Research statement – Frank A. Drews

We live in an accelerated information age. This has three important consequences. First, there is an enormous growth in the amount and availability of information. Second, people more often have to monitor, control, and interact with dynamic, complex systems. Finally, there is a decreasing window of time in which we can respond to this information, but errors and violations can be potentially disastrous. The information age poses an exciting challenge to Engineering Psychology for the development of more efficient ways of presenting information, understanding multi-tasking and conceptualizing human error and violations. But it also provides a unique opportunity for Engineering Psychology to study human perception, attention and cognition and their impact on performance in complex, naturalistic settings.

My research focuses on performance in naturalistic settings (e.g., the hospital, roads, or mining). For example, new technologies provide intensive care nurses with more data in real time that exceed the limited human information-processing capacity. As a result, nurses cannot make full use of all of this information with potential negative consequences for their patients. With the introduction of cellular phones, a new communication technology became available in the automobile. Similar to the nurses’, driver’s information processing capacities have not increased, but the demand of performing multiple tasks, e.g., driving a car safely and conversing on a phone, is taxing the cognitive system heavily with implications for operator performance. Applying Engineering Psychology in the context of naturalistic settings provides me with an opportunity to combine applied and basic psychological research. On the applied side, the questions concern how to improve performance and minimize break-downs, e.g., in the Intensice Care Unit (ICU), the road, or in mining. On the basic side, there is the possibility of understanding how cognition depends on context and how performance is affected and potentially shaped by factors present in complex, dynamic environments.

The long-term goal of my work is to advance our understanding of the relationship between information presentation, cognition, decision-making and performance in naturalistic contexts. My research program supports the notion that information integration is an effective strategy to support and improve cognition and decision making. In addition, by designing the operational environment and the tools used, it is possible to reduce error and non-adherene to best practices. In pursuing my research goals I take a multi-method approach, using surveys, field studies, experiments, simulations, video analyses, eye-tracking, and process tracking methods.

In critical care units, information about the patient’s vital signs is presented to nurses and physicians on computer displays as a combination of digital and waveform-based information. The design of these traditional displays is based on the single sensor single indicator approach: Information about the value of each variable measured by a single sensor is displayed with a single indicator. Given that a typical display shows over thirty variables in real time, such displays exceed the information-processing capacity of the average human. Unfortunately, current displays do not support health care workers in detecting significant vital sign changes, making diagnoses and treating the patient optimally.

An alternative approach is to develop patient displays that integrate graphically the information collected by different sensors. The basic assumption is that integrated information reduces the cognitive workload of the nurse or physician, because there is no need to integrate the information cognitively. Moreover, using graphical objects permits the exploitation of the human visual system’s sensitivity to change and violation of symmetry in objects, and its ability to recognize patterns in graphical displays. Some of my work compared anesthesiologists’ performance in simulated surgeries using integrated displays and conventional displays. In these studies we used high fidelity simulations, eye-tracking and video analyses. The combination of these approaches allowed us to examine the time needed to detect changes in variables, to diagnose the cause for changes and to administer treatment for the patient. Using integrated graphical objects to provide information improved diagnosis, and reduced detection and treatment time. In other health care related work I conducted, and continue to conduct research with the goal to support clinicians when performing complex procedures. Previously, one target procedure was Central Line Dressing Changes that if performed incorrectly can result in Central Line Associated Bloodstream Infections (CLABSI) that have a mortality rate of approximately 25%. This work focused on providing Engineering Psychology based solutions that are rooted in the principles of Adherence Engineering, a conceptual framework that aims at reducing human error and procedural violations. After
implementation of a newly developed dressing change kit in a local tertiary hospital, we were able to significantly reduce the number of CLABSI and to statistically save several patient’s lives over a 12 month time period. Currently, I study the complexity of personal protective equipment use in health care, and potential contributors to its unsafe use, which has significant implications for health care worker and patient health.

Other work conducted in my laboratory and in the field focuses on breakdowns of performance during multi-tasking: Some of this work focuses on nurses engaging in multi-tasking while providing patient care, pharmacists’ multitasking while filling prescriptions, or the impact of using cell phones and other technologies while driving.

Nurses providing care to their patients are frequently interrupted. These interruptions stem from different sources, but mostly are caused by either people or device alarms. In one of my most recent studies, I investigated the impact of interruptions on patient care. The results of this work indicate that interruptions from devices (e.g., alerts) increase the likelihood of patient hazards that can result in adverse events. Given that the ICU is a “pandemonium in the modern hospital” in which alarms occur frequently but are in more than 90% clinically insignificant, this work identifies an urgent need to redesign the work environment of clinicians to increase patient safety.

On a more basic side, in a series of studies I examined in how visual information processing is influenced by performing multiple tasks. This has its real world analog in situations such as administering a drug while monitoring a patient vital signs display, or operating a vehicle while talking on a cellular phone or text-messaging. In one study, participants were driving a car in a driving simulator while wearing an eye-tracker. Half of the participants were conversing on a cell phone, while the other half did not. Randomly, the drivers encountered situations that were potentially important for safe driving. Later, when faced with a surprise recognition task, participants in the dual task condition (conversing and driving) did recognize about 50% less of the previously encountered situations than the single task subjects (driving only). Interestingly, this difference was found despite the fact that participants in both conditions had fixated on those scenes allowing the identification of “inattention blindness” as a result of dual-tasking.

Additional work using the task of operating a vehicle while engaging in multi-tasking identified the dangers associated with text-messaging while driving, a task that requires switching visual attention between monitoring the driving environment and reading or composing text-messages. The competition of the visual demand between the two tasks results in significant interference with driving performance, increasing the likelihood of causing an accident by a factor of 6 in a driving simulator. One of the results of this work was that the majority of states nationally, and many countries internationally banned text-messaging while driving. While there is clear evidence that engaging in multi-tasking can result in performance breakdowns, there are circumstance, when this is not the case. For example, some of my other work demonstrated how engaging in a passenger conversation does not result in an increase in performance breakdowns compared to driving only. This work has important practical and theoretical implications that help to improve our understanding of the factors that contribute to performance breakdowns while multi-tasking. My most recent work focuses on vehicle automation, where primary task responsibilities are delegated, creating a situation of disengagement and under-stimulation.

Overall, my work informs our understanding of contextual influences on information processing and human performance. This is critical for the basic issue of understanding attention, cognition and decision making, and the applied concern of display, tool, and task design in almost every context.

I see my work as one piece in the larger effort of pursuing questions related to safety using Engineering Psychology. On the applied side, I am interested in developing interventions in health care, mining, and other domains, with the goal of improving safety, while, on the theoretical side, the long-term goal of my work is to develop a theoretical framework concerning the relationship between task performance, technology, cognition and decision-making in complex, naturalistic environments. The information age increased the complexity of all contexts in which humans operate. Thus, it is one of the most exciting challenges to understand and improve human performance in these operational environments, by developing better theories of human performance and solutions that will have a positive, long-lasting impact on safety.