Towards a Geovisual Analytics Observatory

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ABSTRACT
In response to the charge "*How can we best develop a systematic understanding of the intersection between human abilities, cartographic design decisions, and map use context? Can we predict what will work?"* I argue for building a geovisual analytics observatory (GeO) to frame and support fundamental investigations based on empirical evidence of the *who*, *what*, *how*, *when* and *why* of human inference in visuo-spatial analytical reasoning, and spatio-temporal decision making with geographic information displays.

Keywords
Geovisual analytics observatory; empirical studies; mobile; crowd sourcing; experimental design, emotion; sensor science

INTRODUCTION
Spatio-temporal decision-making (often supported by visual displays) is a process that people engage in on a daily basis. Increasingly, this process occurs in time-critical situations and dynamically evolving environments, such as when commuters need to navigate through a congested city during rush hour, using several modes of transportation in their daily commutes. In emergency situations, the impact of spatio-temporal decision-making under time pressure can be also live saving: fire fighters, or search and rescue workers may or may not be able to save lives depending on the effectiveness and efficiency of their visuo-spatial decision-making typically supported by visual displays. While current research within the visual analytics and geovisual analytics communities including cartography has focused predominantly on building tools and respective highly interactive computer-human interfaces, fundamental investigations based on empirical evidence of the *who*, *what*, *when* and especially the *how* and *why* of human inference, analytical reasoning, and spatio-temporal decision making with visual displays have received considerably less attention.

Leaving the static desktop comfort zone in the lab
As visuo-spatial displays of geographic information are increasingly used in mobile and dynamically evolving situations, it will be important to consider research on the kind of information that users can get from displays when used in time and attention critical, and potentially also emotionally charged spatio-temporal decision-making contexts. Limited perceptual and cognitive resources of display users—and also often overlooked, autonomic nervous activity—most likely will influence how the depicted information is apprehended, and this will ultimately determine how effective users will be in detecting and reasoning about spatio-temporal phenomena. It is still poorly understood how individual people and groups of people make effective and efficient decisions in time critical situations and especially under uncertainty and dilemmatic decision contexts.

What is missing?
To be able to "predict what can and will work" with current geographic information technology (GIT) coupled with mobile and highly interactive displays, we need to move beyond the dominant comparative A|B display testing paradigm in cartography, borrowed narrowly from psychology to study behavior. To be able to predict whether geovisual analytic displays work, that is, analytics understood here as the *human inference making process*, we need to ask:

What are the fundamental *processes* with which humans make *affective*, *effective* and *efficient* visuo-spatial decisions with geographic information displays?

"Grand challenges research agendas in visualization" call for human factors research (e.g., [1], [3],[7], but we still lack fundamental insights on the respective processes, based on empirical evidence to-date, especially with respect to human factors including *individual differences*, human *affect*, and *cultural* variation ([5]). Specifically we lack insights beyond static, lab-controlled decision making contexts (i.e., when moving in the world, often under uncertainty, and in dilemmatic decision contexts). The few studies that have been performed to-date include mostly methods developed for controlled lab experiments, testing few variables, and few participants, thus respective results typically have limited ecological validity [6]. It is unclear how current systematic evaluation methods, typically designed for a controlled lab environment [4], tested typically with a decision maker using a display alone might transfer to rapidly dynamically changing, messy, outdoor

situations, with broad ranges of collaborative and online decision-making makers and contexts [8].

What next?

To answer pressing open questions *whether, how,* and *why*, geographic information displays support effective and efficient spatio-temporal decision making and action, and for *whom*, especially in increasingly emotionally charged, dilemmatic, and collaborative decision contexts under uncertainty, we need to:

1) **develop unconventional evaluation methods** beyond the controlled lab paradigm by critical examination of how perceptual, cognitive, psycho-physiological, and display design factors might influence visuo-spatio-temporal decision making across broad ranges of users and dynamically evolving use contexts [2], and
2) **scale up empirical methods** from to-date controlled behavioral lab paradigms towards a new in-situ, mobile, collaborative, and crowd-sourced human sensor science in the real world. [8]
3) develop missing, empirically evaluated **design guidelines** for human-computer interfaces of current/emerging mobile geographic information technology to support affective, effective, and efficient spatio-temporal decision-making. [4]

THE GEOVISUALITICS OBSERVATORY (GEO)

The **GeO** framework needs to consider the still poorly understood relationships between the **empirical research settings** (i.e., controlled lab | real world) to study (single | collaborative) behavior with visual displays, and across three **research factors:**

1) the **use and context** of visuo-spatial decision making;
2) the (background and training of the) **human decision makers**, and
3) the **display design** factors.

A critical part of this GeO needs to focus on how to integrate prior research results borrowed from the behavioral sciences in a meaningful way, adapted to GIT use including inference and decision making with geoVA displays. What might be well-tested and sensible methods and approaches in cognitive and psychological sciences, might not readily transfer to messy, uncontrolled, in-situ, crowd-sources, and collaborative uses typically found with geoVA displays.

We need to scale up empirical methods and respective analysis approaches from to-date controlled behavioral lab paradigms (including Virtual Reality settings) towards a new, messy, collaborative, and crowd-sourced, mobile human sensor science in the real world (i.e., including ambulatory psycho-physiological measurements such as EDA|ET|EMG|EEG[1], etc.) [9].

CONCLUSIONS

In short, we need a paradigm shift to radically change the way we study human behavior across science. We need to extend current neuro-cognitive and affective behavior science with single users in the lab towards location-based, mobile, collaborative, and crowd-sourced human sensing in the real world. As a consequence we need new ways of analyzing collected behavioral data beyond classic inferential statistical measures and one-person display use scenarios, when tested populations involve the crowd.

In building a Geovisual Analytics Observatory (GeO), we can improve spatio-temporal every-day decision making with geographic information displays for anyone, and thus facilitate solutions to global environmental problems and pressing societal needs which are in turn critical for advanced mobile information societies.

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[1] Abbreviations: Electro dermal activity (EDA), eye tracking (ET), facial electromyography (EMG), electro encephalography (EEG)

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