Trafton Drew: Research Statement

Modern life presents us with a constant stream of more information than we could possibly process. Neuroscientists and perceptual scientists have been acutely aware of this situation for decades. However, the issue has come into sharper focus as accumulating evidence in a variety of different fields has demonstrated that simple errors are responsible for a startlingly high percentage of unfortunate tragedies that befall people in all walks of life. For example, the National Safety Council estimates that >25% of vehicle crashes are caused by cell phone use during driving. Further, hospital errors are estimated to be the third leading cause of death in America, more the 400,000 people annually. As an attention researcher, I view these as preventable errors in attentional deployment. My research program is devoted to delineating the causes, costs, and consequences of inappropriate attentional deployment. Ultimately, the goal of my work is to reduce the rate of these sorts of attentional errors in specific venues such as diagnostic radiology.

One example of this approach comes from research funded by the Department of Defense (DoD) to examine the promise of providing online feedback to users as they search for difficult to detect targets. Modern eye-tracking allows us to encode exactly where someone has looked in a scene and I hypothesized that providing this information to the user would lead to marked benefits in both search speed and the accuracy. We found that simple methods of conveying eye-position feedback to the searcher were not effective (Drew & Williams, 2017). Although this outcome was unexpected, this research provides converging evidence for a general finding that is often over-looked: the method of conveying information is often just as important as the utility of the information.

I drew a similar conclusion from a different project examining Computer Aided-Detection (CAD) in the context of screening mammography. Here, we found that cueing a likely location for cancer was very effective when the marking was accurate, but those same marks led to huge costs when they cued the wrong region (Drew et al., 2012; Drew et al., *in submission*). This finding may underlie why a number of large studies have shown that clinics that use CAD during screening mammography perform no better than clinics that do not use CAD. Together this line of research has shown that spatial attention is vitally important to consider when cueing a region of space. This idea also has applications to the use of augmented reality (AR). In a new collaboration with Sarah Creem-Regehr and Jeanine Stefanucci, I have recently been asked to submit an extension to the aforementioned DoD grant that will use both Virtual Reality and AR to examine the costs and benefits of spatial cueing in AR. In order to evaluate whether different types of navigational cues are helpful, we will compare performance with no cues, AR cue and no cues with a cognitive load. This design will allow us to quantify the cognitive cost of AR cueing in addition to any navigational benefits. My hope is that by taking this fuller picture into account, we can design more effective AR cueing protocols that lead to better performance without decreasing situational awareness.

My interest in the role of attention in diagnostic radiology has led to a growing network of collaborations around the world. The project I am most excited about is a recently awarded R01 from NCI with Joann Elmore, a breast pathologist at UCLA. We are conducting one of the first, and certainly the largest, longitudinal examinations of the development of medical image perception expertise. We will be collecting eye-tracking data from 10 pathology residency programs over the course of 4 years. There is a great deal of data demonstrating that experts examine medical images in fundamentally different ways than trainees, but there is a large gap in the literature with respect to how the trainees of today become the experts of tomorrow. One of the reasons for this gap is that there is no single training program that is large enough to conduct a within subjects longitudinal examination of this question. The most exciting aspects of this grant is that we will be able to surmount this problem through a network of collaborators across the country. Dr. Elmore and I are also currently planning a grant submission devoted to examining the advent of CAD for breast tomosynthesis, a volumetric image that is associated with improved diagnostic accuracy relative to the mammogram.

One of my favorite aspects of conducting research with clinicians is talking with them and observing them as they work. One radiologist collaborator reported that constant interruptions impair his ability to detect cancer. I was aware of the cognitive literature on interruptions, but had never considered how this literature might be relevant to radiology. I was not alone: though there is a growing recognition across different clinical practices that interruptions are detrimental, there is still very little awareness of the basic science research devoted to understanding why interruptions are so hard to overcome. I believe I have made considerable progress in starting to bridge the gap between these two bodies of literature. The initial phases of the work, which were the focus of my first student's National Science Foundation Graduate Research Fellowship, examined the costs of interruption in naïve subjects performing a modified version of lung cancer screening. Naïve subjects cannot diagnose lung cancer as well as a radiologist, but by artificially increasing the size and opacity of lung nodules, we can measure performance that is very well matched to a common task for most radiologists. In this series of studies, we found that interruptions consistently led to time costs, but not accuracy (Williams & Drew, 2017). In subsequent work, we examined the cost of a telephone interruption for radiologists examining complicated real cases while we monitored eye movements. Again, we found that interruptions led to more time spent per case, but no cost on accuracy (Drew et al., 2018). In ongoing work, we have adapted techniques from the driving literature to measure ongoing cognitive engagement immediately after an interruption to assess the time-course of these interruption costs. In work with naïve subjects, we found that interruptions led to cognitive impairment for ~30 seconds after the interruption. This summer, we hope to extend this work to radiologist observers in order to determine whether this large cost may be reduced in radiologists, who may be more accustomed to frequent interruptions and developed compensatory strategies.

I believe my growing stature in the field of medical image perception is evidenced by three developments in the past year. I was asked to co-author two chapters in the forthcoming new edition of the Medical Image Perception Handbook. This textbook was instrumental in my introduction to the field. It was therefore a great honor to have been asked to help write these chapters on volumetric image perception and gestalt perception. Second, I led a successful bid to host and organize the bi-annual Medical Image Perception Society (MIPs) meeting in Utah. I hope to use this opportunity to bridge the gap between perceptual researchers, who often do not know a great deal about radiology, and radiologist and medical physicists, who often do not know a great deal about perceptual research. Finally, I successfully applied for and organized a symposium at Psychonomics devoted to Medical Image Perception this past fall. I used this opportunity as a kind of inverse to the MIPs conference: Psychonomics allowed me to introduce more radiologists and pathologists to the many perceptual researchers who attend this conference each year.

In addition to the applied questions that I sought to address through eye-tracking and medical image perception, I have continued to cultivate a basic research arm of my lab. This effort led to an Early Investigator Start-up grant through the Binational Science Foundation with Roy Luria (Tel Aviv University). We are working together to understand the neural and behavioral consequences of resetting information in working memory. We argue that this takes place when an item being held in working memory undergoes an unexpected change (Balaban, Drew & Luria, 2018a, 2018b, *in submission*). The project was so successful that we were invited to submit a larger follow-up grant through the BSF that is currently under review. This collaboration and the excellent opportunities available for undergraduate funding available at Utah led to some related research that examines how mnemonic representation transitions from fragile working memory to more durable long term memory (Drew et al., 2018). I was proud to have my first Utah undergraduate co-author (Chris Jones) on this manuscript. This study found that the neural representation of items held in memory is completely different for simple laboratory items compared to pictures of real world objects. In the grant, we propose to examine methods of predicting when representation of an item will successfully transition from working memory to long-term memory. We are also starting to apply new analytic methods, such as neural decoding analyses, to assess how the representation of a particular item changes when the subject encounters the same item multiple times.

The research program that I have developed at the University of Utah is designed to examine the both the neural underpinnings and real world consequences of our limited attentional systems. I think I have made significant progress on both fronts as evidenced by my publication record and my growing network of collaborators around the world. I am confident that this approach will ultimately help bridge the gap between the basic science of attention research and the real world ramifications of these findings.