Expectations and prejudices usurp judgements of schematic map effectiveness

Maxwell J. Roberts*, Ida C.N. Vaeng
University of Essex, UK
*Corresponding author e-mail: mjr@essex.ac.uk
DOI: 10.21606/drs2016.123

Abstract: A usability study is reported in which objective measures of performance were compared with subjective ratings of design effectiveness for two novel schematic London Underground maps. One of these was designed conventionally, but was deliberately intended to have complex line trajectories. The other was a novel curvilinear design, prioritised similarly. The selection of designs was motivated by a previous usability rating study in which the curvilinear map had received the lowest scores. For the current study, people planned a series of journeys using both designs. The curvilinear map yielded superior performance in terms of time to plan each journey. Despite experience with both designs, the curvilinear map still received poor usability ratings. It is suggested that expectations and prejudices about design prevent people from making accurate subjective evaluations of usability.

Keywords: schematic maps; familiarity; usability study; rating study

1. Introduction

Schematic maps, such as the London Underground diagram, first published in 1933 and designed by Henry Beck (Garland, 1994; Roberts, 2005) have become particularly associated with urban rail networks worldwide (Ovenden, 2015). Typically (as per London) these are highly stylised, with routes shown as straight lines – horizontal, vertical, or 45° diagonals – joined by tightly radiused corners. Mathematically, this is known as an octolinear design. Topography may be considerably distorted, and most, if not all, surface details omitted, so that the focus of such designs is on the routes, stations, and inter-connections between lines. This method of information presentation can be amongst the most complex that members of the public are likely to be expected to use in everyday life. Indeed, with ever-increasing network complexity worldwide, a mathematical analysis (Gallotti, Porter, & Barthelemy, 2016) suggests that there is cognitive limit to the understandability of large
transport networks. The challenge for designers – the creation of legible, effective network maps in an attempt to tame the complexity – therefore increases year-by-year. Despite the proliferation of journey-planning software, the network map remains an important source of information. Indeed, many applications for hand-held devices are merely standard network maps with extra functionality added, such as options to add additional layers of information to a base design.

A number of suggestions have been made for optimising schematic map design, although these often take the form of lists of sometimes-conflicting criteria that are only rarely supported by evidence from usability studies (e.g., Nöllenburg; 2014, Ovenden, 2008). Roberts (2012, 2014) attempts to organise the various criteria for effective design into a broad framework of five categories, with simplicity and coherence of particular importance here. Simplicity refers to the line trajectories: the key-most requirement for a schematic map is that complex routes are converted into simple line trajectories on the diagram. Coherence refers to the need to relate the elements of a network to each other so that the overall design has good shape. Failure to address the simplicity criterion can result in routes comprising numerous short zig-zagging segments: reality has not been simplified, instead the shape of the complexity has merely been changed. The coherence criterion can be violated, for example, if the number of angles on a map is increased, and no effort is made to keep the lines parallel (see Figure 1). The worst-designed examples in these respects impact on the overall intelligibility of a map, making the elements of a network hard to identify, concealing its underlying structure, and reducing the effectiveness of a design for planning journeys and learning about the system.

It is suggested by many commentators that octolinearity by itself should be a design requirement (e.g., Nöllenburg & Wolff, 2011; Ovenden, 2005, p. 39). Hence, adherence to this will result in a more effective design than any other possible method of configuration. This has been named the octolinearity as a gold standard conjecture but Roberts et al. (2013) argue that there is little evidence in its support. Roberts (2012) suggests that different networks worldwide have different properties, and that some may have line trajectories and interconnections that are a poor match for octolinearity, causing difficulties for optimisation by preventing the simplification of line trajectories. The gold standard conjecture was refuted in a series of usability studies investigating alternative Paris Metro map designs (Roberts et al., 2013). For this network, the highly interconnected lines have very complex trajectories, and the official octolinear schematic reflects this, with the result that the underlying network structure is difficult to discern. The usability study investigated the times required to plan complex journeys, and a curvilinear design (i.e. no straight lines at all) consistently outperformed the official version, with planning times up to 50% faster across experiments.
Figure 1 The nine London Underground maps from the internet-based rating task reported by Roberts (2014). Image copyright Maxwell J. Roberts, www.tubemapcentral.com, all rights reserved, reproduced with permission.
One difficulty faced by those who wish to produce well-motivated innovative schematic maps is that these may violate people’s expectations about effective design. Informally, this can be observed in commentaries on internet sites worldwide. Roberts (2014) discusses these in terms of the lay-theories of design that underlie them, and notes that these can be entrenched, and yet subject to considerable individual differences. This can result in costly mistakes when unexpected public reaction causes the premature withdrawal of a design. More formally, Roberts et al. (2013) noted that the correlations between an objective measure of performance (planning time) and subjective measures (map preference, and a score derived from questionnaire responses) were effectively zero. Despite the superior usability of the novel curvilinear design, only 50% of people preferred it.

To investigate lay-theories of design in more detail, an internet rating study has been implemented, in which people were asked to assess the usability and attractiveness of nine different specially-created London Underground maps (see Figure 1). These were presented as a matrix of nine designs, which varied by configuration (octolinear, curvilinear, multilinear – a linear map with any angle permitted, and hence at a disadvantage in terms of the coherence criterion) and also by design priorities. The stylised maps were optimised in terms of having the simplest line trajectories, the geographical maps were intended to have high accuracy in this respect, with the inevitable consequence of more complex line trajectories, while the compact maps were intended to have the most complex line trajectories of all, but without any requirement for geographical accuracy. A preliminary analysis of data from the first one-hundred respondents (Roberts, 2014) indicated a considerable octolinear bias, with usability ratings greater for octolinear maps than for curvilinear or multilinear designs by a far higher margin than would have been expected from usability studies. However, people were sensitive to line trajectory simplicity, with map ratings within trios with shared design rules always favouring the simpler designs.

Having identified the usability ratings for nine different maps, the next logical step is to conduct studies using these designs to compare subjective and objective measures. Roberts et al. (2013) organised their study such that each person planned journeys using just one map (a between-subjects design) with the consequence that when people subsequently made a selection from these, only one of the alternatives familiar to them. A more powerful design administers multiple maps to each person, so that each of these is experienced directly before evaluation, and the relative ease of use for each individual can also be identified, and related directly to their subjective assessments and choices. For the internet rating study, the maps were merely assessed visually, and so it is necessary to ask whether direct experience at using the designs (1) enables a better calibration between overall subjective ratings of usability and actual measures of objective usability; and (2) enables a better assessment of the relative usability of particular designs, so that after experience at using both, even for the novel or unusual versions, this enables a better judgement of their relative merits.
Expectations and prejudices usurp judgements of schematic map effectiveness

Figure 2 The London Underground compact curvilinear map selected for the current study Image copyright Maxwell J. Roberts, www.tubemapcentral.com, all rights reserved, reproduced with permission.
Figure 3  The London Underground octolinear map selected for the current study, intended to match the curvilinear map for design priorities – complex line trajectories without geographical accuracy. Image copyright Maxwell J. Roberts, www.tubemapcentral.com, all rights reserved, reproduced with permission.
It would not be practical to administer all nine designs to one individual, but pilot studies have shown that it is possible to administer two or even three maps without measurable crosstalk between versions. For the usability study reported here, the worst-scored map from the internet study was identified. This was the compact curvilinear design (see Figure 2), which was rated as easy to use by only four out of 100 individuals (71 rated the design as hard to use). In contrast, the equivalent compact octolinear design (see Figure 3) was rated as easy to use by 37 people, and overall it was rated as third in terms of usability – only the ratings of the other two octolinear designs exceeded it. It is indeed possible that the difference in usability ratings between compact octolinear versus compact curvilinear will match objectively measured usability: the octolinear design uses tried-and-tested rules (albeit with poor optimisation). Alternatively, the ratings might simply be a reflection of expectations and prejudices, and there is no reason to give adverse ratings to the curvilinear map. This possibility was investigated via a journey planning task. Subjective ratings of the maps were collected after this, to see whether direct experience at the two designs would result in a close match between objective and subjective measures.

2. Method

2.1 Sample
Twenty-two people took part in this experiment, 6 males and 16 females. They were all unpaid volunteers from the University of Essex with a mean age of 21.6 years (SD 1.1). All had at least some experience of travel in London by Underground, rating their frequency of use as, at the very least, a few times a year.

2.2 Materials
The maps for the journey planning task were printed to fit A3 sheets and laminated. Two sets of five journeys were assembled as follows:

Set A – practice trial: Moor Park (Metropolitan Line) to East Acton (Central Line)  
Crystal Palace (London Overground) to West Harrow (Metropolitan Line)  
Queensbury (Jubilee Line) to Crouch Hill (London Overground)  
Colliers Wood (Northern Line) to Finchley Road & Frognal (London Overground)  
Acton Central (London Overground) to Arnos Grove (Piccadilly Line)  
Deptford Bridge (DLR) to Wembley Central (Bakerloo Line)

Set B – practice trial: South Ruislip (Central Line) to Hatch End (London Overground)  
Heathrow Airport Terminals 1/2/3 (Piccadilly Line) to London City Airport (DLR)  
Vauxhall (Victoria Line) to South Acton (London Overground)  
Wanstead Park (London Overground) to Greenford (Central Line)  
Imperial Wharf (London Overground) to Northwood Hills (Metropolitan Line)  
Colindale (Northern Line) to Anerley (London Overground)
These were chosen such that they would be difficult to plan, with distant start and destination stations, a requirement to cross London, and many alternative options. At least two interchanges were required to complete each journey. An attempt was made to represent all lines/regions of the map equally between item sets. Each journey was shown on an individual A4 laminated sheet with the map greyed out except for the start (arrowed) and destination stations.

A 21-item questionnaire was used, based on Roberts et al. (2013). Most questions were answered using seven point rating scale. For these, statements were given along with seven options ranging from strongly agree through neutral to strongly disagree. For each question, an answer or a decision was required for both of the maps. The full set of questionnaire items was as follows.

Questions 1 to 15 were seven-point rating-scale questions as described previously. Asterisks denote questions that directly ask for opinions about usability aspects of design.

*1) I found journeys easy to plan using this map
*2) Routes were difficult to discriminate (identify) using this map
*3) Station names were easy to identify using this map
*4) Station interchanges were difficult to negotiate using this map
*5) Line trajectories were easy to follow using this map
*6) I found this map disorientating to use
*7) I would be happy to use this map to plan real-life journeys around London
8) I preferred a direct-looking route, no matter how many interchanges required
9) Some parts of the map looked complicated, and I planned journeys to avoid them
10) This map is intended for planning journeys but I think it is also geographically accurate
*11) With this map, I would rather walk or take a taxi than use the London Underground
12) The best routes for me had the fewest station stops along the way
*13) I found the map visually disturbing
*14) I found the map clean and uncluttered
*15) I would look for another design of London Underground map to use at the earliest opportunity

Questions 16 and 17 requested brief sentences, i.e. qualitative responses, separately for each map.

16) Briefly, what, if any, aspect of this map did you like the most?
17) Briefly, what, if any, aspect of this map did you like the least?

Question 18 was a forced choice item, one map or the other preferred.

18) Of the two designs you have used, which one do you think you would prefer for everyday use?
Question 19 queried frequency of travel and gave a number of options.

19) Roughly how often do you travel by rail to make a journey in London?
Every day/A few days every week/A few times every month/About once a month/A few times a year/Once a year or less/Never, or not for years

Questions 20 and 21 repeated the map rating task reported by Roberts (2014). All nine London maps were presented (see Figure 1) and people were asked to rate each map for usability and attractiveness on a three point scale; Easy to use/Neutral/Hard to use; and Attractive/Neutral/Unpleasant.

2.3 Design
All people planned journeys using both maps, five journeys for one design, then five journeys for the other. Eleven planned journeys using the octolinear map first, the remaining eleven received the curvilinear map first. Ten people received journey Set A paired with the curvilinear map (and hence Set B with the octolinear Map) and Twelve people received Set A paired with the octolinear map.

This was primarily a within-subjects design, with Map Type (two levels, Octolinear versus Curvilinear) as the independent variable. Measures of map performance included the time taken to plan a journey, and an estimation, made by the experimenter, of the duration that the planned journeys would have taken had they been implemented. Questionnaire data provided a means of measuring people’s subjective assessments of map usability.

2.4 Procedure
People were tested individually in quiet surroundings. They were informed that they would be asked to plan a series of journeys using two versions of the London Underground map. They were to assume that the network was fully operational and that there were no cost considerations. They were given no guidance as to journey criteria or priorities, it was simply stated that they should devise the journey that they would choose if they were actually to undertake it in real life. They were also informed that they should only change between lines at designated interchanges shown on the map.

People were given an opportunity to view the first map while the initial instructions were given. The practice journey was administered, then the five test journeys for that map, presented in a random order. Each trial commenced with the experimenter placing the journey sheet indicating start and end stations above the A3 laminated map, and immediately commencing timing using a stop-watch. The subject was asked to plan the journey as requested, using a dry-wipe marker. Once satisfied with the plan, a verbal announcement was made, timing stopped, and the final chosen route was transcribed onto an A4 paper map, overseen by the experimenter. Following this, the experimenter cleaned all marks from the laminated map and the next trial commenced. Once all journeys were completed, the process was repeated with the second map.
When all journeys had been planned, the questionnaire was administered. There was no opportunity to view the maps for this, except for the final two questions, where the two original maps were re-presented, along with the seven previously unseen, so that the rating task could be completed.

3. Results

For each person, mean planning times were calculated from the five test journeys for each map. For each journey, its duration was estimated by allowing two minutes per station and ten minutes per interchange. This is comparable with the heuristics that passengers themselves use (e.g., Vertesi, 2008) and ignores the variable interchange quality within most metro networks, which is virtually impossible to communicate via maps. There were just two planning errors (both involved a proposal for an interchange where none was shown), both for the octolinear map. Estimated journey durations were simply averaged over the remaining four trials for the two people concerned. Mean journey planning times and estimated journey durations are given in Table 1.

The difference in mean journey planning time between maps is significant. Using within-subjects analysis of variance, $F(1,21) = 7.60$, $MSe = 192.4$, $p < .05$. On average, journeys required less time to plan using the curvilinear map. There was no evidence that the superior planning time was associated with less efficient journeys, with no significant difference between maps, $F(1,21) = 0.09$, $MSe = 18.7$, $p > .05$.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Performance for the two maps showing objective measures and aggregate questionnaire ratings, overall, and by map choice. Means in bold, standard deviations in italics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Octolinear Map</td>
</tr>
<tr>
<td>Mean journey planning time (seconds per journey)</td>
<td>65.6 (23.0)</td>
</tr>
<tr>
<td>Mean estimated journey duration (minutes per journey)</td>
<td>68.7 (4.2)</td>
</tr>
<tr>
<td>Mean aggregate questionnaire score (range 11 to 77)</td>
<td>55.2 (10.5)</td>
</tr>
<tr>
<td>Mean planning time for people who chose the curvilinear map (seconds per journey)</td>
<td>75.8 (27.2)</td>
</tr>
<tr>
<td>Mean planning time for people who chose the octolinear map (seconds per journey)</td>
<td>59.8 (19.0)</td>
</tr>
<tr>
<td>Mean aggregate questionnaire score for people who chose the curvilinear map (range 11 to 77)</td>
<td>47.8 (10.7)</td>
</tr>
<tr>
<td>Mean aggregate questionnaire score for people who chose the octolinear map (range 11 to 77)</td>
<td>59.5 (7.8)</td>
</tr>
</tbody>
</table>
The superiority of the curvilinear map was not reflected in the questionnaire ratings of usability. Aggregate rating scores were created by using the 11 asterisked questions that were relevant to usability (see section 2.2). The questions were bi-directional, so that agreeing with the statements in some indicated positive assessments of a map, but agreeing with the statements of others indicated adverse assessments. Scores on the latter were reversed (so that a rating of 1 became 7, 2 became 6, etc.) and the scores for each person for each map were then totalled separately. This gave aggregate rating task scores, in which 77 indicated the highest possible rating of a design, 11 the worst possible, and 44 a neutral score. Table 1 shows that the octolinear map was given a higher aggregate rating than the curvilinear design, the opposite to the difference in the objective measure of performance, but the difference in means was not significant, $F(1,21) = 1.60, MSe = 197.6, p > .05$.

The poor usability ratings of the curvilinear map, previously identified by Roberts (2014) are not justified by the results here. However, two maps were administered to each person here, so that it is possible to determine whether individuals are sensitive to relative differences in their own performance when evaluating the different designs. Of the 22 people in this experiment, eight chose the curvilinear map when asked to express a preference, and fourteen chose the octolinear version. If people were deciding on the basis of their performance, then those who chose the octolinear map should have better planning times for this compared with the curvilinear map, and those who chose the curvilinear map should have better planning times for this compared with the octolinear map. The means in Table 1 show that this is not the case: irrespective of map choice group, mean planning times for the curvilinear map were better. The statistical test for this hypothesis is to determine whether there is a significant interaction in a two-factor mixed design Analysis of Variance, in which Map Choice is the between subjects factor, and Test Map is the within-subjects factor. There was no significant interaction, $F(1,20) = 1.18, MSe = 190.8, p > .05$.

Despite the lack of a relationship between map choice and the objective measure of performance, the basis of the choice is not arbitrary, and has a clear relationship with the aggregate questionnaire score evaluation of the maps. People who gave the octolinear map a higher rating then the curvilinear map were more likely, subsequently, to select this in preference. Conversely, people who gave the curvilinear map higher ratings then the octolinear map were more likely, subsequently, to select this in preference. This time the interaction, between Map Choice and Test Map, is significant, $F(1,20) = 18.2, MSe = 108.6, p < .01$.

There were no other aspects of individuals that could be related to map choice. Three of the six males selected the curvilinear map, and five of the fourteen females. Also, categorising people into low use (used the Underground once a month or less) versus high use (a few times each month or more), three of the seven high use individuals selected the curvilinear map, compared with five of the fifteen low use individuals.
The lack of any clear relationship between objective performance and map selection is shown in Figure 4, where individual planning time differences between maps are plotted, rank ordered. The graph hints at the possibility that, for people who find the octolinear map particularly difficult to use, with the most adverse difference scores of all, there might be some awareness of this, so that the curvilinear map is chosen in preference. A larger sample size would be required in order to be able to test for this. Conversely, looking at the differences in questionnaire scores between the two maps (Figure 5), the findings are clear-cut, and the map that is relatively positively rated is almost always selected in preference, even where there is only a slight difference in the rating scores.

Unsurprisingly, the correlation between planning time advantage for one map over the other, versus questionnaire aggregate advantage for one map over the other, was low and not significant ($r = -0.12, p > .05$) but was at least in the expected direction. People who had a curvilinear map planning time advantage were likely to score the curvilinear map more highly than the octolinear version on the questionnaire.
Expectations and prejudices usurp judgements of schematic map effectiveness

Figure 5  Difference scores for questionnaire ratings of map effectiveness, for individuals, rank ordered in size, also showing map preference and usability/attractiveness ratings. There is a clear relationship between the subjective measures, with differences in questionnaire evaluations for the two maps clearly related to preference/selection.

The final analysis concerns the single-question usability and attractiveness ratings for all nine maps. Ratings were combined and scaled so that if every person rated the usability of a map as hard to use (or unattractive for the other rating) then it would receive an overall score of zero. Conversely, if every single person rated a map as easy to use (or attractive for the other rating) then it would receive an overall score of 100. Usability ratings are given in Table 2, and attractiveness ratings in Table 3.

Table 2  Overall usability ratings for the nine maps. The two that were used for journey planning in this current study are in bold. Data from Roberts (2014) are also included, in italics.

<table>
<thead>
<tr>
<th></th>
<th>Octolinear Map</th>
<th>Curvilinear Map</th>
<th>Multilinear Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stylised</td>
<td>100%</td>
<td>55%</td>
<td>59%</td>
</tr>
<tr>
<td>(simple line trajectories)</td>
<td>93%</td>
<td>32%</td>
<td>53%</td>
</tr>
<tr>
<td>Geographical</td>
<td>73%</td>
<td>39%</td>
<td>30%</td>
</tr>
<tr>
<td>(intermediate line trajectories)</td>
<td>60%</td>
<td>28%</td>
<td>38%</td>
</tr>
<tr>
<td>Compact</td>
<td>86%</td>
<td>46%</td>
<td>36%</td>
</tr>
<tr>
<td>(complex line trajectories)</td>
<td>53%</td>
<td>17%</td>
<td>32%</td>
</tr>
</tbody>
</table>
Table 3 *Overall attractiveness ratings for the nine maps. The two that were used for journey planning in current study are in bold. Data from Roberts (2014) are also included, in italics.*

<table>
<thead>
<tr>
<th></th>
<th>Octolinear Map</th>
<th>Curvilinear Map</th>
<th>Multilinear Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stylised</td>
<td>84%</td>
<td>55%</td>
<td>34%</td>
</tr>
<tr>
<td>(simple line trajectories)</td>
<td>86%</td>
<td>51%</td>
<td>41%</td>
</tr>
<tr>
<td>Geographical</td>
<td>64%</td>
<td>39%</td>
<td>18%</td>
</tr>
<tr>
<td>(intermediate line trajectories)</td>
<td>54%</td>
<td>42%</td>
<td>25%</td>
</tr>
<tr>
<td>Compact</td>
<td>71%</td>
<td>52%</td>
<td>7%</td>
</tr>
<tr>
<td>(complex line trajectories)</td>
<td>55%</td>
<td>36%</td>
<td>18%</td>
</tr>
</tbody>
</table>

Overall, the results are similar to those reported by Roberts (2014), including the tendency for linear maps to receive much higher usability ratings than attractiveness ratings. The curvilinear maps do not show this trend, and together this implies a general expectation that maps based on straight lines, irrespective of their angles, have usability advantages which are not shared by curvilinear designs. Interestingly, compared with Roberts (2014), the multilinear map scores for both attractiveness and usability are similar, and sometimes reduced, whereas the octolinear and curvilinear scores are generally raised, with particularly high gains for the two designs tested here. This might imply some sort of familiarity effect, or else a confidence effect – having succeeded with these designs during the testing phase, they now receive a more positive response – and yet the gap between the curvilinear and octolinear designs, both for attractiveness and usability, is almost identical to previously, with a 40% difference in rated usability, despite the curvilinear map yielding better performance during the testing phase.

4. Discussion

The key finding of the research discussed here is that there is no relationship between subjective ratings of map usability and the objective measure of time required to plan journeys. The curvilinear map actually had a statistical advantage over the octolinear design in this respect, and yet none of the subjective measures (choice of map, detailed rating question by question, single direct question) reflected this, with the curvilinear map generally receiving adverse scores.

The dissociation between objective and subjective measures has been reported previously (e.g. Roberts *et al.*, 2013) but for the research described here, everyone had experience with both designs and, therefore, in theory, should have been able to identify from their performance that the curvilinear design was not putting them in difficulty. However, this lack of self-awareness is a common finding in psychology. People tend to be poor observers of their own performance, and have little insight into their own cognitive processes (e.g., Chabris & Simons, 2010; Kruger & Dunning, 1999). Without explicit or obvious feedback, a
user would simply be unaware of his or her own performance in terms of a difference in time of a few seconds required to plan each journey.

The suggestion that expectations and prejudices are determining usability ratings is corroborated by the written statements in the questionnaire. Half of the respondents explicitly referred to the familiarity with the octolinear version and/or lack of familiarity of the curvilinear version, as a reason to like/dislike a design. Again, this is entirely in line with findings in the psychological literature. For example, the mere exposure effect is well-documented (e.g., Bornstein, 1989). Repeated exposure to, and increasing familiarity with stimuli, results in more positive ratings compared with less familiar material. Furthermore, an important finding in the expertise literature is that novices in any domain tend to evaluate items according to superficial surface properties (e.g., Chi, Feltovich, & Glaser. 1981). Hence an octolinear map might be over-favourably evaluated by a person who is familiar with such designs but not an expert at usability issues. In terms of the other comments, these generally did not add useful additional information; both maps were praised for being simple, clean and clear, and both were criticised for being messy, disorganised and cluttered.

It is interesting to note, however, that experience at using the maps in the current study does seem to have had some impact on perceived effectiveness of the designs. (Tables 2 and 3). Ratings of the multilinear maps, which were not directly experienced in this study, are comparable with Roberts (2014), whereas ratings for curvilinear and octolinear designs, in general, are higher, and are particularly elevated for the two designs tested here. In part, this might be explained as a familiarity effect, but this also might indicate an appreciation, in the light of experience, that the two designs are at least adequately usable, more so than their initial appearance might suggest. However, the gap in ratings between the curvilinear and octolinear designs was almost identical to previously, indicating that a familiarity effect is the more likely explanation. Any acquired rationally-based self-awareness about the relative usability of the designs would have been expected to close the rating gap between them.

One important caveat concerning the results of the current study is that, similarly to Roberts et al. (2013), a curvilinear map was found to be easier to use than an octolinear version. It is essential not to over-generalise from this finding. The official Paris Metro map is poorly optimised for simplicity of line trajectories, but this does not rule out the possibility that this aspect of the design could be improved while maintaining octolinearity. In the current study, the curvilinear map was superior, but both designs were intended to be poorly optimised, and it is possible that this was more successfully implemented for the octolinear design than the curvilinear one. In general, as per Roberts (2012), it is likely that different networks are suited to different design techniques, and it certainly should not be concluded that one particular new approach (curvilinear maps) will always be superior to conventional octolinear designs.
Overall, the findings highlight the dangers in choosing between competing designs on the basis of, for example, a public vote or similar competition (Boston Globe, 2013). A familiar-looking design that conforms to expectations is more likely to be chosen than one that does not, even if the latter is the more effective design. The subjective measures gathered in the current study were internally consistent and powerful. This is important considering the suggestion by Roberts (2012) that networks have structural differences so that, when creating a schematic map, non-conventional design rules might sometimes be appropriate in order to create a coherent design with simple line trajectories. In order to counter potential adverse public reaction to a radical (and supposedly more effective) innovative design, at the very least its introduction should be supported by objective data from sound usability studies. Even then, it might be advisable to have a transition period in order to boost familiarity with new designs, before phasing out old ones.

5. References


About the Authors:

**Maxwell Roberts** has a PhD in psychology from the University of Nottingham and is a lecturer at the University of Essex. His research interests include human inference and intelligence as well as transit map design. His personal web page is [www.tubemapcentral.com](http://www.tubemapcentral.com)

**Ida Vaeng** graduated with a degree in psychology from the University of Essex in 2015. The data here were collected as part of her final-year dissertation.