The 'when, how and what' of Text Based Wayfinding Instructions for Urban Pedestrians

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Abstract
Increasingly wayfinding in urban environments is supported by smartphone technology using maps and images. But our ambition is technology that is concealed, delivering only spoken instructions, thus leaving the pedestrian 'eyes free' and 'hands free' to enjoy the city. As a precursor to their spoken delivery, we report on the evaluation of a text based system. Subjects were directed by a series of landmark based instructions or street based instructions that were geo-located. Feedback was gained in three ways: trajectory analysis, questionnaire and focus group. Not only did the research compare landmark based delivery against street name based instructions, it also examined user preferences, the relationship between route complexity and announcement frequency, the need for data redundancy in route description, and the most effective form of landmark description.

Keywords: built environment, pedestrian wayfinding, landmark saliency, LBS

1.0 A Context – urban pedestrian wayfinding

The smartphone has become a conduit by which we access many different services (Raper et al. 2007), instantly, at any time, anywhere ('Where am I?', 'Where is my nearest?', 'What's on where?', 'How do I get to?'). There is a growing sophistication in the various modes of interaction with these services, the predominant use is one of 'hand and eye' screen interactions – that demand our full attention. But what of Weiser and Brown's (1998) vision of calm, concealed technology that leaves the user 'hands free' and 'eyes free' to enjoy the environment as they travel through it? This is the vision of the SpaceBook project – a dialogue based system that supports urban exploration, learning and wayfinding (Mackaness et al. 2013) – building on the ideas of Bartie and Mackaness (2006). In this vision where we intentionally conceal the technology, such that the user is not able to use photos and maps to corroborate. A map is data rich (hence requiring a lot of cognitive effort), whilst a dialogue based system needs to be efficient, and minimalist (we don't want to bore the pedestrian to death), yet sufficiently robust that the user does not get lost. What constitutes a minimum set of unambiguous instructions will be governed by:

1. The preferences and previous experiences/area familiarity of the subject;
2. the morphology of the route being followed (topographic (up, down, twisty);
3. topological complexity of the route (multi path junctions, offset roads);
4. whether it is multi modal (stairs, concourses, streets);
5. richness (or absence) of readily identifiable prominent landmarks.

Potentially following landmarks can be much easier than using a map (e.g. 'head towards the Castle on the hill') thus leaving the pedestrian to indulge in all the other tasks associated with city walking. In the following set of experiments, it was our ambition to examine the veracity of this idea, to compare landmark based instructions against street based instructions, and to apply quantitative and qualitative techniques to help understand the motivations and preferences of users.

2.0 A City Model to support Landmark modelling and instruction construction

As part of that project we have built a rich city model, from which we derive a saliency value for each landmark (whether it is a building, a statue, a green space a bus stop, station etc!). The city model includes a 2.5D LiDAR derived model from which we can calculate visibility. We have attached significance to landmarks according to various criteria (Table 1).

Metric	**Method of calculation**
visible façade area	Product of street frontage calculated from OS MasterMap and height from LiDAR data
viewing distance	Dynamic distance of pedestrian from landmark (using smartphone GNSS)
visual unusualness	Count of unique user Flickr images
function(s)	Count of FourSquare venue check-ins
proximity to a decision point	Distance between landmark and 'junction' in multi modal path graph
prototypical form	Ranked preference according to: church, monument, tower, hotel
Name recognition	Recognisable wrt web search (eg 'McDonalds', 'Subway')

Table 1: Saliency metrics and the means by which they were calculated

Adjectives	left, right, sharp, straight
Prepositions	towards
Verbs	turn, walk, carry on
Adverbs	after, before, downhill, uphill, immediately
Nouns	metres, minutes, steps, bend, distance
Proper nouns	streets and landmarks

Table 2: Adjectives, prepositions, verbs, adverbs, nouns and proper nouns

The richness of attribute description, and topological modelling between entities enabled us to enrich the description of landmarks (Table 2). By utilising these metrics and combining these adjectives, we can generate a set of phrases that describe any given action (Table 3). Since the device is GNSS enabled, when asked, the city model can calculate a route from the current location to the requested place, identify the most suitable landmarks, and in this manner guide the tourist to their destination – providing the next instruction at the appropriate point along the route, (rather than requiring the subject to memorise the whole route description at the start of the route).

Street name instructions	Information	Landmark based instructions
Go <x> metres	**Distance of activity**	Walk about <x> metres
About <x> minutes	**Duration of activity**	
Head <cardinal> (cardinal=west, north, etc) Toward <y> (y=streetname) Slightly right/left	**Orientation**	Walk towards <feature>
Turn < direction > (left, right)	**Network guidance terms (path descriptors)**	Turn <direction> (left, right) Immediately turn <direction>
On <streetname>	**Locational information**	Stand with < feature> on your <relativelocation> (relativelocation is left, right)
	Topological descriptions	Opposite < feature >, next to < feature >
	Topographic descriptions	Walk <up hill, downhill, up steep hill>
Stairs, roundabout, street	**Object classifications**	Squares, public gardens, buildings, streets, stairs
Road <street name>	**Object descriptors**	Road <straight, bendy, sharp bend> Building <stone, turrets, towers, domes> Junctions <cross roads, T junction, forks>
	Object visibility	< feature> is visible on your <relativelocation> (relativelocation is left, right)
	Confirmatory cues	You should see < feature >
Continue onto <streetname>	**Decision point features**	At junction <type> turn <direction> before <feature>

Table 3: Sentence construction of street and landmark based instructions

3.0 The Experiment – Text based Mobile App and Subject Analysis

Four routes were identified, in the city of Edinburgh, each taking about 20 minutes to walk, varying in complexity (junction, roads, stairs, plazas), landmark types and vista (Figure 1). The experiments were conducted via an Android App that delivered simple text strings whilst gathering locational data. The instructions (Table 4) were georeferenced such that as the smartphone fell within 30m of the reference point, the phone vibrated, and the text was presented.

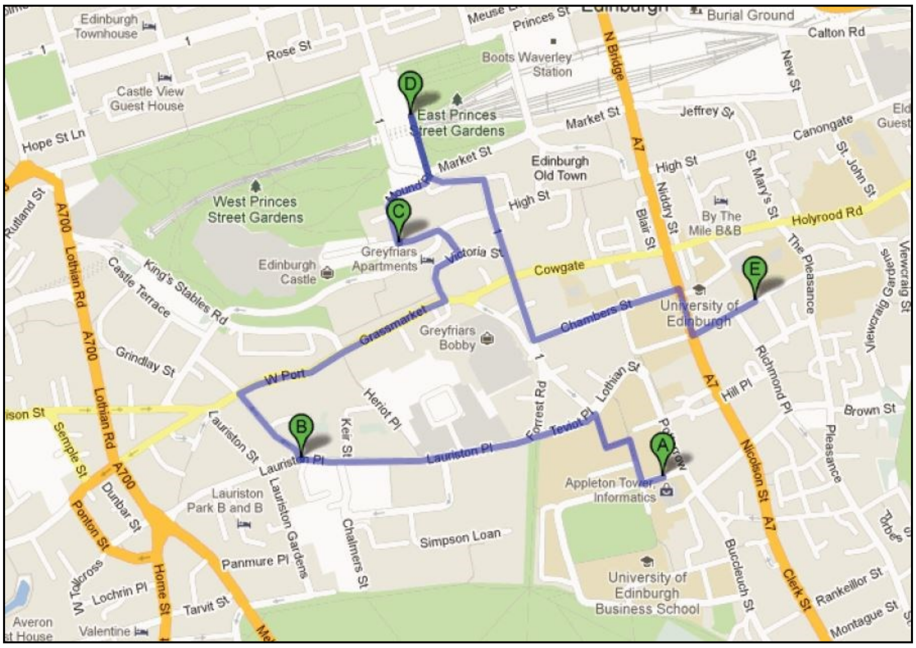


Figure 1: 'end to end' for logistical simplicity – four routes.

Street based instructions	Landmark based instructions
1. Head west on Crichton St toward Charles St - go 45 metres 2. Turn right onto Charles St About 1 min - go 94 metres 3. Turn left toward Teviot Pl About 2 mins - go 120 metres 4. Turn left onto Teviot Pl About 2 mins - go 110 metres 5. Continue onto 1/Lauriston Pl Continue to follow Lauriston Pl 6. Destination will be on the right About 6 mins - go 500 metres * Your destination is: Edinburgh College Of Art	1. Stand with Informatics Forum on your right and Appleton Tower on your left. 2. Walk about 50 metres towards George Square. 3. Turn right before George Square at the cross roads. 4. Walk about 100 metres (with Informatics forum on your right). 5. Turn left to cross Bristo Square walking slightly uphill towards McEwan Hall (large building with a dome). 6. Turn left on to Teviot Place, McEwan Hall on your left. 7. Walk along Teviot Place continuing straight for about 100 metres. You should pass Royal Bank of Scotland on your right. 8. Carry on straight at the junction on to Lauriston Place. Walk for about 500 metres. You should pass George Heriot's School on your right. 9. After the slight bend in the road, you will go downhill. 10. Turn off right on to Lady Lawson Street, and walk for 40 metres. Your destination will be on your right, opposite the Novotel. * Your destination is: Edinburgh College Of Art

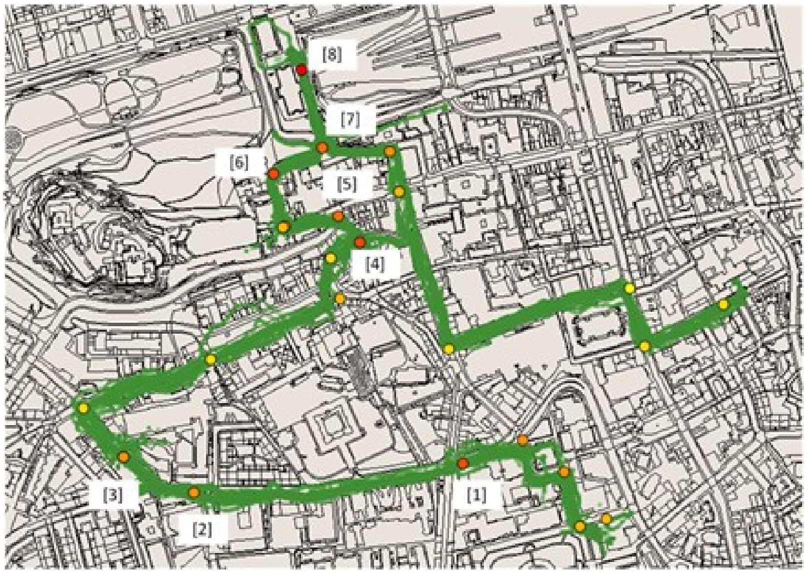
Table 4: route descriptions from street based and landmark based descriptions for the same route.

The subjects were recruited by advertising the experiment across several Facebook community groups in Edinburgh. Each of the 30 subjects (15 male 15 female) was paid £15 to participate in the experiment; half of the subjects used Smartphones on a regular basis and were aged between 17 and 65. Each subject did two of the legs using landmark instructions and two using street based instructions (Table 4). The order and sequence in which subjects used these different instruction sets was managed by the Application and the subjects were not aware of which system they were using during each leg; neither where they told of the final destination to avoid ‘cheating’.

4.0 Observations

4.1 Analysis of trajectories

Figure 2 shows the paths taken by subjects in response to the instructions (revealing a few who took the wrong route). The location of each coloured dot is the point at which the text was displayed on the mobile device, and its colour is the average level of satisfaction (from 5 – very effective instruction, to 2 – hard to interpret instruction). Three observations are made: 1) there are more instructions in the landmark based experiment since it was possible to take advantage of many more landmarks than there are streets, 2) that subjects were far happier with landmark based instructions than street names, 3) there is some correlation between poorer ratings being given to both forms of instructions and the complexity of the route at that point.



(a)

(b)

Figure 2: Comparing effectiveness ratings between a) street based, and b) landmark based instructions.

Analysis of the trajectories recorded on the device identified ‘dwell points’ along the route, and places where subjects became lost. Figure 6 consistently shows shorter dwell time, fewer occasions when subjects became lost. Kernel density analysis identified points along the route that consistently raised problems for the subjects – indicating the need for additional landmarks.

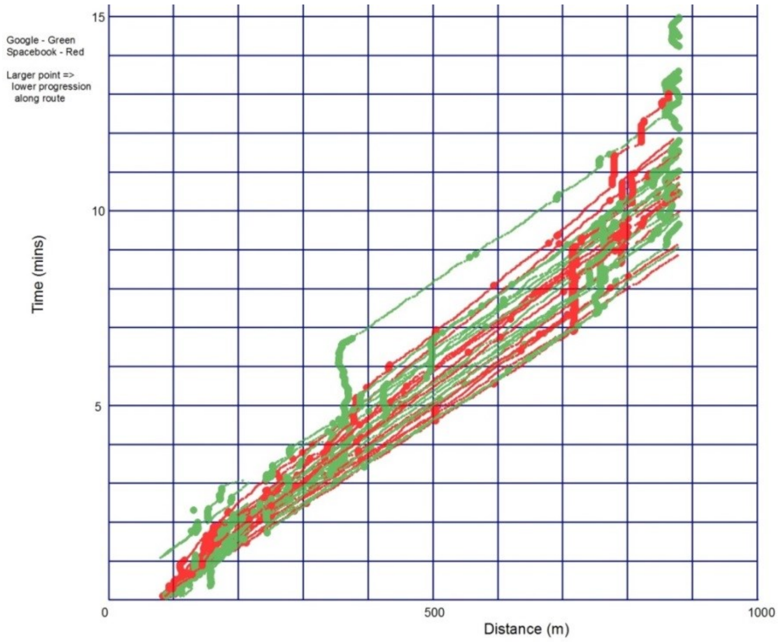


Figure 3: Comparing progress along the route

4.2 Questionnaire Responses

At the end of each leg, subjects were asked to complete a questionnaire covering eight topics. The ambition of the questionnaire was to 1) compare landmark based instructions against street name instructions, and 2) assess the ease with which these different forms were recognised, 3) determine if the instructions were sufficient. A final section allowed subjects to comment generally about their experience, and to comment on the contexts in which they might utilise this sort of technology. Subjects were asked to comment on their familiarity with the area and whether any of the instructions depended on a local knowledge of that part of the city.

Whilst the general focus of this research was on comparing different types of instruction (landmarks as against street names), a general question on the acceptance of technology revealed a clear preference for non-digital forms of media (in particular paper maps). This was particularly the case for those following the street based instructions where all of the subjects expressed a desire to use some other form of media. This may have reflected something of a frustration with street name based instructions, but there is no disguising the relative infallibility of the map:

> *"I am really not interested in electronic/GPS navigation – I would always just have a (paper) map. I much prefer to be more in control of where I am going and see where I am in relation with the rest of the city."*
>
> *"It's fun to work out where you are on a map when you are exploring."*
>
> *"[…] But aside from that I probably prefer maps because there is no technology to go wrong or make me dependent on IT people – i.e. I can fix a broken map with sticky tape myself but I can't fix a phone or any software myself so this reduces my feelings of independence."*

Landmarks easier to interpret than Street Names

Subjects were asked how readily they could interpret the information provided. The majority of subjects commented that landmarks were often easy to distinguish, whilst there were many negative comments that revealed the challenges of using a street name based approach (the absence of street signs or their 'hidden' nature):

> *"The lack of signage in Edinburgh meant that using only street names for directions wasn't particularly helpful."*
>
> *"Reference to street names only very unhelpful, particularly in Edinburgh where there isn't a clear layout. Needs to be more descriptive."*

“It didn’t point out any landmarks or places of interest. Not done in a very engaging way.”

This is contrast to a landmark based approach – the advantage being that it was known that the feature was visible to the subject:

> *“Really good and easy to follow instructions. Especially useful with easy to recognise places e.g. Doctors Pub or Novotel which let you know that you are definitely going in the right direction.”*
>
> *“Easy to use, very accurate and nice to have references (landmarks).”*

Trust, brevity and redundancy in instruction

Subjects desired more instructions when using the street based system:

> *“Instructions could have been more frequent to reassure me I had taken the right route.”*
>
> *“There was quite a long gap between instructions.”*
>
> *“They could have been clearer. Some description of the roads, including landmarks would have made things clearer. I found it difficult to know where I was going.”*

The majority of subjects expressed a clear preference for confirmatory cues:

> *The [landmark based] systems were more reassuring because they told you which buildings you should have walked past if you were going the right way but this one didn’t therefore you could have been walking for 5 minutes and not known.”*
>
> *“Each navigation instruction led perfectly onto the next one so no more was needed in between.”*

For some subjects there was a hunger for more information – either in identifying the landmark, or simply learning more about the landmark.

> *“It tells you some names of emblematic places but it doesn’t tell you anything about them.”*
>
> *“I did not instantly know the Black Watch statue. Possibly a short description about where it is/what it is would be nice.”*

4.3 Focus Group

As a final part to the research, we transcribed results of a focus group meeting held a month after the street experiments were concluded. The meeting of five participants aged between 17 and 65 explored issues of preference in instruction and system improvements. The group was also asked how they remembered and conveyed routes. Four findings were identified: users expressed a preference for mixed media (map, images of landmarks, and text) because they offered a palimpsest of safety nets in terms of knowing where you were, and where you were trying to get to. Secondly the group expressed preference for shape and texture descriptors instead of names (e.g. the tall black statue rather than ‘The statue of the black Watch’). When participants were asked to visualise and describe routes known to them, they relied on objects in the scene rather than names of streets. Participants commented on the large visibility range of landmarks and the limited reading distance of a street sign. In this sense landmark based route following has much greater flexibility and potential than street name based instructions – particularly in complex regions of the city.

5.0 Conclusion: Design Heuristics and Database requirements

That pedestrians prefer landmarks to other visual cues is well understood. However this study has quantified the strength of this preference when compared with street based instructions. The study has also shown that in the absence of maps, gesture, and haptic feedback, it is necessary to provide a degree of superfluous instructions – to help reinforce the instruction, and to provide confirmation along the route. By examining ‘dwell time’, the research has also shown that the frequency or density of instructions needs to take into account the varying complexity of the route.

Can we identify a set of variables that we need to model in order to deliver text/ spoken instructions? Some heuristics useful for someone designing these systems:

i. We need to model the complexity of the city – so we can densify instructions in complex parts of the city.
ii. We need a visibility model so we can determine what can be seen from where.
iii. We need a saliency model so we can use the most striking landmarks in our descriptions, and identify 'landmark deserts' that we should steer our subject around.
iv. We need to include confirmatory instructions to build trust and assure user

The urban pedestrian, at any one time, is typically pursuing a basket of inter related tasks; the creation and form of delivery of wayfinding instructions needs to reflect this competing context. The sole use of text based instructions as a way of guiding pedestrians sought to echo Weiser and Brown's ambition of calm, concealed technologies. Being text based, the user was required to view the screen; clearly the instruction could have been spoken; indeed this work is in anticipation of its incorporation within a dialogue based interaction (such as the one being developed within the SpaceBook project). Dialogue interaction could be used to resolve ambiguity and allow the user to request more detail should an instruction prove to be insufficient (though such an activity incurs a 'cognitive cost'). Given the complicating nature of dialogue based interaction, the experiment was deliberately simplified. The next phase of work will be to incorporate these heuristics within a dialogue based context – their correctness should ensure a minimum of interaction and a simplicity of interpretation that leaves the pedestrian to get on with the many other things they try and do as they race across the city!

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