Conclusions: What has this collection illustrated?

These *Case Studies* form an interesting set. Although we know of interesting work that is not reported, we believe that they are reasonably representative of work by social scientists in the UK using visualisation and VR. There are, perhaps three characteristics of the entire set that should be emphasised by way of conclusion:

- It is clear that by comparison with the activity in visualisation in the physical and natural sciences, this work is limited in its scope. As noted in our introduction, the close engagement with data that modern visualisation provides does not yet seem to have become valued by social scientists.

- Although contributors hail from a variety of disciplines, much of the work reported has its in academic geography where there has always been a very strong visual tradition. We are aware of the extensive use of visualisation by some economists and social statisticians, but it would seem that the community involved does not share the technical concerns shown by all of our authors. It may simply be that the geographers see problems and difficulties that those in other disciplines do not, or would rather ignore.

- It seems obvious that the character of much data within the social sciences remains problematic. We still do not posses robust general methods for visualising much multivariate, categorical, or, even worse, mixed mode data. Despite some of the devices reported here, adding a time dimension or attempting to visualise very large samples of individual 'trajectory' data through space and time remains problematic.

It is both interesting and instructive to speculate on the reasons for these characteristics.

First, it may simply be one of tradition in that the most common 'texts' used within the social sciences have never used visualisation. Written text has been the favoured way by which research results have been reported, and any numerical data, including the categorical data that are a typical product of social survey, have been modelled statistically. There is nothing intrinsically wrong with this, but it ignores many potentially useful avenues both for data analysis and the presentation of results.

Second, it is possible that there is within the social sciences an entirely laudable mistrust of the visual, associated with the reasonable belief that what we see is somehow, like beauty, only 'in the eye of the beholder'. From our background in cartography, much of what we see in scientific visualisation as it is currently practised either ignores, or is ignorant of, decades of work on the perception and psychology of graphics. It is one thing to use all the tricks that modern technology allows such as animation, use of various depth cues, even 'sonification' using sound, it is quite another to demonstrate that they lead to the desired gain in 'understanding and insight into the data', and this applies with equal force to the individual researcher looking for this as it does to a mass audience to which it is intended to communicate.

Third, there may also be a set of social and economic factors. A distinguishing feature of geography as an academic discipline, and one that continues to give University administrators difficulty, is that it sits between the natural and social sciences. The funding implications of this position, at least in the UK, have meant that, by comparison with other social sciences, geographers have traditionally benefited from good access to computing facilities. It may well be that the current bias we see towards mapping applications of visualisation results from this contact with natural science and funding. Almost twenty years ago, when 'micros' were new

and a desk top 32kB machine an object of wonder, one of us was involved in a survey of geographer's use of computing that showed 'a degree of commitment to computing unusual for a social science' (Dawson and Unwin 1984).

Fourth, it may be that those of us anxious to promote visualisation have simply underestimated the problems in its application to social science data. These difficulties were discussed in our introduction and can be summarised in the simple words 'messy' and 'varied'. These *Case Studies* suggest some solutions, but it is very significant to note that almost all have involved extensive and careful programming, often still using programming languages to achieve the desired outputs. Such work is 'not everyone's cup of tea', and the resulting visualisation devices may be of insufficient general use to be incorporated into the standard analysis packages.

Finally, it may simply be that it is too early. The majority of the work reported comes from an *analytical* tradition based in statistics and thus statistical graphics. Yet, as the very rapid growth in the use of imagery on WWW shows, pictures are rapidly becoming more and more used by society for an ever-increasing range of functions. It seems unlikely that the social sciences will be immune from this trend and several of the Case Studies have illustrated this. Maybe, future developments in social science visualisation will come from this new *pictorial*, rather than the older analytical tradition.

References

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Dave Unwin

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