## Emerging Methods for Studying Use of Spatial Technologies
## *@ GIScience 2010, 14 September in Zurich, Switzerland*

This workshop, sponsored by the Commission on Use and User Issues of the International Cartographic Association (*www.univie.ac.at/icacomuse*), aims to bring together researchers from relevant fields to discuss methods for studying the use of spatial technology in the multidisciplinary context of GIScience.

Spatial technologies of all types are becoming an increasingly common part of many individuals' daily lives. We define spatial technologies broadly, including but not limited to location-based services, mobile mapping, mash-ups, interactive maps, geovisualizations, and GIS applications such as decision support systems. Although much effort is devoted to building these technologies, fewer resources have been devoted to making them usable or understanding why and how a technology is usable. Encouragingly, however, a growing number of researchers have shown interest in recent years in working in the area of user studies. This workshop is aimed at promoting interaction and exchange between researchers who do user studies (or would like to do them in the future).

**Workshop Programme:**

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| 9.30-10.15 | Behavioral and Neurological Approaches in Map Use Research, *Amy Lobben* |
| 10.15-11.00 | Sharing experiences from the design and evaluation of tangible and mobile augmented reality interfaces for 3D geovisualization and location-based learning, *Nick Hedley* |
| 11.00-11.30 | Coffee Break |
| 11.30-12.15 | Touching scenes: Towards haptic guidance for complex visual displays, *Ric Lowe and Madeleine Keehner* |
| 12.15-13.00 | Using CogSketch to study and teach spatial thinking, *Tim Shipley* |
| 13.00-14.00 | Lunch |
| 14.00-14.45 | Eye Fixations and Comprehension of Geospatial Displays, *Mary Hegarty* |
| 14.45-15.15 | Poster introductions:<br>• Displaying and Controlling of Geospatial Data in Web Browsers, *Petr Voldán*<br>• Evaluating Visualisations of Geographically Weighted Spatial Statistical Methods, *Tommy Burke*<br>• Eye Tracking for Evaluating Highlighting in Geovisualization, *Anthony Robinson*<br>• Does context matter for the visual identification of geometric movement parameters?, *Anna-Katherina Lautenschütz*<br>• Usability of mobile eye tracking for the design of a pedestrian navigation system, *Connie Blok*<br>• Developing an iPhone App for Collecting Pointing Task Data, *Scott Bell* |
| 15.15-15.45 | Poster mingling and discussion |
| 15.45-16.00 | Coffee Break and further poster mingling |
| 16.00-16.30 | Poster mingling and discussion |
| 16.30-17.00 | Workshop wrap-up session to identify common themes/challenges in doing user research |

## Keynote abstracts:

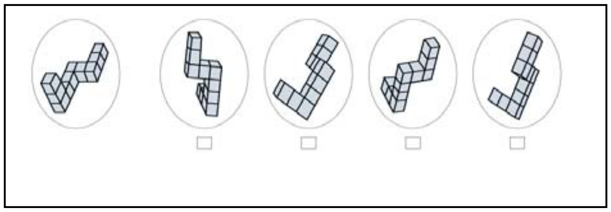
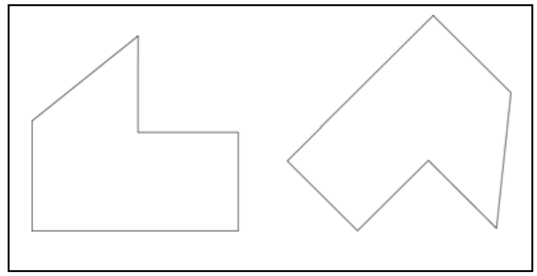
### Behavioral and Neurological Approaches in Map Use Research

Amy Lobben, University of Oregon

Map use is a complex process involving data representation and use in (often) real-world settings. Studying the process is made even messier with the realization that every human being engages in these activities differently. Moreover, to a large extent, these activities are intangible and can be difficult to capture/measure. As a result, my research group often uses several methods to "measure" map use ability and performance, including traditional behavioral measures (i.e. participant observation, interviews, focus groups, ability tests) as well a neuroimaging (fMRI specifically). Our belief is that by using more measurement approaches, the resulting patterns will give us more valid and robust representation of a person's actual thinking process associated with specific map use tasks. We specifically use the combined methods of abilities testing with neuroimaging to identify whether behavioral and neurological correlates can be identified with respect to specific map use tasks. This approach may, for example, be able to tell us whether a neurological difference may be associated with "good" versus "bad" map readers. While fMRI doesn't directly measure *what* a person is "thinking." It does, though, provide a measure of the Blood Oxygen Level Dependent, or BOLD, signal/response and can tell us *where* a person is thinking. The BOLD signal is based on theories of hemodynamic response, or the changes in blood flow and oxygenation. When nerve cells activate, they consume more oxygen than nerve cells that are not active. Magnetic resonance is different for oxygenated versus deoxygenated blood, which are diamagnetic and paramagnetic, respectively. Therefore, oxygenation will create wither a repulsive or an attractive effect, which can be detected by the magnet. This BOLD signal follows a predictive temporal course. In nerve cells that are activated, oxygen increase rapidly when first engaged, then dissipates at a slower rate. It's this predictive time course that allows researchers to identify the areas of the brain that are activated while completing a specific task (a map reading task for example in our case).

In this paper we will discuss our combined behavioral and neurological approach in three map use/reading projects: 1) mental rotation of maps and geometric objects, 2) route survey memory, and 3) self-location.

The first project investigates the mental rotation of maps and geometric objects. Tests of mental rotation ability have been used, primarily by psychologists, for decades. Two examples of mental rotation test instruments are shown below. In both cases, a person must view a reference graphic (on the left) and make a same/different decision about the graphic(s) on the right. In previous research (Lobben 2007), a person's mental rotation ability was shown to be a predictor of whether they physically rotated their map during navigation. In the current project (Lobben and Lawrence in progress), we investigated the impact of stimuli characteristics on mental rotation. Specifically, we wanted to identify whether rotating geometric objects resulted in similar or dissimilar behavioral and neurological patterns as rotating map objects. We conducted two stages of testing, behavioral (computer based) and neuroimaging (fMRI). In the behavioral stage, we created a test with 5 graphics (maps with text, maps without text, simple geometry, complex geometry, and text alone). Over 200 participants were tested. From that group, we selected high and low performers, where performance was measured on three stimuli. We then collected fMRI data for this group (n=20). In this paper, I will present both the behavioral and the neurological results. In brief summary, we found distinctly different factors aligned with each of the 5 behavioral test stimuli. Also, we found neurological differences when subjects mentally rotated the different stimuli as well as differences between performance groups.

Project Two is also based on previous research (Lobben 2007) in which a single task, self-location, was shown to be a significant predictor of navigation ability. As in the previous study, we conducted computer-based behavioral testing with ~200 participants. From that group, we selected the top 10 and bottom 10 performers. Again, we re-ran these participants in the magnet and collected neurological data. Initial results reveal behavioral and neurological correlates associated with this navigation ability prediction test (self-location).

Project Three investigates modality differences while performing route and survey tasks. Research participants include both sighted and blind or low vision groups. We created visual and tactile representations of the same tasks, designing the instruments so exploration time (i.e. the time taken to explore the same graphic visually and tactually) is controlled and the same for both deliveries. We conducted behavioral testing with ~50 sighted and with ~25 blind participants. Following, we conducted fMRI scanning/testing using the same instrument with 10 sighted in both the visual modality and in the tactile modality, and 5 blind in the tactile modality. Analysis in progress will be presented from this project.

**Sharing experiences from the design and evaluation of tangible and mobile augmented reality interfaces for 3D geovisualization and location-based learning**

Nick Hedley, Spatial Interface Research Lab / Department of Geography, Simon Fraser University, Canada

Augmented reality (AR) interfaces have significant potential as a new form of spatial interface. Tangible AR interfaces can provide powerful sensory experiences with 3D geovisualizations. At the same time, mobile AR interfaces provide compelling ways to interact with real geographic environments using both custom and mainstream technologies. This presentation discusses the ways various types of AR interfaces may provide different perceptual experiences, shares experiences in empirical methods to evaluate AR-mediated sense-making, and suggests strategies for the design and evaluation of these interface types. The first part of this presentation will provide an introduction to the features and permutations of augmented reality interfaces. The second part of this presentation reports on research conducted over several years (in pure laboratory testing environments, semi-controlled participant evaluation contexts, and in free-form public venues), using a range of hybrid methods to test and compare 3D tangible augmented reality interfaces with conventional 'desktop 3D' geovisualization interfaces. The third part of this presentation discusses how we are applying lessons learned to the design, implementation and evaluation of mobile augmented reality for in situ environmental and geomatic applications in British Columbia, Canada. The fourth and final part of this presentation reflects on methods, observed interface use, and their significance for the design and evaluation of future sedentary and mobile geospatial augmented reality applications.

**Touching scenes: Towards haptic guidance for complex visual displays**

Ric Lowe* and Madeleine Keehner**
*Curtin University of Technology
**University of Dundee

Advances in spatial technologies provide us with increasingly rich and complex information displays. However, the growing sophistication of geographic visualizations raises fundamental questions about their practical utility. Potential benefits need to be balanced against possible costs, since very complex visual displays impose substantial perceptual, attentional and cognitive demands. For the user, whose task is to navigate and interrogate the display, guidance may be needed to ensure that attention is guided to task-relevant information and that information is perceived and processed effectively, while task-irrelevant information is disregarded. Unfortunately, the practical options for providing such user guidance are limited. For example, text has insufficient spatial precision to provide accurate guidance, while added graphic cues would likely exacerbate the already high level of visual processing demands. In contrast, haptic guidance offers a spatially-based way of directing users to key information in complex visual displays that circumvents the problems of textual or graphic support. However, for haptic guidance to be successful in making these displays more useable, it needs to be based on a careful comparison of how visual and haptic sensory cues are processed. Without proper coordination of these two forms of information, haptic guidance could be at best ineffective, or at worst potentially damaging. This presentation explores the conceptual and methodological challenges involved in making haptic-visual comparisons. Our particular focus is research methods for investigating the similarities and differences of haptic and visual search processes. We discuss distinctive features of visual and haptic perception and the marked differences in resolution, scope, and loci of these two modalities. Such differences have profound implications for quantitative and qualitative aspects of haptically-guided visual search. Technical issues concerned with making haptic-visual comparisons are surveyed and the limitations of various approaches are considered. The presentation concludes with a discussion of methodologies being developed to provide haptic guidance for complex visualizations.

**Using CogSketch to study and teach spatial thinking**

Thomas F. Shipley*, Kuba Glazek*, and Kenneth Forbus**
* *Temple University,* Philadelphia, PA, USA
** *Northwestern University*, Evanston, IL USA

The talk will consider two aspects of CogSketch. In the first part I will give an overview of CogSketch as a spatial reasoning engine that can be used both for education and research on spatial cognition. I will briefly review how CogSketch can apply qualitative reasoning to understand spatial relations in sketches. The use of labeled sketches allows students to directly convey their spatial understanding of specific concepts in a sketch. CogSketch can use human-like qualitative reasoning to provide tutoring feedback when spatial errors are made. The system is designed for easy addition of new concepts in a worksheet-style environment. This will allow speeded feedback on problem sets designed to teach specific spatial concepts.

In the second half of the talk I will describe how CogSketch can be used as an experimental interface. Expert sketches reflect fundamental conceptual information about the domain of expertise. We have developed procedures to coordinate sketch data with eye-tracking data to study expertise. We have used combined eye tracking-sketching to study the encoding and processing strategies used by Geoscience experts and to explore basic and applied aspects of expertise development. To do this eye- and hand-tracking timestamps were synchronized, allowing for in-depth analyses of visual encoding, sketching, and inspection strategies. I will discuss some of the specific strategies that experts use, and how these strategies might be communicated to Geoscience students.

**Eye Fixations and Comprehension of Geospatial Displays**
Mary Hegarty, University of California-Santa Barbara

This talk will review methods of collecting and analyzing eye fixation data and inferring cognitive processes from eye fixations. It will focus on eye fixations on visuo-spatial displays, including maps, diagrams, and graphs. Topics covered will include the history of research on eye movements, basic assumptions of eye fixation research, how eye fixations are directed by both top-down and bottom-up processes, and how eye fixations contribute to comprehension, reasoning, and problem solving with visuo-spatial displays.

To illustrate the use of eye fixation research in geographic information science, the talk will highlight a series of experiments that examined how bottom-up effects of map design and top-down processes of knowledge interact when people view and make inferences from weather maps. In these experiments we varied either the complexity of the weather maps (the number of variables displayed) or the relative salience of task-relevant and task-irrelevant variables. Effects of domain knowledge were also studied by examining performance and eye fixations before and after participants learned relevant meteorological principles.

Map design and knowledge interacted such that salience had no effect on performance before participants learned the meteorological principles, but after learning, participants were more accurate if they viewed simpler maps, or maps that made task-relevant information visually salient. While there were effects of map design on task performance, these were not always mediated by differences in eye fixations. The results support a model in which eye fixations on maps are directed primarily by top-down factors (task and domain knowledge). They suggest that good map design facilitates performance not just by guiding where viewers look in a map, but also by facilitating processing of the visual features that represent task-relevant information at a given map location.

We thank members of the program committee, who helped to review poster submissions to the workshop:

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