

Expanding Cartographic Practices in the Social Sciences

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INTRODUCTION

We live in the age of mapping. More maps exist today than any other time in history and this mapping explosion just continues to expand as digital technologies allow new maps to proliferate. The advent of micro-computing and the creation of web-based geographic information systems such as Google Earth™ and Yahoo® Maps has transformed the laborious process of creating paper maps, so that Internet users can query and transform online maps for their own purposes, creating new maps with the click of a few buttons. Accompanying this explosion in neocartography has been a related expansion in the use of geographic visualizations by researchers in a variety of fields. Computing now allows for the storage and manipulation of huge volumes of geographic data.

While these innovations have been noted and their implications for the field of cartography considered, the focus on the mechanics of these changes has, in some ways, hidden a

fundamental transformation that has begun in the way maps are made and used. The opening of the mapping process to non-experts, in combination with evolving epistemologies, has also created an opportunity for innovators within and outside academia to reconsider the authority and power of maps and in the process develop new ways of creating and using maps. While these new mapping forms do not make up the majority of maps being created or used today, there is a new air of experimentation and cross-disciplinary collaboration that invites the consideration of maps across the social sciences and humanities.

Twenty years ago, many intellectuals would have considered maps only as part of their efforts to critique or deconstruct the hegemonic aspects of such representations (Monmonier and de Blij, 1996; Harley, 2002). Maps have long been implicated in the controlling impulses of empire. While maps existed before the rise of empires, some have argued that mapping began to proliferate as

part of the Enlightenment project of the scientific cataloging of the world in order to render it governable (Scott, 1999), a significant part of what Foucault (1976) termed 'governmentality'.

Critiques of the role of mapping in the fixing of territory and the control of the populace have been widespread within geography and related disciplines (Schoorman, 2000). One response to these critiques has been numerous attempts to transform the practice of mapping, efforts that attempt to reclaim the power of the map, giving rise to a proliferation of new mapping practices such as counter-mapping (Harris and Hazen, 2006), critical geographic information systems (GIS), radical cartography (Mogel and Bhagat, 2007), and participatory GIS (Hallisey, 2005; Dunn, 2007).

In considering how maps and mapping relate to other sorts of visual research, it would be easy to focus primarily on the transformation of mapping practices by the new digital mapping techniques, namely the invention of GIS and the more recent combination of GIS and web-based software applications. This combination has created ubiquitous web mapping technologies such as Google Maps™ and mobile phones equipped with global positioning system (GPS) capabilities allowing users to map and be mapped. Certainly these changes in how maps are created and consumed dominate both the economics of mapping and how maps intrude into the popular imagination. In fact, the rise of interactive web mapping has produced a significant amount of discussion among academics and activists about the possibilities of what has been called 'neocartography' to separate map making from its long association with the power of the state and projects of empire building (Crampton, 2009). However, to focus solely on these technical changes would be a mistake. Such a position would overlook the breadth of critique and theoretical innovation that has come from both activist neocartographers and researchers in a wide variety of disciplines such as political ecology, development

studies, history, women's studies, planning, and the arts.

These theoretical innovations have sought not only to advance technologically but to open mapping practices epistemologically to post-positivist methods of researching culture and society. In this chapter we will consider both the possibilities created by new mapping technologies and those created by new ways of thinking about what mapping is and what maps do, so that visual researchers might consider the variety of ways that maps and mapping fit into their own methods and epistemologies.

WHAT IS A MAP?

Before we can consider the uses of maps in visual research, it is important to consider what we mean when we use the term. One simple and broad definition might be that a map is a visual representation of spatial data. However, this definition would allow us to categorize a large number of visual representations as maps that are not commonly included in the category. Virtually any visual representation includes spatial data of one sort or another. A diagram of an atom communicates important spatial information, as does an image of a brain created by an MRI (magnetic resonance imaging) scan, but these would not commonly be thought of as maps. The frequent usage of the terms 'map' and 'mapping' as spatial metaphors makes a clear division difficult, since a wide variety of diagrams of social connections or virtual spaces are now frequently called maps.

Traditional maps attempt to show spatial relationships while minimizing distortions in spatial attributes – shape, area, direction, and distance. Some mapping techniques such as cartograms, however, rely on distortion to visualize something other than spatial relationships.¹ Other forms of geographic visualization may communicate spatial information, but rather than focusing on the allocentric perspective used in traditional

paper maps, create an immersive first-person view (Wyeld and Allan, 2006). Some visualizations now frequently called maps display not Cartesian spatial relationships between objects or people, but rather the flow of materials or information through networks (Abrams and Hall, 2006).² These relational maps show topological connections rather than fixed spatial relationships. Examples of this type of topological map can be seen in attempts to diagram global economic flows. A similar form of topological map or diagram can be found in situational analysis (a form of grounded theory) developed by Adele Clarke (2005), which uses a process of diagramming to understand relationships between the huge numbers of codes created through grounded theory methodologies.

Another potential source of confusion in our attempts to define maps are the techniques used in aerial photography and remote sensing, which create photographic images, since traditionally maps were drawn representations of geographic relationships in which the cartographer selected out particular features to represent. In fact, John Kirtland Wright in his 1944 essay on the subjective nature of map making, asserts that we have thought of maps too readily as the equivalent of a photograph, 'the object before the camera draws its own image through the operation of optical and chemical processes. The image on a map is drawn by human hands, controlled by operations in the human mind' (Wright, 1942: 582).

Visual researchers are keenly aware of the dangers of relying on the mechanical nature of photography to bolster claims of objectivity. Wright himself goes on to explore the objective and subjective natures of both mapping and photography. Yet in the intervening 60-some years since the publication of his essay, the line between mapping and photography has been significantly blurred. Images that are first created with satellites and cameras or airplanes and lasers can be transformed through the digital technologies of GIS into something greatly resembling a hand-drawn map. Even remote sensing

images, which could nominally be considered photographs, are taken from an allocentric point of view, thus fitting most with our conceptions of maps, which can be linked to Haraway's critique of 'the god-trick of seeing everything from nowhere' (1988: 678).

It is challenging to come to a precise definition of a map under these conditions. An alternative definition of a map from Harley is 'a social construction of the world expressed through the medium of cartography' (2002: 35). However, this definition does not truly answer the question since it leaves us with the task of defining the medium of cartography. For the purposes of this chapter, we will consider a wide variety of visualizations with ties to traditional cartographic practice, including three-dimensional (3-D) maps, immersive visualizations, animated maps, as well as the works of radical cartographers. While many traditional cartographers might argue with this treatment, this will allow an overview of innovations in cartographic practice and consideration of the many ways that researchers use maps and mapping in their praxis.

MAPPING ACROSS DISCIPLINES

Visual researchers know that we are increasingly surrounded by an immense proliferation of all sorts of visual images, including maps (Jay, 1994; Virilio 1994; Mirzoeff, 1999). Increasingly, the traditional divisions between maps and other images are blurred. This is largely the result of the convergence of various types of image-making practices that now principally take place through the use of digital technologies and the growing number of ways that maps are made and used.

The advent of the personal computer has opened up image making, including map making, to millions of computer users. New maps are created through the interactions of the map user with the vast database of geographic data stored in faraway servers,

allowing map users to become map makers in a way never before possible. In fact the 'mashup' of mapping technologies with social media sites has led to almost real-time creation of hazard and resource maps by groups of users. For example, during a rash of wildfires in Southern California in 2007, local news outlets, the *Los Angeles Times* and radio station KPBS in the San Diego area, communicated with those impacted by the fires through the social networking site Twitter, constructing a map using the Google Maps interface not only through reports from officials but also through the stream of tweets produced by those on the ground (Figure 24.1) (Liu and Palen, 2010).

Increasingly, people's locations can be mapped through digital phones that include GPS locators. These technologies allow map users to become map makers as they inscribe

their location and movements onto virtual maps. A large-scale example of this is the Open Street Map project (<http://www.openstreetmap.org/>), which seeks to create freely available street maps of the entire globe. These collaborative maps are created through a combination of existing free data from government sources, GPS traces and local user knowledge.

Academia has experienced a similar flowering of map usage and map making across a broad range of disciplines in the humanities and social sciences (Craglia and Onsrud, 1998; Okabe, 2005; Conolly and Lake, 2006; Knowles and Hillier, 2008; Amoroso, 2010; Harmon and Clemans, 2010). Mapping is pervasive not only in the natural sciences (ecology and geology for example) but also in planning and design (Lejano, 2008). These fields have long had



Figure 24.1 Twitter-Google Maps Mashup, created by Virender Ajmani [Online]. Available from: <http://blog.mibazaar.com/> [Accessed: 23 September 2010]. Reproduced with permission

connections to cartography and in fact the development of GIS technologies was largely fueled by innovators from these landscape management fields. However, the 'spatial turn' in the humanities and social sciences in recent decades has also led to increased awareness of the importance of spatial factors in cultural and social life across a wide variety of disciplines.

This spatial turn emerges from a wide variety of critiques that universalize narratives common to modernist discourses (Foucault, 1982; Soja, 1989; Lefebvre, 1991; Cox, 1997; Rose, 1997; Harvey, 1998). Feminist calls for situated knowledges and post-positivist conceptions of science have also led to an increased interest in how 'things' – i.e. people, cultures and practices – vary spatially (Haraway, 1988; Harding, 1991; Katz, 1994; Rose, 1997). The spatial turn:

involves a reworking of the very notion and significance of spatiality to offer a perspective in which space is every bit as important as time in the unfolding of human affairs, a view in which geography is not relegated to an afterthought of social relations, but is intimately involved in their construction. Geography matters, not for the simplistic and overly used reason that everything happens in space, but because where things happen is critical to knowing *how* and *why* they happen (Warf and Arias, 2008: 1).

On a superficial level, this has led to an increase in the use of spatial metaphors in disciplines from cultural studies to history and sociology. Words like 'space', 'place', and 'mapping' are in common use across a wide range of disciplines. However, the wide acknowledgement of the significance of the spatial did not lead to an immediate or wholehearted embrace of the actual rather than metaphorical practice of mapping among researchers concerned with contingent understandings of the world. In fact, for many associated with this spatial turn, the act of mapping was still linked with universalist and positivist conceptions of the world that were highly suspect (Cobarrubias and Pickles, 2008). Adding to those misgivings, the links – both current and historical – between

cartography and projects of government control, it is not surprising that many were deeply suspicious of the cartographic impulse. The drawing of a line on a map erased the flowing nature of existence and 'fixed' reality, creating one single, official version of reality.³ Certainly, this is one way that maps have been used by states, to fix their borders, and control their populace.

However, this is not the only way to use or think about maps and mapping, and in recent years researchers from a broad spectrum of epistemological stances and disciplines have begun experimenting with using and creating maps to open up traditional cartographic practices to experiential and contingent visions rather than fixing the world in one static representation (Jones and Evans, n.d.; Rocheleau, 1995; Cieri, 2003; Dennis, 2006; Duncan, 2006; Barnes, 2007; Kwan 2007; Middleton, 2010). These new cartographies are not limited to the work of academics. Artists and activists have also increasingly been swept up by the cartographic impulse, often subverting cartographic conventions or the authority of cartography.⁴ A recent exhibit in London, titled 'Whose Map is it?' (Figure 24.2), featured the work of artists seeking to 'subvert the socio-political structures and cultural hierarchies that traditionally inform mapmaking' (Iniva, 2010).

This sort of mapping work often combines the impulses of academic research, art, and activism to produce new sorts of knowledge and commentary. The rest of this chapter will consider the breadth of these new cartographic practices in relation to academic research and the possibilities being developed through these practices. This will include a review of the types of maps being produced and an examination of research applications for maps.

USE OF MAPS IN RESEARCH

The use of maps and mapping in visual research can be divided into three



Figure 24.2 *River of Blood*: © 2010 Artist Susan Stockwell, is 8 meters wide and made from laser cut vinyl attached to the window. This work was exhibited at 'Whose Map is it? new mapping by artists', Iniva (Institute of International Visual Arts), Installation view at Rivington Place. Photo: Thierry Bal. Reproduced with permission

basic groupings: the use of maps in collecting data; the use of maps in exploring data; and the use of maps in displaying data. These three basic divisions could be used to think about ways of using other mediums in visual research. The question then becomes: When might researchers consider using maps as part of their research plan? Many researchers in the social sciences and humanities use maps as part of the presentation of their data without much thought beyond the simple display of their research site or sites. These maps are usually called 'reference maps' and serve to help readers orient themselves to the study area. However, as visual researchers, we seek to take visuals, including maps, more seriously within the research process. So, beyond the rather simple task fulfilled by reference maps, what work can maps do in research?

The answer is usually that maps help us to understand geographic data. So, researchers

who are asking research questions that include a significant geographic component may find themselves considering using a map to collect, explore, or display their data. This is why, despite serious epistemological misgivings, some researchers involved in the spatial turn have in fact found themselves turning to maps.

The spatial turn, at its most basic level, involves a rejection of some of the grand narratives of the twentieth century and the recognition of the ways that the social worlds we live in are impacted by spatial differences. For example, what David Harvey has called the spatial unevenness of global capitalism produces not a single path through time in which each state or each region passes, as through the developmental stages of growth from child to adult, but rather uneven development, in which some locations become sources of raw materials or cheap labor while others develop

post-industrial service-oriented economies (Harvey, 2006). In asking geographic questions, we are not only considering where things occur, but also why and how they occur in one place and not another.

Almost any data we might collect would have some geographic component that could be recorded and mapped. If we conduct interviews or surveys responses, they could be mapped and organized geographically. If we are following the impacts of global economic trends, their impact on local people and cultures could be mapped to show the rates of mortgage defaults in a particular state or city. If we are conducting ethnographic research about the daily use of space by various members of the community, this also could be mapped.

Cartographers commonly consider geographic data to have three components – space, time, and attribute. So while practically any data would have these components, depending on the design of our research, a map may or may not be a useful way to investigate or display your data. Asking geographic questions involves considering how things (attributes) vary, not only over time or because of other variables but also in space.

Even some studies that take seriously the impact of the spatial may not be best served by mapping. Studies that focus on place might focus on a particular location (a place is often defined by geographers as a space imbued with meaning by its users) and focus on the meaning of this place to people in it or how they use or create this place. For example, a researcher might study people in their homes or children in their classrooms. In such a study, the researcher is essentially limiting the scope of his data collection to one particular space in order to better understand how attributes of that space change over time or are different from other places. Data from such a study might be better collected as written observations, drawings, photos, or videos of activities, rather than maps. Now, obviously, activities within these spaces could be mapped, but the

meaningfulness of such maps depends entirely on the conceptualization of the study by the researcher.

Using maps in data collection

One obvious use of maps and mapping in the research process is in data collection. There are several methods that one might use to gather geographic data from research participants. These include soliciting spatial information from research participants as well as the direct collection of geographic data by the researcher (for example, using GPS). During the 1960s interest in how people's internal conceptions of space varied from the Cartesian view we commonly see on maps to a line of research on mental maps (Gould and White, 1986). Such studies often asked participants to draw a map of some space, such as their hometown or route to school. These maps were then analyzed both for their similarities and differences to Cartesian maps, but also to look for similarities among them with an eye to understanding more about how the human brain conceptualizes space.

While this type of mental mapping research is now less frequent, since behavioral geographers now focus on controlled experimental methods to understand mental processes, the drawing of mental maps continues to be a method used by some researchers (Müllauer-Seichter, 2003; Giesekeing, 2007), particularly in relation to participatory research with youth (Al-Zoabi and Riyadh, 2002). Such mental maps are drawn and then either collected and analyzed by the researcher or discussed by the participants in order to identify places of common significance.

Base maps can also be used to solicit geographic information from research participants (Travlou, 2007). For example, Travlou et al. (2008) used street maps of two cities to solicit spatial information from teenagers.

This type of data could also be collected through the use of a paper map or digitally

with the help of a handheld GPS. For example, the researchers at University College London, as part of the Children's Activities, Perceptions and Behaviour in the Local Environment (CAPABLE) project, ask the participants to carry a GPS unit with them as they travel (Figure 24.3). In similar projects, researcher and participant could visit a location together and record the coordinates during their visit. Using a paper or digital map to collect information from study participants has the advantage of avoiding a large investment of research funds in buying GPS units for participants to use. However, it assumes that participants are comfortable reading maps and understand map conventions, and relies on their ability to accurately match their memories or perceptions of places with locations on the map.

Using maps for data analysis

As visual researchers, we know that images allow us to 'see' or understand our data in new ways. Visual representations do more than merely displaying what we already know; they are themselves a type of data and so produce new understandings. A major component of GIS is, in fact, not the visual display of research results, but rather the ability of GIS software to allow researchers to explore the spatial relationships of data from a variety of sources. The bringing together of disparate data sets can produce new insights and reveal relationships that otherwise might remain hidden.

In GIS analysis, data from disparate sources are brought together through the use of GIS software. GIS software differs from other types of graphical software in that data representations are given fixed geographic coordinates within a global reference system, allowing the software to compute spatial relationships between pieces of data. Within a GIS, a database with spatial coordinates for each piece of data is linked to a map, which displays these pieces of data. This has meant that GIS has a long history of association

with quantitative spatial science (Goodchild, 1991; Openshaw, 1991; Pickles, 1994; Lupton and Mather, 1997; Schuurman, 2000) – GIS software allows for the quick production of large numerical data sets detailing spatial relationships such as distances, areas, and densities. However, as Pavlovskaya (2009) points out, much of what GIS software produces is not quantitative, but rather qualitative. One form of qualitative data produced by GIS is new visualizations – i.e. maps.

In the 1990s a surge of interest in using GIS to explore data and formulate hypotheses began. Exploratory spatial data analysis and geovisualization emphasize the use of GIS and other computerized visualizations as a way of data exploration and hypothesis building (Dodge et al., 2008). In these methods, rather than creating maps to visually display the results of research to the public, digital tools are used by researchers to explore spatial relationships in the data. In this process, the researcher uses the software to create and explore numerous map iterations, displaying them immediately and interactively. Through this process new spatial relationships may be hypothesized. Then, if desired, statistical analysis can be performed to quantitatively verify the statistical likelihood of the relationship.

Researchers working with qualitative, and specifically visual, methods may be less interested in using the quantitative and statistical methods. However, some working with qualitative methodologies have begun to incorporate the use of GIS as a complementary tool, rather than seeing GIS as inherently quantitative (Al-Kodmany, 2002; Jiang, 2003; Matthews et al., 2005; Kwan and Knigge, 2006; Cope and Elwood, 2009).

Academics working with ethnographic or mixed methods, for example, have found a variety of ways to incorporate mapping and GIS databases into their research. Rather than creating a map in order to tell one story, the multiple stories created through ethnographic research can be introduced into a GIS database along with quantitative data



Figure 24.3 (a) Student with a GPS unit. Photograph by James Paskins, the EPSRC (Engineering and Physical Sciences Research Council)-funded project CAPABLE (Children's Activities Perceptions and Behaviour in the Local Environment). Reproduced with permission. (b) Resulting map of a child's activities created by James Paskins using OpenStreetMap map images (© OpenStreetMap contributors, CC-BY-SA). Reproduced with permission

from official sources such as census or crime data (Pain et al., 2006; also see Collins (Chapter 25) in this handbook). Through the meeting of disparate data types, disjunctions and discontinuities may be revealed.

Rather than viewing these disjunctions as problematic, mixed methods researchers find that including multiple data types that are not always in agreement may produce new questions and push the research project in new directions (Knigge and Cope, 2006). As Knigge and Cope point out, rather than qualitative research simply pointing to opportunities for the eventual mapping of quantitative data for the purposes of data display, exploratory mapping of quantitative data can inform the researcher and provide background for further in-depth ethnographic research. They term this combination of ethnographic research and iterative visualization of spatial data 'grounded visualization'. An example of this type of research has been completed by Hurley et al. (2008). They examined the impacts of urbanization and gentrification on access to sweetgrass in South Carolina among African-American basket makers. By using a combination of historical data on land use, botanical literature and the reports of basket makers, they were able to map access in a way that would not otherwise have been possible given limited research funding. By working with a combination of quantitative and ethnographic research they found that the changes caused by the development of residences with driveways and gates ('gated subdivisions') was surprisingly uneven, reducing sweetgrass habitat and access in some areas while in others sweetgrass was being conserved and access permitted.

Another common method of using maps and spatial representations in qualitative research is through participatory research with local communities (Al-Kodmany, 1999; Bojorquez-Tapia et al., 2001; McCall and Minang, 2005; Elwood, 2006; Stewart et al., 2008; Shearer and Xiang, 2009). Participatory methods invite the use of maps at all stages of the research process. As discussed above,

maps may be used or created during data collection. Clearly these maps may be presented (perhaps in distilled or edited forms) to the community or in academic publications as part of the culmination of the research. However, a more extensively participatory project would likely involve the local community in the analysis process as well. In this case, community members could be involved in the iterative process of data visualization and exploration.

It should be pointed out that this type of data exploration is not limited to GIS software, but rather may involve a wide variety of digital tools that produce visualizations. For example, several research groups have begun developing what Hudson-Smith (2008) terms 'the visual city': in other words, a visual representation of the built environment. The Centre for Advanced Spatial Analysis (CASA) has created a model of London using a variety of tools, including the 3-D capabilities of GIS software and the online visualization capabilities of Google SketchUp™ and Google Earth™ (Figure 24.4). A number of such digital spaces or virtual models of cities, have been both created and used in research, primarily related to urban planning⁵ (Howard and Gaborit, 2007; Thomas and Hollander, 2010).

Other researcher teams are working on creating large-scale immersive visualizations using stereoscopic projectors and goggles, large screens, and in some cases gloves or control wands to allow the researcher to interact with the visualization⁶ (Shepherd, 2008). Currently, such visualizations require large sums of money and so their use has been limited to fields such as the earth sciences. However, as these technologies develop and costs are lowered there is no reason to think that they won't allow for similar exploration of cultural spaces.

Data display

Displaying geographic data can be considered the traditional role of maps.



Figure 24.4 A 3-D model of London, created by the Centre for Advanced Spatial Analysis (CASA), University College London

Researchers who use cartography as part of their research practice, either through data collection or data analysis, still need to decide whether to include maps as part of their research output. If maps are to be included as one product of the project, then design decisions proliferate. The revolution in cartographic technology over the last 50 years has meant that technology has often outpaced cartographic theory, resulting in the proliferation of new types of maps before their effectiveness as visualizations has been assessed. The format and design of the map should be carefully considered in order to most effectively display the research findings.

Before examining various choices to be made by a researcher wishing to use cartography to display research findings, it is vital

to point out that researchers who use cartography in their research process may choose not to display or publish some or all of their maps. Recording spatial information about vulnerable people or social groups may provide valuable insights into their lives. However, as Packard (2008) argues in relation to participatory photographic methods, such research practices may also present limitations and ethical quandaries for researchers. Photography can be an intrusive act and research participants could be put at risk by attempting to photograph dangerous situations or illegal activities. The collection of spatial data could similarly expose private or community-based knowledge to outsiders. This dilemma is common to researchers working with traditional communities for documenting a community's

claims to traditional land rights. Documenting community members' use of resources is essential to legitimizing their legal rights to traditional lands. Resource use may, however, involve practices that have been made illegal by the enclosure of lands. Researchers working with homeless or other marginalized groups in urban settings may find themselves facing similar dilemmas. In some cases researchers may choose not to publish maps with their research findings or in some way limit the precision of their representations in order to protect community knowledge or sensitive personal information (VanWey, 2005; Wieland et al., 2008).

In making the decision to act as cartographer, the researcher takes on new dilemmas, both practical and ethical. Each cartographic choice – what to include or exclude and how to symbolize the material world – involves the practical limitations of the medium, but also carries with it political implications. If we take seriously McLuhan's proposal that 'the medium is the message', then a map carries with it a particular set of implications (McLuhan and Lapham, 1994). Maps tend to be read as scientific and accurate, despite cartographers' understandings of the limitations and distortions of the medium.

The advent of GIS and the move of cartography into the world of computing has led some to minimize the role of art in cartography, but historically cartography was considered both a science and an art. Cartographic historian J. B. Harley encourages us not to think of maps as mirrors of the world but rather texts, which 'redescribe the world – like any other document – in terms of relations of power and of cultural practices, preferences, and priorities' (Harley, 2002: 35). In recent decades, some artists and academics concerned with spatial representation have taken on the role of cartographer to subvert the authority of the map, highlighting the art in cartography and frequently flouting mapping conventions (Thompson, 2009; Harmon and Clemans, 2010). For example, in her exhibit '*Macropus eugenii* (tammar wallaby)'⁷ Australian artist Perdita Phillips

displaces wildlife mapping by placing the radio trackings of two tammar wallabies in an art gallery, questioning the divisions between the practices of art and those of science.

Even conventional cartographers acknowledge the dialectical tension inherent in map reading and interpretation. Behavioral geographers and psychologists seeking to understand how people read and use maps recognize that much of how people use maps is shaped by limitations in visual perception and cognition (Lobben, 2004). In other words, certain mapping conventions are the result of these limitations and likely to be universal across cultures. However, geographers also frequently lament the inability of the general public to understand many basic mapping conventions – the map illiteracy of their students. So clearly, many of the symbolic choices we make in order to make maps readable are, in fact, culturally specific – for example, symbolizing water with the color blue and danger with the color red.

In the following section we will consider some of the strengths and limitations of various mapping mediums, with a focus on the desire of the cartographer to communicate something, some story about the world through the map. This leads us to a discussion of what experiments have discovered so far about the limits of visual perception and cognition. This does not mean that we should ignore the cultural or textual aspects of map reading, but rather that both biological and cultural factors need to be considered. While some artists and radical cartographers (Mogel and Bhagat, 2007) seek to make maps that include confusion or fuzziness, to understand the impacts of such maps on their readers it is essential to first understand what evidence we have about how people read and understand maps. The emphasis in this chapter is on academic publications, but visual researchers may also generate research products that are displayed through non-traditional means such as personal websites and exhibits.

Although researchers in a number of fields are beginning to experiment with digital

mapping mediums, most academic papers are still limited by the requirements of academic publishers to print maps, frequently in black and white. Paper maps, as many critical scholars have pointed out, simplify the world and fix objects in space, favoring representation of static landmarks over dynamic temporal processes. On a paper map it is necessary to remove extraneous details in order to clearly symbolize a small number of variables. This limits what can be represented, but also offers an opportunity for the cartographer to focus the reader's attention.

Mapping conventions focus on eliminating anything that introduces misperceptions or leads the reader to make erroneous conclusions in relation to the information the map is seeking to communicate. For example, color ramps used in choropleth maps to shade areas in proportion to the variable being displayed are usually limited to 5–7 shades because it has been found that map readers have trouble distinguishing more than 7 shades (Krygier and Wood, 2005). Similarly the introduction of many color variations or strong contrast may serve to distract or confuse the reader. Edward Tufte (1997), in his writings on visualizing data, calls this phenomenon the 'smallest effective difference,' meaning that visual displays should use subtle difference in tone, thickness of lines, in order to avoid exaggerating distinctions in the data. As Tufte points out, often simpler is better in terms of communicating clearly.

Beyond the consideration of basic cartographic conventions, it is also important to consider the publication medium. As academic publishing has moved online, there has been an increase in the creation of digital maps in research. Although many of the maps now published online are dynamic or interactive in some way, static digital maps should be considered as well, since digital displays differ significantly from what is possible on paper.

Print maps are limited by the size of the printed page and resolution of the printer. However print maps are frequently created in

large scales – in the case of wall maps and many art maps, or at least in the case of atlases, in large-sized books. Print maps are often produced using the best-quality printing technology and the cartographer can control the details of the map's production.

Digital maps face additional, or perhaps different, limitations. Computer screens have until recently been limited in resolution to 72 pixels per inch although some screens now display up to 100 pixels and digital phones up to 160, whereas print media can accomplish 200 or more pixels per inch. This limits the clarity and precision of the map being displayed on the screen. High-quality print maps are often printed using offset printing, which avoids the issue of pixels altogether. Additionally, computer screens differ in their sizes and display specification and different Internet browser softwares introduce additional variations in the way that a map is finally presented. A full discussion of the issues involved in displaying and printing maps is not within the scope of this chapter, but researchers can consult general texts on cartography (for example, Brewer, 2005; Krygier and Wood, 2005; Peterson, 2009).

Cartographers working with digital maps must also learn the conventions of web designers: for example, learning to examine their maps through a variety of browsers and differing screen types and sizes. The popularization of web browsing through handheld devices such as cell phones further complicates questions of presentation. Map reading to a large degree relies on the ability of the reader to examine different portions of the map in relation to each other and so the tendency of small screens of handheld devices to show only portions of the map renders common map-reading tasks challenging (MacEachren, 2004).

Putting maps online, though, presents the opportunity to create interactive and animated maps. Although these maps are relatively common now and familiar to many users, the implications of these technologies in terms of legibility of maps is still being explored.

Well-known sites such as Google Maps™ and MapQuest™ provide users with the opportunity to manipulate maps as well as add their own content to online repositories. There are also a growing number of academic projects that attempt to make paper map archives available to larger numbers of researchers by creating interactive atlases or in other ways share spatial data with the public through interactive map interfaces. For example, the Center for Neighborhood Knowledge created and hosted by the University of California, Los Angeles, allows users to access and manipulate geographic data on California from a variety of sources (<http://www.api.ucla.edu/>). Such interfaces allow the user to manipulate various layers of data in a manner similar to conventional GIS software, although in a more limited manner. This interactivity allows for the inclusion of many more layers of data and hands over some power to the user. Users are able to examine the map at varying scales and select variables to compare.

Historians have been increasingly involved in projects that work to place historical maps within a GIS system, georeferencing known points on these maps, allowing for temporal comparisons to be made (Knowles, 2002; Gregory and Ell, 2007; Knowles and Hillier, 2008). Often such projects include initiatives that make historical data available online such as the National Historical Geographic Information System (www.nhgis.org) or develop interactive online historical atlases, such as the China Historical GIS (www.fas.harvard.edu/~chigis/). Recent experiments with historical GIS even allow users to examine spaces through time by manipulating a temporal scale interface, often a slider-style button with a timeline.

These innovations provide many opportunities but also complicate the ability of the cartographer to focus the user's attention on particular aspects of the data. Additionally, the cartographer must either use available software platforms with their conventions in terms of user interfaces or take on the formidable task of either modifying existing software or programming an interface

specific to their application. Since existing software by and large has not emerged from academic applications, it may not be ideal for use in academic projects. On the other hand, using online interfaces could make research findings widely available beyond the limited audience of academic journals.

Another innovation available to the cartographer – similar to interactive maps, but with its own set of challenges – is the creation of animated maps. Numerous projects in recent years have worked on representing the passage of time in maps (Weber and Kwan, 2002; Miller and Bridwell, 2009; Lei and Church, 2010). One obvious method is through animation of the map. While not all map animations are temporal, this is the most common use of animation in mapping. Although map animations may seem an obvious choice for historians or other researchers wishing to represent changes in the use of space over time, there are still some questions about the best way to use animation in mapping. In general, research on the effectiveness of map animation has shown mixed results (Harrower and Fabrikant, 2008).

Map animations may reveal previously unknown spatio-temporal patterns, for example, or allow users to see general trends that would otherwise be difficult to grasp (Dorling and Openshaw, 1992). However, some research has shown that individual changes are likely to be more difficult to grasp in animated maps (Slocum et al., 2004). One way to deal with this issue is to allow users to pause and step slowly through each frame of the animation. This, though, means that mostly what users are experiencing is not an animated map, but rather a series of static maps, which may actually reduce the benefits of the animation. In such a case, users might learn more from the opportunity to examine each frame side by side, in what Tufte calls 'small multiples'.

Another step beyond the limitations of traditional two-dimensional maps – assisted by rapidly developing software – is the 3-D map, which in fact is most often a 2.5-D map. These representations use the principles of

perspective to construct a map that appears three-dimensional while being viewed on a flat page or a flat computer screen. Many of these maps have the additional benefit of being interactive, allowing the user to rotate and change the position of their view. This is an interesting feature on Google Earth™, which allows the user to view the earth not only as a smooth marble but also with satellite imagery draped over topography and with 3-D models of buildings in many major cities.

Some cartographic researchers have noted that representing a three-dimensional world in 2.5-D may actually provide readers with more familiar visuals, thus making map reading easier (Robertson, 1990). While this may be true for some maps, many maps that use the 3-D capabilities of GIS software make use of the third dimension not to realistically model space, but rather to increase the number of variables that can be displayed on the map. For example, work by Mei-Po Kwan (2002) uses the third dimension to visualize the daily activities of African-American women in Portland, Oregon as they move through the city (available online⁸). This research showed that African-American women were spatially restricted in comparison to women of other ethnicities. These maps show the path an individual woman traveled, with a line gradually climbing off the flat page as time passes. Other visualizations create poles from points, walls from lines, and prisms from flat polygons in order to display additional variables. However, 3-D maps may introduce unintentional distortions. Comparing sizes and distances within such 3-D maps is considerably more challenging and care should be taken to minimize distortions (Shepherd, 2008).

INNOVATION AND PRACTICAL CONSIDERATIONS

While the combination of new technology and new epistemological perspectives has led

to a small renaissance in mapping both within academia and among artists and activists, there are a number of limitations facing those of us attempting to use maps as a form of visual research. First, while technology provides an opportunity, becoming fluent with the rather complex software used in cartography can be a challenge for some academics. Although many visual researchers are relatively technologically savvy with photo- or video-editing software, learning to use GIS software can take a significant investment of time. Additionally, the most commonly used software, ArcGIS™ technology from ESRI, might be cost-prohibitive if a researcher does not have access through a university-wide license. There are low- or no-cost open-source software alternatives available, but they tend to have limited tools available or require additional technical skills to use. Certainly in the USA, many private companies and government agencies currently use ESRI software and most colleges and universities train students to use it, so it may be easier to find technical help and research assistants familiar with the ArcGIS® product. This leaves researchers with difficult choices in terms of affordability and accessibility versus ease of use and availability of technical support. Hopefully, as open-source options become more widely used, the functionality of these packages will expand, providing expanded access.

For those working with participatory methods the challenges of the digital divide can present additional roadblocks. Researchers collecting spatial information from local communities are often faced with difficult gaps in both technical knowledge and access that put the researcher in the role of cartographer and spatial 'translator'. In such situations the researcher transforms local forms of knowledge into visualizations for the community (Roth, 2007; Collins (Chapter 25) in this handbook). The alternative, providing access and training to locals, might be considered the ideal in terms of a participatory methodology, but may not be practical given

limited time and money. Additionally, local politics and institutions have a strong impact, either positive or negative, on the outcomes and impacts of participatory mapping projects (Elwood and Ghose, 2001; Ghose and Elwood, 2003).

Using mapping as a method of visual research is additionally challenging because theoretical concepts have tended to lag behind technological innovations. New visualization methods are driven largely by the commercial market and the work of neocartographers. Social scientists need to consider in a deeper way the implications of new visualization technologies for their research practices.

For example, the question of how to visualize uncertainty is an issue that researchers have sought to solve through new techniques. On a basic level, the problem is how to visualize an object on a map if there is uncertainty about the accuracy of the data in terms of locations or instances of the phenomenon being studied. On a traditional paper map, something either occurs or does not occur; there is no easy way to show an object or characteristic that cannot be directly and precisely measured. Placing a symbol on the map implies a level of certainty that may not be warranted. However, this provides an opportunity for researchers to develop new visualization methods and combine mapping with other research methods. Some research teams have created secondary maps that accompany their primary visualization, indicating the level of certainty in the data at different points on the map (Deitrick and Edsall, 2008).

Other researchers have suggested that another way to visualize uncertainty and disrupt the perception of certainty in maps is through subverting official representations using artistic practices (Kwan, 2007). Researchers working in qualitative GIS maintain that the value in such methodologies is in the tension produced by the differing perspectives engendered by differing methodologies (Cope and Elwood, 2009). Thus, by including maps with conflicting

information on them, the question of the certainty of any one map is brought into question.

The tension in such works is produced in part at least by the interdisciplinary nature of such research, requiring researchers to either learn the research traditions and techniques of more than one discipline or adapt to working in interdisciplinary teams with others who may have very different epistemological standpoints. Another danger of the renaissance in map making is that it is difficult to keep up with new developments and innovative work in multiple disciplines. As a result there is a tendency to reinvent the wheel in terms of the development of effective cartographic techniques.

However, this interdisciplinarity is also an opportunity for disciplinary cross-fertilization, which produces beautiful and innovative new work. In practical terms it may be more productive for researchers interested in working with cartography to enlist the assistance of experienced map makers than to start from scratch in developing their cartographic skills. However, such collaborations require comfort with differing perspectives not only in research subjects but also among members of the research team.

CONCLUSIONS

Mapping is, in some ways, a natural addition to other visual research techniques, particularly with the recognition by many researchers of the influence of the specifics of space and place, thanks to the spatial turn. However, maps have traditionally had more in common with drawing than photography or videography. Yet GIS and related digital technologies have pushed innovations in geographic visualization into the realm of computer and information science.

Taking on mapping as part of one's research practice involves a new set of technical skills and requires careful negotiation

of cartography's difficult history. Cartography's long association with science and empire has obscured its potential for productive alliance with visual research. Recent work in a variety of disciplines, spurred on by the spatial turn and new epistemologies of qualitative research, has produced new forms of research using mapping. Researchers across a variety of disciplines have been drawn to experimentation with these new cartographic techniques and epistemologies. While maps have traditionally been used to display spatial data, social science researchers also use maps to collect and analyze data. New visualization techniques such as animated and 3-D maps present opportunities for social scientists to innovate in terms of what can be represented via a map.

However, there is still much work to be done before these new beginnings produce a full revolution in the way that we think about and create maps. Digital map making technologies may require significant investments of time and money. Social scientists must also carefully consider the politics of representation: increasing numbers are choosing to wade into participatory methodologies or volunteered geographic information created by neocartographers in order to disrupt power differentials between cartographers and map users. Because of the complexity of new visualization technologies, in order to develop the full potential for mapping as a social science research tool, it will be necessary to develop new interdisciplinary connections between scholars from a variety of fields.

Now is a great time to incorporate cartography into your research. New cartographic technologies and epistemological developments have opened the possibilities of mapping as a research technique. More than ever before, social scientists are recognizing the value in thinking spatially and asking spatial questions. Using and making maps is a vital part of this spatial turn. Researchers who choose to experiment with mapping will find themselves in excellent company.

NOTES

1 One of the most compelling examples of this type of visualization can be found at www.worldmapper.org. For a discussion of the creation of these cartograms see Barford and Dorling (2008).

2 Also see the work of the Counter-Cartographies Collective on the flows of knowledge economies of the University of North Carolina: <http://www.counter-cartographies.org>.

3 For a discussion of conceptions of space and time in relation to this tendency, see Massey (2005).

4 Examples of this type of art work with mapping can be seen at the following websites: <http://www.nienschwarz.com/>; <http://www.perditaphillips.com/>; <http://www.johnwolseley.net/>; <http://www.land2.uwe.ac.uk/>; and <http://aporee.org/maps/work/projects.php?project=jgrzinich>.

5 Additional examples of the use of 3-D models in urban planning can be viewed at the Environmental Simulation Center website: <http://www.simcenter.org/>.

6 See also the W. M. Keck Cave for Active Visualization in the Earth Sciences at the University of California Davis: <http://keckcaves.org/>.

7 See Perdita Phillips' online gallery at www.perditaphillips.com and follow the path: archive > by theme > to map > *Macropus eugenii* (tamar wallaby).

8 This visualization of space-time paths of a sample of African-American women in Portland, Oregon (Kwan, 2002) can be viewed online at: http://www.geography.osu.edu/faculty/mkwan/Figures/Annals_links.htm.

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WEBSITES AND BLOGS RELATED TO CARTOGRAPHY

This list includes just a few of the many websites and blogs related to neo-cartography, critical cartography, and participatory mapping. These sites are offered as potential starting points for researchers interested in exploring the potentials of such practices. This list is by no means exhaustive, but it will give the reader some idea of the range of work being done at the intersection of art, activism and academia.

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