Situation Awareness: Should We Stop for Directions?

Situation Awareness Analysis and Measurement
by Mica R. Endsley and Daniel J. Garland (Eds.)
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Situation awareness (SA) is, simply put, understanding the situation in which one is operating. The importance of studying SA has been communicated quite well in this volume. Because loss of SA can often result in the loss of human life, it is important to understand the factors relevant to the development of SA. The desire to fill the gap between ideal and achievable SA leads to important applied work relevant to design of human interface technologies, training programs, and teamwork. The possibility that individuals can differ in principled ways in the amount of SA they possess has led to work on individual differences, including a look toward our aging population.

The original impetus for research in SA was its application to aviation and this volume reflects those origins, although there are sorties into driving and firefighting. Volumes of readings on SA have been produced in the past, and researchers familiar with the area are likely to recognize several chapters as later stages of some of that early work (Garland & Endsley, 1995), although this more publicly available volume is pebbled with some recent findings. We are told of evidence that free-flight, a change in procedures planned for future air traffic controllers, has negative consequences for SA; individuals skilled in SA seek to monitor and communicate with teammates, and SA with heads-up displays is typically superior to heads-down displays, unless the event is truly surprising.

Although the importance of SA is clear, it is less apparent exactly how researchers should think of SA. As one reads this edited volume, the sense that SA is an ill-defined construct becomes evident. A popular definition is provided by Endsley: "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (p. 5). This definition describes SA as a process; however, SA is also explicitly defined in the same chapter as a product, "a state of knowledge about a dynamic environment" (p. 25). This product, it is argued, only resides in conscious awareness and is disconnected to a degree from performance on the task at hand. Other authors within this volume, notably Klein, argue that SA cannot be disconnected so easily from performance because SA is a function of the affordances in the environment and the decisions that spring forth from their perception. Still other authors define SA only in terms of the operational and mission goals of the task under consideration. The sheer complexity of the construct itself and the many different processes involved in the development of SA make determining exactly what constitutes SA a very difficult prospect. This has implications, most notably, in efforts to measure SA within a complex, dynamic environment.

A large part of this volume is, thus, dedicated to describing the various measurement techniques available to SA researchers, and providing guidance for researchers unfamiliar with the literature on SA. Many (but not all) methods for the study of SA are discussed in this volume: direct performance measures, Endsley's memory probe method (Situation Awareness Global Assessment Technique), subjective measures, verbal protocols, testable responses, and even the possibility of psychophysiological assessment. The work would have benefited from a chapter that helped the reader resolve some of the methodological distinctions. For example, consider the difference between testable responses and memory probes. In the former procedure, events are inserted into the simulation, the discovery of which directly implicates SA (and not, for example, decision making). Gugerty and Tirre used a measure of a driver's awareness that a collision was imminent (braking or turning) as an indication that the driver was aware of the problem even if the choice (e.g., turning) resulted in a different accident. It seems to us that such testable responses are, if chosen well, indisputable measures of SA. One problem is that it may be difficult to embed many of these target events in any particular scenario. A proponent of memory probes would add that studying targeted performance does not provide a one-to-one measurement of SA, because good performance can result from bad SA purely by chance.

Proponents of testable response might counter that measuring SA through particular performance measures is the best way, because the measurement techniques do not mandate intervening cognitive processes, as do memory probes. For instance, it can be argued that memory probes for assessing SA rely artificially on working memory processes when those processes may not have been necessarily needed in an actual task environment, and thus any dis-

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covery of, say, a relationship between working memory and memory for probe queries would be assured by the measurement procedure. In either case, choice of methodology is not independent of the researcher's theoretical position and intellectual presuppositions.

The theoretical position of many SA researchers is cognitive. Although models of SA often include a wide variety of cognitive processes, considerably less effort has gone into identifying those potential cognitive mechanisms that are important in SA. Research on attention and SA has shown us that we attend to what is important in our environment and that elite pilots show better performance at divided attention tasks. There is also work on individual differences (e.g., working memory, intelligence) and SA discussed in the collection.

Another cognitive issue, which many of the chapters in this collection mirror, is the struggle in the field with how to deal with information that is outside awareness and its role in SA. Some methods consider only that which is available to memory seconds or minutes later as being the proper province of SA. Others allow less verbal, more tacit information about the situation to be an important part of SA. Because memory probe procedures rely on the operator's ability to recall (not recognize) 20 seconds to several minutes later (not immediately) with the computer screen blanked (different context), the procedure relies on the inference that what the operator had available while processing the situation is reflected in what the operator recalls later. In fact, the cognitive and social literatures both point to the fact that considerable information (not just the processes) used by people to understand is not available to awareness. For example, researchers have shown that correlations among features in the environment can influence understanding and decisions even though one is unable to identify the features used to make the decision.

Of course, the environment is filled with such correlations, and SA researchers ignore them at their peril. In addition, it has been argued (Durso & Gronlund, 1999) that it is not always necessary to remember information if the environment supplies it; in fact, it may be an unwarranted expenditure of vital resources. Why remember something that is dynamically changing and presented in front of you? So, if I am able to monitor my speed by looking at the speedometer or by assessing the pattern gradient in the passing foliage, I need not continually refresh a memory that indicates I am going 70 mph. In one chapter, although Endsley admits there is information overload in a variety of tasks, in a later chapter she dismisses the idea that knowing how to monitor is an important part of SA. The dismissal, unfortunately, avoids the issue. She argues that the officer giving you a speeding ticket would not be interested in the fact that you could have monitored your speed, but we would argue that neither would the officer be interested in the excuse that you *forgot* how fast you were going. Part of the problem is that most methods of measuring SA are capable of revealing insights only when SA fails. This is similar to the verbal learning research of the 1950s, when all inferences about memory were based on forgetting, that is, when memory failed. Only with the work of Collins and Quillian (1969) and their use of time did cognitive psychology begin to study successful memory and knowledge structures. Such a transition seems especially important if we are to understand "knowledge of the situation." It seems to us that it would be valuable to understand the cognitive processes of the driver who does not get caught; the one who recognizes the subtle signs of a police trap, who quickly looks at his speedometer (without deciding), and who slows in time to avoid the query, "Do you know how fast you were going?"

Issues of automaticity and expertise also raise important concerns about awareness and about how SA can be measured and understood. Clearly, experts understand a situation within their domain better than do novices, but this does not guarantee that experts are more able than less skilled journeymen to verbalize that information. Work on the intermediate effect (Schmidt & Boshuizen, 1993), for example, suggests that experts encapsulate much of their knowledge and must "unpack" information before they can articulate it. Thus, although better SA for experts compared with novices should be demonstrable for any measure of SA, it is not clear that all measures in this volume meet this standard. Along a similar line, Wickens argues convincingly that SA in a routine situation and SA when a surprising event occurs are likely different psychologically, have different design consequences, and may have consequences for how SA is measured. Shebilske and colleagues also address the role of the unexpected in their attempt to articulate a model of automaticity and SA that has implications for training. They make the provocative suggestion that control processes reenter the equation as the operator gains additional expertise. Thus, what is available to awareness early in training may not be the same kind of information that is available to awareness later. The distinction between surprising and expected events and how they are processed has always been an important component of Klein's recognition-primed decision model that contends that sometimes situation assessment leads automatically to a decision. Such a view suggests that it may be difficult to find any component of SA that is universally subject to conscious scrutiny; presumably, in some situations an expert operator can go directly from the perception of a pattern to an action, with little trace of comprehension or projection left in awareness.

With this volume as backdrop, several lines of research on SA are suggested. Our understanding of SA would benefit from more work directed at the underlying cognitive mechanisms of SA. Because a myr-

iad of cognitive mechanisms are presumed to underlie SA, it should be possible to discover empirically which mechanisms are, in fact, relevant. Related to this issue is the need for researchers less enamored with the cognitive approach to explore ecological approaches more thoroughly. Considering both cognitive mechanisms and the environment together raises further questions. For example, how should a scientific view of SA differ from the existing models of reading comprehension (Van Dijk & Kintsch, 1983, are cited in several of the chapters). Clearly, the SA world is more dynamic, but little is understood about what a dynamic environment does to change a reading comprehension model. Finally, one kind of dynamic environment is one in which other operators are a part; a socially dynamic environment may be worthy of study from an SA perspective, and research areas like discriminative facility, transactive memory, and empathic accuracy can develop a synergism with SA research.

In short, an understanding of how people understand the situation in which they operate is worth consideration from both applied and basic research. For basic research, it provides scientists a crucible to test their laboratory-derived general principles. For applied research, it is a concept of clear and immediate importance. ❑

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