Faculty of Design, Industrial Design, Inclusive Design, Perceptual Artifacts Lab (PAL)

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Research statement

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RESEARCH STATEMENT

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My research lies in the domain of visual media, and graphic representation in particular. I seek a scientifically-grounded understanding of established and emerging conventions in the fine & applied visual arts. This is a perceptual-cognitive approach to understanding visual media.

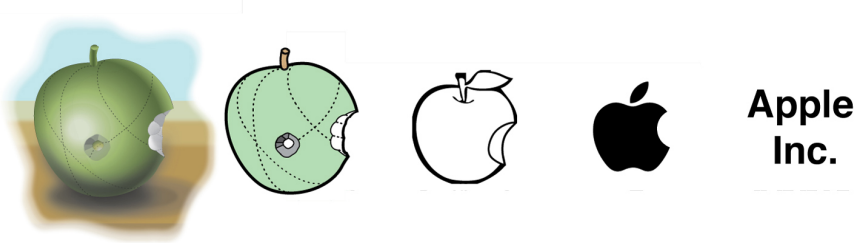

Figure 1: What perceptual-cognitive properties distinguish pictures and symbols?

Background

Currently the design of graphic representations used to make decisions, even in critical digital media systems, is more of an art and craft than a science. In visual information design, the majority of the research, training, and practice is focused on the techniques for creating graphic representations, such as how to draw them, arrange them, or use computer programs to generate them. Typically, very little effort is put into understanding how and why people perceive, cognitively process, react to, and socially interact through graphic representations. I seek a scientifically-grounded understanding of established conventions in the applied visual arts to inform a principled and rational approach to Visual Information Design.

Realistic pictures are thought to provide rich details, yet outline drawings, and even caricatures, have been shown to enable responses with greater speed and accuracy. If outline drawings are more effective, which details of the rich graphic representation should be eliminated, and which should be "amplified" or "caricatured"? Does color aid or detract from decision-making in this context? And, if the former, to which elements should color be added? Are animations more effective than static pictures, such as a time series, or even a comic strip? Or would a static time series, or comic strip, enable the audience to "step outside of time" in order to perceive relationships, across the "frozen" snapshots, that would be imperceptible in an animation? Which graphic representation properties require learning before they can be understood, and which are more intuitive, perhaps by making use of less-learned, biologically grounded, perceptual-cognitive processes?

These issues lay at the heart of problems in many fields, from education to public policy communications to effective rhetoric and persuasion skills. As just one concrete example, in the field of human-computer interaction, a decade of research has focused on the usability of programming languages. These communities (e.g., Visual Languages and Human Centered Computing, 2012) seek to design visual modeling languages to make software programming, and information system design, easier and more accessible for both practitioners and non-specialists alike. Many efforts have failed (Blackwell, 2006). Moody (Moody, 2009) noted that language designers lack an understanding of the ergonomic affordances of the representations they are designing into their languages. I seek to address this class of problem through my research.

In my ongoing research, I have developed a theoretical framework for understanding graphic representations distinguished by their perceptual-cognitive affordances. Such a theory is a departure from existing treatments of representation in that it neither treats representations as "in the head" (as some do in the Cognitive Sciences) nor merely "in the media" (as is commonly done in artistic traditions), but rather seeks to characterize representations as emerging in the interaction between the media and our biologically-based and learned perceptual abilities. My work addresses this question from multiple angles, including examining:

- how *properties* of graphic representations can be distinguished and understood in terms of biologically grounded and learned perceptual-cognitive capabilities;
- how these *capabilities* can be understood in terms of the dynamic environments within which they are naturally selected;
- how *graphic representations are naturally selected* and evolve to perform functional roles as an interface between perceptual capability and a state of affairs, based on capabilities, contexts, and their purposes.

I pursue these issues from three overlapping perspectives as a: visual artist, applied visual information designer, and as a scientist. My work in fine and applied art, and engineering and science, is a mutually reinforcing ecosystem. Artistic exploration develops and explores the affordances of a medium; affordances can then be applied to a specific design problem. Real-world application exposes issues that invite research questions that build a theoretical understanding of the medium's affordances.

For example, my artistic exploration of telepresence art helped develop a medium for remote experience, and exposed its affordances (e.g., (Coppin, 1999; Metahuman, 1998)). I was then able to apply the affordances of remote experience to practical problems, leading to the development of telescience and telepresence systems for education and science exploration (e.g., (Coppin, Morrissey, Wagner, Vincent, & Thomas, 1999; Coppin et al., 2000; Myers et al., 2005)). This applied work exposed issues that invited questions that could be addressed empirically and scientifically. This led to my current research focus at the intersection of graphic representation and cognition.

In what follows, I describe major themes in my theoretical framework that serve as the starting point for the research plan that follows.

A Perceptual-Cognitive Framework for Graphic Representation

For my research, I conceptualize media as material objects intentionally configured to cause percepts. If media emerges at this intersection of perceptual capability and intentionally configured object, then it can be understood in terms of how it makes use of capabilities that were naturally selected in dynamic, and social, environments. In this way, *new* media, such as information visualization-visual analytics, in human-computer interfaces and the web, share common properties with *old* media, such as comics, outline drawings, books, and cave paintings. These common properties are a function of perceptual-cognitive capabilities made use of by old and new media alike.

Pictorial and Symbolized Information

In particular, the framework distinguishes graphic representation types in term of two perceptual-cognitive properties: *pictorial* information and *symbolized* information (Coppin, Submitted). The framework distinguishes these properties in terms of two interrelated perceptual-cognitive capabilities: perceptual *emulation* and mental *simulation*.

I conceptualize these as capabilities that enable reactions to environmental changes in dynamic environments: *current change* and *future possible change*.[1] Current change impinges on an organism in real-time, and survival requires the organism to react in real time. I talk of the the mental work of this capability as perceptual emulation. To survive future possible changes, the organism must predict and plan reactions. I talk of the mental work of this capability as mental simulation.

In this conceptualization, *recognition* is the intermediary between emulation and simulation. I view recognition as occurring when an emulated current state-of-affairs makes use of *memory traces* from previous emulations to construct simulations of possible states-of-affairs. In this view, recognition is *more-learned*, and perceptual-emulation is *less-learned*.

- I conceive of *pictorial information* as visual information, that makes use of less-learned perceptual capabilities to mentally emulate a current change in order to react to a current change.
- I conceive of *symbolized information* as visual information, that makes use of more-learned recognition capabilities, to mentally simulate ("predict") a possible change.

In a similar way, this framework distinguishes graphic representation types: *realistic pictures, outline drawings, diagrams,* and *sentences* (Figure 2). These types are distinguished in terms of how object relations, shapes, or details, are pictured or symbolized.

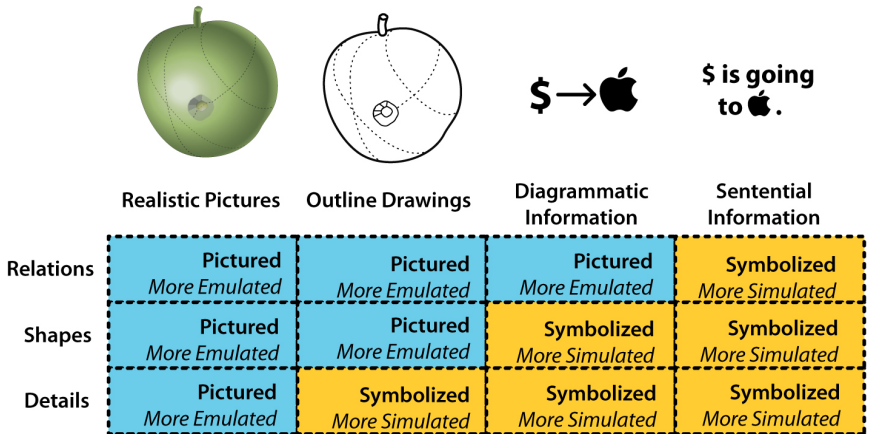

Figure 2: My project's perceptual-cognitive framework for graphic representation, in tabular form.

Affordances of Graphic Representation Types

The framework enables preliminary hypotheses regarding the perceptual-cognitive *affordances* of graphic representation types typically used in design. I build on the idea that capabilities for emulation and simulation share a common, and limited, resource. I use the framework to argue that:

- pictured object relations or attributes interfere with mental simulation of object relations or attributes, intended by an author.

[1] I developed this distinction by "reverse engineering" from central themes in Goodale et al.'s (2005) dual-route hypothesis. In this view, the so-called dorsal "where" visual-spatial processing stream egocentrically references an organism to an environment in real-time, whereas the ventrally located "what/how" stream's connections to memory traces of prior percepts enable the construction of predictions and action plans based on a currently perceived state-of-affairs. I suspect that emulation and simulation are embodied in many systems throughout a human body, however.

- pictured object relations or attributes can scaffold, or support, a mental emulation, intended by an author.
- combinations of pictured and symbolized information can a) free resources for mental simulation of symbolized objects., and b) symbolized information affords mental simulations that are difficult, or impossible, to emulate.

My current work demonstrates this framework using case studies of graphic representation properties and types that are the products of "artifact evolution" in "natural laboratories." These are naturalistic environments where forces of economic-like natural selection shape the evolution of graphic representation properties relative to purposes, capabilities, and contexts. In this way, among other things, I describe why geometric proofs are typically "non-visual," and how pictorial information affords early phases of information system design, while symbolized information, and text-sentential information (e.g., programming languages) affords later phases.

Moving Forward — A Research Agenda

I describe my plan forward in temporal and structural terms as: a set of milestones following my PhD; and the laboratory, classes, symposia, and community that I will develop. I describe, in approximate terms, roughly the next six years of my career.

Milestones. I am emerging from my PhD with a strong theoretical foundation for graphic representation and cognition, and with initial empirical work that I used to guide my theory development, and that I then used to illustrate the framework. I expect that my immediate next step is to use my framework as a "prism" for additional qualitative and quantitative empirical work, mixed with selected applied graphic representation and/or system development.

Though my research agenda is tightly focused to graphic representation and cognition, potential observation sites and application areas continue to be vast, enabling me to craft an agenda to numerous research environments, without deviating from my current focus (see Figure 3). This is because graphic representations are found in almost every imaginable human endeavor, and each example is like a "sonar ping" that exposes phenomena that can be explored through my framework. I expect to use this to my research program's advantage, through a combination of: applied graphic representation development, such as information design applied to real world problems; cognitive ethnographies, to understand functional roles played by graphic representation in naturalistic settings; and selected experiments, to "test" theories developed through qualitative observations. I expect that a major focus during this period will be publishing remaining unpublished parts of my dissertation, and these additional empirical studies. I expect that the end goal for this line of work could be two kinds of books: a theoretical book that outlines my framework, and a "text book" for applied graphic representation and cognition. This is elaborated in my teaching statement.

Lab and community. During this time period, but with greater intensity as I reach around the third year after my PhD, I expect to be developing a laboratory focused on graphic representation and cognition. The lab will be modeled after my NASA funded EventScope Laboratory that I developed at Carnegie Mellon, but oriented toward my new research focus. As before, I expect to develop project classes that intersect with the lab's research area, and the research of students in the lab. Possible research directions that would directly extend my current work are noted in Figure 3, but fall within the broad areas of: tool development for creating graphic representations, perceptual-cognitive theories of graphic representation, applied graphic representation to communicate complex ideas to audiences, and a focus to individual perceptual cognitive differences and graphic representation (e.g., autism and/or dyslexia).

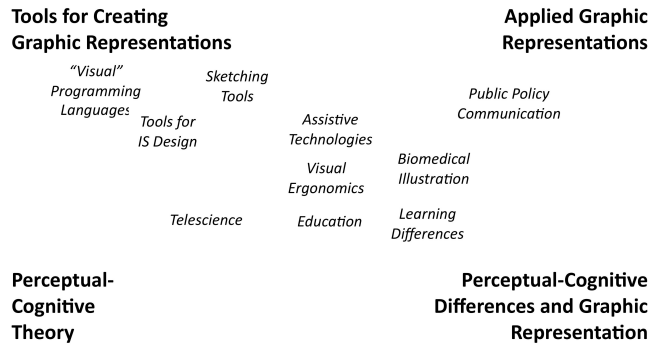

Figure 3: Potential research areas.

I expect to also extend the lab's conversation in ways that intersect with, and help develop, the communities that surround and intersect the lab. I could run a new version of the "Visual Thinking" lecture and seminar series that I co-developed at the University of Toronto. This would be a seminar style class with a small project component, but that runs in parallel to a public lecture series with guest speakers who are focused on graphic representation and cognition.

Conclusion

I feel fortunate to be writing this statement. I feel that environments now exist that are an institutional and disciplinary resolution to a frustration that began when I entered educational systems that forced most of us to choose between art, science, engineering, and beyond. For me, and perhaps for many in new media, there was never a clear distinction, and choosing always felt awkward. I seek environments where I can collaborate with others on the ground floor of a new perceptual-cognitive science of graphic representation that integrates across themes at the university, industry, and in society, and my interests, without splitting my attention. I see these environments as a place where I could truly flourish. My earliest memories are of drawing and depicting. And depicting—through new or old media— is the activity where I gained the most skill, and where I have had the most personal and professional success. But also, I seek environments where I can use my passion, life experiences, and knowledge, to make a true contribution. Beyond the reality that few people in cognitive science were trained, or worked professionally in, the fine and applied arts, too few people know how to graphically depict: their ideas, plans, passions, and dreams. This position could enable me to empower a wide audience as a professor.

As I look at the problems facing our worlds, and that could be tackled at the contemporary research university, I see communication—particularly across boundaries—as one of biggest challenges facing society. Spanning those boundaries through graphic representations—through new and old media alike—as computer interfaces, new kinds of television shows, remote sensing systems, documentaries, games, films, information graphics, visualizations, and beyond, is an area where a handful of people can make a real difference. I feel that institutions are starting to emerge that allow those people to come together. I would like to be in a place where I could work with others to develop a scientific understanding that informs our art and craft, and makes us more effective actors in the world, and in our fields.

Peter Coppin, Toronto, Ontario, Canada, November 14, 2011

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