Handbook of Applied Cognition
Second Edition

Edited by

Francis T. Durso
Texas Tech University, USA

Associate Editors

Raymond S. Nickerson
Tufts University, USA

Susan T. Dumais
Microsoft Corporation, USA

Stephan Lewandowsky
University of Western Australia, Australia

Timothy J. Perfect
University of Plymouth, UK

John Wiley & Sons, Ltd
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John Wiley & Sons, Ltd
To our mentors
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**About the Editors**

**Frank Durso** received his PhD from SUNY at Stony Brook and his BS from Carnegie-Mellon University. He is Professor of Psychology at Texas Tech University on the faculties of the human factors program and the applied cognition program. He currently is president-elect of APA's Applied Experimental division, is chair of the Aerospace Technical Group of Human Factors and on the executive council of the Society for Applied Research on Memory and Cognition. He was President of the Southwestern Psychological Association and founder of the Oklahoma Psychological Society. A fellow of APA and APS, he serves on the editorial boards of the *Journal of Experimental Psychology: Applied*, *Human Factors*, *Air Traffic Control Quarterly*, and *Cognitive Technology*. He is recipient of the Regents' Award for Research and the Kenneth E. Crook award for instruction from the University of Oklahoma where he served as professor and founding director of OU's Human–Technology Interaction Center. He has been funded by NSF and the FAA, the latter continuously since 1990. His research interests have focused on cognitive factors in dynamic situations, in particular air traffic control. He is coauthor (with Nancy Cooke) of the forthcoming book titled *Stories of Human–Technology Failures and Cognitive Engineering Successes* designed to promote cognitive engineering to students and the public.

**Raymond S. Nickerson** received a PhD in experimental psychology from Tufts University in 1965. He was a researcher and manager at Bolt Beranek and Newman Inc. for 25 years and retired as a senior vice president; he is now a research professor at Tufts University. He is a fellow of the American Association for the Advancement of Science, the American Psychological Association (Divisions 1, 3, 21), the Association for Psychological Science, the Human Factors and Ergonomics Society, the Society of Experimental Psychologists, and a recipient of the Franklin V. Taylor award from the APA's Division of Applied Experimental and Engineering Psychology (1991). Dr Nickerson was founding editor of the *Journal of Experimental Psychology: Applied* and of *Reviews of Human Factors and Ergonomics*, and is a past chair of the National Research Council’s Committee on Human Factors. He is the author of several books, the more recent of which are *Looking Ahead: Human Factors Challenges in a Changing World* (1992), *Psychology and Environmental Change* (2003), and *Cognition and Chance: The Psychology of Probabilistic Reasoning* (2004).

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**Timothy Perfect** graduated with his PhD in 1989 from the University of Manchester. From there he worked first at the University of Liverpool and then the University of Bristol. He is currently Professor of Experimental Psychology at the University of Plymouth, where he heads the Memory Research Group. His research interests are broadly in the area of the applied psychology of memory, and he has published on topics of eyewitness confidence, face recognition, retrieval induced forgetting, unconscious plagiarism and cognitive aging. His work has been funded by several UK funding councils and charitable trusts: the Economic and Social Research Council, the Biotechnology and Biology Research Council, the Medical Research Council, The Leverhulme Trust, and The Nuffield Foundation. He is currently on the editorial board of the journals *Applied Cognitive Psychology* and *Memory*, and is a member of the Experimental Psychology Society, the Society for Applied Research in Memory and Cognition, and the Psychonomic Society. He is married (to Tara) and has two sons (Jake and Sam), and he harbours the ambition to score a century at cricket for his local team.
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ALL THE DIFFERENCE

It has been over a decade since I received the original proposal from the Society for Applied Research in Memory and Cognition (SARMAC) to put together a handbook that brought together the myriad of work in applied cognition. That first edition appeared in 1999, and we were gratified by the favorable comments we received in the press and personally. Thus, I was happy to take on the second edition when approached by Gillian Leslie of John Wiley & Sons.

The field of applied cognition is different than it was 10 years ago. Some of the changes were anticipated in the first edition. Others are the consequence of the unhappy circumstance in which the world finds itself. For example, there is no doubt that as the initial work matures, topics like security will find their way into a future edition of this handbook. Applied cognitive researchers should also become involved in issues such as the evacuation of cities and the transfer of information between teams and between organizations.

The second edition is substantially different from the first. Some topics that continue to characterize work in applied cognition, such as aviation, eyewitness testimony, and decision making remain, although many of these are written by new authors, who add their perspective to the ones admirably conveyed by contributors to the first edition. Even those chapters from authors reprising their roles are substantially revised and updated. Readers familiar with the first edition will note that some chapters have not reappeared in the second edition making way for areas not covered in the first edition that have made substantial progress. Thus, we were able to add many new chapters covering domains not included in the first volume but which are important arenas of applied cognition, for example, personal information management, sports, media, and false memory to mention a few.

In other respects, the second edition shares much in approach and philosophy with the first. As before, here we leave the lab to understand cognition in the uncontrolled world of interesting people. The focus is on applied work, not applicable work that could, potentially, be applied someday. As before, this edition does not assume that applied cognition necessarily means applied cognitive psychology. In fact, some of the authors are quite clear in eschewing traditional cognitive psychology. For example, cognitive systems engineering will seem quite un-cognitive to a traditional cognitive psychologist. Finally, the current edition attempts to gather a variety of applied work on cognition from a variety of domains and perspectives. Each of these chapters is intended as a broad review of the relevant literature, but perhaps one with more pedagogy than a chapter written exclusively for experts already inculcated in the area. Instead, basic researchers interested in taking a step into an applied domain, and applied researchers interested in undergirding their work with basic research will find value in these pages.
The 30 chapters that make up this handbook could obviously be put together in more than one way. We chose to organize the chapters into three large sections. Section 1 comprises 10 chapters that reflect the processes generally considered when people talk about the cognitive activities that happen in applied settings. When potential contributors were approached, the instructions for authors to the first section differed from those given to the contributors of the remaining chapters. Authors of chapters in the first section were asked to consider the basic science of their construct and then to take a slice through the applied work that showed that construct as it is studied in applied domains. Interestingly, although no one was asked to compare basic and applied research in those chapters, several did. Resolving the relation between basic and applied seems especially important to researchers doing work under the banner, applied cognition.

The remaining chapters draw from on the work discussed in the first 10. Whereas authors of Section 1 took a broad horizontal slice through the literature, the 20 chapters in Sections 2 and 3 sliced the literature vertically, into domains and applied areas of research. These final 20 chapters, although all about application, show differences. They seemed to me to form two collections. One collection, Applied Cognition in Human–Technological Systems, tends to focus on domains and issues in which the “system” is primarily the human working with technology. The other collection, Applied Cognition in Human–Social Systems, comprise chapters in which domain issues focus on a system of the human operating within a social milieu.

It is interesting that there is another apparent, at least to me, difference in these two collections. I think of the second section of the Handbook as research by human factors, or cognitive engineering, types. These authors tend to be known to members of, for example, The Human Factors and Ergonomics Society, Division 21 of APA, and SIGCHI. On the other hand, the authors of the third section might be regarded as applied cognitive psychologists, known to members of SARMAC and the Psychonomics Society for instance. Of course there are exceptions; many are known to all applied experimental psychologists and some have intentionally stretched beyond their home turf to address an issue in a different type of system.

Nevertheless, the fact that there is substantial association between the system focus that characterizes a section and the people who conduct that type of research suggests that there are at least two brands of researchers, both of whom are applied cognitive scientists in the sense that they both take advantage of the basic work reviewed in the first section of this handbook.

What does this difference between the subfields of applied cognition, between Sections 2 and 3, tell us about the field? At one level, it tells us that human cognition is an important part of much of what we do and what we ask industrial operators to do. Unlike at the turn of the last century, when most workers earned a living doing physical labor, today’s jobs – and today’s problems – are heavily cognitive. Our ability to address issues in such complex and dynamic real-world environments is also a testament to the knowledge that has accumulated about human cognition over the past 60 years. On the other hand, the expansiveness of applied cognition captured by two relatively distinct collections of research (together with the explosion of interest in neurocognition) suggest that the pressures on the basic cognitive paradigm are taking their toll. Yet, it remains unclear how the new paradigm will shift. Will applied cognitive psychology and cognitive engineering proceed down separate paths, or will a synthesis of applied cognitive work emerge?
So, should these cognitive engineers and applied cognitive psychologists interact more, or is it unavoidable that scientists in Section 2 interact little with those in Section 3 while both groups borrow tenuously from Section 1? After all, it is difficult enough to keep up with one’s own specialization, and maybe another within your “section,” but to read so far afield as to read a chapter from another section may simply be unrealistic. Although it is difficult to ignore the pragmatics behind such a position, I believe there will be rewards for those willing to take such a journey. There is the added perspective not only on the field generally but on one’s own work as well. There is the realization that the old work on vigilance might inform my new work on prospective memory; that the old work on eyewitness testimony seems relevant to this new work on driving. We hope that the second edition of the *Handbook of Applied Cognition* can serve as a travel guide for such a journey, or, at least, a map that points out that there is indeed a fork in the road. Which road in the wood should you take? That question has been answered by writers wiser and more eloquent than I.

This handbook is a cooperative accomplishment in the truest sense. The associate editors are world authorities in applied cognition and were gracious in assenting to help, some for a second time. Each was an effective steward of several of the chapters you will read. They advised me from the beginning on content and structure. They cajoled colleagues to serve as reviewers. In fact, each chapter was reviewed by two or three experts in the field and at least one of the five editors, often two. Some of our reviewers agreed to help out with impossible deadlines, some helped with more than one chapter, and one reviewer did both. A special thanks. Several of the chapters were subjected to the reviews of my graduate Cognitive Ergonomics class at Texas Tech. Their critiques were often insightful and routinely contributed to my reviews of the chapters. Finally, and most importantly, there are the world-class contributors from throughout applied cognition. We are honored by their participation and appreciative of their cooperation.

The book also benefited from the cooperation and understanding of my colleagues at Texas Tech University. Thanks to Ruth Maki and David Rudd, who chaired my department during the preparation of this volume, for their patience and assistance, and to my graduate students who tolerated this intrusion. Special thanks to Lana Jackson, my sedulous office manager, who is now off to graduate school. Lana helped with every onerous task associated with a production of this size, from nudging late reviewers to organizing the submissions. Throughout, I have enjoyed working with the representatives of Wiley. Gillian Leslie has been an important factor and a pleasant one from the initial invitation until now. An editor could have no better publisher. Gillian’s patience as well as the help and patience of Ruth Graham, Nicole Burnett, and Claire Ruston at Wiley and their affiliate Richard Lawrence made production of this volume a great experience. Finally, to my *raisons d’être*, Kate, who has been my partner through this edition and the last, and my son, Andrew, who has grown since the last edition into the finest young man I know.

The contributions of the authors speak for themselves in the pages that follow.

F. T. D.
September 2006
Texas Tech University
Preface to the First Edition

During the past 40 years a large number of bright people have embraced the reemergence of human mental functioning as a viable topic of scientific study. Indeed, the theories, models, and methodologies that have been developed to understand the human mind stand as tributes to the enthusiasm and intelligence of these scholars. Much of this progress has been in gaining an understanding of basic or fundamental cognitive functioning. Psychology has participated in, and often led, this initiative as one of the empirical arms of the cognitive science movement.

This Handbook explores another dimension of what it means to be interested in human mental functioning: the attempt to understand cognition in the uncontrolled world of interesting people. When I was first asked to edit this volume, I thought the timing was right for a number of reasons. First, a large amount of applied work was being conducted that was very strong, but not easily accessed – hidden in this specialty journal or tucked away in those proceedings. A Handbook devoted to applications of cognitive research could help bring this work to the notice of others. Second, exactly how to characterize basic research to applied researchers seemed a noble although difficult problem. Leaders in the applied community had routinely stated that basic cognitive research was not worth very much. Explicit condemnation of the value of cognitive psychology had been the topic of more than one thought-provoking address, including Don Norman’s eloquent address at SARMAC, the organization that initiated this volume. Thus, for applied researchers, this volume offers a collection of chapters of successful and not-so-successful applications of basic principles. These chapters include reviews from the perspective of a basic cognitive process as well as reviews from the perspective of an applied domain. Third, basic research did not always appreciate the value of applied cognition, and even when cognitive research looked applied it was often what Doug Herrmann has called “applicable,” not applied. More important than the under-appreciation of applied work, there did not seem to be the realization that good applied work was being conducted by people other than cognitive psychologists – a fact that should interest scientists who believe the empirical study of mind should be the province of cognitive psychology. Such a Handbook would supply a compendium of research that would move such debates from the general “useful/useless,” “good/bad” debates to more sophisticated considerations of science, engineering, and mental functioning. Finally, and of most interest conceptually, a number of pressures on the current paradigm of cognitive psychology seemed to revolve around the ability to apply cognitive psychology. Debates occurred and are continuing on qualitative methods, hypothesis testing, situated cognition, the AI agenda, and Gibson. At their hearts, these debates confront various issues about the real-world applicability of what applied researchers would call academic cognitive psychology. As one looks over the pressures on cognitive psychology, the paradigm pressures seem to have a ring of familiarity.
Kuhnians amongst us would argue that cognitive psychology replaced neobehaviorism as the dominant paradigm in scientific psychology. In fact, a popular textbook of the early 1980s (Lachman, Lachman & Butterfield, 1979) stood out for its attempt to supply young cognitive psychologists a context from which to understand the demise of one paradigm and the rise of the other. Neobehaviorism had been under a number of paradigm pressures:

1. Models were attacked as becoming overly complex sequences of Ss and Rs.
2. Concepts like reinforcement and stimulus control looked circular outside the laboratory.
3. Applied researchers challenged fundamental assumptions of neobehaviorism by making it clear that humans were not passive recipients of impinging events.
4. Advances in technology (i.e. computer science) provided new opportunities, but neobehaviorists tended to ignore or under-utilize the new technology.
5. Finally, and perhaps most critical, neobehaviorism was not making advances in areas it should have (like language and perception) but, importantly, other disciplines were.

Today, modern cognitive psychology is buffeted by paradigm pressures just as its predecessor was. Several of these points are eloquently discussed elsewhere in the literature. In my view, the pressures seem surprisingly reminiscent:

1. Cognitive psychology’s typical method of explanation is the construction of underlying mechanisms (e.g. short-term memory) and not by inducing abstract categories for the experimental variables (e.g. this is a force, this is a mass). The proliferation of cognitive models is apparent. From the perspective of the applied community, large amounts of effort and talent have been spent on relatively small, model-specific problems.
2. Like reinforcement and stimulus control, cognitive constructs are often not well specified in the applied arena. Consider elaborative rehearsal versus maintenance rehearsal. Although they are important additions to our theories of short-term memory and are supported by ingenious laboratory experiments, it is difficult for the applied researcher to employ the concepts. An air-traffic controller remembers one plane, but not another. The first must have undergone elaborative rehearsal because it is remembered better, and so on.
3. It is becoming clear that, not only are humans active processors of events, but that humans impinge on events as well as being impinged by them. The fact that humans control and modify their environment, have choices about what to look at and what to do, is not only abundantly clear in a field setting, but becomes critical in any attempt to apply basic research to an applied problem. Typically, when an expert is doing his or her job, the experimental intervention is the least interesting part of the environment; in the laboratory it is often the most interesting, if not only, part of the environment. This assertion is perhaps made most clearly by the distributed cognition initiatives. An important part of a human’s environment is often other humans. We could say that such issues are the responsibility of social cognition, but that is just second millenium think-
ing. Besides, many social psychologists have affirmed their intent to become more like cognitive psychologists, making it difficult for cognitive psychologists to become more like them.

4. New technologies today include virtual reality and high fidelity simulations. Ignoring these technologies makes sense within the current cognitive paradigm where the environment plays a role secondary to internal cognition. However, to cash out the promise of cognitive psychology in the applied marketplace will require complex, dynamic, interactive, yet controllable environments. Use of these technologies can take advantage of new methodologies and statistical procedures for the understanding of sequential data.

5. Despite these paradigm pressures, if neobehaviorism could have made reasonable contributions to language and perception, not only might Chomsky have read *Verbal Behavior* before he reviewed it, but neobehaviorism may have participated in a Hegelian synthesis rather than being the paradigm lost. How well is cognitive psychology doing in the applied arena? The answer is not a simple one. The many chapters of this *Handbook* are attempts to characterize cognitive research in applied settings, but not necessarily applied cognitive psychology. Several of the chapters do not rely much on cognitive psychology and make that point explicitly. Several other chapters have easily imported the findings and views of cognitive psychology into their applied domains. In addition, several authors draw heavily from social psychology. The domains covered in this *Handbook* clearly vary from relatively new areas about which little is understood, to large, well-researched, well-understood domains.

The *Handbook* begins with a chapter on applying cognitive psychology and then continues with six chapters that overview applied research from perspectives familiar to most cognitive psychologists. These overviews are followed by chapters that focus on particular applied domains. These domains fall roughly into four broad arenas: business and industry, computers and technology, information and instruction, and health and law, but it will be clear that issues raised in one section of the *Handbook* will echo in others.

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The contributions of the authors speak for themselves in the pages that follow.

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REFERENCES

SECTION 1

Applied Cognition Fundamentals