Human Factors
University of Illinois Urbana-Champaign

Book Review and Chapter Synopsis
Applied Attention Theory

Christopher D. Wickens and Jason S. McCarley
©2008 CRC Press, Taylor & Francis Group

Review and Synopsis by Stu Moment, University of Illinois Human Factors
Stu Moment web page
Other Stu Moment articles:
.. Human Error
.. Partials in Human Error Systems

Attention theory has been discussed in psychology publications for over 100 years but came into its own with the publishing of hundreds of studies in the 1980’s, 90’s and current decade. Government and corporate emphasis on safety was enriched by studies of attention on many dimensions. These studies provided findings which, when presented with qualification, provide description and direction for assembling knowledge and solving issues of attention. Wickens and McCarley present theory and findings with qualification plus place the topics of attention theory into a structure which aids understanding and ease of application.

Throughout the book, studies are referenced at a fast rate. The concentrated presentation of studies and their implications is integrated to provide cohesiveness to individual topics as well as the whole study of attention theory.

The book is easy reading, even for people with little background in human factors. The topics are interesting to the general public, perhaps because of the relevance of examples such as distraction during driving or finding a specific icon on a cluttered computer screen.

Even though chapters build on the knowledge presented in previous chapters, the individual chapters can be read quickly, in any order.

The book is a master reference to publications on the many dimensions of attention theory. Over 750 publications referenced throughout the book are listed in the reference section.

Selected Chapter Highlights

Chapter 1 – Attention

Five varieties of logical attention types are presented; focused, selective, switched, divided and sustained. These types will be used throughout the book. The authors illustrate a simple model of attention which shows events passing though filters into information processing, affected by mental resources. The filters are in two groups: salience and effort (environmentally driven or ‘bottom up’ filters) and expectancy/value (knowledge based or ‘top down’ filters). Later in the book, this structure develops into the SEEV trade-off model.

A section titled “Relation to Other Domains”, connects attention topics to human factors sub-disciplines. “Scaling Up to Applied Research” introduces the challenge of addressing specific real-word applications. “The Role of Models” shows types of models (used often in this book) and their value in research.

Chapter 2 – Single-Channel Theory and Automaticity Theory

Task combinations affect efficiency of parallel processing. This chapter introduces “automaticity”, a term enhanced throughout the book. The authors present the structure and implications of “single-channel theory” and give areas where single-channel theory is directly useful. The concept of workload is introduced and is presented as an important parameter to performance. Both, automaticity and workload considerations, will be integrated into theory and findings presented in later chapters.

Chapter 3 – Attention Control

Many real-world tasks require timely detection of important information at unpredictable times. This chapter presents many concepts regarding types of detection failures, types of attention shifts (covert vs. overt) and cueing. The authors contrast ‘attention guidance’ against ‘attention alerts’ and develop a structure, presented graphically, to understand then analyze systems. Implications of ‘automation errors’ on attention performance are discussed. Not specifically discussed, yet illustrated in this chapter, is the difference between senses and combinations of senses used in detection and the resulting evaluation of an alert.

The synopsis of Chapters 4, 5 and 6 *grossly understate the section’s contents. Chapters 4 ,5, and 6 are a book within a book which could be titled “Visual*

Attention and Processing". An enormous volume of visual research takes the reader from theory to application. It is written efficiently, potentially taking the reader from novice to knowledgeable in display/signage/page design within two hours. The findings may be used directly by practitioners. For readers with pure academic interests, it provides a compact and relatively comprehensive overview and resource guide to the topic.

Chapter 4 – Visual Attention Control, Scanning, and Information Sampling

Terminology such as Area of Interest (AOI), fixation, dwell, percent dwell time (PDT) and Event Fixation Latency (EFL) are defined. Factors which influence the purpose of individual eye movements; habit, salience, information content, information value and information access effort, are documented in terms of significant findings. The SEEV trade-off model, introduced in chapter 1, is refined and applied. Finally, studies noting novice-expert differences in scanning ability are presented.

Chapter 5 – Visual Search

This chapter concentrates on aspects of visual search. The topics in this chapter apply to many aspects of life, from a doctor searching medical imaging, a driver looking for a sign, a person searching a display in a machine control function, a person looking for a desktop icon, etc. Given the variety of search types, the authors point out different ways to characterize search. A 'Model of Applied Search' serves most analysis.

Serial vs. Parallel (for speed) processing is explained and applied (almost prescriptively) in terms of [purposely] designed target attributes such as color. The authors document findings related to features like color, shape, size and conspicuous properties plus an added dimension of asymmetry. The authors then give rules of thumb for more efficient search. Sections on "Attention Guidance and Display Design", "Spatial Grouping and Search" and "Contextual Constraints on Search" enhance the previous sections.

A discussion on the human's useful field of view plus scanning and fixation, moves smoothly into a section on search accuracy.

Chapter 6 – Spatial Attention and Displays

Space-based and object-based theories are presented as two major dimensions of attention. The proximity compatibility principle integrates these theories into a structure to analyze and design. Proximity and object features need to be chosen for compatibility with different types of tasks such as integrated [vs.] focused tasks. The authors further illustrate the proximity compatibility principle with applications in graphic design.

In recognition of many dynamic systems (medical monitoring, vehicle control, industrial processes) the authors expand the application of the proximity compatibility principle to the concept of ecological interface design (EID).

Chapter 7 – Resources and Effort

The chapter starts with a simple construct regarding the personal decision of the amount of effort to apply to a single task and quotes studies and findings in topics of 'stop search and limit surveillance', 'behave safely', 'choice of decision strategy' plus 'salience and accessibility'. The chapter also addresses the choice of simple vs. more powerful tools and choice of effort in finding multiple information sources to aid task performance.

The aforementioned 'multiple information source integration' section leads into the topic of dual-task performance. The authors integrate two structures, the Performance Resource Function (PRF) and Performance Operating Characteristic (POC) into resource demand/performance charts showing varying return on investment depending on task type as well as resource availability. Methods of measuring effort and mental workload are discussed in terms of availability and value in workload assessment.

The authors end the chapter with a consideration of effort in learning. The reader will note some surprising findings with regard to training techniques for skill acquisition. As emphasized throughout the book, the reader will learn to use a conditional approach to many applications.

Chapter 8 – Time Sharing and Multiple Resource Theory

A variety of studies on this topic are integrated into a four dimensional multiple resource model. Effects on performance in divided attention task sets can be predicted on dichotomies of processing stage (perception-cognition-responding), perceptual modality (visual-auditory), visual channel (focal-ambient) and processing codes (special-verbal). All four dichotomies are defined and studies related to individual dichotomies are cited. The authors note predictability of interference between tasks sharing common levels on individual dimensions of the four dimensional model.

Auditory preemption, similarity cooperation and similarity confusion are presented as enhancements to multi-task performance analysis.

Chapter 9 – Executive Control: Attention Switching, Interruptions, and Task Management

When task priorities are ambiguous, executive control (attention management) theory can explain performance and variations of performance. Models of attention management are divided into bottom-up and top-down models. Most studies of executive control relate to the more cognitive top-down models.

The authors illustrate the cost of task switching, as dependent on task similarity. Other factors which contribute to task switching costs are described. A structure which illustrates task interleaving is presented and leads into a discussion of interruption management. Task switching performance parameters are defined. Factors which influences task switching performance parameters are documented.

Chapter 10 – Individual Differences in Attention

Individual differences in attention are addressed on three fronts. 'Attention as a Skill' (training and expertise) is broken down into other, well documented performance considerations. 'Attention as an Ability' is broken in two classes of studies which produce useful findings. The authors enhance the topic of 'Attention as an Ability' with an important discussion of attention and working memory, an area of study with also has produced significant findings. Finally, the obvious topic of 'Attention and Aging' is presented with a focus on the causes of decreased attention with age.

Chapter 11 – Cognitive Neurosciences and Neuroergonomics

The study of neuroergonomics is a blend of neuroscience and human factors. Measurements available in neuroscience such as heart rate, pupil diameter and EEG can be correlated with mental activity. The authors present neuroergonomic measurment methods then discuss their application to the measurment of resources and workload as well as the assessment of operator state.

References

More than 750 publications referenced throughout the book are listed in the reference section.