User-centred design of neogeography: the impact of volunteered geographic information on users' perceptions of online map 'mashups'

Christopher J. Parker[1], Andrew May and Val Mitchell

Loughborough Design School, Loughborough University, Loughborough, UK

Abstract: This paper investigates the influence of presenting volunteered and professionally created geographic information to 101 wheelchair users through an interactive website that included information collected by wheelchair-using volunteers. The aim of this experiment was to understand the influence that (1) *knowing* a map-based website contains volunteered information and (2) *actually including* volunteered information within an online interactive map (a mashup) have on the perceived trust of the user, described in terms of quality and authority. Analysis using Kruskal–Wallis showed that judgements of *currency* were influenced by *including* geo-information from untrained volunteers (volunteered geographic information) within the mashup, but not influenced by the participant *being told* that the online map contained volunteered information. The participants appeared to make judgements based on what information they saw, rather than what they were told about the source of the information.

Practitioner Summary: Since 2004, information services have combined crowdsourced (volunteered) alongside professional information within online interactive maps. An online experiment presented both of these information types to wheelchair users within a travel context. Including volunteered information was shown to increase the perceptions of how up-to-date the maps were.

Keywords: information; access; trust; human factors; crowdsourcing

1. Introduction

1.1 Background

The world is changing in terms of how individuals create and access information. Drivers include Web 2.0, democratisation of geographic information systems from the professional and users (Hall 2007; Ricker, Johnson and Sieber 2013), more widespread and higher bandwidth of fixed and mobile networks and the increasing ubiquity of connected mobile devices. It is now easier for individuals to *create* information relating to specific points on our globe, and this has led to an increasing realisation that user-generated information can be both *useful* and *reliable*. Web 2.0 has enabled a shift in the commercial focus for mapping from the exclusive use of professional information for commercial products (Crone 1968) to contemporary mobile services, such as

[1] Corresponding author. Current address: Department of Design, Fashion and Business, The School of Materials, The University of Manchester, Manchester, UK. Email: Christopher.Parker@manchester.ac.uk

Apple Maps which use crowdsourced data and reviews alongside that of the expert (Goth 2013). Additionally, Cardonha et al. (2013) highlight how some platforms must have a certain critical mass of data in order to be effective, which strengthens the case for inclusion of volunteered geographic information (VGI) in order to help reach desired levels of utility.

However, despite the obvious potential benefits, the general reaction to many new product forms has been mixed, with reports of varying consumer reaction, inaccuracies and incomplete information (Ricker, Johnson, and Sieber 2013). There have also been descriptions of how crowdsourcing can be centred around subversive activities (Johnson 2014).

In relation to online maps, a current issue is the extent to which knowledge of the source of data impacts on the trust that an individual has in those data. This is particularly true in the light of current research which suggests that volunteered information may have a negative impact on the judgement of the information set within which it is included (Das and Kraak 2011; Keen 2007; Flanagin and Metzger 2008; Jackson et al. 2013).

1.2 The world of volunteered information

An outstanding example of volunteered information being fundamental to the success of an information-based 'product' is OpenStreetMap (OSM), a volunteer-generated online map that – with more than 84,000 editors (OSM 2012) – has come to be the geo-framework underpinning services such as Apple's iOS Maps (Wood 2012), Trip Advisor (Weait 2011) and Flickr (Oates 2008). A particularly interesting phenomenon is that of neogeography: 'the domain where users make use of geographic information using web 2.0 applications' (Das and Kraak 2011, 1). These integrations of data from various sources are typically termed *mashups*, which are defined by Flanagin and Metzger (2008, 138) as 'web applications that combine data from multiple sources to form a new integrated resource'. There are several examples of information coming from both trained professionals (professional geographic information; PGI) and amateur volunteers (VGI) being combined into a single service offering for an individual, including *WikiMapia* (2012), *The Great British Toilet Map* (Knight and Bichard 2012) and *Google Maps*[2]. Parker, May, and Mitchell (2012b) demonstrated that in an actual usage scenario, consumers are likely to use VGI and PGI alongside each other (where available) in order to converge on a *truth,* as opposed to using individual VGI or PGI data-sets on their own. Note that the word *geographic* is not confined to traditional topographical identifiers such as physical features but to any data where a geospatial element is present (Goodchild 2007). Simple online mashups (such as those including customer reviews) make it clear when information comes from volunteers. However, as mashups become more sophisticated, and data are more integrated, it may become increasingly difficult for end-users to determine whether information has come from professionals or volunteers. It is currently unclear whether this ambiguity over the source actually matters, or whether an information delivery system (e.g. website, application) is judged on the basis of the information elements present, irrespective of the knowledge of the source of this information.

This study is based around providing wheelchair users with relevant public transport information. The approach of combining different information sources through an online portal has been shown to offer distinct advantages to users within a disability access context (Cardonha

[2] In regions enhanced by data from Google Map Maker (http://www.google.co.uk/mapmaker)

et al. 2013).

At present 15–45% of the UK adult population experience mobility impairment to some degree (DWP 2012), and despite recent legislation, there is still lack of information on the accessibility of transport facilities. Ray and Ryder (2003) pointed out how even the most outgoing and risk-taking of the wheelchair user community actively and carefully evaluates the risks before engaging in travel. Importantly, within a travel context this risk is not experienced in the same fashion by able-bodied individuals. Managing risks through access to information that is trusted is a central element of the task undertaken by the less able-bodied traveller.

1.3 Measurement of trust in online map mashup judgements

Trust has a long and well-established history in interpersonal relationships (Rotter 1967), task automation (Bainbridge 1983) and also peoples' reactions to information (Kitao 1978). Trust in information implies credibility, and several authors (Fogg and Tseng 1999; Flanagin and Metzger 2008; Fogg et al. 2001) have demonstrated the importance of credibility as an expression of perceived trust in web-based information. Credibility has also been shown to be one of the key factors in a person's decision to use or not use a source of geographic information (Keßler, Trame, and Kauppinen 2011; Bishr and Janowicz 2010). Additionally, Parker, May, and Mitchell (2012a) highlighted how factors that contribute to trust are a critical factor in the user's *evaluation* of information originating from volunteers.

Several authors (Fogg and Tseng 1999; Flanagin and Metzger 2008; Fogg et al. 2001) have discussed the definitions, complex relationships and ambiguities associated with terms such as 'trust', 'credibility' and 'quality'. For the purposes of this study, trust in the information in a 'mashup' is assumed to be dependent on (amongst other factors) perceptions relating to (1) its attributes and (2) its source, which are the aspects of interest in this study.

In investigating the judgements people make when searching for information online, Rieh and Belkin (2000) presented a model to describe how users perceive *information quality* and *cognitive authority* in online information. Within this framework, 'quality' is defined by the constructs of *goodness*, *accuracy*, *currency*[3], *usefulness* and *importance*, and 'cognitive authority' by *trustworthiness*, *credibility*, *reliability*, *scholarliness*, *officialness* and *authoritativeness*. In line with the above, information quality and cognitive authority relate approximately to (1) information attributes and (2) information source, respectively. The framework of Rieh and Belkin (2000) is expanded by Rieh (2002) and has also been used in a similar research context to this paper by Idris, Jackson, and Abrahart (2011a).

1.4 Research aims

The overall aims of this research were to inform the design of online map-based mashups. The specific objectives for this study were to use wheelchair users to investigate:

1. the extent to which *including* VGI within the mashup alongside PGI affects the user's judgement of that mashup, based on a 'quality' and 'authority' framework; and
2. how users react to *being told* that their mashups contain VGI alongside PGI.

[3] Within this paper, currency refers to the ability for the information to reflect current conditions: being 'up to date'.

2. Methodology

2.1 Experimental design

To maximise the ecological and external validity of the results, this study was designed with a *field experiment* ethos. A website was created to host the experiment, which was accessed by participants in their own home or workplace, unaccompanied by the experimenter. By hosting the experiment online, the issue of participant availability was reduced since it is relatively easy to provide access to the experiment and participants may take part at any time they have access to the internet. Fogg et al. (2001) highlighted how hosting such experiments online offers distinct advantages without sacrificing the validity of the research.

The experiment was a 2 (source) x 2 (communication) between-subjects design. The independent variables were (1) source: *presenting participants* with PGI or PGI + VGI, and (2) communication: *telling participants* that their mashup contained PGI or PGI + VG. This created four between group conditions, as shown in Table 1.

While experimental in its nature, the website was designed to closely mimic existing services such as *AccessAdvisr*[4] (https://accessadvisr.net/) and *Wheelmap* (http://wheelmap.org/). The scales to measure the Dependent Variables of Information Quality and Cognitive Authority were based on the construct definitions of Rieh and Belkin (2000) and Rieh (2002), described in section 1.3. The original construct of *scholarliness* was removed, since her original work was undertaken in the context of information search by academics, where scholarly work was appropriate. Within this study, all of the data displayed had already been pre-screened to ensure it was appropriate for the study.

The main questionnaire was broken down into sections representing the five constructs each for information quality and cognitive authority within this experiment. For each construct, five items were presented to the participant (three positively and two negatively coded), with a five-point agree–disagree Likert scale. From this, scores were averaged to derive a value for each of the constructs, after reverse coding the negatively coded items. A full list of questions used in the study (packaged as the Online Usability Toolkit) is available freely through a creative commons license at http://usabilitytoolkit.wordpress.com.

Participants were presented with a mashup unique to their assigned group according to the between-subject variables. The participants were presented with a series of three travel routes (e.g. Figure 4) to create a realistic context for engagement between the participant and the information. They were then asked to judge critically the information environment presented via the mashup (see section 2.3). A similar approach was undertaken successfully by Collins (2006) who presented a data-set online to experiment participants while informing them that it was either from source A or B in order to understand perceived bias in information judgement. Previous research has shown such an approach to be highly relevant when researching geographic information use (Bishr and Mantelas 2008; Idris, Jackson, and Abrahart 2011b; Mummidi and Krumm 2008).

[4] At the time of publication, the current AccessAdvisr website represented a proof of concept site, and is under ongoing development based on end-user and wider stakeholder involvement.

Table 1. Independent variables and group allocation

		Source: Information *actually presented* in mashup	
		PGI	*PGI + VGI*
Communication: Participant *told* *that* the mashup contained	*PGI*	Group 1	Group 3
	PGI + VGI	Group 2	Group 4

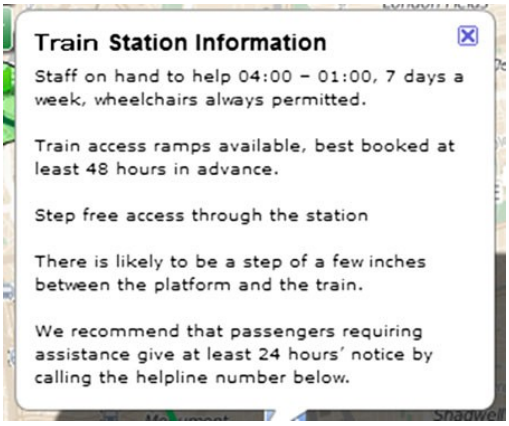

Figure 1. An example of PGI presented within the mashup

Participant judgements were collected using an online survey that was integrated into the website design (see section 2.3) and presented to the participants after they had completed their experimental condition. However, Wathen and Burkell (2002) demonstrated that a person's assessment of credibility of an online environment can be considered risky due to the ease of which factors such as aesthetics (Robins and Holmes 2008) may influence the persons judgements. The risk of aesthetics confounding the results was minimised by ensuring that each group of participants was presented with a visually identical website environment, differing only in the detail of the content and the information on source that was provided to participants.

2.2 Collection of VGI and PGI

The study presented both PGI (professional information) and VGI (volunteered information) to participants. PGI about accessibility-related issues along the specified route was collected through official sources (e.g. TFL 2011; Southeastern 2011; Network Rail 2011) (see Figure 1).

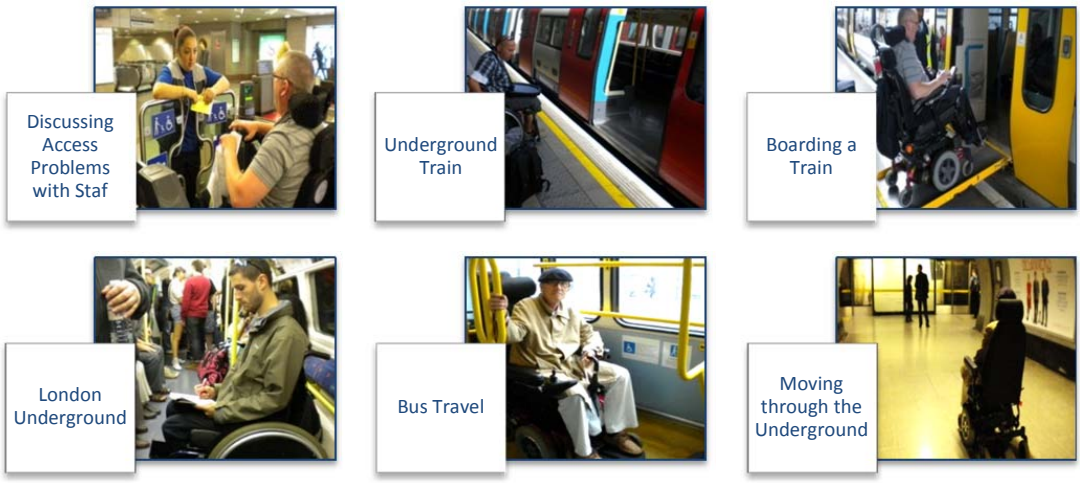

Figure 2. Collection of VGI using wheelchair users in London.

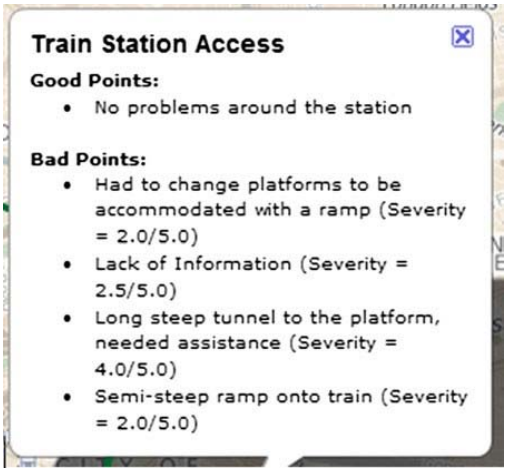

Figure 3. An example of VGI presented within the mashup.

While current research suggests a high potential for remote analysis of wheelchair accessibility (Hara, Le, and Froehlich 2013; Cardonha et al. 2013; Koch et al. 2013), such methodologies do not currently generate detailed audit information, and therefore were not appropriate for use in this study. Therefore, VGI was collected through five prior participant observation sessions, working with wheelchair users along a specific public transport route in London (see Figures 2 and 3). Further details of data collection are given within Parker et al. (2013).

2.3 Website design

The main features of the website (see Figure 4) were: (1) introduction to the study, (2) training in use of the online maps via embedded videos, (3) random allocation of the participant to one of the four independent variable groups, (4) presentation of three interactive maps including clear labelling according to group allocation and (5) collection of rating scale data via an embedded

interactive survey.

A pre-test ($n = 12$) and pilot study ($n = 36$) were run testing the mechanisms of the study using non-disabled members of Loughborough Design School. Following these tests, refinements were made to the design of the website. Finally, a usability assessment of the experiment website was conducted, with all highlighted areas of poor usability addressed, in order to minimise the impact of poor usability on the ratings obtained. The final development of the website can be viewed in an achieved format at http://chris210.wix.com/free-traveller.

2.4 Participant sampling

It was important that the participants who engaged with the experiment were in a position to critically evaluate the information in relation to their specific needs, increasing both internal and external validity. Multiple points of contact were used in order to recruit participants, including wheelchair-specific disability services, internet forums and targeted advertisements within social media (i.e. *Facebook*, *Twitter*, *Google*). Participants were required to meet the following criteria:

1. Physical disability which limits movement and necessitates the use of aids similar to and including wheelchairs;
2. Only exhibiting physical disabilities, excluding cognitive and sensory disabilities;
3. Compatible with non-vulnerable persons description under the Loughborough University Ethics committee (aged 18–65, no cognitive or sensory disabilities, non-pregnant), except in circumstances listed above;
4. Full access to and competence using a PC, laptop, tablet or other internet-enabled computer with a full-sized screen;
5. Have familiarity with using online maps; e.g. *Google Maps*.

Figure 4. Example of mashup presenting VGI alongside PGI.

Although non-parametric statistics (including Kruskal–Wallis) have less stringent assumption requirements (Pallant 2010, 211), Lehmann (1998) recommends calculating the required participant numbers for parametric statistics, and then adding 15%. As one-way analysis of variance requires 20 participants per cell (Tabachnick and Fidell 2001), with four cells the non-parametric statistics required a minimum of 92 participants. Consequently, a sample of 100 participants was targeted for appropriate statistical analysis. In order to reduce participant dropout part way through the experiment, and to maximise engagement with the website (Frick, Bächtiger, and Reips 2001), all participants who successfully completed the survey were entered into a prize draw for £150.

2.5 Procedure

Participants were directed to the website where (before they could begin participation in the study) they were screened for compliance with the desired sample through some simple demographic questions. If meeting the recruitment criteria, they were then randomly allocated to their experiment group, instructed on the purpose of the research and taught how to use the mashups in the experiment through interactive videos. During this time, participants were not told what information the mashups they were about to use *actually* contained; instead they were led to believe that the content was a defined by their group allocation (see Table 1).

In line with the requirement for active and realistic information seeking tasks (Rieh and Belkin 2000), the participants were instructed to consider:

1. What information they would need if they were to make a similar journey in London in the near future;
2. To what extent the information presented to them fulfils their specific requirements as a disabled passenger;
3. How confident the information presented in the mashup would make them feel if they were to conduct that journey independently in the near future.

Participants were then presented with a short demographic questionnaire that included qualifying criteria on age (18–65), disability (permanent wheelchair user) and computer literacy (regular online map user). If the answers to these indicated that the participant was within the target group, they proceeded to the rating scale section of the survey, otherwise they were thanked for their participation and told they would be entered into the prize draw. All participants were entered into the prize draw.

Current guidance suggests that Likert scale responses (i.e. multiple measurement items aggregated to construct an overall scale response, as opposed to the analysis of single item responses) can be treated as interval data and analysed using the *F*-test (Carifio and Perla 2007, 115). However, analysis of the 10 constructs revealed nine significant Kolmogorov–Smirnov values (range: [KS = 0.111, $\rho = 0.004$] – [KS = 0.167, $\rho<0.0005$]) and only one non-significant value, for the construct of reliability (KS =.074, $\rho =.200$). Therefore, Kruskal–Wallis was used due to violation of the assumptions for normality.

2.6 Hypotheses

It was unclear a priori whether any differentiation would arise due to the independent

variables. Therefore, both null and alternative hypothesised were constructed (see Table 2). As previous work on the influence of VGI and PGI on users may be considered somewhat contradictory, with both positive (Haklay 2010; Parker, May, and Mitchell 2012a) and negative (Flanagin and Metzger 2008; Jackson et al. 2013) effects recorded, a two-*tailed* hypothesis was used.

Table 2. Null and alternative hypotheses within the study.

	Null Hypothesis	**Alternative Hypothesis (2-Tailed)**
1)	No significant difference between the judgements of maps *actually containing* PGI, and those containing PGI + VGI	Significant difference between the judgements of maps *actually containing* PGI, and those containing PGI + VGI
2)	No significant difference between the judgements of maps when users *are told* they contain PGI or PGI + VGI	Significant difference between the judgements of maps when users *are told* they contain PGI or PGI + VGI

3. Results and analysis

3.1 Descriptive statistics

A breakdown of the participants involved within the study by gender is given in Table 3. Internal consistency in the survey was considered through the Cronbach's alpha coefficient[5]. Of the 10 elements of the survey, all achieved a satisfactory minimum alpha (Kline 2000, 13) level above 0.7 (range, 0.710–0.868) with the exception of Importance ($a = 0.634$). As a minimal alpha of 0.7 has been identified as being important for the internal reliability of the scale data (Guilford 1956, 145; Nunnally 1978, 245), the scale of Importance was removed from the data-set.

3.2 Statistical analysis

A Kruskal–Wallis Test revealed a statistically significant difference in perceived currency of information across the four different groups, x^2 (3, n = 101) = 8.86, $\rho = 0.031$. Separate non-parametric tests were then run to isolate the two independent variables of interest (*source* – what they were presented with – and *communication* – what they were told it was).

In relation to the effects of source (i.e. what information they actually *used*), a Kruskal–Wallis Test revealed a statistically significant difference in perceived currency of information between those who were presented with PGI (Groups 1 and 2) and those who were presented with PGI + VGI (Groups 3 and 4), x^2 (1, n = 101) = 7.78, $\rho = 0.005$. Those who used PGI + VGI maps recorded higher median scores (Groups 3 and 4, $Md = 3.5$) than those who used only PGI

[5] The extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of the items within the test (Tavakol and Dennick 2011).

maps (Groups 1 and 2, *Md* = 3). No other significant differences were found in any of the other dependable variables due to the effect of *source*.

Investigating the effects of communication (i.e. what information they were *told* they were using), a Kruskal–Wallis Test revealed no statistically significant difference in any of the quality or authority constructs between those who were told their information was PGI (Groups 1 and 3) and those who were told their information was PGI + VGI (Groups 2 and 4).

3.3 Recall of actual and communicated source

The experiment controlled what information participants were presented with, and what they were *told* this was. The experiment therefore did not (and could not) control what participants *actually believed* they were being presented with – this was therefore treated as a dependent variable. On completion of the final survey, participants were asked what information they *believed* the maps they had just used contained (see Table 4).

Because of the possible interaction effect between the two independent variables (what they were presented with and what they were told), chi-square tests for independence were conducted in four instances, isolating the independent variables within the data.

3.3.1 Information presented

Considering only Groups 1 and 3 (removing the influence of information communicated, since both groups *were told* it contained only PGI), a chi-square test for independence indicated a significant association between the information presented within the mashups and the content participants believed the mashup to contain, x^2 (2, n = 45) = 18.04, ρ<0.0005, *phi* = 0.633. In contrast, a chi-square test for independence considering only Groups 2 and 4 (where both groups *were told* the mashup contained PGI + VGI) did not indicate a significant association between the information presented within the mashups and the content participants believed the mashup to contain, x^2 (2, n = 49) = 0.57, ρ = 0.754, *phi* = 0.101.

Table 3. Breakdown of participants per group by gender

	Gender		
Group	**Male**	**Female**	**Total**
1	**11**	**12**	**23**
2	**16**	**17**	**33**
3	**6**	**16**	**22**
4	**7**	**16**	**23**

Table 4. Participants' belief of the source of the data, by allocated group.

Group	Presented with:	Told that it was:	Believed Mashup Contained Professional + Volunteer	Professional Only	Volunteered Only
1, N=23	***PGI***	***PGI***	**18**	**2**	**3**
2, N=33	***PGI***	***PGI + VGI***	**2**	**3**	**28**
3, N=22	***PGI + VGI***	***PGI***	**4**	**14**	**4**
4, N=23	***PGI + VGI***	***PGI + VGI***	**1**	**1**	**21**

3.3.2 Information communicated

Considering only Groups 1 and 2 (removing the influence of information presented, as both *were presented* with only PGI), a chi-square test for independence indicated a significant association between the information communicated within the mashups and the content participants believed the mashup to contain, x^2 (2, n = 56) = 32.41, ρ<0.0005, phi = 0.761. Similarly, a chi-square test for independence considering only Groups 3 and 4 indicated a significant association between the information communicated within the mashups and the content participants believed the mashup to contain, x^2 (2, n = 45) = 24.62, ρ<0.0005, phi = 0.740.

4. Discussion

4.1 Influence of VGI on user judgements

Several authors have suggested that VGI has great potential to capture and represent a wide range of data not easily captured by traditional techniques (Goodchild 2007; Kingsbury and Jones 2009; Ricker, Johnson, and Sieber 2013). When analysing the impact of the addition of VGI within the study, including VGI within the mashup produced a significant and positive influence on the judgement of *currency*. PGI tended to cover more objective features, e.g. 'the station is step free for easy wheelchair access' (see Figure 1). VGI within this study contained not only objective data not readily attainable through traditional/ professional methods, but also experiential and perceptual (or emotively derived) data which can *only come* from specific end-users (see Figure 3). For example VGI may capture and present information which (1) is not readily identifiable by individuals outside of a specific user group, (2) is not perceived as significant by non-user groups or (3) is not appropriately expressed by non-user groups.

Although adding VGI to the mashups increases perceived currency, this finding could be attributed to the fact that as more information is made available to an individual, user trust (of which currency is an element) tends to increase. In a study examining user perceptions of Wikipedia using the information judgement framework of Rieh and Belkin (2000), Yaari, Baruchson-Arbib and Bar-Ilan (2011) highlighted how increasing the amount of information available to the user increased perceptions of *trust*. This outcome was consistent with the findings of Tillotson (2002), although from a more general context involving university students' assessment of online information. In these studies an increase in the quantity of the *same kind* of

information caused the increase in quality perceptions.

Since this study did not *require* participants to provide qualitative justification for their opinions, it is not possible to determine categorically which factors led to the belief that the inclusion of VGI increased the currency of the mashup. However, Table 4 suggests it is based on a combination of what participants *saw* and what they were *told* (discussed in section 4.2). The amount of information presented online has been shown to be correlated to perceived overall quality (Tillotson 2002; Yaari, Baruchson-Arbib, and Bar-Ilan 2011), so the addition of VGI is likely to increase this. In particular, it is possible that the specific influence of VGI on currency is due to the relatively 'informal' (Gitelson and Crompton 1983) nature of this information – coming from non-official sources, and being colloquially expressed. Participants may have associated this with social media (e.g. *Facebook*, *Twitter*), which have regular updates as a central concept of their service offerings. This impact of VGI on currency is in line with the comments by Goodchild (2008, 6) that 'perhaps the most significant area of geospatial data qualities for VGI is currency, or the degree to which the database is up- to-date'. Schuett (1993) and Hawkins, Best, and Coney (1995) have also suggested that this kind of information is particularly beneficial to non-work-related activities where there is a need to reflect current conditions, as simulated within this study and seen implemented in services such as TripAdvisor.

By contrast, *telling people* how the contents of their mashup were derived had no significant influence on how they perceived the information in that mashup. Therefore, this experiment accepts the *null hypothesis 1* (see Table 2). This was slightly unanticipated, since it might be expected that *telling* participants that their mashups contained data from other wheelchair users would increase the trust in that information. Adding volunteered information which is complimentary to the existing PGI seems to be treated by participants as simply enhancing the information environment, without much conscious deliberation of where that information came from.

4.2 Influence of VGI on memory recall

Table 4 shows (with high levels of statistical significance) that participants did not correctly recall either the source of information they were provided with or the description of the information provided to them. Although difficult to interpret, two main factors can be used to explain these findings. Adding VGI increases the quality of the information present, and causes participants to believe it comes from professional sources – there is an association between a 'professional' label and the quality of an observed information environment. In addition, telling participants that the mashup included VGI might have tended to cause them to forget that it also included PGI.

Fuzzy-Trace Theory (Reyna and Brainerd 1995) describes how a person's reasoning and recollections are based upon how information is stored and recovered non-sequentially, often leading to incorrect or partly factual retrieval. Within this study, the experiences of using the mashup might have influenced their recall of instructions given during the tutorial, resulting in *false memories*. While it is unlikely that there exist any innate properties within mashups which cause a bias towards VGI in memory recall, users may have an expectation for such mediums to include crowdsourced materials, particularly given the current acceptance of social media. Consequently, under a *Fuzzy-Trace Theory* framework such expectations would work as cues, increasing the likelihood of the VGI element being remembered. While further research on the

influence of the mashup on users' perceptions of information content is needed, this does suggest that designers should not see the inclusion of VGI within a mashup as a negative influence. Instead, it may be an extension of user expectations within the context of current use of online media.

4.3 Limitations

The main limitation of this study is the lack of qualitative information from participants which would help explain how judgements were being made. Participants were not *required* to provide comment due to concerns following piloting that this would increase the dropout rate, particularly as it had been extremely challenging to recruit the target sample. There are also potential concerns over how representative the recruited sample was due to the extensive efforts made to recruit participants and the relatively low response rate in relation to the targeted population. It is possible that those who volunteered to participate were more socially motivated and confident using online maps than the general population, although these are also likely to be the particular subset of the user group who would make most use of online mashups. A further limitation of this form of study was that the user outcome measures were based on participant judgements, as opposed to actual differences in task-based outcomes arising from use of alternative information sets within a geographic context (May 2013).

The question of external validity is also important. While wheelchair users represent a very specific audience, their important characteristics were not so much their disability, or their use of maps, but (1) the fact that they rely on information in order to travel successfully (i.e. that *information matters* within the travel context) and (2) that they form an identifiable homogenous group (and hence the value of creating and using information within a homogenous user group can be assessed). Although the study uses maps as the form of information presentation, the key issues (and hence the influences on generalisability) are related to the creation and use of information by a homogenous user group. There are many examples of this within the general population, for example those groups defined by culture, language or interest.

Additionally, while the constructs demonstrated (with one exception) acceptable internal consistency through the Cronback's alpha coefficients, repeatability could not be tested due to the nature of the experimental design which included specific information to the participant and the limited sample availability. Future research could also investigate the extent to which these results can be reproduced, with similar and different participant samples.

5. Conclusions

Within this context, *actually including* VGI within a mashup influenced the perception of the information presented and, more specifically, the judgement of information being *up to date*. In comparison, *telling participants* that their mashup contained VGI had no influence on their judgements of trust, although it did increase the likelihood that they would forget about the professionally derived element within the mashup.

Consequently, this study suggests that information from volunteers should be included in map-based products where it provides unique information that can be used to supplement professional sources. Users of mashups appeared to pay little attention to the stated source of the information in relation to subjective quality, and instead made judgements based on what

information they saw, rather than what they were told. A designer should not look to utilise VGI with the hope that adding a *crowdsourced* tag should increase trust in that data, rather they should see VGI as a way of including content that cannot or would not be sourced through more conventional routes.

Funding

This study was undertaken as part of a PhD at Loughborough University Design School under the auspices of the Ideas in Transit project (www.ideasintransit.org), which was funded by the UK government via the Engineering and Physical Sciences Research Council, the Technology Strategy Board and the Department for Transport.

References

Bainbridge, Lisanne. 1983. "Ironies of Automation." *Automatica* 19 (6): 775–779.

Bishr, Mohamed, and Krazysztof Janowicz. 2010. "Can We Trust Information? – The Case of Volunteered Geographic Information." In *Towards Digital Earth: Search, Discover and Share Geospatial Data 2010. Workshop at Future Internet Symposium*. edited by Devaraju, A. Llaves, P. Maue, and C. Kessler, 1–6. Berlin, Germany: STI International.

Bishr, Mohamed, and Lefteris Mantelas. 2008. "A Trust and Reputation Model for Filtering and Classifying Knowledge about Urban Growth." *Geo Journal* 72 (3–4): 229–237.

Cardonha, Carlos, Diego Gallo, Priscilla Avegliano, Ricardo Herrmann, Fernando Koch, and Sergio Borger. 2013. "A Crowdsourcing Platform for the Construction of Accessibility Maps." In *Proceedings of the 10th International Cross-Disciplinary Conference on Web Accessibility – W4A '13*, 26–30 New York: ACM Press.

Carifio, James, and Rocco J. Perla. 2007. "Ten Common Misunderstandings, Misconceptions, Persistent Myths and Urban Legends about Likert Scales and Likert Response Formats and Their Antidotes." *Journal of Social Sciences* 3 (3): 106–116.

Collins, J. 2006. "An Investigation of Web-Page Credibility." *Journal of Computing Sciences in Colleges* 21 (4): 16–21.

Crone, Gerald Roe. 1968. *Maps and Their Makers: An Introduction to the History of Cartography*, edited by W. G. East. 4th ed. London: Hutchinson.

Das, T., and M. J. Kraak. 2011. "Does Neogeography Need Designed Maps?" In *Proceedings of the 25th International Cartographic Conference and the 15th General Assembly of the International Cartographic Association*, 1–6. Paris: International Cartographic Association (ICA).

DWP. 2012. *Family Resources Survey 2010/11*. London: Department for Work and Pensions.

Flanagin, Andrew J., and Miriam J. Metzger. 2008. "The Credibility of Volunteered Geographic Information." *GeoJournal* 72: 137–148. Fogg, B. J., Jonathan Marshall, Tami Kameda, Joshua Solomon, Akshay Rangnekar, John Boyd, and Brown Brown. 2001. "Web Credibility Research: A Method for Online Experiments and Early Study Results." In *CHI'01 Extended Abstracts on Human Factors in Computing Systems*, 295–296. Seattle: ACM.

Fogg, B. J., and Hsiang Tseng. 1999. “The elements of computer credibility.” In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: The CHI Is the Limit*, 80–87. Pittsburgh: ACM.

Frick, Andrea, M. T. Bächtiger, and Ulf-Dietrich Reips. 2001. “Financial Incentives, Personal Information and Drop-Out Rate in Online Studies.” In *Dimensions of Internet Science*, edited by U. D. Reips, and M. Bosnjak, 209–220. Lengerich: Pabst Science.

Gitelson, Richard J., and John L. Crompton. 1983. “The Planning Horizons and Sources of Information Used by Pleasure Vacationers.” *Journal of Travel Research* 21 (3): 2–7.

Goodchild, Michael F. 2007. “Citizens as Sensors: The World of Volunteered Geography.” *Geo Journal* 69 (4): 211–221.

Goodchild, Michael F. 2008. “Spatial accuracy 2.0.” In *Proceeding of the 8th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences*, edited by J.-X. Zhang, and M. F. Goodchild, 1–7. Shanghai: World Academic Union.

Goth, Greg. 2013. “Where It’s At: Mapping Battle Highlights New Era of Revenue and Development Models.” *IEEE Internet Computing* 17 (1): 7–9.

Guilford, J. P. 1956. *Fundamental Statistics in Psychology and Education*. 3rd ed. Tokyo: McGraw-Hill.

Haklay, Mordechai. 2010. “How Good Is Volunteered Geographical Information? A Comparative Study of OpenStreetMap and Ordnance Survey Datasets.” *Environment and Planning B* 37 (4): 682–703.

Hall, Mark. 2007. “On the Mark: Will Democracy Vote the Experts Off the GIS Island?” Accessed November 9, 2009. http://www.computerworld.com/s/article/299936/Will_Democracy_Vote_the_Experts_Off_the_GIS_Island_

Hara, Kotaro, Vicki Le, and Jon Froehlich. 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*, 631–640. New York: ACM Press.

Hawkins, Del, Roger J. Best, and Kenneth A. Coney. 1995. *Consumer Behavior: Implications for Marketing Strategy*, edited by G. A. Churchil Jr.. 6th ed. Chicago: McGraw-Hill Education.

Idris, Nurul Hawani, Mike J. Jackson, and Robert J. Abrahart. 2011a. “Colour Coded Traffic Light Labeling: A Visual Quality Indicator to Communicate Credibility in Map Mash-up Applications.” Presented at the International Conference on Humanities, Social Sciences, Science & Technology (ICHSST), Manchester, pp. 1–7.

Idris, Nurul Hawani, Mike J. Jackson, and Robert J. Abrahart. 2011b. “Map Mash-ups: What Looks Good Must Be Good?” In *Proceedings of the 19th GIS Research UK Annual Conference*, edited by C. E. Jones, A. Pearson, G. Hart, and N. Groome, 119–127. Portsmouth: GIS Research UK.

Jackson, S. P., W. Mullen, P. Agouris, A. Crooks, A. Croitoru, and A. Stefanidis. 2013. “Assessing Completeness and Spatial Error of Features in Volunteered Geographic Information.” *ISPRS International Journal of Geo-Information* 2 (2): 507–530.

Johnson, C. W. 2014. “Anti-social Networking: Crowdsourcing and the Cyber Defence of National Critical Infrastructures.” *Ergonomics* 57 (3): 419–433.

Keßler, Carsten, Johannes Trame, and Tomi Kauppinen. 2011. “Provenance and Trust in Volunteered Geographic Information: The Case of OpenStreetMap.” In *Conference on Spatial Information Theory: COSIT ’11*, 1–3. Belfast, ME: COSIT.

Keen, Andrew. 2007. *The Cult of the Amateur*. London: Nicholas Brealey.

Kingsbury, P., and J. P. Jones III. 2009. “Walter Benjamin’s Dionysian Adventures on Google Earth.” *Geoforum* 40 (4): 502–513. Kitao, Abe. 1978. “Levels of Trust and Reactions to Various Sources of Information in Catastrophic Situations.” In *Disasters: Theory and Research*, edited by E. L. Quarantelli, 147–158. Oxford: Sage.

Kline, Paul. 2000. *The Handbook of Psychological Testing*. 2nd ed. London: Routledge.

Knight, Gail, and Jo-Anne Bichard. 2012. “The Great British Public Toilet Map.” Accessed October 30. GreatBritishPublicToiletMap.rca.ac.uk

Koch, Fernando, Carlos Cardonha, Jan Marcel Gentil, and Sergio Borger. 2013. “A Platform for Citizen Sensing in Sentient Cities.” *Lecture Notes in Computer Science* 7685: 57–66.

Lehmann, Erich Leo. 1998. *Statistical Methods Based on Ranks*. Revised ed. Upper Sallde River, NJ: Prentice-Hall.

May, Andrew J. 2013. “Using a ‘Value-Added’ Approach for Contextual Design of Geographic Information.” *Applied Ergonomics* 44 (6): 895–908.

Mummidi, Lakshmi, and John Krumm. 2008. “Discovering Points of Interest from Users’ Map Annotations.” *Geo Journal* 72: 215–227. Network Rail. 2011. “London Waterloo.” Accessed August 11. http://www.nationalrail.co.uk/stations/wat/details.html

Nunnally, J. C. 1978. *Psychometric Theory*. 2nd ed. New York: McGraw-Hill.

Oates, George. 2008. “Around the World and Back Again.” Accessed November 5, 2012. http://blog.flickr.net/en/2008/08/12/around-the- world-and-back-again/.

OSM. 2012. “OpenStreetMap Stats.” Accessed January 12. OpenStreetMap.org Pallant, J. 2010. *SPSS Survival Manual*. 4th ed. Maidenhead: McGraw-Hill Education.

Parker, Christopher J., Andrew J. May, and Val Mitchell. 2012a. “The Role Of VGI And PGI in Supporting Outdoor Activities.” *Applied Ergonomics* 44 (6): 886–894.

Parker, Christopher J., Andrew J. May, and Val Mitchell. 2012b. “Understanding Design with VGI Using an Information Relevance Framework.” *Transactions in GIS* 16 (4): 545–560.

Parker, Christopher J., Andrew J. May, Val Mitchell, and Alison Burrows. 2013. “Capturing Volunteered Information for Inclusive Service Design: Potential Benefits And Challenges.” *The Design Journal* 16 (2): 197–218.

Ray, Nina M., and Mary Ellen Ryder. 2003. “‘Ebilities’ Tourism: An Exploratory Discussion of the Travel Needs and Motivation of the Mobility-Disabled.” *Tourism Management* 24(1): 57–72.

Reyna, V. F., and C. J. Brainerd. 1995. “Fuzzy-Trace Theory: An Interium Synthesis.” *Learning and*

Individual Differences 7 (1): 1–75. Ricker, Britta A., Peter A. Johnson, and Renee E. Sieber. 2013. "Tourism and Environmental Change in Barbados: Gathering Citizen Perspectives with Volunteered Geographic Information (VGI)." *Journal of Sustainable Tourism* 21 (2): 212–228.

Rieh, Soo Young. 2002. "Judgment of Information Quality and Cognitive Authority in the Web." *Journal of the American Society for Information Science and Technology*, 53 (2): 145–161.

Rieh, Soo Young, and Nicholas J. Belkin. 2000. "Interaction on the Web: Scholars' Judgment of Information Quality and Cognitive Authority." *Proceedings of the 63rd ASIS Annual Meeting* 37: 25–38.

Robins, David, and Jason Holmes. 2008. "Aesthetics and Credibility in Web Site Design." *Information Processing and Management* 44 (1): 386–399.

Rotter, Julian B. 1967. "A New Scale for the Measurement of Interpersonal Trust." *Journal of Personality* 35 (4): 651–665.

Schuett, Michael A. 1993. "Information Sources and Risk Recreation: The Case of whitewater Kayakers." *Journal of Park and Recreation Administration* 11 (1): 67–77.

Southeastern. 2011. "Greenwich." Accessed August 11. nationalrail.co.uk

Tabachnick, Barbara G., and Linda S. Fidell. 2001. "Using Multivariate Statistics." edited by R. Pascal and W. Brown. 4th ed. Needham Heights: Allyn and Bacon.

Tavakol, Mohsen, and Reg Dennick. 2011. "Making Sense of Cronbach's Alpha." *International Journal of Medical Education* 2: 53–55. TFL. 2011. "Transport Accessibility: Buses." Accessed August 5. tfl.gov.uk

Tillotson, Joy. 2002. "Web Site Evaluation: A Survey of Undergraduates." *Online Information Review* 26 (6): 392–403.

Wathen, C. Nadine, and Jacquelyn Burkell. 2002. "Believe It or Not: Factors Influencing Credibility on the Web." *Journal of the American Society for Information Science and Technology* 52 (2): 134–144.

Weait, Richard. 2011. "OpenStreetMap Used by TripAdvisor." Accessed October 8. opengeodata.org

Wikimapia. 2012. "Wikimapia Home Page." Accessed November 30. wikimapia.org

Wood, Harry. 2012. Apple Maps j OpenStreetMap Blog. Accessed August 25, 2013. blog.openstreetmap.org

Yaari, Eti, Shifra Baruchson-Arbib, and Judit Bar-Ilan. 2011. "Information Quality Assessment of Community Generated Content: A User Study of Wikipedia." *Journal of Information Science* 37 (5): 487–498.