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What Do You See? Perception, Algorithms, and Statistical Graphics

Statistical graphics and other scientific images are incredibly powerful and efficient ways to convey numerical information in a way that humans can use for decision making. However, research on visual perception of statistical graphics and other data visualizations is a patchwork of inconsistent methods, and most recommendations are based primarily on experience rather than empirical study; this may result in ineffective graphics that communicate scientific results poorly, or worse, inaccurately. Over the course of my career, my long-term goal is to leverage research in statistical graphics and data visualization to *help humans and algorithms work together more efficiently and effectively*, leveraging my research and toolkit to educate a new generation of data scientists and programmers as well as the wider community.

My **research goal** is to advance our understanding of the use and perception of charts, and how the design of statistical graphics impacts our ability to use them successfully. To address this goal, I will (R1) develop multimodal methods for testing statistical graphics to examine how the same chart might be used for different tasks, such as comparison, prediction, and estimation. Applying these methods, I will (R2) assess the decisions scientists make when creating statistical graphics for exploration or communication of results. I will leverage this insight into visual perception to (R3) develop new statistical features that mimic human performance in tasks which are currently conducted visually, such as examination of forensic pattern evidence, developing statistically validated, empirical tools to assist scientists with reproducible decision-making.

My **education goal** is to develop tools and curricula to support statistical learning and scientific decision making in society. To address this goal, I will (E1) develop experiential learning activities in statistical graphics for undergraduate introductory statistics courses, (E2) integrate tools for reproducible science and open-source software into statistical programming courses at the graduate and undergraduate level, and (E3) engage with forensic scientists, lawyers, and judges to discuss scientific and statistical validity, assess the support for different forensic evidence evaluation techniques, and promote the importance of open, reproducible science in forensics and the legal system.

Intellectual Merit

I will produce and validate a set of experimental methods (R1) for conducting graphical user studies, laying a foundation for future work in this area. The studies we conduct while developing and validating these tools will examine fundamental questions in statistical graphics design (R2) in general, expert, disabled, and neurodivergent populations, advancing scientists' ability to communicate results with professionally and to the public, and producing new avenues for research in information visualization, perception, and statistical graphics. Furthermore, E1 will provide new information about the design of introductory statistics courses, and E2 will produce new curricula and tools that can be broadly disseminated to the academic community.

Broader Impacts

The educational objectives will produce students who are more engaged in STEM coursework and less averse to STEM (E1,2), who understand the importance of reproducible science and implement best practices for reproducibility in their own research (E2), who contribute to the open-source community (E2), and who understand the importance of ongoing engagement between scientists and society, with particular focus on the legal/justice system (E3). The information we accumulate on perception of graphics (R1) will inform the development of open-source, explainable algorithms to replicate human perception of forensic data (R3); these algorithms will provide additional tools to the forensic science community and result in better use of forensic evidence within the legal system. In addition, the interactions we have with judges, lawyers, and forensic scientists (E3) will promote the importance of good statistics and experimental design when evaluating new techniques in forensic science.