Evaluating a concept design of a crowd-sourced ‘mashup’ providing ease-of-access information for people with limited mobility

This item was submitted to Loughborough University's Institutional Repository by the/an author.

Citation: MAY, A. ... et al., 2014. Evaluating a concept design of a crowd-sourced ‘mashup’ providing ease-of-access information for people with limited mobility. Transportation Research Part C: Emerging Technologies, 49, pp.103-113.

Additional Information:

- This is an Open Access Article (CC-BY 3.0). It is published by Elsevier as Open Access at: http://dx.doi.org/10.1016/j.trc.2014.10.007

Metadata Record: https://dspace.lboro.ac.uk/2134/16703

Version: Published

Publisher: © The Authors. Published by Elsevier Ltd.

Rights: This work is made available according to the conditions of the Creative Commons Attribution 3.0 Unported (CC BY 3.0) licence. Full details of this licence are available at: http://creativecommons.org/licenses/by/3.0/

Please cite the published version.
Evaluating a concept design of a crowd-sourced ‘mashup’ providing ease-of-access information for people with limited mobility

Andrew May a,⇑, Christopher J. Parker a,1, Neil Taylor b, Tracy Ross a

a Design School, Loughborough University, Loughborough LE11 3TU, UK
b Integrated Transport Planning Ltd, 32a Stoney Street, Nottingham NG1 1LL, UK

ABSTRACT

This study investigates the impact of using a concept map-based ‘mashup’ (www.accessadvisor.net) to provide volunteered (i.e. user contributed) ease of access information to travellers with limited mobility. A scenario-based user trial, centred around journey planning, was undertaken with 20 participants, divided equally between (1) those who have physical restrictions on their mobility, due to disability, illness or injury, and (2) those with practical mobility constraints due to being parents with young children who have to use a child’s pushchair when using public transport. Both user groups found the concept useful, but its potential impact was less for the pushchair user group. There were mixed views in relation to the ability of the mashup to convey the trustworthiness, credibility and reliability of information necessary for journey planning. The study identified a number of key information-related user requirements which help enable effective design of user contributed web-based resources for travellers with mobility-related issues.

© 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/3.0/).

1. Introduction

1.1. Lack of support for travellers with limited mobility

Physical mobility plays a key role in social inclusion (Lucas, 2012). This applies to individuals with a physical disability, as well as those with other constraints on using the transport network. There still exists a problem of providing effective, easy to use travel information for public transport users with limited mobility. Nearly 20% of the UK population experience a disability, defined as ‘long standing illness, disability or impairment which causes substantial difficulties with day-to-day activities’ (Dept. Work and Pensions, 2013). Over half of this group experience some form of mobility impairment, which represents approximately 6.7 million of the UK population who have find using the public transport network difficult to some degree. Information is critical for supporting independent travel for this group. Waara (2009) has highlighted the need for information supporting journey planning, and how ‘targeted traveller information for older and disabled travellers should enable assessment [by the passenger] of the usability of the public transport environment’. In relation to a user group with...
specific mobility limitations, Ray and Ryder (2003) describe how active and considered evaluation of the travel risks is undertaken by even the most outgoing and risk-taking of the wheelchair user community, before they start a journey.

Despite equality legislation (Equality Act, 2010) there is still believed to be a lack of reliable and up to date information on accessible transport networks (Commons Select Committee, 2013). Those with mobility impairments have reported that they find it difficult to obtain information that enables them to undertake independent travel. When studying the barriers to travel by older/disabled passengers, Waara (2009) found that 24% of their sample stated poor accessibility, and 21% stated difficulties in obtaining the information needed to plan a journey. Research commissioned by the UK Dept. for Transport (2004) showed that disabled peoples’ experience of public transport is that it is often inaccessible and of poor quality, and that difficulties in obtaining information about the accessibility of services tend to add to their problems when travelling and make them less inclined to use public transport.

The majority of previous research on accessibility of transport (e.g. Waara, 2009; Ray and Ryder, 2003; Dept. for Transport, 2004; Lucas, 2012) has focused on older passengers, travellers with permanent or temporary disability, or other forms of social exclusion. However, a recent large-scale EU funded project (ISEMOA, 2013) has highlighted that ‘people with limited mobility’ includes a broad range of potential travellers, amongst others, those with physical and practical barriers to using public transport successfully, such as those pushing pushchairs. For this reason, this study included both travellers with physical disability, and adults with young children who needed to travel with pushchairs (termed ‘pushchair user’ in this study), and compared and contrasted these two user groups.

1.2. The phenomena of user contributed data

A relatively recent phenomenon has been the emergence of volunteered geographic information (Goodchild, 2007) and neogeography – described by Das and Kraak (2011, p.1) as ‘the domain where users make use of geographic information using web 2.0 applications’. These have resulted in the emergence of information products where volunteered data (including geographic topology and location-referenced information) is combined with professionally produced geographic data to form a ‘mashup’. Mashups are defined by Flanagin and Metzger (2008) as ‘web applications that combine data from multiple sources to form a new integrated resource’. An example is provided by Knight and Bichard (2012) where the locations of public toilets are identified by members of the public, and are located onto a base layer map to provide an online map of facilities. Cardonha et al. (2013) describe development of a crowdsourcing platform to enable creation of accessibility maps. Hara et al. (2013) demonstrate that even untrained volunteers can identify the presence of accessibility problems with relatively high degrees of accuracy.

One advantage of user-contributed data is that it can be very current. Goodchild (2008) stated that ‘perhaps the most significant area of geospatial data qualities for VGI [volunteered geographic information] is currency, or the degree to which the database is up-to-date’ and Parker et al. (2014) found that judgements of currency were influenced positively by including VGI within mashups. Mashups incorporating VGI can easily reflect changes in the environment, for example temporary closure of facilities or the accessibility of facilities during construction works. They can also provide a personal perspective on the potential facilitators and barriers for those with mobility limitations using the transport network.

Since information can be provided by any member of the public, map mashups can capitalize on the capabilities of ‘citizens as sensors’ as described by Goodchild (2007). In particular, information can be provided by those with mobility limitations, for those with mobility limitations. However there are also several potential limitations to volunteered information (Parker et al., 2012; Zielstra and Zipf, 2010). For example, coverage may be patchy, and information incomplete with a lack of quality control. Web-based Wiki style sites are often cited as needing large user-bases in order to generate any sizeable quantity of content due to the ’1% rule of thumb’, or ‘90-9-1 principle’, which suggest that only around 1% of users of a website contribute the vast majority of new content, with a further 9% contributing sparingly (e.g. editing or rating content). The majority of individuals will use but not contribute content. In one of the few published empirical studies of this phenomenon, this general observation was supported within the digital health social network context (Mierlo, 2014).

For map mashups incorporating user-contributed data to be successful, they need to meet the needs of target users. It is currently unclear how some user groups (who may have some specific needs and varying internet experience) react to these forms of data aggregation, and how volunteered, geographic-referenced information might be best presented to end users.

1.3. Aims

Based on the ongoing information needs of travellers with limited mobility, and the emergence of map mashups, there are opportunities for web-based resources that provide user generated information on transport accessibility. The aims of this research were to better understand (1) users’ attitudes towards these integrated information products and (2) how they may be designed. The specific objectives of the study were to:

- Assess reaction to a crowd-sourced travel information mashup using theoretically robust constructs.
- Compare the responses of two distinct user groups with mobility limitations.
- Identify key user requirements for presenting this kind of data to end-users.
2. Theoretical framework

There are several theoretical perspectives that are useful for analysing the impact of information products. These emanate from differing disciplines, although they, to some extent, overlap in definition and intended application. A typical usability perspective (ISO, 2008) focuses on user goals within a context of use, and the interface being used to interact with the user. Closely related to usability, a user experience (UX) approach describes the ‘perceptions and responses that result from the use and/or anticipated user of a product, system or service’ (ISO, 2010) – although there has been discussion for several years over the definition and measurement of UX, and its relationship with other more goal-based frameworks such as usability (Law and van Schaik, 2010). In contrast, an information perspective (e.g. Barry and Schamber, 1998; Saracevic, 2007; Rieh, 2002) focuses on the attributes of the information being conveyed to the end user. Perspectives based on outcomes focus on the changes in behaviour that result from presenting alternative information sets to the end user. An example related to the added value of geographical information is provided by May (2013). Finally, a perceived value approach (Zeithaml, 1988; Sweeney and Soutar, 2001) takes a consumer perspective, and analyses the overall assessment of a product or service based on what is ‘received’, versus what is ‘given’.

The aim of this study was to investigate the concept of using a mashup to provide information on the accessibility aspects of the transport network, such that other travellers can then use this information to form judgements in relation to their own travel. The study was less interested in the specific design of the website, or the judgement of it as a consumer product, as long as the usability was sufficient to not limit the potential impact of the information conveyed by the mashup. Therefore the study used the information perspective outlined above, and specifically that developed by Rieh (2002) that uses Information Quality and Cognitive Authority as the key dependent variables of interest. These were adopted by Rieh (2002) in relation to information search on the Web, and developed and used by Parker (2012) to assess user contributed data within geographically based information products. Information Quality is defined as ‘a user criterion which has to do with excellence or in some cases truthfulness in labelling’ (Taylor, 1986, p.62). Based on Wilson (1983), Rieh (2002, p.146) describes Cognitive Authority as ‘the influences that a user would recognize as proper because the information therein is thought to be credible and worthy of belief’. These two variables focus mostly on aspects of the information that is conveyed via a product (Table 1). Her original work (2002) included the term ‘scholarly’ since it was undertaken in the context of information search by scholars and this indicated work that was appropriate. For the purpose of this study, the term ‘appropriate’ was used instead. The table includes typical keywords in the text that were coded in relation to the construct.

3. Mashup incorporating volunteered travel data

A concept website (www.accessadvisr.net) was developed that enabled information to be contributed to the mashup by travellers, relating to the accessibility of the local transport provision. The website was designed using HTML5 technology to enable the geolocation of users in relation to nearby transport stops and stations, and places of interest (‘Destinations’). Data were obtained from multiple sources in order to build the mashup – primarily:

- Geospatial data and address/street view metadata on places of interest; such as restaurants, coffee shops, libraries, etc. were derived from Google using the Maps and Places APIs.
- Data on the geospatial locations and names of all UK transport stops (bus, train, tube, light rail, airports) were obtained from the National Public Transport open dataset (NaPTAN).
- Data on the accessibility of local bus stops were brokered from Nottingham City Council and Nottinghamshire County Council (and have subsequently been made available as part of the NaPTAN dataset).
- Data on the locations of on-street taxi ranks were brokered from Nottingham City Council.
- Data on the accessibility of local railway stations were manually scraped from the National Rail station features website.
- Data on the accessibility of local tram stops were brokered from the NET tram website.

| Variable                | Construct     | Keywords used for coding (positive phrasing)                        |
|-------------------------|---------------|---------------------------------------------------------------------|
| Information Quality     | Good          | Good job, excellent, fine, nice, great, best, perfect, wonderful, incredible, state of art, well developed site |
|                         | Accurate      | Accurate, correct, right, precise                                    |
|                         | Current       | Current, recent, up-to-date, timely                                 |
|                         | Useful        | Useful, informative, helpful, understandable                         |
|                         | Important     | Important, critical (related to goals of the user)                  |
| Cognitive Authority     | Trustworthy   | I trust it, trustworthy, believe in, confidence that this is true, seems real, faith in the quality |
|                         | Credible      | Credible, believable                                               |
|                         | Reliable      | Reliable, reliably done                                             |
|                         | Appropriate   | Serious, appropriate, cuts to the heart                              |
|                         | Official      | Official                                                            |
|                         | Authoritative | Authoritative, worthy of respect                                     |
Users had access to a number of features through the AccessAdvisr concept website’s Graphical User Interface (GUI). From the homepage they could choose to browse a Google map and use toggles to turn on/off the locations of bus and coach stops, points of interest (e.g. cafes, shops, banks), taxi ranks, tram stops, and train stations. They could also navigate to separate pages in order to search for places of interest or transport stops. These searches could be based on their current location (automatically detected), or in a specified location of interest. These features could be accessed without creating a profile. By creating a profile a user gained access to additional features which enabled them to add places as favourites (for quick reference in the future), as well as the ability to add free-text comments and upload photos of places they visit.

Basic geospatial information for each location could be supplemented with an overall Ease of Access rating, which could then be broken-down further in terms of the helpfulness of the staff, and whether the degree of accessibility experienced was ‘as advertised’. Examples relating to a train station are shown in Fig. 1.

The transport locations also contained photographs which had been uploaded to the mashup, showing key aspects of the infrastructure that were relevant to travellers with limited mobility. Some examples are shown in Fig. 2; these include the date of upload so that travellers can see the currency of the data.

For the purposes of the trial, and to support the travel scenarios described below, the concept website was pre-populated with volunteered data tagged to features of the transport network in Loughborough and Nottingham, a small town and city respectively in the East Midlands of the UK.

4. Method

This research took the form of a user trial of the mashup described above, based on travel-planning scenarios with two selected participant groups who have mobility-related issues when using the public transport network. Qualitative and quantitative data was collected from trial participants; details provided below.

4.1. Participants

Twenty participants were recruited based on the broad description of ‘people with limited mobility’ of O’Dolan and Carreno (2012), and were adults aged at least 18, users of the internet, and used public transport at least once a week (or were willing to do so). Two specific groups of travellers with limited mobility were targeted: (1) those who have physical restrictions on their mobility, due to disability, illness or injury; (2) those with practical mobility constraints due to being parents with young children using a child’s pushchair when using public transport. The participant sample therefore represented two distinct groups for whom an online travel information portal would be both relevant and feasible to use.

4.2. Scenario design

Journey planning scenarios were designed that represented typical journeys that are undertaken using the transport network. These scenarios were designed by the research team based on dialogue with members of Nottingham City Council’s Accessible Transport Group about journeys they often make in the local area. Their purpose was to impose a number of goal-directed tasks on the participants that required them to perform active information search and assessment. The travel scenarios are shown below, and were chosen because they provide a good cross-section of travel contexts, travel modes, trip purposes and locations that combine static and dynamic ease-of-access information. They were intended to prompt the participants to try and use the concept website in different ways:

**Task: Journey planning.** “You are travelling from the Holiday Inn Express hotel on Maid Marion Way, where you have stayed the night, to Loughborough and need to find an accessible way of doing this. A journey planner has suggested you travel to Station Street by tram from Old Market Square and then access the rail station to catch the train back to Loughborough.”

**Task: Wayfinding between railway and bus station.** “You arrive in Nottingham by train from Loughborough, where you are catching a National Express coach from the nearby Broadmarsh bus station.”

![Fig. 1. Public rating of accessibility.](image-url)
Task: Trip planning. “You will be arriving by bus from Loughborough at the Broadmarsh bus station, and you are trying to get to Marks and Spencer on Albert Street in the centre of Nottingham to meet a friend for coffee.”

Task: Finding accessible parking. “You are trying to get to Café Rouge on Bridlesmith Gate in Nottingham and plan to drive from home into the city centre.”

Task: Trip planning. “You are arriving at Nottingham Rail Station from Leeds and need to change trains, and purchase a ticket at Nottingham station for the remainder of your journey to Loughborough.”

For each scenario the participants were asked to consider the usefulness of the portal in relation to the specified planning task.

4.3. Data collection

There were three main forms of data collection:

(1) Data were gathered from the 20 participants (Section 4.1) using a ‘think aloud’ protocol (Ericsson and Simon, 1993) as they worked through the travel planning scenarios. This was minimally prompted, to enable participants to focus on information search and assimilation. The session was audio recorded, which enabled post session review of content, focussing on expression of barriers and enablers to using the website successfully.

(2) Quantitative data from these participants, relating to Information Quality and Cognitive Authority were collected using Likert scale items, originally adapted and validated by Parker (2012), based on Rieh (2002). Information Quality was comprised of five constructs as in Table 1. Within the questionnaire used for data collection, each construct contained three items (i.e. statements), two of which were positively phrased (increasing degree of agreement = ‘better’, and one negatively phrased (increasing degree of agreement = ‘worse’). Participants were asked to state their level of agreement with each statement, ranging from 1 (‘strongly disagree’) to 5 (‘strongly agree’). Cognitive Authority comprised six constructs shown in Table 1, with three items per construct as above.

(3) In addition to the ‘think about’ protocol, qualitative data were also collected using a short semi-structured interview undertaken with each participant. This comprised approximately the final 10 min of the session, and included questions relating to their initial reactions to the concept, their views on contributing data (accessibility ratings, photos and video), issues of trust in the data, the need for additional or specific features or functionality in order to support the maximise the quality, and credibility or usability of the information presented. Each interview was recorded and transcribed in full. A thematic-based coding scheme was used to categorise responses.

4.4. Procedure

Participants were selected using a screening questionnaire to ensure they had the demographic characteristics described in Section 4.1. They were given an information sheet, and completed an informed consent form and a short demographic questionnaire. After a demonstration of the information and features of the map interface via a short instructional video incorporated into the website, participants spent up to 30 min working their way through the travel scenarios (Section 4.2). Participants were asked to reflect on their own recent personal experiences when undertaking a similar journey, and to think about the extent to which the type of information being shown to them would or would not help them to complete the scenario successfully. Participants were not necessarily required to complete all of the scenarios – rather they could concentrate on those most relevant to them.

The focus of these scenarios was not to test the ability of the individual to complete the tasks successfully, but rather to enable the participants to assess the volunteered information provided in relation to realistic activities that they might undertake using the concept of volunteered ease of access information. Whilst working through the scenarios, participants were encouraged to ‘think aloud’, drawing on their own experiences when planning and undertaking travel, and comment on...
any aspect of the information available. They then completed the rating scales, and undertook the structured interview. On completion, participants were thanked and given a £20 shopping voucher to recompense them for their time.

5. Results and analysis

5.1. Participant details

Ten participants experienced specific impairments (both temporary and permanent) that limited their mobility. These included: double knee replacement; fractured (healing) pelvis; arthritic knee joints; stroke; arthritic knees and hip replacement; arthritis; fibromyalgia; Charcot–Marie–Tooth disease; heart disease and peripheral neuropathy; macular degeneration and peripheral neuropathy. The other ten participants were parents currently using pushchairs with young children, who experienced difficulty when using public transport. Table 2 presents a breakdown of the participant demographics.

5.2. The reaction to the quality and authority concepts

The concept site was tested for its overall usability, to check that judgements in relation to Information Quality and Cognitive Authority were not unduly impacted by the usability of the interface. This used a toolkit used successfully by Clarke et al. (2005) and adapted and validated by Parker (2012) within an information use context. This comprised standard usability components of perceived Usefulness, Clarity, Efficiency, Support, and Satisfaction. Each of these five components also comprised multiple items which were a range of positively and negatively phrased statements that the participant expressed levels of agreement or disagreement, similar to those described in Section 4.3.

Usability was judged as acceptable, since the overall median values for usability (aggregating all components) was 3.0 (on a scale of 1–5) for each participant group. This included a low component score for Support (\( \bar{x} = 2.3 \)) which was to be expected, since the site was a concept rather than full service offering.

Figs. 3 and 4 are boxplots showing the distributions of the participant ratings in terms of the Information Quality and Cognitive Authority constructs shown in Table 1. The negatively phrased Likert scale items within each construct were converted to equivalent positively phrased scores (e.g., 1–5, 2–4 etc) to enable aggregation of the items for each construct. The boxplots below show the median (solid horizontal line), and a box that represents the interquartile range (IQ) based on the 25th and 75th percentiles. This represents the central 50% of the distribution. The whiskers extending from the end of each box show the largest and smallest observed values that are not statistical outliers. Outliers (at a distance of between 1.5IQ and 3IQ from the end of the box) are shown with a circle, and extreme values (>3IQ) thus ∗.

Although it is accepted practice that parametric statistics can be undertaken on aggregated Likert scale constructs (Carifio and Perla, 2007), the sample violated the assumptions needed for parametric statistics; therefore non-parametric statistical analysis was undertaken for between and within-sample comparisons. In addition, caution is needed in interpreting the results due to the low sample sizes.

For the individual constructs shown in Figs. 3 and 4, the only significant difference between the two participant groups was in relation to the currency component of Quality, which was higher for the Pushchair User group (Median = 4.0) than for the Physical Disability group (Median = 3.33), (Mann–Whitney \( U = 24.5, Z = -1.977, p = .048, r = .45 \)). This value of \( r \) represents a medium/large effect size (Cohen, 1988).

Comparison of different constructs focussed on the elements of Information Quality, due to the differences apparent in Fig. 3 (there was less differentiation between the Cognitive Authority constructs, Fig. 4). For the Physical Disability group, the Goodness of the information (Md = 2.50) was assessed as lower than its Accuracy (Md = 3.33), (Wilcoxon, \( Z = -2.530, p = .011, r = .57 \), large effect size). The same effect was present for the Pushchair Users group, where Goodness of the information (Md = 2.83) was assessed as lower than its Accuracy (Md = 3.67), (Wilcoxon, \( Z = -2.567, p = .010, r = .57 \), large effect size).

Table 2
Demographic summary of sample.

| Age   | Mean (S.D.) Physical disability N = 10 | Pushchair user N = 10 |
|-------|----------------------------------------|------------------------|
| Gender| Male                                   | 6 (1.0)                | 1 (3.3)                 |
|       | Female                                 | 4 (1.0)                | 9 (3.3)                 |
| Frequency of public transport use | <once a week | 3 (1.0)                | 4 (3.3)                 |
|       | 1–2 days a week                         | 7 (1.0)                | 5 (3.3)                 |
|       | 3–4 days a week                         | 0 (1.0)                | 1 (3.3)                 |
|       | 5–7 days a week                         | 0 (1.0)                | 0 (3.3)                 |
| Frequency of internet use       | 1–2 days a week                         | 1 (1.0)                | 0 (3.3)                 |
|       | 3–4 days a week                         | 2 (1.0)                | 0 (3.3)                 |
|       | 5–6 days a week                         | 1 (1.0)                | 0 (3.3)                 |
|       | Every day                               | 6 (1.0)                | 10 (3.3)                |
The Usefulness of the information (Md = 3.67) was assessed as higher than its Importance (Md = 3.00), for the Pushchair User group, (Wilcoxon, $Z = -2.814, p = .005, r = .63$, large effect size). There was no difference between Usefulness and Importance for the Physical Disability group.

The ratings for the overall Quality and Authority were also compared. At an overall level, participants rated Cognitive Authority (Md = 3.44) higher than Information Quality (Md = 3.20), (Wilcoxon, $Z = -2.072, p = .038, r = .32$, medium effect size).

5.3. Qualitative analysis

The transcripts from the structured interviews were coded using NVivo (a qualitative analysis tool – QSR, 2010) in relation to: attitudes towards using public transport; trust in the information; attitudes towards contributing data; potential future use of the website; interface-related issues to maximise the usability of the volunteered information. Summaries are tabulated below. Unless stated, the numbers refer to frequency of utterances of specific points, rather than number of participants who made that point. *Braun and Clarke (2006)* discuss how there are many ways of representing prevalence in qualitative analysis, and therefore this measure was used to provide an overall ‘strength of feeling’ measure for each
participant group, rather than a participant frequency count. Cumulative frequencies therefore may differ to the total participant count (2 x 10) (see Tables 3–6 below).

The main interface related issues raised by the Physical Disability group were (in priority order): the need for integration of information around a journey planner; logical flow based on the planning activities within the travelling task; clarity of information at all levels of zoom; effective search and filter functions. The key issues raised by the Pushchair User group were: journey planner integration; the need for additional information, and particularly toilets and child-relevant content; accessibility information between (rather than at) POIs.

6. Discussion

Fig. 3 and Table 6 show that in general, the incorporation of volunteered accessibility information in the mashup used in this study was useful to travellers, supporting the original claims of Goodchild (2007) that individuals can act usefully as ‘sensors’ for the common good. The individual construct of ‘Goodness’ (which is related to the level of development of the design) was rated relatively poorly by both participant groups (largely as expected given the concept nature of the site), and for both participant groups, significantly lower than the attribute of Information Accuracy. This suggests that participants were discriminating between (1) the aesthetics of the concept site, and (2) their judgements of the extent to which the information reflected the ‘real world’. The quality attributes of Accuracy, Currency and Usefulness of the content were rated relatively highly by both groups.

Figs. 3 and 4 show that although there was general consistency in terms of response across the two user groups, there were some differences in how the user groups reacted to the mashups: the content was rated as more current by the Pushchair User group, probably as a result of their higher frequency of use of the internet (Table 2). The Physical Disability group tended to focus on the structure and clarity of the information presented, whereas the Pushchair User group identified the need for additional content specifically relevant to their travel context.

An interesting distinction arose between the two groups when comparing the attributes of Usefulness and Importance. Whilst Usefulness describes whether the information present can be used successfully for a particular purpose, Importance refers to the level of importance of that purposive activity. The Pushchair User group gave a significantly higher rating for Usefulness than for Importance, a difference which was not apparent for the Physical Disability group. This suggests that while both groups felt they were able to make use of the information within the context of their travel, the information actually mattered less, and particularly so for the Pushchair User group where there was general uniformity of response. In comparison, there was much greater variability in relation to Information Importance (related to real world impact) for the Physical Disability group. This indicates that the potential impact of the information on this group varied considerably according to the individual. This variability may be attributable to the diversity of the impairments (and therefore impact on mobility) experienced by participants in this group (section 5.1). It is likely that the restrictions on mobility for the Pushchair Users group were in general more of an inconvenience; whereas for the Physical Disability group, the actual impact of provision of accessibility information varied considerably, as can be seen in the wide interquartile range and differences between the smallest and largest observed values (Fig. 3). This variability is consistent with the findings of research commissioned by the UK Dept. for Transport (2004) that showed that the greatest demand for pre-trip information was found amongst disabled people who demonstrated the lowest propensity to travel independently, whereas more independent disabled travellers were more concerned with the quality (including currency) of the information accessible in real time. This distinction was partially reflected among participants in this study, who typically fell into one of these two categories. Older participants who experience more severe disabling impairments and demonstrated a lower propensity to travel, were more concerned ‘pre-trip’ by the fact the information was accurate and useful. Younger disabled people who experienced less-severe conditions, and those using pushchairs with young children, were less concerned by this.

The responses in relation to aspects of Cognitive Authority (i.e. trustworthiness, credibility, reliability etc.) show a generally positive but quite variable response to the concept of including volunteered information on transport accessibility. This variability is supported by the qualitative data demonstrating a range of views from participants, which were sometimes contradictory. Table 4 shows a range of positive and negative views in relation to trust; for example for the Physical Disability group, there were eight explicit references to trusting the volunteered information, but also nine comments about not fully trusting the information. Interestingly this group was also clearly more willing to trust the volunteered data than

| Attitude towards public transport | Physical disability | Pushchair user |
|----------------------------------|---------------------|---------------|
| I am positive about it            | 5                   | 6             |
| I use it but not out of choice    | 2                   | 2             |
| I avoid it as I find it difficult | 1                   | 1             |
| I am slightly nervous but generally enjoy using it | 2       | 0             |
| I use it with difficulty          | 0                   | 2             |
It is interesting that the predominant issues appeared to be related to queries over who contributed the data. This echoes some of the concerns of Goodchild and Li (2012) over the quality of volunteered data, although these authors focus more on the spatial accuracy of geographic data, rather than the Cognitive Authority (i.e. trust-related) constructs in geographically-tagged information. Whereas Goodchild and Li (2012, p.112) describe approaches to increase the ‘degree to what a purported fact is likely to be true’, the issue with accessibility information is that it is by its nature subjective and individually interpreted – and not necessarily ‘true’ or ‘false’. For example, an inclined walkway may prove no obstacle to an individual in a powered wheelchair, yet the same incline may be almost impassable to the average self-propelled wheelchair user. In this case the accessibility of the given walkway is neither impassable nor passable: it is dependent upon personal experience, equipment, and physical ability.

Based on the qualitative data collected during the travel scenarios, it is likely that the concept nature of the site was (with just adequate levels of usability) influencing the perceptions of Cognitive Authority – i.e. that how a site looks influences attitudes in relation to the constructs in Fig. 4. This is in line with the amelioration effect of visual design and aesthetics on content credibility – where aesthetics are shown to increase user judgements of the credibility of the content being presented (Robins and Holmes, 2008).

The data in Table 5 supports the empirical investigation of Mierlo (2014) that only a minor proportion of the population would actually create content for others, although a greater percentage would edit or synthesise web content. However, other commentary such as Schneider (2011) has suggested that as individuals have become more comfortable interacting with digital content (due to the ubiquity of web access and social media in particular), approximately a third of an online community may be willing to edit or create content. This would be equivalent to providing ease of access ratings or uploading photos, in the context of this study.

### Table 4
Trust of professional and volunteered information.

| Attitude                                      | Physical disability | Pushchair user |
|-----------------------------------------------|---------------------|----------------|
| Positive                                      |                     |                |
| I would trust the website                     | 8                   | 5              |
| I trust the volunteered information           | 8                   | 3              |
| I trust the professional information          | 0                   | 4              |
| Negative                                      |                     |                |
| I don’t fully trust volunteered information   | 9                   | 2              |
| I am unsure about trusting the website        | 0                   | 5              |

### Table 5
Attitudes to contributing data.

| Activity          | Attitude                  | Physical disability | Pushchair user |
|-------------------|---------------------------|---------------------|----------------|
| Check accessibility| I would check out locations | 9                   | 10             |
|                   | I wouldn't check out locations | 1                   | 0              |
| Rate POIs         | I might rate accessibility | 2                   | 2              |
|                   | I would rate accessibility | 5                   | 6              |
|                   | I wouldn't rate locations  | 1                   | 3              |
| Upload photos     | I wouldn't upload photos  | 5                   | 10             |
|                   | I might upload photos     | 0                   | 2              |
| Upload videos     | I wouldn't upload video   | 5                   | 8              |

### Table 6
Future use of the site (no. of participants).

| Evaluation                  | Physical disability | Pushchair user |
|-----------------------------|---------------------|----------------|
| It is a useful Idea         | 8                   | 8              |
| I would use this site again | 6                   | 7              |
| I wouldn't use this site    | 3                   | 0              |

7. Conclusions

The aims of the study were to investigate attitudes towards the use of a map mashup that provided volunteered information on the ease of access of points of interest and transport nodes. Two groups of travellers with limitations on their personal mobility (those who experienced some form of disabling impairment, and those using pushchairs with young children) found the concept potentially useful, although the outcomes actually mattered less for those using pushchairs. There were very mixed views in relation to the trustworthiness, credibility and reliability of volunteered information contained within the mashups.

The study identified a number of key information-related user requirements which were common to both groups that had mobility related difficulties in using transport. These are summarised below.

7.1. Organize information around user tasks

The qualitative data in particular identified key user requirements if such a concept is to be useful to travellers with restricted mobility. The primary requirement is that support is user-centric rather than data-centric. Information must be structured around the activities the user is trying to perform, as opposed to being presented according to categories or sources of data. In this context, the overall task of the user is journey planning, based on start and destination locations, and taking into account the specific needs and constraints of the traveller.

7.2. Join up the information

This study focused on accessibility information at discrete points of interest (POIs). However some form of journey-planner-style approach might enable ease-of-access information to be provided by individuals on the sections between POIs, e.g. the walking route between a car park and a café. It is not clear how users anticipated they might contribute value-added sentiment data (photos, videos, ratings) in practice since this question was not explored through the research study.

7.3. Tailor the content

Information on the accessibility of the transport network is relevant to all those with restrictions on mobility. However specific groups will have particular information needs, and inclusion of this tailored content will increase the usefulness of the concept. For the pushchair users, child-related content including location of toilets is needed alongside descriptions of the accessibility of the transport network.

7.4. Describe the context

Although the accessibility ratings are useful, individually they lack the contextual information to enable individuals to make judgements about the likely impact on their travel, based on their specific constraints. The photographs were especially useful in illustrating specific barriers to travel; however they ideally need to be integrated within some form of journey planning tool and shown at specific locations so that relevant images can be easily accessed by potential travellers.

7.5. Include the provenance of volunteered information

Volunteered information was useful to the participants, but caused some concern in relation to its trustworthiness and associated constructs. In particular, where the contributing user group may be very diverse, tagging volunteered information with limited personal details will help users understand ‘who’ contributed that data.

7.6. Enable mobile data contribution

This study focused on the use of volunteered accessibility information for pre-journey planning. A fundamental component of volunteered information is its contribution, so that others can use it. However it is recognized that providing sufficient motivation, and easy tools for doing this, is non-trivial (Doan et al., 2011). Ongoing work is investigating the use of a mobile application to enable individuals to pass judgement on aspects of the transport network and to upload geographically referenced photographs.

A challenge remains in terms of creating map mashups that incorporate crowd-sourced data. The crowd-sourced element has been shown to be useful; however an outstanding question arises over how to collect this subjective data in the first instance so that it can be used to populate a mashup. One solution may be to pre-populate a local region to create critical mass, and then look to expand the coverage. An alternative approach may be to provide a mashup that adds value without the crowd-sourced data, and provide easy means of users adding their own content.

The main limitation in the study was the heterogeneity in the Physical Disability group, which contributed to quite wide variability in some of the responses. In addition, the Pushchair User group were younger and predominantly female (Table 2), which introduced a potentially confounding factor when comparing the two user groups. However, the aim of the study was not to isolate the impact of the presence of physical disability per se, rather to determine and compare the outcomes based on typical user groups who face mobility-related difficulties in using the transport network. The other limitation is the relatively low participant numbers which limited the quantitative analysis of data.

Acknowledgements

This study was undertaken within the Ideas in Transit project (www.ideasintransit.org), supported by the UK Government (via the Engineering and Physical Sciences Research Council, Grant Ref. EP/F005172/1, the Technology Strategy Board, Grant Ref. 400050, and the Department for Transport). The study was devised, undertaken, analysed and reported by the authors alone. Please feel free to contact the authors for further details of the study.
References

Barry, C., Schamber, L., 1998. Users' criteria for relevance evaluation: a cross-situational comparison. Inform. Process. Manage. 34 (2), 219–236.

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3 (2), 77–101, doi: 10.1191/1478088706qp063oa.

Cardonha, C., et al., 2013. A crowdsourcing platform for the construction of accessibility maps. In: Proceedings of the 10th International Cross-Disciplinary Conference on Web Accessibility – W4A ’13, p.1. Available at: http://dl.acm.org/citation.cfm?doid=2461121.2461129.

Carifio, J., Perla, R.J., 2007. Ten common misunderstandings, misconceptions, persistent myths and urban legends about Likert scales and Likert response formats and their antecedents. J. Soc. Sci. 3 (3), 106–116.

Clarke, K., Lewin, M., Atkins, D., Kalawsky, R., 2005. Testing a framework for multimodal control in the home environment. In: Perspectives in Pervasive Computing. IET, London, pp. 85–95.

Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences. Lawrence Erlbaum Associates, Hillsdale, NJ.

Commons Select Committee, 2013. Access to Transport for People with Disabilities. Available at: http://www.parliament.uk/business/committees/committees-a-z/commons-select/transport-committee/inquiries/parliament-2010/disabled-access-to-transport/

Das, T., Kraak, M.J., 2011. Does neogeography need designed maps? In: Proceedings of the 25th International Cartographic Conference and the 15th General Assembly of the International Cartographic Association. International Cartographic Association (ICA), Paris, France. pp. 1–6.

Dept. for Transport, 2004. Traveline & Transport Direct Disabilities Customer Research. Available at: http://www.dft.gov.uk/rmd/projectasp?intProjectID=11715.

Dept. Work and Pensions, 2013. Family Resources Survey.

Doan, A., Ramakrishnan, R., Haley, A.Y., 2011. Crowdsourcing systems on the world-wide web. Commun. ACM 54 (4), 86–96 (Available at: http://dl.acm.org/citation.cfm?doid=1924442 [Accessed November 27, 2013]).

Ericsson, K.A., Simon, H.A., 1993. Protocol Analysis: Verbal Reports as Data. Revised Edition. MIT Press, Cambridge, MA.

Flanagan, A.J., Metzger, M.J., 2008. The credibility of volunteered geographic information. GeoJournal 72 (3–4), 137–148. Available at: http://www.springerlink.com/index/10.1007/s10708-008-9188-y [Accessed July 22, 2011].

Goodchild, M., 2007. Citizens as sensors: the world of volunteered geography. GeoJournal 69 (4), 211–221. Available at: http://link.springer.com/article/10.1007/s10708-007-9111-y [Accessed January 16, 2014].

Goodchild, M.J., 2008. Scientific accuracy 2.0. In: Shan, J.-X., Goodchild, M.F. (Eds.), Proceeding of the 8th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences. World Academic Union, Shanghai, pp. 1–7.

Goodchild, M.F., Li, L., 2012. Assurance the quality of volunteered geographic information. Spat. Stat. 1, 110–120. Available at: http://linkinghub.elsevier.com/retrieve/pii/S2211675312000097 [Accessed November 11, 2013].

Great Britain, 2010. Equality Act 2010, London, UK. The Stationery Office.

Hara, K., Le, V., Froehlich, J., 2013. Combining crowdsourcing and google street view to identify street-level accessibility problems. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems – CHI’13. ACM Press, Paris, France, pp. 631–640. Available at: http://dl.acm.org/citation.cfm?doid=2470654.2470744.

ISO, 2008. ISO 9241–151:2008. Ergonomics of Human–System Interaction, Part 151: Guidance on world Wide Web user interfaces.

ISO, 2010. ISO 9241–210, 2010. Ergonomics of Human–System Interaction – Part 210: Human-centred Design for Interactive Systems. Knigge, G., Richard, B., 2012. The Great British Public Toilet Map. Greatbritishpublictoiletmap.rca.ac.uk. Available at: Greatbritishpublictoiletmap.rca.ac.uk.

Law, E.-C., van Schaik, P., 2010. Modelling user experience – an approach for usability design and practice. Interact. Comput. 22 (5), 313–322.

Lucas, K., 2012. Transport and social exclusion: where are we now? Transp. Policy 20, 105–113. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0967070X12000145 [Accessed November 12, 2013].

May, A.J., 2013. Using a ‘value-added’ approach for contextual design of geographic information. Appl. Ergon. 44 (6), 895–908.

mierlo, T., 2014. The 1% rule in four digital health social networks: an observational study. J. Med. Internet Res. 16(2), 33. Available at: http://www.jmir.org/2014/2/e33/.

O'Dolan, C., Carreno, M., 2012. Developing a quality management scheme for improving accessibility: implications for Scotland's national transport strategy. In: 8th Annual Scottish Transport Applications & Research Conference. Available at: http://www.ustg.org/star/2012/ODolanCarreno.pdf [Accessed May 21, 2014].

Parker, C., 2012. A Human Factors Perspective on Volunteered Geographic Information. Loughborough University.

Parker, C., May, A., Mitchell, V., 2012. Understanding design with VGI using an information relevance framework. Transact. GIS 16 (4), 545–560. Available at: http://doi.wiley.com/10.1111/j.1467-9671.2012.01302.x [Accessed November 14, 2012].

Parker, C., May, A., Mitchell, V., 2013. The role of VGI and PGI in supporting outdoor activities. Appl. Ergon. 44 (6), 886–894. Available at: http://www.sciencedirect.com/science/article/pii/S0003687012000816 [Accessed March 3, 2014].

Parker, C.J., May, A.J., Mitchell, V.A., 2014. User centred design of neogeography: the impact of volunteered geographic information on users’ perceptions of online map ‘mashups’. Ergonomics 57 (7), 987–997.

QSR, 2010. NVivo 9.

Ray, N., Ryder, M., 2011. ”Ebilities” tourism: an exploratory discussion of the travel needs and motivations of the mobility-disabled. Tourism Manage. 24, 57–72. Available at: http://www.sciencedirect.com/science/article/pii/S0261517712000037 [Accessed January 16, 2014].

Rieh, S.Y., 2002. Judgment of Information Quality and Cognitive Authority in the web. J. Am. Soc. Inf. Sci. Technol. 53 (2), 145–161. Available at: http://doi.wiley.com/10.1002/asi.10017 [Accessed March 7, 2012].

Robins, D., Holmes, J., 2008. Aesthetics and credibility in web site design. Inf. Process. Manage. 44 (1), 386–399. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0306457307000068 [Accessed September 23, 2013].

Saracevic, T., 2007. Relevance: a review of the literature and a framework for thinking on the notion in information science. Part II: nature and manifestations of relevance. J. Am. Soc. Inf. Sci. Technol. 58 (13), 1915–1933.

Schneider, P., 2011. Is the 90-9-1 Rule for Online Community Engagement Dead? Available at: http://www.etcetera.com/c-conocimiento/p-datos-curacion-contendidos/.

Sweeney, J., Soutrar, G., 2001. Consumer perceived value: the development of a multiple item scale. J. Retailing 77 (2), 203–220. Available at: http://www.sciencedirect.com/science/article/pii/S0003687001000410 [Accessed March 3, 2014].

Taylor, R., 1986. Value-added Processes in Information Systems. Ablex Publishing, Norwood, NJ.

Waara, N., 2009. Older and disabled people's need and valuation of traveller information in public transport. In: Proceedings of the Association for European Transport Conference, pp. 1–21.

Wilkinson, P., 2001. Second-hand knowledge: An Inquiry into Cognitive Authority. Greenwood Press, Connecticut, USA.

Zeithamal, V.A., 1988. Consumer perceptions of price, quality, and value: a means-end model and synthesis of evidence. J. Market. 52 (3), 2–22. Available at: http://www.jstor.org/stable/1251446 [Accessed December 13, 2011].

Zielstra, D., Zipf, A., 2010. A comparative study of proprietary geodata and volunteered geographic information for Germany. In: 13th AGILE International Conference on Geographic Information Science. Guimarães, Portugal, pp. 1–15. Available at: http://agile2010.dsi.uminho.pt/papers/pdf/142_doc.pdf [Accessed January 16, 2014].