The Usability of Online Data Maps: An Ongoing Web Based Questionnaire Investigation into Users' Understanding and Preference for Geo-Spatial Visualisations

Craig Allison[1], Richard Treves[2], Edward Redhead[3]

[1]Web Science Doctoral Training Centre, University of Southampton, Highfield Campus, University Road, Southampton, SO17 1BJ

Tel. +44 (0)23 8059 2738

Craig.Allison@.soton.ac.uk

[2]School of Geography, University of Southampton, [3]School of Psychology, University of Southampton

KEYWORDS: Geo-Visualisations, Neo-Cartography, Usability, Neo-Geography, Crime Maps

1.0 Introduction

The last decade has seen the large scale growth of web based maps, Google reports there are 800,000 uses of the Google Maps API on the web (Marks, 2012). This explosion of use since around 2005 has been matched by an increase in the tools and visualisation types available for producing web maps such as JavaScript libraries and developer tools, for example the Google maps API (Google, 2012). However, usability of the visualisations produced with these new tools is rarely discussed within both the formal and informal literature which is similar to the lack of usability testing within early GIS systems (Haklay & Zafiri, 2008).

This article presents early findings from a web based task and survey set up to investigate the usability of two particular visualisations: cluster maps and heat maps. Both techniques are common on the web and are designed to overcome data crowding, a key limitation of geo-visualisations (see Figure 1.). This problem occurs when the number of point symbols on a map rises to a level where they obscure both additional points and the underlying map, reducing overall clarity (Krygier & Woods, 2005).

Figure 1. An example of a data crowded map from transport for London showing bike stations.

Cluster maps (Figure 2.) solve this visual problem by clustering points in a catchment area and replacing the group with a single symbol, usually marked with the number of points it contains. The clustering is recalculated at each zoom step into or out of the map, (Mahe & Broadfoot, 2010). Note that the 'catchment' of each cluster point is recalculated at each zoom step and is not visible to the user, this can raise issues of usability as cluster markers actively appear, disappear and migrate as the user zooms in or out.

Figure 2. An example cluster map. Taken from http://www.police.uk/crime/?q=London,%20UK#crimetypes/2012-09

Heat maps (Figure 3.) are density choropleth maps usually using a yellow to red or blue to red 'heat' palette. Similar to cluster maps, the densities are calculated by a variety of algorithms whose variables can be adjusted. Density plots have received criticism for being easy to bias (Alcada-Almeida et al., 2009, Monmonier, 1996), potentially damaging user confidence.

Figure 3. Heat map used within this study.

This study aims to investigate whether there is a difference between users' ability to understand the two visualisations and also if there is a difference in users' preferences for both visualisations.

2.0 Method

Methods used were based on the work of Midtbo and Nordvik (2007) who used a web based interaction task and survey to investigate the impact of zoom on map based interactions. This was because we wished to reach a large and diverse user population. The aim of our questionnaire was to obtain qualitative data about how the users felt about the maps and quantitative data about their performance of using the map to solve typical questions. The questions used a five point likert scale, using the “System Usability Scale” (Brooke, 1996 cited in Bangor, Kortum & Miller, 2008). Demographic characteristics (age, gender, etc.) were also collected. The questionnaire took approximately 10 minutes to complete and is available at https://www.isurvey.soton.ac.uk/condition_start.php?id=145

2.1 Participants and Recruitment

The users tested consisted of 80 respondents, aged 19 – 72 years (M= 27.46 years, SD= 10.94 years). Participants were invited to participate in the study via Twitter, facebook, online fora, an online advert on an intranet and posters disseminated across The University of Southampton’s Highfield campus. Participants were not offered compensation for their time.

2.2 Map Videos

Participants were presented with videos of a map visualisation displaying fictitious crime data being zoomed and panned. Volunteers in the test were shown a video of both the cluster and heat map sequentially. The participant was zoomed in to one corner of a square study area then back out to a high view, then back in to the opposite corner. This ‘journey’ ensured that users experienced the dynamic symbol changes in both types of visualisation as they were zoomed in and out. An example video used within this study is available at http://www.youtube.com/watch?v=-ufnzeAsTvU, which shows a cluster map of Minsk.

The maps used were of cities in Eastern Europe to try to ensure that participants were not affected by previous knowledge and all data used was fictional. Participants viewed the alternative maps with different cities. Map type and city were randomised to avoid any location effects due to a particular map or city. Pilot studies were run to ensure that the questionnaire was functional and clear.

2.3 Data Collection and Analysis

All questionnaire data was automatically stored within a survey web application 'isurvey'. We aim to fully analyse results when we reach 200 completed tests, since we currently have 80 completed tests, this report will focus on participants responses so far to open questions examining accuracy, understanding and preference of the map displays. Content analysis (Holsti, 1969) was used when examining qualitative data to describe trends within the communication.

3.0 Results and Discussion

Results clearly indicate that a significant number of users were unable to accurately interpret the data within either the cluster or heat display. Accuracy was based on participants' ability to correctly identify the densest area of crime within the visualisations. The map was divided into a 3 x 3 grid, and participants' responses compared to the densest crime region. Participants were judged as providing either correct or incorrect response. Accuracy across map type and location is presented in Table 1. Although accuracy for both conditions was considerably lower than anticipated, participants were more successful when interacting with the heat maps.

Table 1. Accuracy Across location and Map Type

	Minsk		Tiraspol	
Map Type	Correct (%)	Incorrect (%)	Correct (%)	Incorrect (%)
Cluster	47.50	52.50	37.50	62.50
Heat	60.00	40.00	55.00	45.00

This trend continues when describing the visualisations, with users frequently being able to better explanations of what the heat map visualisation represents:

"Crime density in a specific area is represented as shades of colour ranging from blue to orange/red. The more intense the orange/red the colour the higher the crime density in the area"

However, many participants did make considerable errors when interpreting this visualisation including confusing density of crime events per km with severity of crime.

"Red areas: particularly extreme crime, blue outline crime dissipates to less serious crime (e.g. shop lifting as opposed to knife crime)"

Users' general understanding of the cluster maps was far weaker. Although the majority were able to offer a basic explanation of what a cluster map shows, they seldom provided sufficient detail to illustrate clear understanding.

"Balloons indicate individual crime, circles show multiple crime that occurred close to one another"

Issues relating to amalgamation of points into clusters were rarely mentioned, suggesting that users did not fully understand this process.

Preferred map type was addressed as a closed question once participants had interacted with both visualisations, the results of which are presented in Figure 4. Despite many users inability to accurately interpret the cluster maps, many users preferred this visualisation.

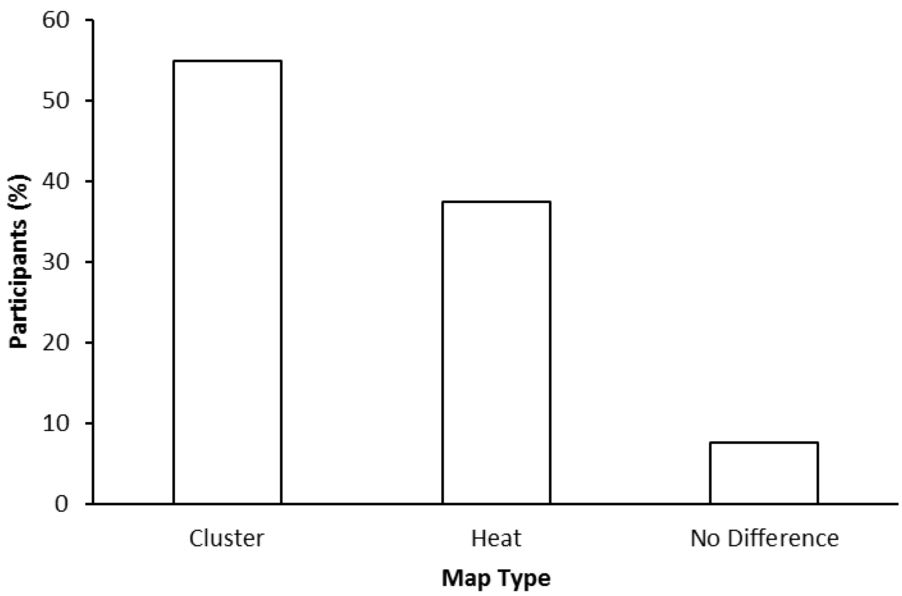

Figure 4. Participants Preferred Map Interface across all locations

Participants were also asked to explain their reasoning, with the most common being introduction of numerical values.

"Because there was a number it was easier to comprehend the actual number of crime"

Participants who preferred cluster maps mostly gave reasons about the number symbols used being specific and easy to interpret. In contrast, users who preferred the heat map suggested that clusters were unreliable due to aggregation effects. Although reliability is not the focus of this investigation, these results show that data reliability is in an important aspect that participants considered in evaluating the two map types. It is our opinion that participants who preferred cluster maps because of the perceived reliability of the number symbols are misguided because they do not know the catchment area which was used to generate that number. However, this is not to say that those who prefer the heat map because of this problem are necessarily 'right', the heat map has been produced using an algorithm with variables which were not explained to them so this visualisation also has problems of reliability.

Further analysis and data is required to examine whether variance within the data can be explained by demographic factors, including age, gender and experience.

4.0 Conclusions

The results show that there are a number of problems with users' understanding of both types of map visualisation. Amongst a number of issues our preliminary analysis has identified two important interpretation problems: mistaking density of crime events with severity of crime and a belief that the number symbols associated with clusters are more reliable than a choropleth visualisation of data. It is vital that map producers using these types of visualisation need to be aware of these problems which lead to the misinterpretation of their carefully produced maps.

Alongside more detailed analysis of the data, further work will investigate if quick screencast tutorial videos can help avoid misinterpretation problems of dynamic maps.

6. Acknowledgements

This research was funded by the Research Councils UK Digital Economy Programme, Web Science Doctoral Training Centre, University of Southampton. EP/G036926/1

7.0 References

Alçada-Almeida, L., Tralhão, L., Santos, L., Coutinho-Rodrigues, J. (2009) A multiobjective approach to locate emergency shelters and identify evacuation routes in urban areas. *Geographical Analysis*, 41, 9–29.

Bangor, A., Kortum, P. T., & Miller, J. T. (2008) An Empirical Evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction*, 24, 574–594

Haklay, M., & Zafiri, A., 2008, Usability Engineering for GIS: Learning From A Screenshot, *The Cartographic Journal*, 45(2) 87-97.

Holsti, R, 1969 *Content Analysis for the Social Sciences and Humanities*. Reading, MA: Addison-Wesley.

Google Developers, Google Maps API 2012, Google, Available at:

<https://developers.google.com/maps/>. [Accessed 25th October 2012]

Krygier, J. & Wood, D. (2005). *Making Maps: A Visual Guide to Map Design for GIS.* New York: Guilford Press.

Mahe, L., & Broadfoot, C. Google Geo APIs Team, 2010. Too Many Markers! Available at: <https://developers.google.com/maps/articles/toomanymarkers> [Accessed 28th October 2012].

Marks, M. 2012. Google Geo Developers Blog, GoV3: It's time to Upgrade. Available at: < http://googlegeodevelopers.blogspot.co.uk/2012/06/gov3-its-time-to-upgrade.html> [Accessed 28th October 2012].

Midtbø, T., & Nordvik, T. (2007). Effects of Animations in Zooming and Panning Operations on Web-maps: A Web-based Experiment. *The Cartographic Journal,* 44 (4), 292– 303.

Monmonier, M. S. (1996) *How to lie with maps*, 2nd ed., Chicago: University of Chicago Press

8.0 Biography

Mr Craig Allison is a second year Ph.D. student at the University of Southampton. A member of the Web Science DTC, Craig has a background in Psychology. His research interests focuses on factors which affect individuals' interaction with spatial mediums, currently focusing on the accessibility of geo-visualisations.

Mr Richard Treves is a learning developer in the School of Geography and Environment, University of Southampton. His research interest is in map usability in an educational context and he is particularly interested in Google Earth tours and map symbolisation.

Dr Edward Redhead is a Senior Lecturer within the School of Psychology, University of Southampton. His research interests focus on spatial cognition and associative learning. Of particular interest is monitoring the cues that individuals use to remain orientated within changing and nested environments.