methods that can be used to examine the outcomes from active transport interventions for children are examined. These include diaries, physical activity monitors, global positioning satellite (GPS) monitors, and maps. This is based on experience of these techniques gained by the authors in their research with children in Hertfordshire and Lewisham in London.

1 INTRODUCTION

The purpose of this paper is to discuss some techniques that can be used to measure the outcomes from active transport interventions, such as schemes to increase the amount of walking. They can also be used in exploratory analysis, for example to establish how many children walk to school, possibly as part of a campaign to increase the amount of active transport, or to establish the extent to which remedial action is required.

The information here all comes from two projects carried out at University College London. The first, a project entitled 'Reducing children's car use: the health and potential car dependency impacts' was carried out in the Centre for Transport Studies at University College London (UCL) in collaboration with others including Hertfordshire County Council, with fieldwork being carried out in Hertfordshire, an area immediately north of London. The project ran from January 2001 to February 2004. There is more information at http://www.cts.ucl.ac.uk/research/chcaruse/. The most innovative part of that was to fit about 200 children with activity monitors and ask them to keep diaries from which it was possible to establish the relative contribution of various activities, including walking, to children's energy consumption (Mackett et al, 2005).

This work was followed by another project, entitled CAPABLE (Children's Activities, Perceptions and Behaviour in the Local Environment). (see http://www.casa.ucl.ac.uk/capableproject/). CAPABLE involves staff from the Centre for Transport Studies, the Centre for Advanced Spatial Analysis (CASA), the Bartlett School of Planning and the Department of Psychology all at UCL. In CAPABLE, children are being fitted with GPS (global positioning system) monitors as well as using the activity monitors and diaries, so that it is possible to establish where children go for various activities. Another aspect of interest is whether or not children are allowed out without an adult. Questionnaire surveys have been conducted of children and their parents, and various drawing and mapping exercises carried out with the children. The fieldwork was carried out in Lewisham in south-east London, and in Hertfordshire, the area immediately north of London.

This paper is not intended to be a comprehensive review of all aspects of the various techniques, because that would not be practical. Instead, it is intended to illustrate the range of approaches that can be used, and pass on some information about practical aspects of using the techniques. Each technique will be considered in turn, in terms of the type of issue that might be addressed using it, how it was used in the Children's Car Use and CAPABLE projects, some practical aspects of using it, and how it might be used in combination with other techniques. It covers seven of the techniques that were used: activity monitors, diaries, body composition measurement, GPS (global positioning satellite) monitors, map annotation, map drawing and cameras. Other techniques that were used, but are not reported here, include questionnaires completed by both parents and children, interviews, and spatial reasoning tests.

2 ETHICAL ISSUES

Any fieldwork raises a number of ethical issues. Working with children requires particular sensitivity, not only to protect the children, but also to protect the researchers involved. The requirements will vary from country to country, and there may be cultural differences that also have an impact. In the work at UCL, it was necessary to obtain approval of the project from the UCL Research Ethics Committee. Because there are health issues involved, and also because some researchers in this field are from a health background, some similar research is considered by ethics committees from the local health authority. There is more information about research ethics on the UK Economic and Social Research Council (ESRC) website, including a document describing the Research Ethics Framework (ESRC, 2005).

In Britain, it is necessary to obtain clearance from the Criminal Records Bureau for any field workers who are going to be involved in work that requires them to be in direct contact with children. This will confirm that the person involved does not have any criminal convictions that suggest that he or she poses a risk to children.

In the two UCL projects some rules were developed about how research should be conducted, for example, the researchers should always have another adult in the room when working with children, and the work should always be carried out with the door open. These rules were devised to ensure that the researchers did not find themselves in a compromising situation with a child.

The two UCL projects were carried out through schools. Written consent was obtained from both the children and their parents for all work that involved the children being with the researchers without a teacher being present, or work that required active co-operation from the child or her or her parent. There were some activities that were carried out in class, with the teacher present that were used as part of the lesson. Explicit consent was not obtained from the parents or children for these activities.

In Britain there are also issues about how the data are looked after once they have been collected. These issues are covered by the Data Protection Act, and, for example, require that sensitive information about individuals is not stored on a computer in a way that the individual can be identified. Instead a code has to be given to each record which can be used to identify the person in one file and his or her data in another file.

3 SOME GENERAL ISSUES IN WORKING WITH CHILDREN.

As mentioned above, the UCL projects were carried out through schools. This was very efficient as it meant that many children could be contacted at once. Obviously it required the co-operation of the school, in particular of the headteacher. Some headteachers were very enthusiastic, because they saw children's physical activity and reducing car use as important issues, particularly as they rise up the public policy agenda and schools are required to consider such issues. Other headteachers were not able to help, mainly because they were too busy. The co-operative schools tended to be in higher income areas, while those where they were too busy tended to be in low-income areas, often with high levels of street crime. Clearly it is important to be aware of this possible source of bias in interpreting the results.

It was found to be relatively easy to organise work in primary schools (up to the age of 11). Once the headteacher had agreed she, or he, passed the responsibility on to one or more class teachers who facilitated the researchers working with the classes or a group of children. In secondary schools a slightly different approach had to be adopted. The children move from subject to subject therefore any research activity has to be fitted in with this. After checking the curriculum of various subjects, it was found that if the activities were adapted slightly, they would fit in either under the PSHE (Personal, Social and Health Education) programme, Citizenship programme or into a Geography lesson. When it was presented like this, headteachers were very keen for their pupils to participate and there were very high levels of cooperation from the schools with two or three periods dedicated to the research activities for each class. In one school the research activities were fitted in with a PSHE lesson, in the other two schools they were slotted into the Geography course.

The children are used to carrying pieces of paper between the school and their parents, and this method was used to carry consent letters, questionnaires and reminders. This worked well, but it was not surprising that the response rates for completing questionnaires were much higher for the children who completed them in class than for their parents because there were more steps to go through for the questionnaire to be completed, and so more places for the process to break down.

An interesting question is one of incentives. In the Children's Car Use Project, no incentives were offered. In the CAPABLE project, some balloons and similar cheap goods were given away and seemed to give the children great pleasure. Later, some cheap plastic puzzles involving making a ball go through a maze, complete with UCL logo, were given away. These were also very popular, but it is not clear whether they increased the response rate. It would also be possible to provide incentives to schools, such as tokens to buy books for the library, but this was not found to be necessary in the research at UCL. Certificates were produced for each of the secondary school children who took part, confirming that they had participated. The children could then add these to their portfolios of achievement.

At one school a local newspaper became aware of the research and provided free publicity for the work. This may have been instrumental in the co-operation obtained from another local school.

4 PHYSICAL ACTIVITY MONITORS

4.1 The nature of activity monitors

Activity monitors are portable electronic monitors that are worn on the body. They measure movements in three directions. These can be converted to measures of the volume of physical activity or calories. In the latter case it is necessary to input the subject's height, weight, age and gender. They may be regarded as sophisticated versions of pedometers.

4.2 The use of activity monitors in the UCL work

The activity monitors used in the UCL work were RT3 tri-axial accelerometers, manufactured by Stayhealthy, USA. The RT3s combine all three acceleration vectors to produce an overall vector magnitude (VM) expressed in terms of activity counts. These can be converted into activity calories using formulae programmed into the equipment using data on the age, gender, weight and height of the child. Activity calories are calories used in undertaking physical activity. The RT3s can also convert activity calories to total calories, that is, including the calories that are used by the body to function and develop even when the person is passive, by adding on a constant based on the physical characteristics of the person. Activity calories have been used in the UCL work. The RT3s are the size of a small pager and are worn around the waist in a purpose-made holster on a belt, as shown in Figure 1. They can be worn for all events except those which would make them wet. They were set to record movements on a minute-by-minute basis. Trost et al (2000) have shown that four days of monitoring of physical activity are required. The researchers went into the schools on a Wednesday to weigh and measure the children, issue them with the equipment and brief them on its use. The children wore the monitor from the Wednesday until the next Monday, with data being collected for the four days Thursday, Friday, Saturday and Sunday. On the Monday researchers went into the school to collect the equipment, download the data, email it back to UCL for processing. The resulting graphs were emailed back to the field researchers so that they could sit down with the individual children to reconcile the results from the RT3s with the activities described in the diaries. This reconciliation exercise meant that the

times for the activities came from the RT3s rather than from the children, who were not very accurate in their estimates of time.

4.3 Lessons learnt in using the activity monitors

The RT3s worked well. They required no attention from the wearer and look fairly uninteresting and so the children did not tend to interfere with them. Some appeared to lose accuracy with time. The main technical difficulty with them was the rather crude connections in the docking stations used to download the data from the RT3s.

Figure 1 The RT3 activity monitor

5 DIARIES

5.1 The nature of diaries

Diaries are used extensively in transport studies to record trips that are made over a period, typically a week by members of a household. They include the purpose of the trips (to go to work, to go to the shops, and so on).

5.2 The use of diaries in the UCL work

In the UCL work, the diaries were used to record the travel and the activities of the children to complement the data from the RT3s so that it was possible to identify the levels of energy consumed in various activities, including travelling. They were used in both projects, with the addition of questions about whom the children were accompanied by, in the CAPABLE study. The children were asked to complete the diaries for four days. An example extract from the diary is shown in Figure 2. The RT3 output was used as a visual aid to refine the times of specific events identifiable from the trace by the child and a researcher. The events recorded in the children's activity and travel diaries had to be classified. A three-level typology was devised. It

is shown in Mackett et al (2005). The diaries also provided a rich source of data in their own right, since they show how long children spend in various activities, how they travelled, whom they travelled with, and so on.

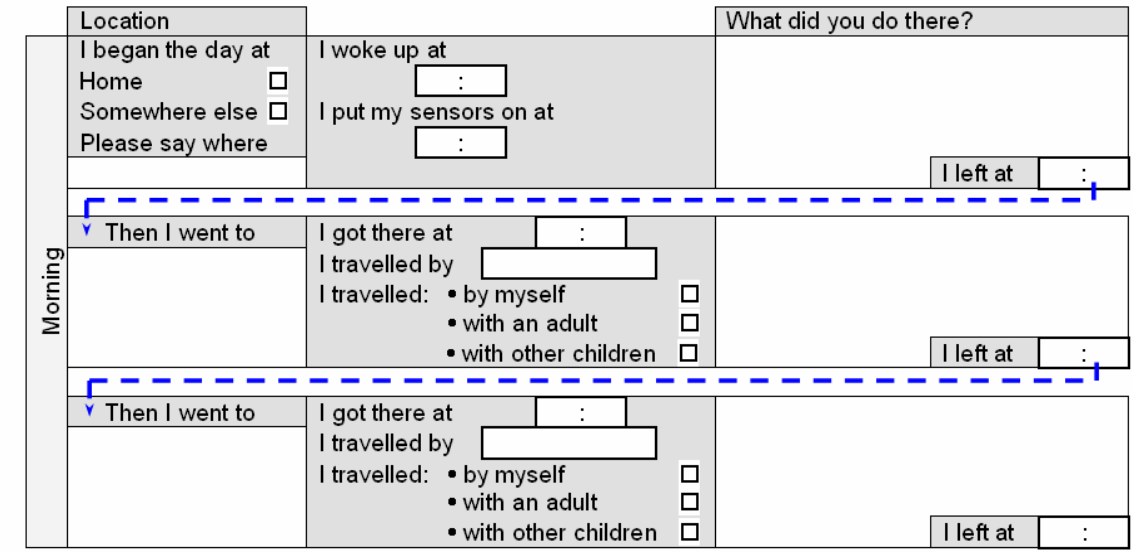

Figure 2 The activity and travel diary

The diaries were trialled over quite a long period in order to ensure that the children could complete them. They were good for identifying activities which were associated with an explicit trip. They were not very good for identifying activities at home, or in the garden. This is not surprising, since activities are home such as playing, watching television, playing on a Playstation or reading tend not to have well defined time boundaries and it is not realistic to expect children to record all the transitions. Hence there were quite long periods, particularly at the weekend that at simply classified as 'at home'.

5.3 Lessons learnt in using diaries

The diaries were designed especially for this project. They were trialled extensively, and many revisions made. Overall, the diaries provide a rich source of data, but they do require the children to put in a lot of effort, and they require a lot of work to collect, input and classify the data. About 200 children were studied in each of the two projects. Many of the children did not complete the diaries for the full four days, but did provide useable data.

6 MEASURING BODY COMPOSITION

6.1 The nature of measuring body composition

This means measuring various parameters associated with the physical characteristics of children. It includes weight, height and body fat content. From height and weight it is possible to calculate the Body Mass Index (BMI) which is defined as weight in kg divided by the square of the height in metres. BMI is a measure of body fatness. There is information about BMI at Centers for Disease Control and Prevention (2006) including advice on interpretation of the value.

6.2 The measurement of body composition in the UCL work

It was necessary to measure the children's height and weight as an input to the RT3s. The children's body fat was measured directly using a Tanita electronic body fat monitor. Height and weight were measured using conventional methods. The BMI and body fat content were found to be fairly highly correlated.

6.3 Lessons learnt in measuring body composition

The use of the equipment was all fairly straightforward. Some children, particularly the older girls were not willing to be weighed. Tests were carried out using callipers to measure body fat but these were found to give inconsistent results because of the lack of experience of the researchers in using them.

7 GLOBAL POSITIONING SATELLITE (GPS) MONITORS

7.1 The nature of GPS monitors

The GPS is a satellite-based positioning system. Twenty four GPS satellites are orbiting the earth at a very high altitude. By picking up signals from these satellites, a GPS receiver can identify the user position over the ground to an accuracy of several metres. From this it is possible to tell where people go, and how fast they travel, since time is also recorded. It is possible to record the locations in a data logger either built into the monitor or as a separate piece of equipment attached by wire. Alternatively, the location parameters can be transmitted back to a central point, for example, by using mobile phone technology.

7.2 The use of GPS monitors in the UCL work

Several types of GPS equipment were tested, in order to decide the best in terms of precision, battery life and acceptability to the children. The GPS equipment used in the CAPABLE project is the Garmin Foretrex 201 which is small and light-weight so that children can easily wear it on their wrists all day long, as shown in Figure 3. It monitors children's locations at set intervals and records them in its memory in chronological order. These data can be superimposed subsequently on a map or input into a GIS (geographic information system) so that they can be linked with other spatial data and analysed.

7.3 Lessons learnt in using the GPS monitors

The GPS monitors presented a number of problems, including the need to recharge them at night. The equipment has to be visible in order to establish contact with the satellites. For this reason, the monitors were not used in Lewisham with its high levels of street crime since it was regarded as essential to avoid any risk to the children from mugging, which is common in that area. They were used in Hertfordshire, but the children were told to surrender the equipment if challenged rather than risk any physical harm coming to them. Also, it is very important that wearing the equipment does not change travel behaviour, since that would negate the value of the experiment. Weight was particularly critical in this work because the

subjects were children, but it is questionable whether many adults would be willing to carry 0.5 kg of extra weight around with them for several days. This is why it was decided to use the Garmin Foretrex 201, which is worn on the wrist. It had the disadvantage that batteries had to be charged every night, but that was less problematic than expected. It is not, however, as precise as some other types of GPS monitor.

Figure 3 The Garmin Foretrex 201 GPS monitor

The equipment does not normally function within buildings. There are problems in outdoor areas with tall buildings because the signal can bounce off the buildings and give false readings. There were a number of false readings even in open country, and this is a commonly recognised problem. This happened particularly with the first reading on leaving a building. Rules have to be adopted to allow for these problems.

8 MAP ANNOTATION ACTIVITY

8.1 The nature of map annotation

Participants can be given maps and asked to mark on them various information about their lives. These can then be interpreted directly or used as the basis of an interview. The annotation can be in the form of stickers, for example indicating the places that people go to for various activities, or lines drawn with coloured pens.

8.2 The use of map annotation in the UCL work

The aim of the map annotating activity was to examine children's patterns of travel behaviour and see how this was influenced by their social networks, particularly walking and being able to travel on public transport without an adult. This was seen as important because if children have this type of independent mobility they are likely

to be getting more exercise and to be less dependent on being driven around by their parents.

It was decided to carry out the map annotating activity in secondary schools partly because it was suspected that social networks might change with entry into secondary schools and partly because the slightly complex nature of the activity lent itself better to older children.

In this activity the children were asked to mark on a map all the people and places they visited and provide supplementary data about these visits to provide a picture of transport use, the distances they travelled and to what purpose, whether they travelled on their own and so on. The procedure that was adopted was to ask children to complete some tables and then to annotate the map according to details provided in the tables. The children were given three tables to fill in, one asking about the friends they spent time with outside of school, another about relatives who lived within an hour of where they lived and finally a table asking about places they visited. The tables required details such as where the friend or relative lived, how often they saw them and how they knew that friend, where they spent time together, how they travelled there and whether they could travel there without an adult.

They were then given a map of their part of London which covered approximately 108 square km and which had the school and the approximate location of their home marked on it (they had supplied their post-codes in a previous activity). They were then asked to plot friends, relatives and places they visited using stickers with numbers on; they then wrote down the number of each sticker alongside the friend, relative or place that the sticker represented.

In addition they were asked to draw on the map where they were allowed to travel by bus and walk on their own. They were also asked to mark the area they considered to be their neighbourhood. They were given felt pens to do this and drew a key on the back of their tables to help identify what the colours stood for.

To analyse the data concentric circles were drawn around where the person lived at intervals of 500m, 1km and 2km and distances for every other point were measured. The data from the maps provide information on the distances at which friends and relatives live, the distances of places the children travel to as well as information on patterns of friendship which have been categorised according to the extent to which they were ‘clustered’ or ‘scattered’. The maps also show how far children can travel without an adult. Examples of the maps and their interpretation are shown in Figure 4.

This has provided a substantial data set with many possible directions of analyses. The above information can also be analysed in the light of the data from questionnaires completed by the children and their parents. These provide additional data on a wide range of subjects including parent’s employment status, household structure, ethnicity, length of time living in area, type of accommodation and access to public space.

In this map the pupil has a very small range of independent mobility which is entirely concentrated within the 1km ring around her home. Four of her listed friends live in Poland suggesting she is a fairly recent migrant. Another three live very close to her home (a cluster) and she is allowed to walk to them. She is not able to walk to the friends who live beyond the 1km ring. It is also significant that the school (in blue) is within this. The other stickers on her map represent places she visits on the journey back from school such as Macdonalds and the Park. Her neighbourhood is the very small circle in green around her home.

This pupil had 13 friends living within 3 km all of whom she was allowed to visit on her own. The distance she could walk on her own extended to within the 2km ring and she was able to take the bus to a point over 4km away (not in the picture). The area she marked as her neighbourhood (in orange) likewise extended beyond the 2km circle in places. She also had two sets of relatives living in the local area.

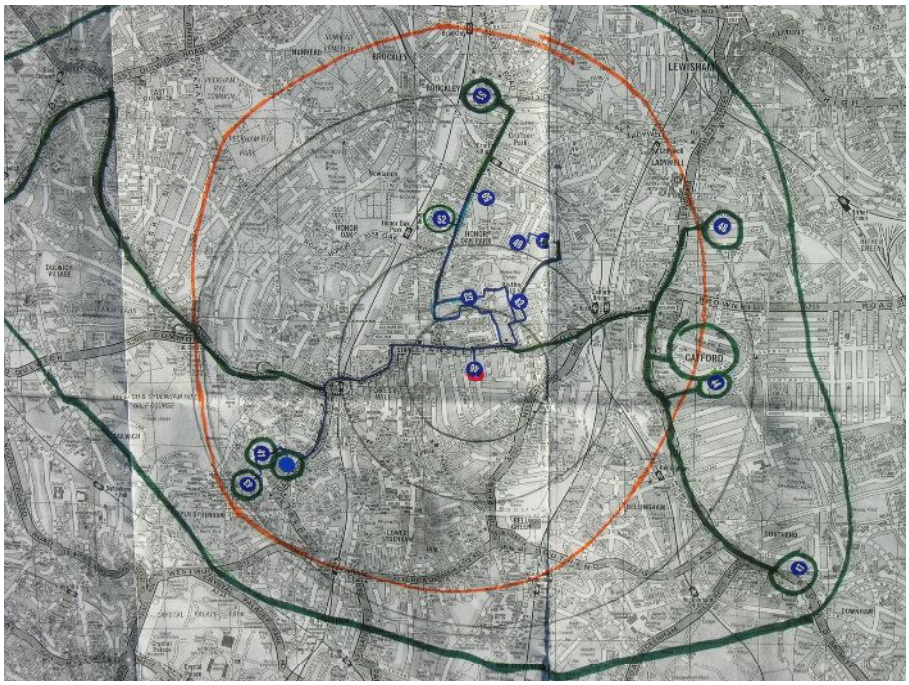

Figure 4 Examples of the outputs from the map annotation exercise

8.3 Lessons learnt in using the map annotation exercises

It was not until the research activity had been completed with at least two classes that the best methodology was found. Alterations which were made included: changing the map sizes so they were easier to fill in, changing the order of activities and simplifying the sticker system. This suggests that when deciding how many classes to involve, one needs to take into consideration that data from earlier classes will not be of the same quality as subsequent data. If resources permit the above research activity could be fruitfully carried out on an individual basis as part of an interview with each child. As the data currently stand, they contain many ambiguities and therefore show broad trends amongst this age group rather than individual portraits of everyday life.

9 MAP DRAWING

9.1 The nature of map drawing

By drawing maps, children demonstrate their recall of their stored knowledge of elements of the local environment. Interpretation of the maps reveals differences in their perceptions and interpretation of the world around them. Differences may arise from the differential levels of interaction with the environment, for example, between those who walk frequently and those who travel as car passengers much of the time. It may well be possible to demonstrate differences between children who use active transport and those who do not, for example in terms of cognitive development.

9.2 The use of map drawing in the UCL work

The aim of the sketch mapping exercises was to produce representations of the children's spatial knowledge. In the first task, on the route to school map, children were asked to recall the routes they had taken from their homes to the school that morning. Each child was asked to produce an accurate map, that is, one that would allow someone else to follow the route that they had used that morning. The children were encouraged to use as many landmarks as they could remember and to label as many of them as they could. This was followed by the area mapping task. In this the children were asked to draw a map of the area around their school. Once again children were asked to be as accurate as possible and to include, and label, as many landmarks as they could recall. Children were given A4 worksheets for each task: the route to school worksheet included a space to write down the mode they had used to travel to school that morning, the area mapping sheet included a plan view of the school in the centre of the sheet.

Both tasks involved the recall of stored spatial knowledge. A number of factors can affect a child's ability to draw these maps, including their drawing ability. However, pilot work had suggested that the tasks do demonstrate different levels of spatial knowledge. The children's maps can differ in terms of detail, the number of landmarks recalled, and accuracy, and how closely the landmarks in the map match the real world. Pilot work has suggested a link between how independent a child is when travelling and the level of his or her spatial knowledge. This suggestion will be further investigated using the results from the main CAPABLE study. The use of GPS

tracking also allows the routes recalled in the route to school task to be compared with the actual routes taken by the children.

9.3 Lessons learnt from the map drawing exercises

The sketch mapping tasks were easily understood by the majority of children and provide a relatively straightforward way to make stored spatial knowledge explicit. Apart from some children with special educational needs, difficulties only arose for children who live very far away or very close to the school. Children who lived close to the school often finished the route to school task very quickly and became bored. Children who lived a long way from the school sometimes found it difficult to fit their routes, which might involve a car journey from another town, onto the sheet; some of these children also had difficulty with the area mapping task as they had limited experience of the area around the school. The schools used have local catchment areas so most children live near to the school.

10 CAMERAS

10.1 The use of cameras

Cameras can be used by participants to record the places they visit. The resulting photographs can then either be analysed in terms of content or used as the basis of an interview. Usually, disposable cameras are used because of their low cost.

10.2 The use of cameras in the UCL work

The aim of photographic exercise with the children was to find out more about the sorts of spaces and places in which they spent their time. First, letters went home to parents to tell them about the activity and to check they did not object to their child participating. The children were then each given disposable cameras which had the child's name on. The first photograph was taken of their name so that the subsequent set of photographs film could be identified. The children were then asked to take their cameras with them everywhere and to photograph places which were special to them. They were also shown how the cameras worked and provided with the rudiments of photograph taking. The cameras were given to them before the Easter half term so that they had plenty of opportunity to take photos.

The biggest problem encountered was getting the cameras back: the teachers set specific days when they asked the children to bring the camera back and if they failed to do so they were told that it was too late. Children explained to the researchers that sometimes they had bought the camera back after the set date and had been told to take it back home. The main problem here therefore was inadequate communication with the teachers. Partly as a result of this, the return rate was just over 50%, despite the fact that children knew they would get a complete set of photos when they returned their cameras.

This made it difficult to proceed with the planned activity which had been a written one involving the whole class. Instead, the children who had brought the cameras back were interviewed briefly, being asked for each photo:

- The place in the photo

- The person in the photo
- Who they go there with
- How often they go there
- Why the place is special to them.

It had been hoped that the photographic activity would have increased children's engagement in the project and that this would be reflected in the interviews. This was not the case. On interviewing the children they often became suspicious and reticent, particularly the boys.

The sets of photographs were analysed independently of what the children said about them, looking at:

- Whether the photos were of indoor or outdoor places
- Whether they were public or private, domestic places
- Did they appear to be in the local area?
- Numbers of people or pets appearing in the photographs

Then the material from the photographs was correlated with data emerging from questionnaires and drawings that they had completed. With regards to the former, it was found for example that those children who visited more friends tended to have photographed more places. It was also sometimes found that there were relationships between the children's drawings and photographs. What was not found, but had been hoped for, were 'secret' or 'hidden' places. It had thought that children might have their own spaces which existed independently of (even if parallel to) the public realm of the adult world or the domestic realm of their families. This did not appear to be the case. Nearly all the places photographed by the children were fairly predictable.

10.3 Lessons learnt from the camera exercises

It is important that teachers are kept involved and informed at all stages of the activity because they are important in ensuring the return of the cameras, even though they do not see their use. When operating with a whole class it is highly likely that many children will not return their cameras; this needs to be taken into account into the subsequent activity. In dense urban areas where children spend a great deal of time at computers and when a large portion of their lives is institutionalised (for example in after school clubs and extra-curricula activities) they are less likely to occupy a hidden or secret spatial arena which can be revealed through the camera. While they may have their own arenas these are perhaps more likely to take a 'virtual' rather than a spatial form. Therefore photographic exercises may not be as fruitful as they were in the past or as they might be in a more rural area.

11 CONCLUSIONS

This paper has attempted to provide an overview of some of the techniques that have been used in the last five years in two projects involving children's active travel amongst other themes. The emphasis has been on practical aspects and lessons learnt so that others can gain from the experience.

One of the main aspects of this work has been the combination of the techniques. Children were fitted with RT3 and GPS monitors and asked to keep diaries. From this

they were able to provide information about where they went, whom they went with, what they did when they arrived, and how active they were, as shown in Figures 5 and 6. From these data it is possible to establish which sort of places children go to for various activities, which sorts of places they are most active in, whether children are more or less active when they are with adults than when they are with other children, or alone. From these data it is possible to learn above children's active travel and how they use the neighbourhood. Then it may be possible to create more lively neighbourhoods, in which they can lead more active, healthier lives.

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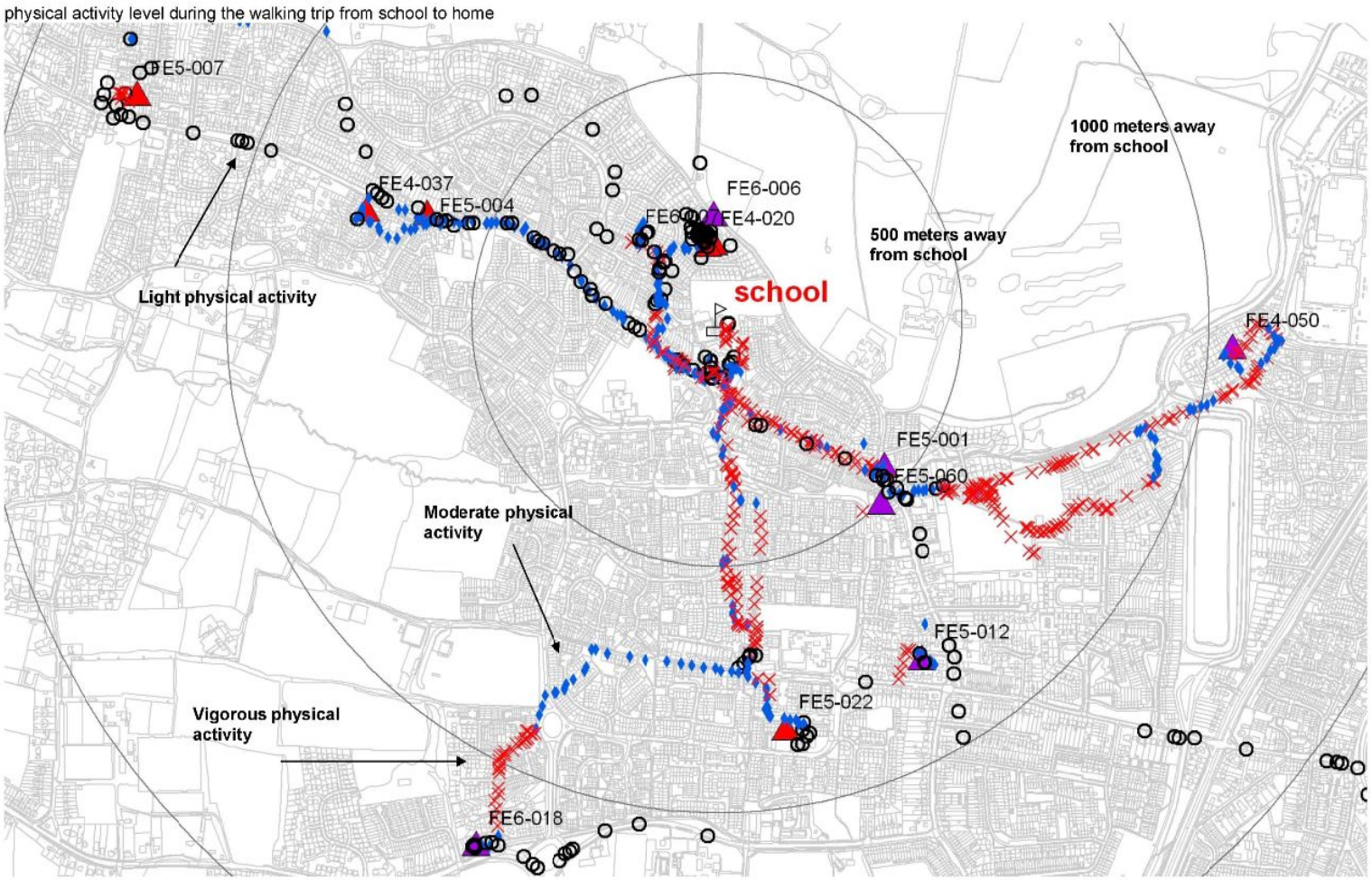

Figure 5 Physical activity levels during walking trips home from school

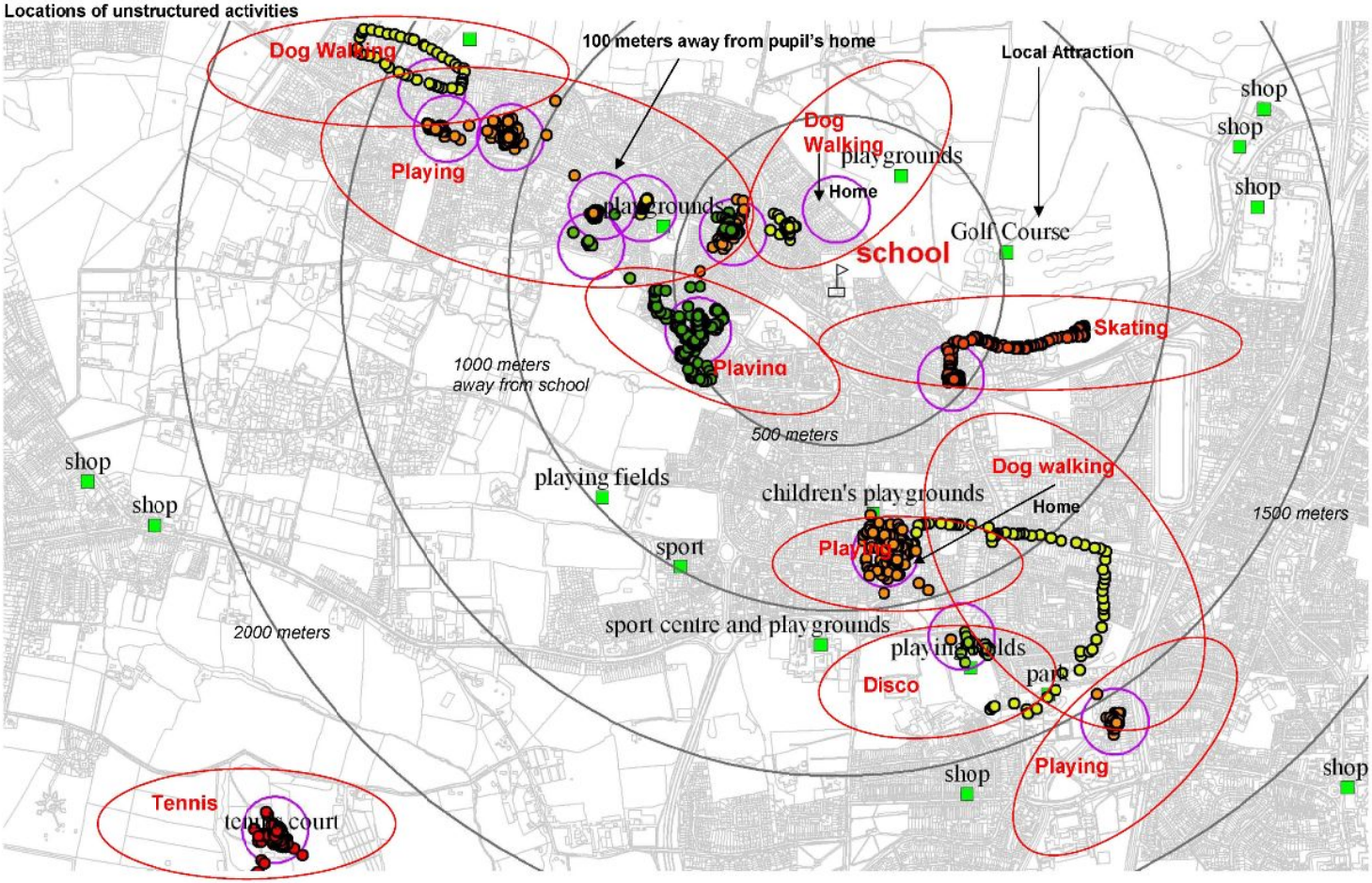

Figure 6 The location of unstructured activities