Attention for Designers

Review of Applied Attention Theory (2nd ed.), 2023, by Christopher D. Wickens, Jason S. McCarley, & Robert S. Gutzwiller

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This book is the second edition of one published in 2008 by Wickens and McCarley. The goal, then and now, is for the book to reunite basic research on attention to applied research conducted in engineering psychology. In addition to updating the coverage of the main topic areas, the second edition includes two new chapters, one devoted to automation in general and the other to five specific disciplines—aviation, driving, education, health care, and cybersecurity. These two chapters reflect contemporary issues and replace ones on cognitive neuroscience and individual differences, for which some of the material has been incorporated into other chapters. The text is 181 pages and is relatively easy to read. The authors say on p. 4 that the domain of engineering psychology "represents the spirit of this book." Consistent with this spirit, the book emphasizes how to design interfaces for attention. This is reflected in the content, for which the organization is oriented around design issues and how to capture, direct, and maintain the attention of human operators.

The coverage of material in the book is concise and straightforward. As a consequence, not much background for many complex topics is provided, which requires readers to possess additional fundamental knowledge if they are to comprehend the material at a very deep level. For example, in Chapter 1, the authors provide a simplified model of attention that focuses on bottlenecks at early selection by a filter and later in processing by resources that can be allocated to multiple tasks. Although they expand on these topics in subsequent chapters, to understand the importance of these mechanisms the reader would need to have some background knowledge on attention and human information processing. Chapter 2 goes directly into issues of single-channel processing and automaticity, without much explanation of the underlying mechanisms. The authors introduce the terms *compatibility*, *working memory*, and *motor programming* without defining them. Moreover, throughout the book, the authors refer to working memory and the memory system, but these constructs are not discussed in detail, especially as they relate to attention.

Chapter 1 has a heading, "Scaling Up Basic to Applied Research." However, the chapters switch between directions, with the organization of the early chapters being primarily around design issues rather than

basic aspects of attention. The final paragraph of Chapter 1 states, "We try to maintain a balance between theory and application, although occasionally, we may veer more one way than the other" (p. 7). The middle chapters 5, 7, 8, and 9 have a balance of basic theory and application, whereas the earlier and later chapters veer toward design issues. For designers, the level of coverage in this book provides a good starting point for design guidance, but for understanding attentional mechanisms, the book just scratches the surface. Thus, for use as a textbook in psychology courses, it would need to be supplemented by original articles or readings that consider the topics in more detail. In the following paragraphs we discuss the individual chapters of the book.

Chapter 1 provides an introduction to the book on varieties of attention and their relation to applied design topics. We've already touched on several key elements because the chapter sets up the book. An additional section highlights "The Role of Models," providing a general description of different types of models. The section goes into detail only on the SEEV (Salience, Effort, Expectancy, and Value) model of Wickens (2015) as an example of an applied computational model. We think that other models could have been described to illustrate the value that each type of model brings to knowledge of attention.

Chapter 2 introduces single-channel theory with the psychological refractory period (PRP) effect, which is covered relatively thoroughly. The PRP effect is probably the most widely studied multitasking paradigm in psychology. The text emphasizes, "The PRP thus appears to arise at one or more central stages of processing, in between sensory encoding and overt response execution" (p. 11), which Wickens et al. (2023) note is conventionally considered to be response selection. Yet, response selection receives minimal coverage in the book, and there is little further discussion of the PRP effect in the context of concurrent task performance, which is the central topic of Chapter 8.

Consistent with the engineering psychology perspective, the attentional mechanisms presented in the book are those relevant to the design of interfaces. Chapter 3 is titled "Attentional Control", but the authors define attention control from the system designer's priorities: "The system designer is faced with a challenge of attention control, catching the operator's attention and orienting it toward a timely piece of Information" (p. 21). Consequently, they downplay the distinction between covert and overt attention, stating that the two work together in concert in naturalistic behavior. In human information processing, attentional control is typically used to refer to endogenous processes by which individuals direct their attention to various locations and events. Control in this sense of attention is covered as switching strategies in Chapter 9 when discussing multitasking, but that discussion is again from the design perspective. Chapter 3 also covers multimodal interactions. Consistent with the orientation of the

chapter on the capture of attention, the authors emphasize auditory preemption for alerts and alarms. However, they downplay the large literature on visual dominance that is also relevant to display design.

Chapter 4 continues to illustrate the power of SEEV as a model for predicting visual scanning and information sampling on displays. SEEV captures the roles of habit, visual salience, event rate, and information and value in determining the effort required to identify target stimuli in operational environments. The topic of areas of interest (AOIs) is thoroughly covered, with the relevance for design clearly made. The chapter also introduces expert-novice differences in visual scanning, which is a topic highlighted for specific applications in Chapter 11.

Our favorite chapter of the book is Chapter 5, Visual Search. This chapter provides a relatively concise and up-to-date overview of the visual search literature. It is distinguished from the others by inclusion of a bulleted list of guidelines derived from attention theory. We find this chapter to provide excellent coverage of the key points of the visual search literature and their implications for designers. The balance of theory and application in this chapter makes it a good resource for both designers and students interested in visual search.

Chapter 6 provides a comprehensive overview of display design. In terms of attentional mechanisms, though, coverage of space-based and object-based attention is rather limited. The two are used mainly to set up the proximity compatibility principle (PCP) as it applies to display design, which covers the bulk of the chapter. Given that Wickens has developed and championed PCP (Wickens & Carswell, 1995), it is not surprising that this coverage is detailed and comprehensive. For practice, designers will find much of value in this chapter to increase their knowledge of display design.

Chapter 7, Resources and Effort, provides an in-depth coverage of the relation of effort to strategies in selection of resources and their relation to performance. The last part of the chapter is devoted to mental workload measurement, with only the psychophysiological methods covered in much detail. The orientation of this chapter is closer to that of Chapter 5 than earlier chapters in that the basic issues concerning the relation between effort and performance are covered before the applied topic of mental workload for design and assessment.

In-depth coverage of Wickens's (2005) multiple resource model and time sharing is provided in Chapter 8, for which the main title is Concurrent Task Performance. As noted earlier, the PRP effect was described in Chapter 2, so we were surprised that the authors did not return to this well-known limitation of concurrent task performance in this chapter. There is brief mention of the bottleneck, but the emphasis

is in terms of the motor resources rather than "central" bottleneck, a term that was used several times in Chapter 2 to describe the source of the PRP effect. As depicted in Figure 8.2, the model of stage-defined resources has the resources for working memory as being the same as those for perception. Response selection, in contrast, is shown as not sharing resources with working memory and perception but as sharing them with the motor processes of response execution. However, it is more customary to depict response selection as a central cognitive process that draws on the same attentional resources as those involved in perception, working memory, and decision-making (e.g., Schmidt et al., 2019; Wickens & Carswell, 2021), distinct from response execution. The separation of response selection from the resources involved in perception and working memory results in the role of response selection in concurrent task performance being downplayed.

Chapter 9 covers three topics listed in the chapter subtitle: attention switching, interruptions, and task management. The chapter is organized around the basic research on task-switch costs, beginning with the first demonstration by Jersild (1927). Task switching is then examined in the applied context of designing for interruptions of an ongoing task by distractor tasks and management of multiple tasks that must be performed sequentially. The chapter also examines some individual differences in task-switching performance by groups that differ in terms of fluid intelligence, working memory capacity, and executive control. The chapter introduces the term "task set" – representation in working memory of the task that is to be performed – but with little elaboration. It is mentioned only in the context of a need to maintain multiple task sets and to reconfigure task sets when a task switches from one that was just performed. The lack of emphasis on task set is consistent with downplaying the role of response-selection processes since the task representation presumably involves the possible actions to be made and the alternative responses.

Chapter 10 introduces the topic of automation and issues of reliance on and trust of automation. A taxonomy for degree of automation is presented: (1) event detection and attentional guidance, (2) diagnosis and situation assessment, (3) decision support and (4) action. Because the chapter is relatively short, it might have been better to include the sections on Driving and Cybersecurity from Chapter 11, both of which highlight automation issues.

Chapter 11 provides 5 areas of application in which the authors recap attentional principles and illustrate how the principles tie together within each domain. The first area is *aviation*, which was covered extensively throughout the book. This section provides a chapter-by-chapter analysis, mainly providing additional references for key points. Chapter 6 is the only one for which much new information is

introduced, where specific principles come together with new examples relevant to piloting an aircraft. The *driving* section provides good coverage of attentional issues for distracted driving and automated driving. *Healthcare* focuses mainly on sampling of information by medical practitioners using the SEEV model. The section covers group differences in expertise, which were also highlighted in the *driving* section. The next area is *education*, where the authors cover principles of learning and how to design instructional material for cognitive load. The final area is *cybersecurity*, which highlights a number of critical issues in this emerging domain. The focus is on the attentional demands placed on professional cyber operators and how designers may be able to accommodate for those demands. Automation is again discussed, in this case with regard to how it can assist detection of cyber-attacks. This chapter, which relates attentional phenomena and principles discussed earlier in the book to contemporary domains, provides a fitting ending to the book.

We end our review with some overall comments, making comparisons to our book *Attention: Selection and Control in Human Information Processing* (Proctor & Vu, 2023). As noted, we place more emphasis on response selection than do Wickens et al. (2023). As noted, they characterize response selection as sharing resources with response execution and not with working memory (see their Figure 8.2). We locate response selection in the central cognitive stage, separate from an action stage that includes motor programming and execution (see our Figure 2.1). This distinction reflects our view that response selection is largely a central, cognitive process that relies on stimulus and response codes activated in working memory.

Another big difference between the books is the approach taken in organizing the content. We take an information-processing approach, whereas Wickens et al. (2023) take an engineering psychology approach. As a consequence, Wickens et al.'s book highlights attentional principles and phenomena relevant to interface design, whereas our book stresses fundamental aspects of attention. Moreover, due to their taking an engineering psychology approach, their applications are design-focused, whereas many of our applications are representative of other areas of psychology. We think that designers will benefit greatly from Wickens et al.'s book because it provides a good primer for attentional issues that are of most concern to them. Our book is less prescriptive in nature, conveying empirical and theoretical processes from which knowledge concerning attention is derived. For that reason, our book is longer than Wickens et al.'s book and will require more effort for readers to work through. Thus, the two books are complementary in nature, with the Wickens et al. book providing intuitive applications of attention

research and ours providing a fundamental background to allow readers to engage in a deeper dive into attentional mechanisms.

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