Cognition Usability and Evaluation

Rebecca Barney, Rachel Stobb, Carl Reim, Pete Wiringa

Describe the subject

With the now ubiquitous nature of interactive mapping and mobile-mapping, there has been greater investment in cognition, usability, and evaluation research in geovisualization. Cognition is how the human brain understands the real world. For our topics, we will be considering cognition in the contexts of how humans make sense of the tool in front of them and how humans create and utilize mental representations of the Earth's environments (Slocum 2). Geovisualizations and systems need to be constructed in a manner understandable by the user. Complexity in applications may increase the cognitive load on the user, and make it less usable. Usability is the question in which technologies are easy to use and whether it responds satisfactorily to the tasks the users expect from it (Slocum 2). Evaluation within our topic, comes in two types: formative and summative evaluation. Formative evaluation is an iterative process that takes place during development, while summative evaluation is done near the end of development (Slocum 2). Evaluation is important because technology is expensive and if people are going to invest in expensive technology than they want to be sure that their funds are not wasted (Slocum 2).

Existing methods, tools, approaches

Contemporary evaluation of geovisualizations and geovisualization tools in the context of cognition and usability is typically considered in the space of usability analysis and engineering, for applications and web. Usability studies and evaluation may be used to identify problem areas that relate to human cognition. Evaluation processes may be either formative or summative (Slocum 62), ideally both formative, to allow for iterative change to improve the user interface and experience, and summative to determine the ultimate usability of the tool and cognition/comprehension of the data by users.

Care must be taken when developing geovisualizations and tools to ensure that users are able to relate the visualized data and any controls for its display to their real-world understandings (Slocum 65-66), to decrease unnecessary cognitive load on the users, so that overall usability is not negatively impacted. Additionally, interfaces should strive for simplicity (consider Krug) and take into account user differences, such as expertise, culture, gender, color vision deficiency, etc. (Slocum 66). Simplicity and consideration of users will be reflected in both the user interface and experience, which feeds into overall usability, and may be evaluated alongside understanding of the data.

A standard set of contemporary, mainstream usability and comprehension evaluation methods may be employed to evaluate a geovisualization or tool in multiple areas, such as satisfaction, efficiency, and effectiveness (SEE). These methods may include user testing on a set of tasks with direct observation, think-aloud protocols, eye-movement tracking, results evaluation, and standardized surveys. Focus groups may also be held, both to inform design decisions through prospective user input and to provide insights into a final product.

It is important to consider the SEE measures in any evaluation. Satisfaction describes users' satisfaction with the tool, efficiency describes how quickly users are able to complete a task (such as arriving at an answer to a question), and effectiveness describes successful users are at successfully complete a task (e.g., arriving at a correct answer). These measures are not correlated and must be carefully considered, especially in evaluation of similar systems, as the system that results in higher user satisfaction and/or efficiency may have lower effectiveness (for an example, see Coltekin).

Measurement of effectiveness may be broken into components, representing degrees of understanding of results. For instance, change detection in animated choropleth maps may be considered at three levels: awareness of change, knowing the direction of change, and understanding the meaning of the change itself (Goldsberry 209).

Prior to any usability evaluation, tasks must be clearly defined, measures of effectiveness agreed upon, users trained (so that measures of effectiveness are not skewed by issues not related to the tool), and observers and systems ready to collect information. Notes from direct observations and recordings (audio, video, and eye-movement tracking) are collected and time-synchronized to allow for later review.

Following an evaluation, user surveys may be conducted to gauge satisfaction quantitatively. Standard surveys, such as the System Usability Scale, are available to facilitate this, and the use of the same survey tool in a controlled environment may allow for quantitative comparisons between multiple iterations of the same tool, or across informationally equivalent tools. Direct observation of users during evaluation may also provide valuable, anecdotal-only insight.

Possible applications

Alongside the growth of technology, social media, and open data sources, the world of geovisualization has effectively entered into the lives the everyday people. This is largely attributed to the ease of use, natural designs, and seemingly endless applications that are now available to academia, industry, and the general public.

Not only can scientists and researchers use geospatial products to discover valuable spatial relations in their research, but with modern visualization techniques, they are able to effectively communicate and display their research to both peers and to the general public. Local governments can use simple and easy to use web applications to share relevant information with their citizens. Various available online tools can help take data sets and turn them into beautiful, captivating displays or animations that can be easily embedded or displayed. With limited time and resources that local government employees often have, easy-to-create and easy-to-use applications can be embedded into webpages and used on mobile devices. By creating simple, intuitive applications, developers can take advantage of the spatial component of their data, but in a way that is effective for their target audience.

In the late 1990s, former US Vice President Al Gore coined the term Digital Earth as a way to display a model of our planet that holds various layers of physical, environmental, and social phenomena (Goodchild 8). This would be used as a way to visualize, share, and analyze the endless amounts of geographic data that could be brought together to inform decisions and reveal patterns. Although an all-encompassing Digital Earth, connected to the world's digital archives, does not exist, various aspects of the vision have come to fruition. When Google Earth and Maps were released in 2005, the general public now had access to extremely powerful earth-exploration tools (Gould, et al 11088). Likely the easiest to use GIS tool, Google Earth allows users to explore all parts of the world through various data and imagery layers, while inserting their own KML layers (Gould, et al 11089). With the release of Google Maps API, it also became relatively simple to use Google Maps in everyday websites and applications Gould et al 150). Additional features like Google Street View and 3D buildings have also contributed to the usability of the system and the relatability of these digital maps to the real-world.

Advantages and disadvantages (or promises and challenges)

Cognition and usability research as applied to geovisualization holds several promises for the future. With the ubiquitous nature of mobile-mapping and interactive mapping, this research will play an ever more important role. It will contribute to the overall effectiveness of these maps and will be "critical in ensuring that applications are both easy to use and meet their intended tasks" (Slocum 72). Additionally, this research may assist in greater knowledge construction. In some cases, geovisualization and interactive maps have been shown to communicate information more effectively than static maps. Further cognition, usability, evaluation research can, in turn, aid greater general knowledge creation and discussion.

However, there are still several challenges that cognitive and usability research must acknowledge. Many of these challenges are in direction relation to the interdisciplinary and integrated nature of geovisualization. First, there is the challenge of developing a methodology to evaluate the effectiveness of geovisualization in general (Slocum 71). Due to the broad and exploratory nature of geovisualization, interdisciplinary study collaboration is required.

Additionally, there is the challenge of determining the best mix of realism and abstraction to influence cognitive processes involved in knowledge construction (Slocum 70). Paired with that is the challenge of determining the correct "mix of cartographic, graphic, statistical, and geocomputational approaches necessary for understanding geospatial data," (Slocum 70). Geovisualization can employ all of these approaches, however they must be balanced for optimal data communication. The last challenge relates to the user base. Individual user differences must be accounted for when designing systems and applications. Due to the diverse backgrounds, skill levels, and intents of geovisualization users, it is incredibly challenging to establish a universal usability standard.

Future developments

Future developments for cognition, usability and evaluation are considerably minor since much of the research for cognition, usability and evaluation has been considered for many user interfaces and user systems in software and technological development (Fish 360). However, areas that could still be developed include more analysis, specifically on individual tasks, scan paths, and background training bias (Coltekin 16). Further research is would be desirable to understand the issues to change blindness in order to inform future designs to overcome or minimize their effects. Technologies, such as eye tracking technology could also be improved.

Works Cited

Coltekin, Arzu., et. al. "Evaluating the Effectiveness of Interactive Map Interface Designs: A Case Study Integrating Usability Metrics with Eye-movement Analysis." *Cartography and Geographic Information Science*, vol. 36, no. 1, 2010, pp. 5-17.

Fish, Carolyn., et. al. "Change Blindness in Animated Choropleth Maps: An Empirical Study." *Cartography and Geographic Information Science*, vol. 38, no. 4, 2011, pp. 350-362.

Goldsberry, K. et al. "Issues of Change Detection in Animated Choropleth Maps." *Cartographica: The International Journal for Geographic Information and Geovisualization*, vol. 44, no. 3, 2009, pp. 201-215.

Goodchild, Michael F. "Cartographic Futures On A Digital Earth." *Cartographic Perspectives* 36 (2000): 3-11. Web.

Goodchild, Michael F. et al. "Next-Generation Digital Earth." *Proceedings of the National Academy of Sciences of the United States of America*, vol. 109, no. 28, 2012, pp. 11088–11094. www.jstor.org/stable/41684701.

Krug, Steve. *Don't Make Me Think: A Common Sense Approach to Web Usability*. 2nd ed. Berkeley, Calif: New Riders Pub., 2006. Print.

Slocum, Terry A., et. al. "Cognitive and Usability Issues in Geovisualization." *Cartography and Geographic Information Science,* vol. 28, no. 1, 2001, pp. 61-74.