Integrating GPS technology into large scale, population level, data collections: practical utility for science, and concerns and considerations regarding its application in 10-11 year old children

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Date

What is SPACES?

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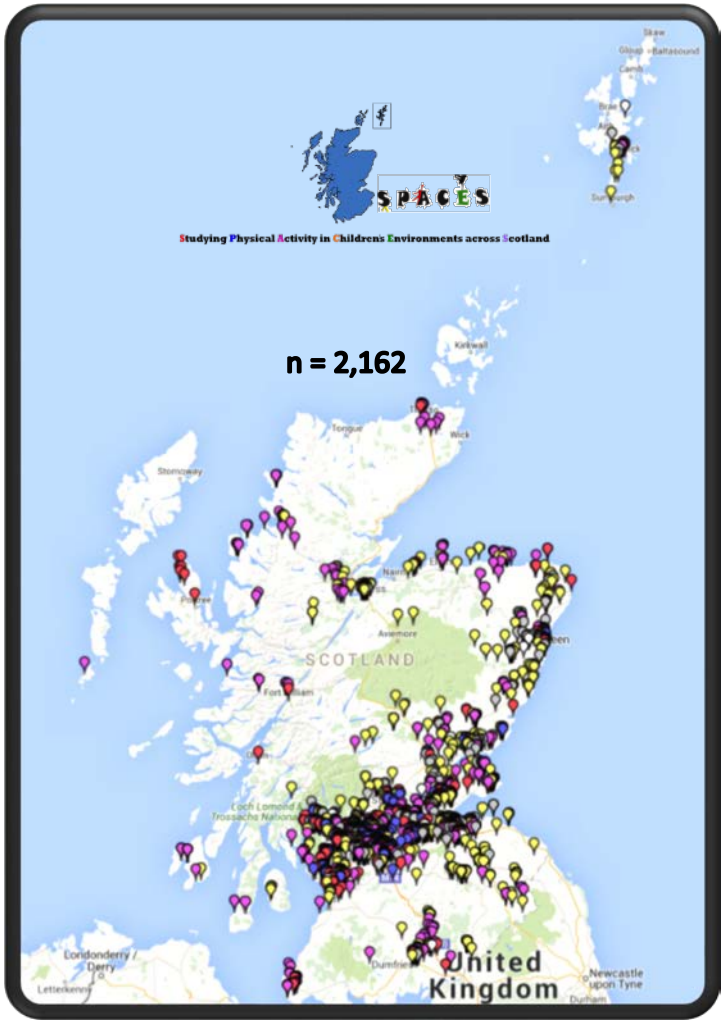
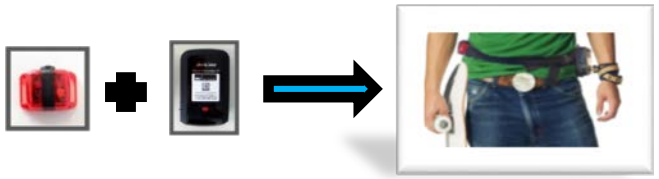


GUS original Birth Cohort 1
C. 5,000, born between 2004-2005

GUS sweep 8, n = 2,402
(2014-2015)
10/11 years old

Growing Up in Scotland



8 days
Waking hours

What is GPS?

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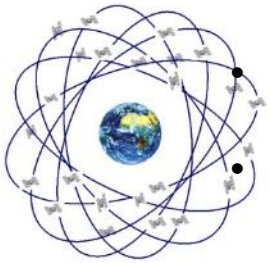
- The Global Positioning System (GPS)
  - U.S owned utility that provides users with positioning, navigation, and timing (PNT) services
  - Launched in 1973
    - **Space segment** – 24 operating satellites (network of 31) that transmit one-way signals of position and time.
    - **Control segment** – worldwide monitor and control stations that maintain satellites in orbit.
    - **User segment** – GPS receiver equipment (the user) to calculate 3D position and time.



- Originally a military based utility although has become widely used by non-military for a number of years. Advances of the technology and removal of 'selective availability' has led to increased precision.

- GLONASS (Russia), GALILEO (Europe), BDS (China), IRNSS (India)

- Mobile phones
- Watches
- Car navigation systems

What can GPS technology enable us to explore?

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What does a GPS device record?

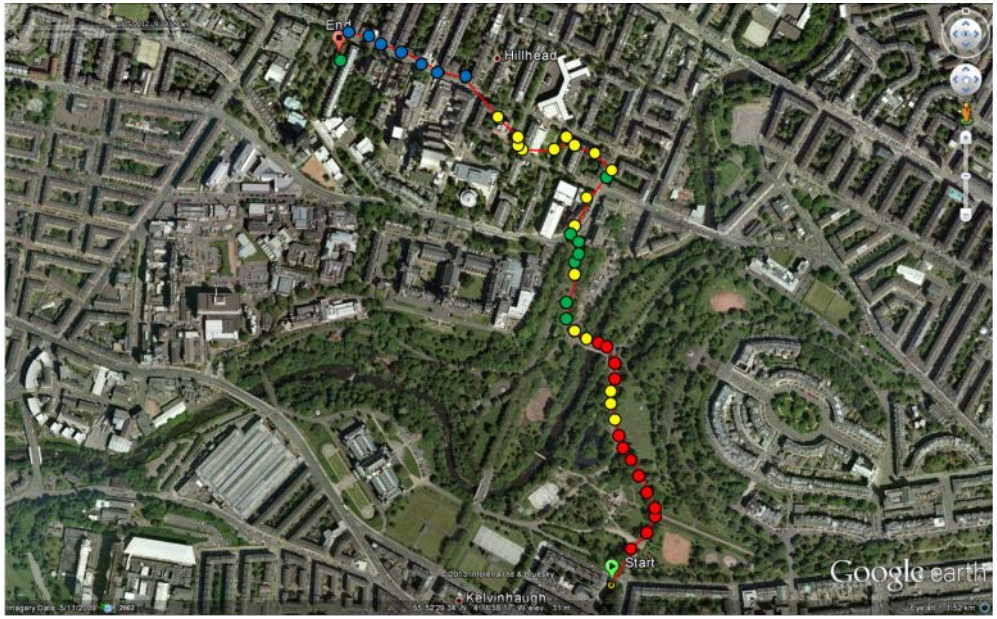
- A record of position (longitude and latitude)
- Timestamp
- Altitude

- Speed
- Precision estimates
- Number of satellites in view/used
- Ratio of signal to noise

Why is that useful?

- Actual exposure to our environment
- Interdependent relationship between person and place

- Implications
  - Health
  - Transport
  - Service industry



Example mapping of physical activity data (spatial and intensity) within Google earth: green = sedentary, yellow = light, red = moderate, blue = vigorous

Initial considerations

- Cost
  - GPS device - £60
    - Purchased 170 and borrowed 230
  - Activity monitor - £150
    - Purchased 225 and hold 175 for other projects.
  - Project cost - ~£500k
- Ethics
  - Sensitive issue for ethics committees and educational authorities
  - 'Tracking' 'Big Brother' 'real-time observation'
  - Data is translated into unidentifiable numbers to represent outcome
    - Mins spent in greenspace, mins spent walking to shop.
    - Never presented at individual level.

PILOT 1

Piloting work and issues identified

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Pilot 1

- One urban school (n=32), one rural school (n=40)
- Asked to wear both devices for 8 consecutive days

Actigraph GT3X+, Actigraph, Pensacola, FL, USA

Garmin Foretrex 301 as worn on the wrist

Piloting work and issues identified

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Compliance issues

" To begin the watch thing was pretty cool as it felt like I was Ben 10…."

"After one day it started digging into my wrist and…was really annoying"

Number of days	% of sample with valid data
1 day	95.7
2 day	78.6
3 day	62.9
4 day	30

Modification

Piloting work and issues identified

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Modification of GPS device choice and placement

- More accurate device – QSTARZ BT-Q1000XT
  - Indoor/outdoor estimate
- Easier interface
- Central location
- More comfortable
- Both should be worn at same time
- Less burdensome

PILOT 2

Piloting work and issues identified

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Piloting work and issues identified

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- Initial charging devices bought in bulk.
- When packaged and sent to survey office staff they were unable to fit through the letterbox.
- The dimensions of the charger were too big.

- Potential engagement Implications for a number of sub population groups (e.g. rural, deprived)

Sources of concern - processes

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Variability in GPS pouch size

Issue

- GPS device held in a pouch then attached to an elastic belt
- Large variability in size of the pouch

Implication(s) for Participant

- Device can easily fall out and become lost
- May have implications in more vigorous activities

Solution

- Modified pouch that incorporates a Velcro strap

Real-time and post-processing

Sources of concern – real-time and post processing

GPS memory and battery life

- Memory storage
  - User defined 'epoch' setting
  - Manual claims 400,000 points over 40 days every 5 seconds, 12 hours/day
  - In practise this is not the case (~50,000 over 8 days)
  - Protocol was set to record every 15 seconds, 24 hours/day but found memory full after 6.5 days
    - Immediate protocol change to 'waking hours'

- Battery life
  - Manual claims up to 42 hours
  - In practise this is not the case (~30 hours)
  - Impact on participant engagement
    - Charged overnight

Sources of concern – real-time and post processing

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GPS data post processing

- Built up areas and issues with signal quality
  - Cleaning of 'bad' data
- Indoor/outdoor disaggregation
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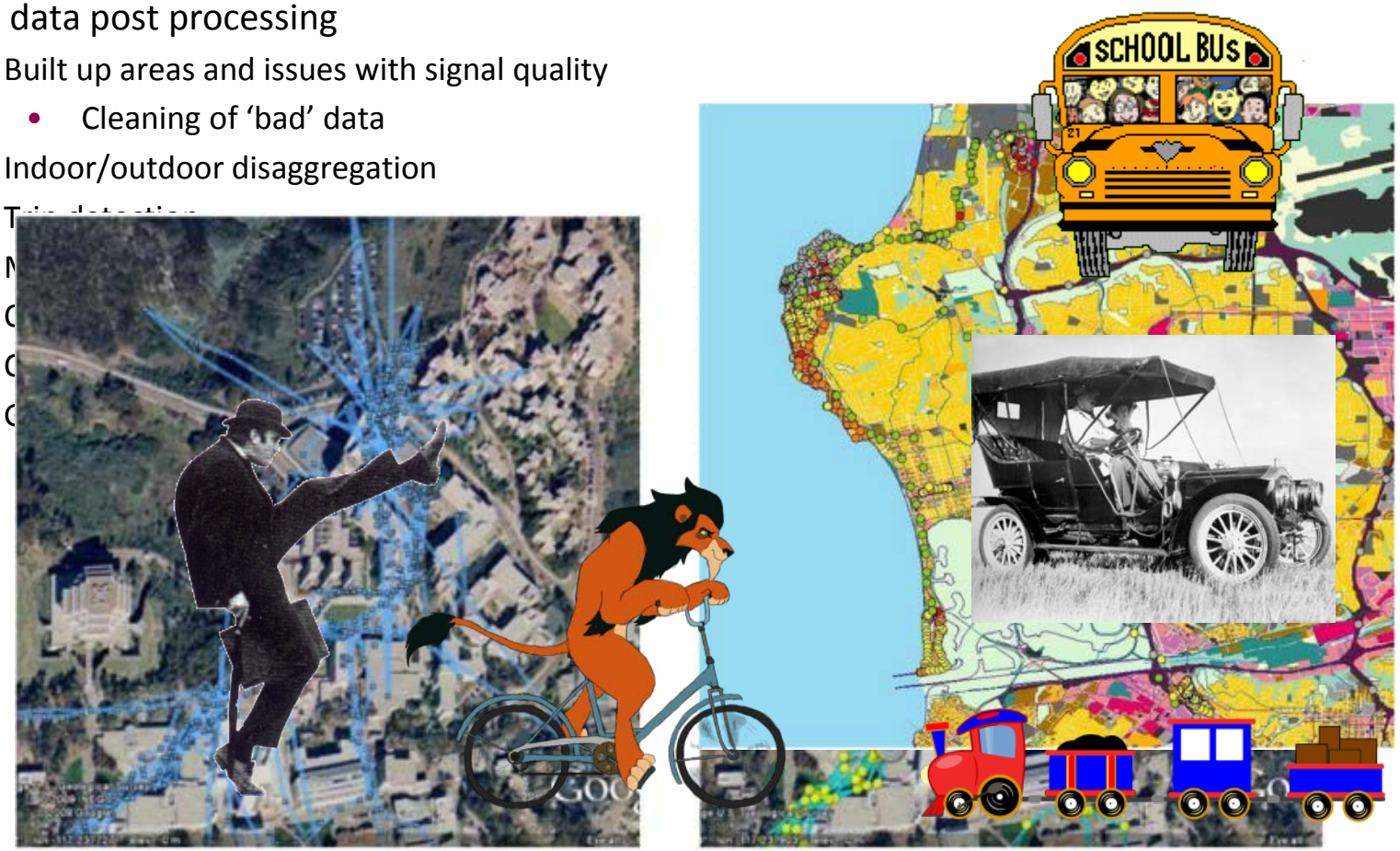

Figures courtesy of University of San Diego PALMS system

Participant response

Main study participants

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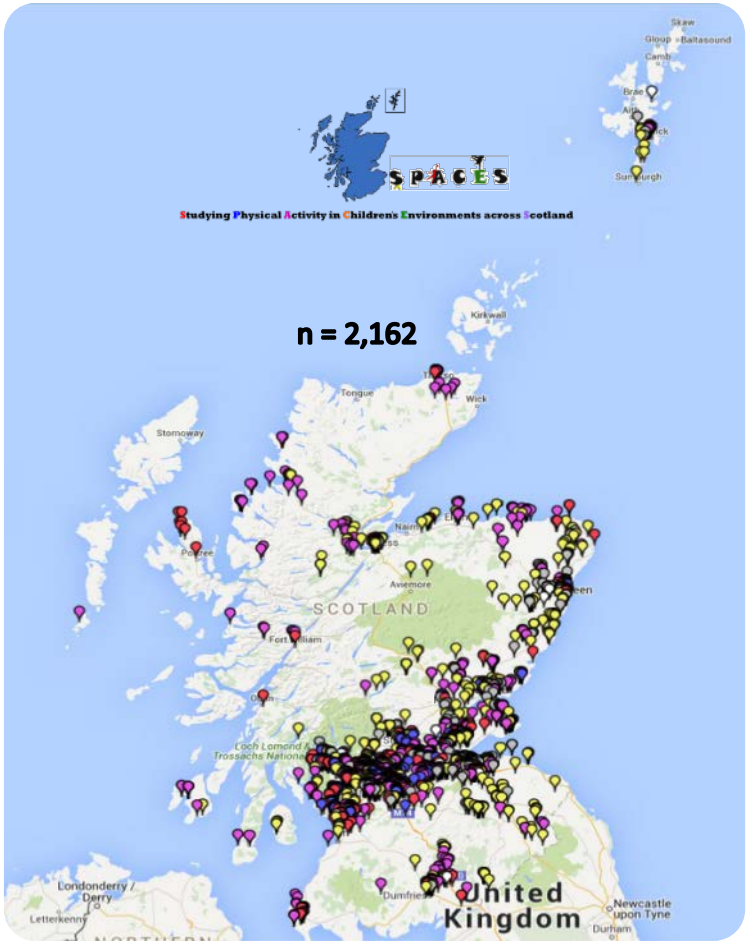

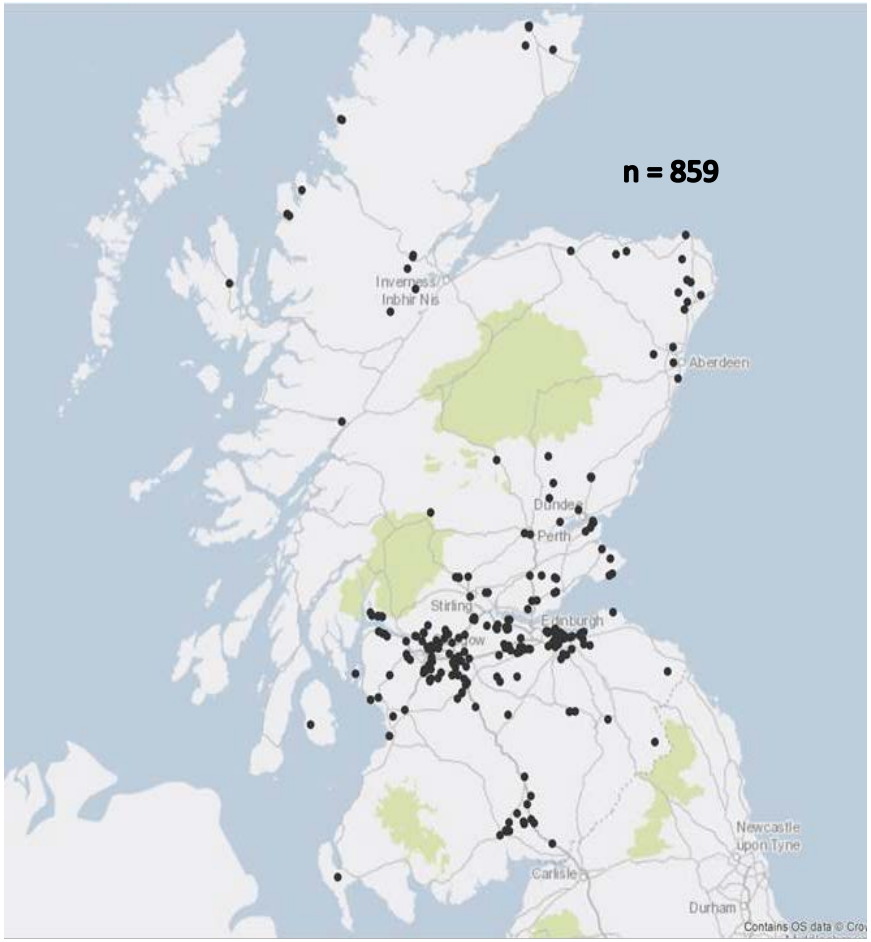

Sample

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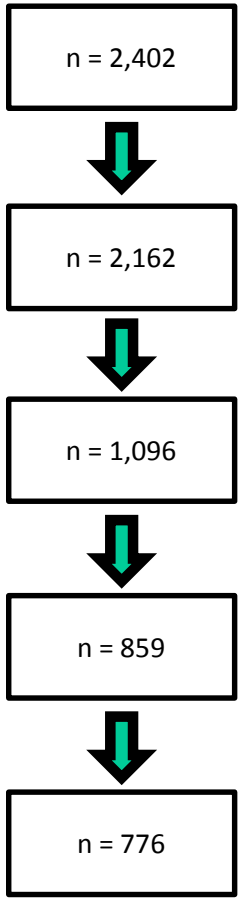
- 1,096 children agreed to take part
  - 51% of children contacted
- 859 children returned data
  - 78% of those agreed to take part
- 776 children provided sufficient data
  - 36% of those contacted
  - 71% of those who agreed to take part
  - 417 (54%) girls and 357 (46%) boys
- 39% overall response rate



Sample non-response

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Socio-economic characteristic	SPACES sample	SPACES weighted sample	Sampling frame (original cohort or GUS sweep 8)
Income (per annum)			
<£3,999 - £9,999	1%	3%	3%
£10,000 - £19,999	9%	20%	16%
£20,000 - £28,999	15%	18%	14%
£29,000 - £37,999	15%	14%	15%
£38,000 - £49,999	17%	14%	16%
>£50,000	42%	27%	35%
SIMD quintile (2012)			
Most Deprived	8%	21%	25%
2nd	13%	18%	18%
Middling	22%	19%	19%
4th	27%	21%	20%
Least Deprived	30%	21%	18%
Highest educational qualification in household			
No qualification	1%	3%	5%
Lower level Standard Grades or equivalent	2%	3%	4%
Upper level Standard Grades or equivalent	13%	19%	20%
Higher Grades or equivalent	34%	39%	33%
Degree level academic or equivalent	49%	35%	38%
Other	1%	1%	1%

Sample non-response

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Demographic	SPACES sample	SPACES weighted sample	Sampling frame (GUS sweep 8)
Urban/Rural dwelling			
Large urban	31%	36%	38%
Other Urban	29%	33%	32%
Small accessible towns	10%	9%	10%
Small remote towns	3%	3%	3%
Accessible rural	17%	12%	13%
Remote rural	10%	7%	4%
BMI UK categories			
Underweight	2%	2%	2%
Healthy weight	69%	64%	65%
Overweight	16%	18%	16%
Obese	13%	16%	17%

Device loss

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Demographic	Device loss (n=1096)
SIMD quintile (2012)	
Most Deprived	13%
2nd	7%
Middling	8%
4th	4%
Least Deprived	5%
Urban/Rural dwelling	
Large urban	5%
Other Urban	7%
Small accessible towns	10%
Small remote towns	3%
Accessible rural	7%
Remote rural	2%

Data quality

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Demographic	5 days	6 days	7 days	8 days	9 days	10+ days
SIMD quintile (2012)						
Most Deprived	2%	8%	19%	60%	13%	0%
2nd	3%	12%	16%	60%	8%	0%
Middling	3%	7%	17%	65%	8%	1%
4th	1%	10%	22%	59%	5%	3%
Least Deprived	2%	7%	15%	65%	9%	2%
Urban/Rural dwelling						
Large urban	2%	8%	15%	64%	10%	2%
Other Urban	3%	8%	23%	57%	8%	0%
Small accessible towns	3%	18%	13%	56%	8%	4%
Small remote towns	0%	8%	19%	73%	0%	0%
Accessible rural	1%	8%	15%	69%	6%	2%
Remote rural	1%	5%	19%	63%	8%	4%

What can GPS technology enable us to explore?

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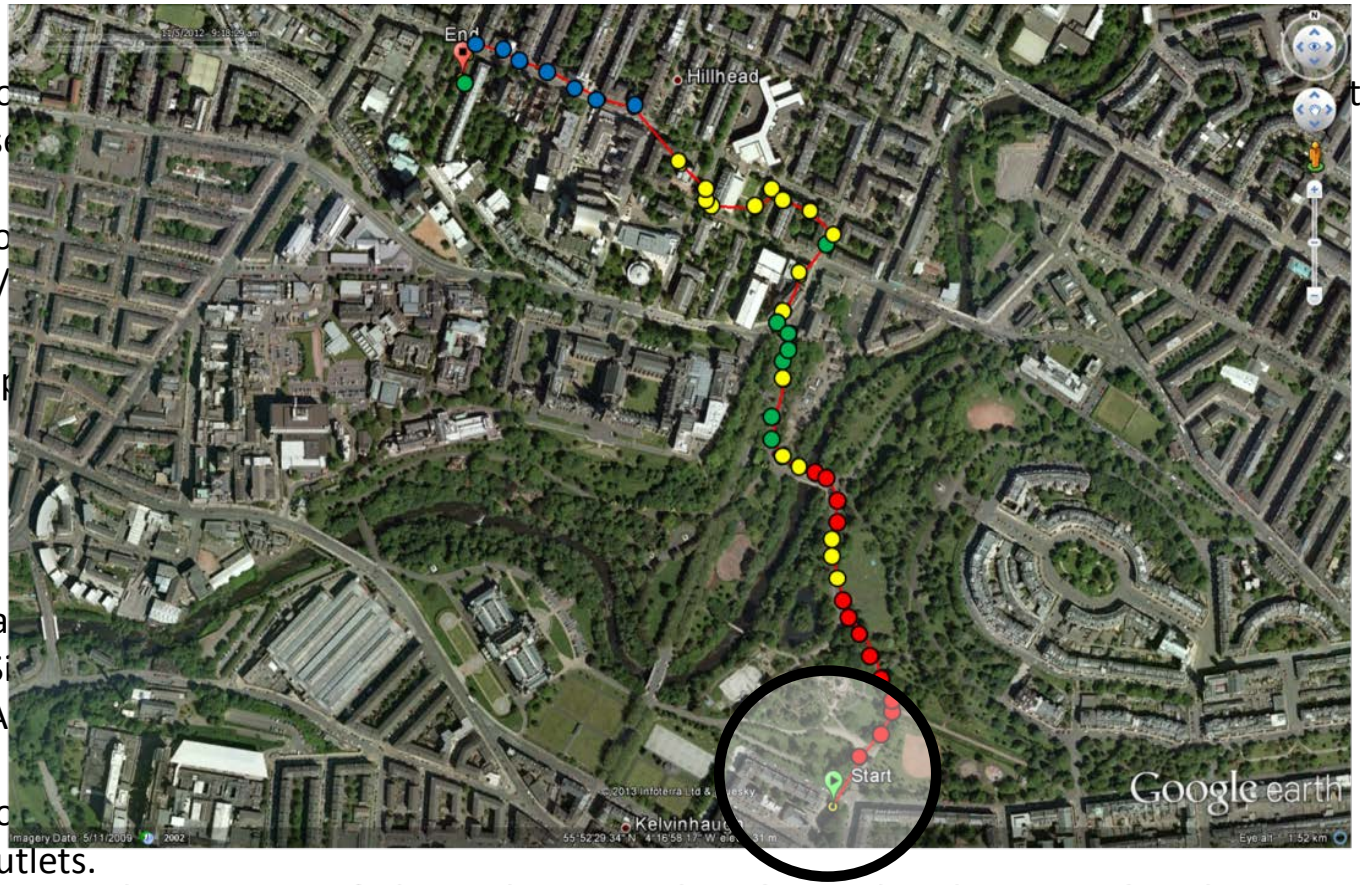

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Acknowledgments

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- Professor Anne Ellaway and the SPACES team

What can GPS technology enable us to explore?

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Transport

- What percentage of transport is active and passive?
- What distance do people travel by bike, or on foot?
- Does traffic volume determine transportation mode to school?
- Does cycling/walking to school/work expose us to harmful levels of air pollution?
- Does built environmental change influence active travel?

Neighbourhood

- How far do children roam from their home location?
- How long do children spend indoors and outdoors?
- What factors influence/determine being outdoors?
- How big are children's neighbourhoods and what drives their size and shape?
- How does neighbourhood change influence X?

Exposure

- Is greenspace accessible? If so, is it used? If so, what kind of activity occurs in greenspace?
- Are children/adults exposed to 'environmental bads' and does this have an negative effect on health? Is this relationship socially patterned or moderated by urbanicity?
- What are the longitudinal effects of systematic change in exposure on health/behaviours?

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