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A concise, straightforward presentation can be worth more than a thousand words

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From inception of research to presentation of results, emphasis on lucidity and clear transfer of information is crucial. Visualisation can enhance comprehension but finding the proper tools can be a challenge. It is well known that pictures facilitate understanding compared to written reports and tables. However, the way that findings are visualised is often the weakest link of the long chain stretching from the field to the corridors of power where final decisions governing which research to support and which results to implement are made. John Snow's map depicting the cases resulting from one of the many cholera epidemics in London in the mid-1800s is the classic example (Snow, 2013). Interestingly, without knowledge of the existence of infectious agents such as bacteria, Snow linked the cause of the disease to the quality of water and was able to end the epidemic by insisting on the closure of the street pump nearest the area where most of the victims were found. Maps have since come to play an increasingly important part in epidemiological surveillance and have been used for various medical applications, cancer-related research projects in particular. For example, the *exploratory spatio-temporal analysis toolkit* (ESTAT), which links bivariate mapping and scatter plotting with a time series, emphasises the role of advanced cartography and visual approaches (Robinson, 2005). However, it has taken a long time for such advanced approaches to reach mainstream use as attempts to exhibit spatial and temporal relationships in epidemiological presentations, showing the propagation of epidemics and formation of hotspots in the form of images or even videos, have been hampered until very recently by technical limitations.

A simplistic representation of how events occur and change in space and time is needed not only for specific studies and predictions but also for rapid transfer of vital information to stakeholders ranging from study participants to decision-makers. In this connection, the Swedish geographer Torsten Hägerstrand's work in the mid-1960s must be mentioned as he developed the idea of visualising how people relocated within his country over certain time periods which very clearly showed where and when events occurred. He called his approach *time geography* (1970) and further enlargement of this concept culminated in the creation of the *space-time cube* (STC). This has been chronicled by Ellegård and Svedin (2012) as an example of how sophisticated concepts, proposed before the tools for their application were available, can be revisited and developed to their full potential when the technology needed, in this case the modern computer, finally becomes available.

Hägerstrand may have been influenced by the two-dimensional (2-D), pictorial representation of the elementary particles of mass and force and their interactions introduced by the physicist Richard Feynman in 1949 (Kaiser, 2005). What goes on at the most basic level of physics cannot be understood intuitively (if at all), but Feynman provided a way forward by translating the forbiddingly arcane mathematics required into simple diagrams, based on one time and one space dimension. These diagrams turned out to be so useful that they today permeate almost all of theoretical physics. Hägerstrand's space-time cube (STC) can be seen as a 3-D version of the Feynman diagram where the base represents a 2-D geographical map with the height of the cube, normally used for expressing altitude, instead being treated as the time axis. This produces a volume representing merged space-time in which internal objects, *e.g.*, study subjects, move along *world lines* and events are shown as points representing both space and time. Note that space-time does not exist in space and time, rather space and time exist in space-time. This might seem as gibberish but it represents in fact a deep deliberation that goes a long way explaining the space-time concept first introduced by Einstein where time emerges as series of thin slices of space-time, which indeed is the way Hägertrand's STC operates.

As proposed by Gatalsky and colleagues (2004), the fusion of space and time and the use of appropriate spatial analytical visualisation techniques, *e.g.*, geographical information (GIS), facilitates easy understanding of spatial data. This is not only helpful for researchers but also fosters a swift distribution of information to stakeholders, *e.g.*, study subjects, decision-makers and donor agencies. As soon as graphic presentations could be created by tapping a few keys on a computer keyboard, the opportunity to rapidly switch between data packages and geographical perspectives revived interest in Hägerstrand's innovative idea (Hadley *et al.*, 1999). This meant an enormous improvement over previous efforts to display events as illustrated by the 3-D reproduction of Minard's famous 1869 flat map of Napoleon's ill-fated 1812-13 Russian campaign (https://www.youtube.com/watch?v=laXh2cgE2g0).

The STC analytical tool is highly useful for visualisation of spatio-temporal patterns of events in a way that can be easily grasped. Kraak and Madzudzo (2007) made brilliant use of the

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STC capabilities by incorporating temporal visualisations based on statistical and other computational methods in relation to the 14th century *Black Death* epidemic. For this they used an alternative visualisation method extending the STC by adding a third spatial dimension representing altitude as well as other views including parallel coordinate plots, scatter plots and bar graphs. By demonstrating findings visually, insights not directly obvious when consulting the surviving records became apparent demonstrating the usefulness of their methodology for health studies. Indeed, the spatio-temporal analysis by Abdrakhmanov *et al*. (2017) published in this issue of Geospatial Health makes good use of visualisation based on the traditional STC approach for anthrax epidemics in livestock in Kazakhstan. They provide a clear picture of how the anthrax risk has waxed and waned over the last 80+ years in various parts of the country. For those interested in a hands-on experience of the STC approach, the Environmental Systems Research Institute (ESRI) (https://www.esri.com/) has recently released a *Space Time Pattern Mining Toolbox* for analysing data patterns in the STC context.

This issue of the journal also includes other good examples where research results are presented in an unusually clear and comprehensible manner. Ahmad *et al*. (2017) demonstrate convincingly the need for situation maps when confronted with the need to support large numbers of refugees forced to move due to war or natural disasters, a situation that is more pressing today than at any previous time in recent history. Similarly, the results by Li *et al*. (2017) with regard to the variation of alanine aminotransferase serum levels in China are shown in 3-D, which gives an immediate revelation of how these levels vary in relation to altitude and geographical direction.

The voices of the study participants and local decision-makers are heard more and more often today since they are the ones whose well-being would be impacted most by the outcome of proposed studies. Indeed, they must be provided with full and clear details so that they can give their informed consent before any study can go ahead. In addition, donor agencies will only release funds to carry out proposed research when fully informed of its local and global impact with respect to potential benefits. Finally, once research results have been produced, political decision-makers and international organisations will become involved. At this step, it is important to realise that a visual approach could prove vital in the efforts to convince those involved of the possible rewards. It should be noted that if the scientific message based on the research does not reach all levels, the whole undertaking could well come to nothing. The onus thus falls on the researchers to present their findings in a manner that can persuade the authorities that new control programmes based on their results are worth implementing. It is felt that there is no better way of achieving this than through utilising visualisation techniques.

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