SECTION 1

Applied Cognition Fundamentals

CHAPTER 1

Applied Cognitive Psychology in the Context of Everyday Living

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Psychological science is the study of behavior. We all learned that definition in our introductory psychology class. What then is the difference between "basic psychological science" and "applied psychological science? Some would argue that there is no difference – understanding behavior is the focus of psychology whether that behavior occurs inside or outside of the laboratory. However, others argue that the difference is the purpose of the research – is it intended to contribute fundamental knowledge (i.e., basic) or is it intended to solve a specific problem (i.e., applied)." (See the enlightening debate between Hoffman & Deffenbacher 1993, 1994; Vicente 1994.)

Another perspective concerning the dichotomization of basic and applied psychology is that theories are developed in basic scientific endeavors and simply put into action in applied science. There is certainly some benefit in attempting to apply psychological theories as Broadbent (1973) elegantly stated: "the test of intellectual excellence of a psychological theory, as well as its moral justification, lies in its application to concrete practical situations" (p. 7). However, as is clear from Broadbent's work, the goal is not to develop theories of behavior and only then attempt to apply those theories. Instead, applied psychological science provides a *problem space* within which principles of behavior can be developed (see also Brunswik 1952, 1956). The behavior in question is often complex, influenced by multiple variables, and susceptible to contextual influences as well as

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individual differences. Attempting to understand such behavior is the essence of applied psychological science.

This perspective is not new. In fact, this view was well stated by Thorndike in the context of discussing the importance of psychological science contributions during the First World War:

> Applied psychology is much more than cleverness and common sense using the facts and principles found in standard texts. It is scientific work, research on problems of human nature complicated by the conditions of the shop or school or army, restricted by time and labor cost, and directed by imperative needs . . . The secret of success in applied psychology . . . is to be rigorously scientific. (Thorndike 1919, p. 60)

Applied psychology, done well, has the potential to solve specific problems, to lead to the development of general principles of behavior, and to improve lives. Thorndike concluded his paper with the following statement: "the psychologists of America worked to help win the war" (Thorndike 1919, p. 60).

Too often it seems that the distinction between applied and basic psychology is made with trite or stereotypic definitions. Such thinking can constrain progress in psychological science (Landauer 1989; Fisk & Kirlik 1996). Our perspective is that applied psychology, to be effective, should be thought of as "use-inspired basic research" (Stokes 1997, p. 73). A prominent general science example of such research described by Stokes is Louis Pasteur's quest to understand microbiological processes and to control these processes so as to minimize spoilage and conquer disease. Examples from the field of applied cognitive psychology are the focus of this chapter.

Much of human behavior involves cognitive processes such as perception, attention, memory, language, reasoning, decision-making, and problem-solving. Consequently, applied cognitive psychology may be defined as the science of the cognitive processes involved in activities of daily living. In this chapter we first provide a general discussion of applied cognitive psychology. We then describe the knowledge, skills, and abilities required for applied cognitive psychologists. Next we provide examplars of research conducted within different problem spaces that have successfully contributed to our understanding of human behavior. We conclude with a more in-depth discussion of applied cognitive psychology in the context of advanced technological solutions designed to improve the health and well-being of older adults. This discussion is meant to illustrate the potential for applied cognitive psychology to contribute to an important social issue facing the world today.

OVERVIEW OF APPLIED COGNITIVE PSYCHOLOGY

There is a variety of misconceptions about applied cognitive psychology and clearing up misconceptions about a research field can aid in defining that field. We address just a few of these misconceptions here (adapted from Fisk & Kirlik 1996; see also Landauer 1989).

Misconception #1 – Applied Cognitive Research is, by Definition, Designed to Answer a Practical Question for a Specific Task in a Specific Context

Although some applied research may be conducted to answer a specific question, that is not the hallmark definition of all applied cognitive research; nor should it be. The same criticism can be levied at some basic cognitive research which may be overly specific. Ideally, the goal should be to develop general principles that will have relevance to a range of problems and to specify the boundary conditions under which such principles will be valid. This is really a concern for generality (Petrinovich 1989). Certainly, external validity may be lacking in some applied research. However, the problem with, and limitation of, such research seems to rest on its piecemeal approach and the fact that such research is often driven primarily by technology. Hence, the integration of some bodies of applied research is quite difficult, as is the generality of that research beyond the specific targeted problem or context. Recognizing the importance of advancing both the practice of cognitive psychology and theories within cognitive psychology can do much to overcome this problem.

Misconception #2 – The Critical Basic Cognitive Psychology Research Must be Conducted First and Only then Can the Application be Made

Applied cognitive research is not simply the application of cognitive theories. Basic and applied science should be considered as having a symbiotic relationship whereby attempts at application can bring to light the inadequacy of a theory, but application should also guide the study of fundamental issues in psychology. The idea that application must follow basic research assumes that "basic" and "applied" research represent ends of a linear continuum. We think of "basic" and "applied" cognitive psychology as part of a circular continuum with both giving to and taking from the other (see also Hoffman & Deffenbacher 1993).

Misconception #3 – Applied Cognitive Research Does Not Allow Proper Research Control

Conducting applied research does not imply that research is not done well or is not done with consideration for control (see Cook & Campbell 1979). Well-designed research efforts must consider internal validity as well as external validity. Such designs may ultimately be complex but are not impossible.

Misconception #4 – Tasks That Are Context-rich Weaken Generalization

Some researchers argue that understanding "pure" cognitive processes necessitates studying them in controlled situations that remove potentially influential environmental contexts. An extension of this view might be that the study of complex tasks that are embedded in a representative context will not yield generalizable results because few other situations will have exactly the same context. However, stripping a task of its context does not assure that a context-independent activity is being engaged through performance of that task and the resultant task may not be at all representative of typical behaviors. Moreover, understanding the role of environmental context in performance may provide more generality to the principles of behavior that can be developed on the basis of contextually-rich research studies. This idea is grounded in the ideas of "ecological validity" and "representative design," as suggested by Brunswik (see Hoffman & Deffenbacher 1993; Hammond & Stewart 2001).

Moving beyond the Misconceptions

This discussion of misconceptions is not meant to imply that we do not recognize the important contributions of fundamental cognitive psychology. Indeed, we consider ourselves cognitive psychologists searching for basic, fundamental knowledge. Cognitive psychologists have conducted many elegant, detailed, and controlled studies to understand the fundamentals of cognitive processes. Consider the cognitive process(es) of attention: it is well documented that there are varieties of attention (Parasuraman & Davies 1984), that through extensive consistent practice attentional demands can be reduced (e.g., Schneider & Shiffrin 1977), that attentional capabilities change with age (Rogers & Fisk 2001), and that different attentional functions are localized in different areas of the brain (Posner & Petersen 1990; Parasuraman 1998). Yet without taking an applied cognitive psychology approach we would not know how attention affects driving behavior, flying an airplane, or monitoring gauges in a control center.

KNOWLEDGE, SKILLS, AND CAPABILITIES OF APPLIED COGNITIVE PSYCHOLOGISTS

The knowledge and skill set of an applied cognitive psychologist must be a *superset* of the skills held by a cognitive psychologist. That is, in addition to the training that a cognitive psychologist receives (e.g., cognitive psychology, research design, statistics), applied cognitive psychologists need collateral knowledge and skills.

To illustrate this point, consider the curricula of graduate programs in cognitive psychology and applied cognitive psychology. A review of cognitive psychology graduate programs reveals that the typical coursework involves cognitive psychology (with specialized courses in perception, memory, language, etc.), statistics, research design, and other optional, specialized courses (e.g., neuroscience, aging). On the other hand, applied cognitive psychology programs (sometimes called engineering psychology or applied experimental psychology) include the above curriculum as well as courses in engineering psychology methods, human factors, human performance, biomechanics, computer science, industrial design, and so on. Such declarative knowledge is required to study applied problems that may span many content areas. In addition to coursework, special emphasis is placed on skills and tools used to analyze the person, environment, and machines that make up a system. Applied cognitive psychologists also require the capability to work as a part of a multidisciplinary team and to translate principles and theories from simple to complex task environments.

It is worth noting that similar knowledge, skills, and capabilities are required in the field of cognitive engineering which may be considered the engineering companion to the psychology of applied cognition. Cognitive engineering generally focuses on complex work domains such as nuclear power plants and hospitals, using techniques such as cognitive task analysis, focusing on the human–system interaction, and taking a problem-driven approach (Rasmussen 1986).

Knowledge

If one of the goals of applied cognitive psychologists is to study complex behavior in complex situations, they must possess a certain breadth as well as depth in many areas of psychology. This knowledge includes the core areas of psychology such as perception, cognition, and movement control. This fundamental knowledge illuminates the cognitive, perceptual, and physical capabilities or limitations of individuals. But applied cognitive psychologists may also need to be aware of social and industrial/organization psychology to understand the larger surrounding context in which the behavior of interest is situated. Or to have knowledge of developmental psychology to understand how age-related changes in cognition affect the behavior of interest.

Additionally, depending on the problem domain of study, domain-specific knowledge will be required. For example, if the focus is on behavior that is situated in computer systems, a technical understanding of human–computer interaction issues would generally be necessary. Similarly, understanding general aviation would inform studies of pilots and cockpit design, whereas knowledge of driving would enhance studies of intelligent vehicles and highway signage. The psychologist in this case does not need performance expertise, but solid domain knowledge. If one were investigating how best to train the perceptual decision-making skills required of an NFL quarterback, a thorough knowledge of what a quarterback must do as well as the perceptual cues used to "read defenses," and so on is required (Walker & Fisk 1995), but having the physical prowess to be a football quarterback would not be necessary.

Skills

A powerful aspect of applied cognitive psychological research lies in the production of general principles about behavior in complex situations. This capacity of the field of applied cognition comes from the design of studies that sample a wide range of user characteristics in different situations (i.e., representative design; Hammond 1998). As a beginning, it is critical to understand the user and the system or environment in which that user is interacting (e.g., Rogers *et al.* 2001). There are methods, tools, and techniques that can be used to garner the requisite understanding such as knowledge engineering and task analysis (Nichols *et al.* 2004). There are clear benefits to having multiple methods and techniques available to study a problem domain (Vicente 1994). The scientific method should be used in conjunction with these additional methods to enhance understanding of human behavior in situ (Durso & Manning 2002).

Knowledge Engineering

In addition to understanding the capabilities and limitations of people in the task context, it is critical to understand the knowledge and experience that people bring to various situations. Such an understanding can be obtained through the use of knowledge engineering which is a systematic method to examine the knowledge and cues that people use to make decisions (Sanchez *et al.* in press). This knowledge can be obtained by conducting focus groups, interviews, questionnaires, or observing operators in their environment. Therefore, skills in survey development, interviewing techniques, questionnaire design, and ethnographic methods are required.

Analysis of the data from knowledge engineering studies requires specialized skill. Qualitative data analysis is a process of reducing the massive quantities of text that can come from the transcription of focus groups or structured interviews. The process involves an analysis of the common themes that frequently occur in the raw data (i.e., transcripts). These themes constitute the *coding scheme*. Although qualitative data analysis can be extremely time-consuming, it offers a way for researchers to "study things in their natural settings, attempting to make sense of, or interpret phenomena in terms of the meanings people bring to them" (Denzin & Lincoln 1998, p. 3). It is also important to recognize that qualitative data can be quantified and analyzed statistically (for an example, see Melenhorst *et al.* 2006).

Knowledge engineering is also referred to as "knowledge acquisition" or "knowledge elicitation," and this process has been used extensively in the development of expert systems (see Hoffman *et al.* 1995; Cooke 1999 for reviews). For example, the development of an intelligent system can be based on an understanding of how experienced operators interact with a system. Similarly, knowledge engineering can be used to guide the transition from a manually controlled system into one with a higher degree of automation.

Knowledge engineering can be used to understand information-processing components of a task. For example, Fisk and Eggemeier (1988) used knowledge engineering to identify consistent trainable components in a real-world tactical command and control mission and to develop a part-task training approach based on those components. Another example is the work by Klein (1998), where he used a knowledge engineering approach to investigate the decision-making processes of firefighters operating in stressful situations. These findings have since been applied to aid in the design of military decision support systems.

Task Analysis

To understand the system and environment, a critical skill for applied cognitive psychologists is the capability to conduct a thorough task analysis. A task analysis is a general class of techniques that can provide a detailed analysis of the individual steps of a task and how the steps are arranged (Luczak 1997). The levels of detail can vary depending on the method, but a properly executed task analysis can be a powerful tool to reveal the physical and cognitive demands placed on a user by the system and environment.

For example, a blood glucose meter is a device used by diabetics to monitor the level of glucose in their blood. Rogers *et al.* (2001) found that although a manufacturer of blood glucose meters advertised their system as consisting of three easy steps, a task analysis revealed that proper use of the device required 52 individual, sequential steps. The task analysis was crucial in identifying the complexity of the "simple" task of using a blood glucose meter. Table 1.1 presents a portion of the task analysis to illustrate the level of detail that a task analysis can provide concerning the task the user has to perform at each step, the knowledge required for each task, the feedback (or lack thereof) provided by the system, and the potential problems the user might encounter.

Psychometric Methods

In addition to general statistics (e.g., analysis of variance, regression), measurement and modeling tools are a valuable part of the arsenal of an applied cognitive psychologist. For example, Gillan and Schvaneveldt (1999) described the utility of network models to understand knowledge differences between novices and experts, to make predictions about student learning, and to design computer interfaces.

Developing valid and reliable questionnaires and surveys will also be a critical component of successful applied projects (Babbie 1990; Moroney & Cameron 2004, unpubl. manuscript). It is a challenge to develop outcome measures that capture the complexity of behaviors that may be manifested in various task domains. The measures must provide reliable estimates across testing occasions and across the people being tested (who may vary widely in their level of performance). Moreover, the measures must provide a valid index of the behavior of interest whether it be performance, learning, expertise, retention over time, transfer across tasks, and so on.

Capabilities

Being Part of a Team

Because of the desire to study behavior in complex settings, an applied cognitive psychologist often works on interdisciplinary teams. For example, research in aviation psychology may involve collaboration work with aircraft designers and pilots. Someone interested in older adults' ability to use medical devices may be working with computer scientists, industrial designers, cognitive psychologists, medical doctors, and independent living facility coordinators. Because of the need to ground psychological research in a domain representative of the target behavior's context, working in diversified teams is often a requirement for applied cognitive psychologists.

Translation

Many talented scientists can interpret the psychological literature. However, given the goal of understanding behavior in contextually rich and often complex environments, applied cognitive psychologists must be able to abstract the critical principles of theories of perception or attention or memory and translate those ideas into testable hypotheses for tasks that comprise perception, attention, *and* memory components. Something as seemingly simple as the selection of an input device for a system is complicated by issues such as task demands, the specific controls being manipulated (e.g., radio buttons or scroll bars),

Table 1.1 Partial Task Analysis for a Standard Blood Glucose Meter

Task Number	Task	Task/Knowledge requirements	Feedback	Potential problems
1.0	Set up the meter			
1.1	Select the display language			
1.1.1	Press and hold the C button	Location of C button	Tactile (feel button action)	Cannot locate button
1.1.2	Press and release the On/Off button	Location of On/Off button	Meter beeps when turned on; meter displays last reading	Cannot locate buttonfail to release button
1.1.3	Release the C button	Location of the C button	Tactile (feel button action)	Cannot locate button
1.2	Code the meter			
1.2.1	Turn on the meter	Location of On/Off button	Meter beeps when turned on; meter displays last reading	Cannot locate button
1.2.2	Compare the code numbers on the meter and test strip package	Location of correct code number	None	Cannot find correct code number on package
1.2.3	Press the C button until the codes match	Location of the C button	Tactile (feel button action); code changes on display	Enter incorrect code number
2.0	Check the system			
2.1	Perform a check strip test			
2.1.1	Make sure the test area is clean	Location of test area	None	Test area not cleaned
2.1.2	Turn the meter on	Location of On/Off button	Meter beeps when turned on; meter displays last reading	Cannot locate button
2.1.3	Wait for meter to say "INSERT STRIP"	Location of display	Meter displays instructions	Does not observe instructions on display; inserts strip too early
2.1.4	Slide side 1 of the check strip into the test strip holder	Location of the test strip holder; proper orientation of check strip	Meter displays "APPLY SAMPLE" when it detects something	Insert check strip incorrectly; insert something other than a check strip
2.1.5	Wait for the meter to say "APPLY SAMPLE"	Location of the display; correct procedure	Meter displays instructions	Does not remove check strip from holder; applies blood or control solution; does not wait for instructions
2.1.6	Slide the check strip out of the test strip holder	Correct procedure	Meter displays "INSERT SIDE 2" when strip is removed	Does not remove check strip
2.1.7	Wait for the meter to say "INSERT SIDE 2"	Location of the display; correct procedure	Meter displays instructions	Does not wait for the instructions

Note: The full task analysis of the 52 steps is presented in Rogers *et al.* (2001).

the context of use, and the age of the user (McLaughlin *et al.* 2003; Charness *et al.* 2004; Rogers *et al.* 2005).

THE NEED FOR APPLIED COGNITIVE PSYCHOLOGY

During the First World War, a critical issue was selecting the right person for the right job in the military and ensuring that task-appropriate training was provided. These goals were met through applied psychology (Thorndike 1919). The Second World War brought issues of human–technology collaborations that revealed the limitations of a purely reductionist approach to psychological theories (Schvaneveldt 2005). The wartime needs required psychologists to solve complex problems in complex settings and to develop principles of behavior that would transcend the specific instance to guide design and training more generally (Hoffman & Deffenbacher 1992; Taylor 1994; Parsons 1999).

Today, technology continues to evolve, and quite rapidly; population demographics are changing; and psychologists recognize the importance of trying to understand behavior in the context of complex and varied environments. Applied cognitive psychologists are intrigued by design and training problems they observe; and their curiosity and concern for society lead them to want to understand, and perhaps improve, the world around them.

To illustrate applied cognitive psychological research, we selected six exemplar papers. We chose these examples to illustrate a range of cognitive functions (perception, attention, monitoring, learning, decision-making, memory, and comprehension) in a variety of everyday contexts (driving, security, sports, collaboration with technology, and safety). These examples are illustrative of the philosophy of use-inspired basic research (Stokes 1997), but they are by no means exhaustive. Myriad other examples are presented in other chapters of this book.

For each paper, we first present the impetus for the research, which we learned through a personal query sent to the lead author of each paper. We then describe the specific research question and the key findings. These examples illustrate the range of problems that are studied (i.e., the breadth of applied cognitive psychology), the variety of research methods used, and the contributions of this research to our daily lives, as well as to the science of psychology.

Training New Drivers

> At the time I started thinking about undertaking research on driving simulators, I had two young children. I thought constantly about my daughters' safety . . . Personally I was in a near fatal crash as a teenager . . . And professionally, as a mathematical psychologist, I was used to predicting behaviors that differed by only a few milliseconds. But those behaviors were relatively inconsequential. In the car, however, those few milliseconds can make the difference between life and death. (Don Fisher)

Novice drivers are more likely to suffer fatal accidents than are other drivers (Insurance Institute for Highway Safety 1988). In addition to a lack of experience among novice drivers, another potential reason for their increased fatality could be a lack of the higher-level cognitive skill of risk perception. One reason that novice drivers may suffer more fatal accidents could be that they are less likely to understand the consequences of risky driving. Fisher *et al.* (2002) examined the degree to which the skill of risk perception could be trained using low-cost personal computers (PCs). Determining how to train the complex cognitive skill of risk perception could lead to the widespread adoption of a low-cost way to train young drivers.

The question in the research was how best to train risk perception, a skill requiring perceptual and cognitive components. Could training encourage young drivers to drive more cautiously during demanding driving situations, and if so what are the psychological properties of training that would most facilitate the skill development? Another question Fisher *et al.* (2002) addressed was the extent to which PC-based training would generalize to more complex, riskier situations. They tested three groups: (1) college-aged bus drivers; (2) high school-aged novice drivers enrolled in a driver education course; and (3) high school-aged novice drivers enrolled in a driver education course and given the PC-based risk-awareness training program. The risk-awareness training program was composed of 80 scenarios that contained film of the windshield view and the driver's and rearview mirrors. Depending on the mode of the training program, users were asked to identify all potential risky elements in the scenario (e.g., a child playing on the sidewalk). In another mode, the training program was stopped and users had to report on important elements of the situation (e.g., "was there a vehicle approaching you?").

All three groups were tested in a high-fidelity driving simulator where they experienced various potentially risky driving situations (e.g., needing to pass a parked truck that obscures the view). The results showed that novice young drivers who participated in the risk-awareness training were indeed more cautious (i.e., made superior driving-related decisions) in risk-related driving scenarios compared with novice drivers who did not participate in risk-awareness training. This cautious driving was even apparent in situations with no apparent risk. For example, trained drivers were slower in their approach to an empty pedestrian cross walk. The driving patterns of the trained novice drivers were more similar to the untrained experienced drivers. The importance of the results is that risk-awareness training through a low-cost means (PC-based risk-awareness training) can have a pronounced effect on driving behavior in a highly vulnerable population (novice young drivers). Most importantly, the results generalized to novel situations in a high-fidelity driving simulator, which suggests that they may translate to actual driving.

Driving while Talking on a Cell Phone

> While observing drivers on the roadway, it became clear that the multi-tasking demands of the driver were beginning to increase in ways that were similar to the increases in workload of pilots years ago . . . What began as a simple exploration has become a sustained research project . . . Our latest series of studies came about because the aging and dual-task literature suggests that older adults have more difficulty multi-tasking than younger adults . . . we are now exploring the other side of the age continuum – 16 & 17 year-olds just learning to drive. . . . (Dave Strayer)

With decreasing costs, cell phones have been enthusiastically adopted by an estimated 160 million Americans (CTIA 2004). Previous research has shown that driving while talking on a cell phone is disruptive to driving performance among young adults (e.g., Strayer & Johnston 2001) such that when driving and talking on a cell phone, they were more likely to miss critical events such as stop signs and traffic lights.

Driving is a complex activity that involves the coordination of many activities. The literature on dual-task performance and aging has shown consistent effects, with older adults having more difficulty performing multiple tasks than other age groups (see Rogers 2000). Age-related differences in the ability to divide attention to multiple tasks may make driving and talking on a cell phone more difficult for older adults. However, older adults have more driving experience, which may moderate potential dual task decrements of driving and talking on a cell phone.

Strayer and Drews (2004) investigated whether talking on a hand-free phone while driving would disrupt driving performance and whether the effects would differ for younger and older adults. They examined age-related differences in dual-task performance in a research context representative of the target behavior: talking on a cell phone and driving in a simulator. Based on the literature in dual-task performance and aging, they predicted that older adults' performance on the driving task would deteriorate more rapidly than younger adults'.

In the driving-only condition of the study, participants followed a "pace car" in a driving simulator. The task was to avoid collision with the pace car by applying the brakes when the pace car applied the brakes. In the driving and talking condition, participants followed the pace car, but also engaged in a conversation with a research assistant (sitting out of view of the driver). This latter condition was meant to simulate talking on a hand-free cell phone. The dependent measures were how quickly the brakes could be applied in response to the pace car's brakes, the distance between the pace car and the driver, speed, and how quickly participants could recover speed lost during braking. The results showed that drivers who were conversing and driving took longer to brake and longer to recover lost speed, but they also had longer following distance than participants who were not conversing on a cell phone. Interestingly, older adults' driving was not more affected by hand-free conversations than younger adults'. The authors explained that this could be due to the high fidelity of the simulator, which allowed older adults to draw upon their extensive experience in a driving task.

The research conducted by Strayer and Drews (2004) illustrates that theories based on novel tasks used in basic cognitive aging research studies of dual-task performance may overestimate the effect of aging on everyday task performance (see also Walker *et al.* 1997). However, for both younger and older adults, talking on a cell phone, even when it is hand-free, has the potential to disrupt driving performance.

Support for Baggage Screeners

> We began the work largely because the screening task gave us a nice real-world domain in which to do theoretical work/apply theoretical knowledge. Basically, we saw an RFP [Request for Proposals] from the FAA [Federal Aviation Administration], and the topic seemed relevant to our general research interests (vision, attention, eye movements) so we pursued it. (Jason McCarley)

Most travelers are familiar with the process of getting their bags checked at the airport. Looking at the images of x-rayed baggage, one is likely to wonder how anyone can discern potentially threatening objects in the images (e.g., guns, bombs). Searching x-ray images for threatening objects in the presence of noise, clutter, and degraded image quality is a difficult task, which is made more difficult by time pressures and other external stressors. Whereas research has been conducted examining how expert radiologists examine medical x-rays, radiologists have additional information that may help guide their search. For example, anatomical constraints guide their search to very specific areas. Security screening of x-ray images represents a more difficult task because there are fewer constraints that may guide visual search. There seems to be little trial-to-trial regularity, even for training at the category level (Fisk & Schneider 1983). Additionally, the potential shape of targets (i.e., threatening objects) is vast. Consequently training detection of particular target shapes may not transfer to novel shapes that may also represent threats.

McCarley *et al.* (2004) examined the question of whether practice on a simulated baggage screening task improved performance in that task. Specifically, did training enhance search skills, recognition skills, or both? The second goal of their study was to determine how well training of search and recognition skills transferred to novel situations.

The observer's task was to view images of x-rays of bags. In some of the images, a picture of a knife was inserted. The training phase consisted of five sessions of 300 trials per session. Feedback was given after each trial. In the fifth session, the transfer phase, observers were told that they would be again searching for knives, but the shape of the knives was different than that on which they had been trained.

The results may not be surprising but they are important. The data indicated that across the training phase (comparing sessions 1–4), sensitivity improved; that is, observers were better able to recognize targets with practice. To determine whether training benefits would transfer, session 4 was compared to the transfer session, session 5. Results indicated that observers were less able to recognize the new knife shapes, suggesting that the training of target shapes was indeed stimulus-specific and did not transfer.

Did the practice provide any advantage to searching? McCarley *et al.* (2004) compared session 1 performance (first exposure to the task and to the targets) with session 5 (familiar with the task but searching for new targets). This comparison showed that recognition performance as well as target detection time was significantly better for session 5, suggesting some general benefit of task practice.

These results suggest that training efforts for baggage screeners should focus on training them to detect a wide variety of threats instead of modifying visual scanning behavior. McCarley *et al.* (2004) used eye-tracking measurements and found that the effectiveness of scanning did not change with practice; it was learning the targets that improved performance. Because of the heterogeneity of potential targets in this task domain, training programs should provide a wide variety of potentially threatening targets, possibly extending the research to examine superordinate or higher-order categories as suggested by the perceptual decision-making literature (e.g., Kirlik *et al.* 1996, 1998).

Deciding Where to Throw the Ball

> When I was in graduate school I was taught that practice (albeit practice of a particular sort) was *the* royal road to skill acquisition. But if that was the whole story, why could I rapidly learn to use technologies designed in one way, but only slowly and painfully learn to use other sorts of designs? I realized that skill acquisition simply had to have

> an environmental dimension . . . I wrote in 1995 on what I called Ecological Task Analysis, a technique for specifying the environmental support for, and impediments to, fluent behavior. [This article showed] that the presence of perceptual information that did a good job of specifying the environmental constraints on behavior facilitated skill acquisition. (Alex Kirlik) [Kirlik 1995]

Operators engaged in complex, dynamic situations often rely on simple perceptual heuristics to guide behavior. Kirlik *et al.* (1996) wondered whether specifically training simple perceptual and pattern-recognition heuristics would help performance in a complex task. The idea was that decision-making in complex environments is most likely dominated by the use of heuristics ("automatic" processes) rather than cognitively intensive procedures ("controlled" processes).

Although the heuristic aspect of decision-making may be a very important contributor to performance in complex decision-making tasks, very little work had been done to examine how best to train this kind of behavior. The purpose of the Kirlik *et al.* (1996) study was to examine how best to support skilled decision-making through display augmentation (highlighting important aspects of the display) with the goal of allowing an operator to quickly extract critical, task-relevant information.

Playing the role of an American football quarterback, participants had to decide to whom to throw the ball, as well as the exact time to throw the ball. In general, this decision-making behavior is dictated by specific rules based on general patterns of players on the field. If a specific pattern of players was evident, there was always one correct answer. Participants were assigned to one of four training conditions (the factorial combinations of rule training vs. no rule training, and visual enhancement vs. no visual enhancement). After training, participants were given similar tasks with no enhancement (transfer tasks) to measure the effects of training.

Simple rule training was better than no rule training, but the addition of visual enhancement (highlighting important task aspects in the display) improved response speed at transfer. The first study showed the performance benefits of static perceptual augmentation given during training; a second study showed that perceptual augmentation was also beneficial in a dynamic decision-making task.

The results of these studies illustrate how complex decision-making can be enhanced by exposing operators to concrete task situations. Such exposure allows operators to learn the relationships between abstract concepts (rules) and the perceptual information from the environment to which the rules are referring. Understanding these relationships informs theories of dynamic decision-making, provides guidance for training, and informs display design.

Let the Computer Do it: Automation

> The idea for the study did not stem from any one single observation of real world behavior, but from many, which all converged on the issue at hand. That is, when a task that is formerly done manually is given over to a computer, memory for the skill relevant to the task declines and people tend to become over-reliant on the computer, sometimes not bothering to check the computer results manually. I had noticed the same phenomenon in such diverse domains as my kids using an electronic calculator, myself using a spell checker in a word processing program, airline pilots using the autopilot in commercial aircraft, and control room personnel going through an "electronic check list" in a power plant. (Raja Parasuraman)

Automated systems are embedded in many products and systems we use throughout daily life. Some systems are completely automated with nothing required of the user other than to turn it on and push a button to activate it (e.g., disposable cameras). In these systems, the system takes over all functions (exposure, flash control, etc.), and allows the user only rudimentary control (take the picture or not). Other systems are more adaptive, allowing users to maintain control when they desire it. For example, the cruise control function in most cars offloads the driver's need to monitor the speed of the car, but the driver can obtain control when needed (e.g., to brake when the car ahead brakes). It has been suggested that with strict allocation of functions (as in traditional automation), users are left "out of the loop"; that is, they are not aware of what is going on in the system. On the other hand, adaptive systems may be less prone to the "out of the loop" syndrome because the operator is always in the loop, deciding when to turn off automation.

The question of whether adaptive task allocation (sometimes the machine has control, sometimes the human) would result in improved monitoring performance was examined in a study by Parasuraman *et al.* (1996). Two groups of participants monitored three control panels: engine status, fuel status, and tracking task. For one group, detection and correction of engine anomalies was automated throughout the study. This condition represented an instance of automation that is not adaptive. For the other group, the automation for the engine was turned on for the beginning of the study, turned off and under human control in the middle of the study, and turned back on for the rest of the study (adaptive automation). The automation in both conditions was not perfectly reliable and sometimes failed to detect engine problems. The dependent variable was the operator's detection rate of automation failures. The group that had the engine automation turned off for part of the study was better able to detect automation failures when the automation was turned back on. The results suggest that turning over control of certain automated monitoring tasks to the operator, at least for brief periods, has a beneficial effect on the ability detect automation failures. The results are important because operator failure to detect automation errors can, in some cases, lead to disastrous consequences. However, keeping human operator "in the loop" enabled them to better detect failures of automation and initiate corrective actions.

How do People Interpret Warning Symbols?

> The idea originated with thinking about how people who are not primary English speakers might need to accurately interpret a symbol's meaning in one word or a short phrase. When they first see the symbol, they shouldn't have to … think of a meaning that consists of several sentences. In everyday living situations, upon viewing a safety symbol, someone might have to make a snap judgment and only have time for a quick, concise thought, an instinctive impression … Furthermore the thought should be in line with the intended message of the symbol. (Holly Hancock)

Looking around one's home or workplace, one is likely to notice that most products contain a warning label or image. These warnings are provided to inform the user of potential hazards of products. However, are people easily able to decipher the symbols used in many warning labels? The American National Standards Institute (National Electrical Manufacturers Association 1998) recommends that symbols be used only if they are recognizable by 85 per cent of the general population. However, there is evidence that symbols often are not comprehended at this level, especially by older adults (Hancock *et al.* 2001) although other studies failed to find age-related differences in symbol comprehension (e.g., Halpern 1984). The inconsistency was hypothesized to be due to differences in testing methods to assess comprehension (e.g., some studies used multiple-choice responding while other studies used ranking tests).

Hancock *et al.* (2004) further examined age-related differences in symbol comprehension by using a methodology new to the warnings research area (phrase generation procedure) to assess symbol comprehension. In the phrase generation procedure (based on Battig & Montague 1969), the participants were presented with a safety symbol and asked to write down all the phrases that came to mind. The benefit of this type of procedure was that it allowed global comprehension to be evaluated from all of the phrases that participants generated. The procedure also allowed an analysis of the first phrase that came to mind which would represent the concept that was most strongly associated with the particular symbol.

The first phrase that was generated by younger adults more closely matched the actual meaning of the symbol compared to older adults. Younger adults also had better overall symbol comprehension than older adults (the sum of all the generated phrases more closely matched the intended meaning of the presented symbol). Another important finding was that accuracy rates among both younger and older adults was well below the 85 per cent recommended by ANSI. These results show that important safety-related symbols commonly in use may not be comprehensible by people of different ages.

SUCCESSFUL AGING

As we have argued, applied cognitive psychology is rooted in understanding behavior in context, extending psychological theories to more complex tasks and environments, and developing principles and guidelines that might improve lives. In this section we explore one specific area in more depth, namely, the potential of applied cognitive psychology to provide solutions for an important societal dilemma: how to support the desire of older adults to maintain their independence and autonomy.

It is a fact that the average age of members of most developed countries is increasing. For example, in the US, approximately 12 per cent of the population was over age 65 in 2000 with a projection of 20 per cent by the year 2030.This translates to roughly 71.5 million people (US Census Bureau 2000).

Longer life, however, does not mean life without disease, physical frailty, or cognitive decline. There are age-related changes in capabilities that make everyday activities more challenging as individuals grow older. There are perceptual changes (Kline & Scialfa 1997; Schieber 2003), cognitive changes (Craik & Salthouse 2000; Park & Schwarz 2000), movement control changes (Vercruyssen 1996; Ketcham & Stelmach 2004), and changes in functional anthropometry (Kroemer *et al.* 2001; Kroemer 2006). The research discussed in this book (as well as in the first edition; Durso *et al.* 1999) has the potential to support successful aging.

Everyday Activities

What does it mean to age successfully? The specific answer probably varies by individual, but there are likely common themes. One must be able to perform basic activities of daily living (ADLs) such as bathing, toileting, and eating (Katz 1983). Also critical is the ability to maintain one's household, manage a medication schedule, keep track of financial records, and prepare nutritious meals. These are referred to as instrumental activities of daily living (IADLs; Katz 1983; Lawton 1990). Performance of ADLs and IADLs is critical, but successful aging means more than performing these activities. Successful aging also involves being able to perform activities that contribute to the quality of life such as communicating with family and friends, continuing a hobby, or learning a new skill. These are referred to as enhanced activities of daily living (EADLs; Rogers *et al.* 1998).

How can applied cognitive psychology support these everyday activities? We will focus our discussion on IADLs and EADLs, which are more heavily influenced by cognitive capabilities (ADL performance is mostly influenced by physical functioning). Even with that constraint, supporting aging-in-place is a complex, multifaceted problem. What are the activities that need to be supported? What is the optimal way to provide support? Will older adults accept the supports into their daily activities? The tools of applied cognitive psychology can be used to begin to answer these questions. However, there is much work to be done if these efforts are to be successful.

What are the Activities that Need to be Supported?

To answer this question requires a needs analysis. The older adult user population has unique needs, capabilities, and limitations that must be considered throughout the design process. "Needs assessment and requirements analysis are the most important activities for initiating system improvement because, done well, they are the foundation upon which all other activities build" (Beith 2001, p. 14).

If home technologies are to be successful in supporting the independence of older adults, they must be designed with the needs of those older adults in mind. On the surface, this is an easy principle to follow. However, by not considering capabilities and limitations of older adults as well as the perceived benefits of technology, useful and acceptable technologies will not be developed. "Needs arise from the ways in which people perceive their everyday world and how they decide and act upon their own self-determined priorities. The ways in which needs arise thus depend upon the individual, but are also driven by the norms shared with other people within their social group … technological solutions must adequately account for the full complexity of human experience if they are to be useful" (Sixsmith & Sixsmith 2000, p. 192).

How do older adults spend their time? Moss and Lawton (1982) conducted a time-budget analysis of data from two samples (mean age 75 and 79). They found that 82 per cent of all waking behaviors of older adults occurred in the home. In a similar, more recent study, Baltes *et al.* (1999) examined activity patterns for two age groups. For individuals aged 70–84, primary activities were as follows: self-care activities such as getting up, eating, shopping (19 per cent), instrumental activities such as household chores, banking, and medical treatments (17 per cent), leisure activities such as cultural events, reading, gardening, watching television (42 per cent), social activities such as talking to people, visiting, telephoning (7 per cent), work (1 per cent), and resting (12 per cent). The distribution pattern was similar for their sample of adults over age 85, except for a marked increase in resting behavior (25 per cent). Approximately 80 per cent of the behaviors of both groups occurred in the home.

To move toward development of supports to bridge the gap between the demands of the tasks that must be performed and the capabilities of the individuals who must perform them, we need to have more detailed analyses of the sources of the problems, the nature of the problems, and the contexts in which they occur. In particular, more focus needs to be placed on the role of *cognition* in home functioning. Willis *et al.* (1999) suggested that qualitative research focusing on patterns and processes of behavior represents a useful tool for understanding age-related functional changes. They conducted a detailed analysis of the types of errors that older adults made on the Everyday Problems for Cognitive Challenged Elderly test (see Willis *et al.* 1998 for details). The strength of Willis *et al.*'s (1999) error analysis was that it provided specific information about the types of error participants made. Most notably, 90 per cent of their sample (aged 70–94) made "incomplete processing" errors. For example, they were deficient in combining and integrating information, they made procedural memory errors such as leaving steps out of a process, or they made selective attention errors such that they only processed portions of the necessary information. In addition, 22 per cent of the participants made errors indicating an inappropriate reliance on prior experience, which may indicate a tendency for older adults to rely on their intact semantic knowledge even when it may not be appropriately applicable. This study illustrates the role of cognitive processes in everyday home activities.

What is the Optimal Way to Provide Support?

We need to understand within the home context where and when cognitive supports are needed. For example, it is crucial to establish the prevalence of memory problems within the home-based environment. Currently, existing databases do not provide such information. Also important is understanding the knowledge and human information-processing demands placed on the human when interacting with the "system." It is through understanding the vulnerabilities of older adults, and capitalizing where possible on strengths, that a principled approach to effective aware home cognitive augmentation is possible.

Unfortunately, general principles of age-related system design that can be systematically applied to aware home technology design and development have not yet emerged. We believe that such principles can emerge; however, they will be tied to an understanding of age-related interactions with characteristics of the system interface, human information-processing demands, and goals associated with use of the system. Indeed, in domains more fully explored (e.g., "standard" technology such as computer input devices) such principles have emerged (Fisk *et al.* 2004).

One logical focus area for aware home technology is the support of memory-related tasks. There is substantial evidence in the literature that older adults have declines in their memory capabilities (for recent reviews, see Anderson & Craik 2000; Balota *et al.* 2000; Zacks *et al.* 2000), and that perceived memory complaints have an influence on the well-being of older adults (Verhaeghen *et al.* 2000). In addition, cognitive capabilities such as memory contribute to everyday cognitive competence, which is considered essential for independent living (Willis 1996).

To maintain their functional independence, older adults must remember to do certain things: pay the electricity bill before it is overdue; adhere to a specific medication regimen; purchase the appropriate items at the grocery store; go to scheduled physician's appointments on the appropriate day at the appropriate time; eat nutritious meals; exercise regularly; and take the roast out of the oven or the kettle off the stove. If these tasks are not carried out, individuals may not adequately be tending to their nutrition, health, and safety needs; indeed performing such tasks is, arguably "essential for independent living" (Maylor 1996, p. 192).

Future research must identify characteristics of the memory complaints reported by older adults in the context of the home and develop and test empirically-based methods of providing cognitive aids to support recovery from memory failures. To do so, it will be necessary to study the ecology of forgetting in the home – the "everyday content" of memory-intensive activities. Everyday content is loosely defined as the continually shifting set of information that a person uses to perform tasks (Mynatt *et al.* 1999). This flow of information is often incomplete, unnamed, informal, heavily context-dependent, and transient. Examples are notes, to-do lists, drafts, reminders, sketches, and the like that are in sharp contrast to archival material typically filed electronically or physically. Everyday content in the home includes a written or unwritten list of tasks, other reminders, frequently used objects, notes, messages, and other transient pieces of information common to daily living. Intuitively it is clear that memory functioning (in a variety of ways) is critical to the myriad tasks we carry out. However, "relatively little research has been done on the rich and complex strategies and tactics that we use every day to interrogate our memory systems" (Baddeley 1998, p. 217).

Will Older Adults Accept These Supports into Their Daily Activities?

"Older adults prefer to do things the old-fashioned way." "You can't teach an old dog new tricks." "New technologies are for the young." While it is true that older adults are slower to adopt many new technologies, and they typically require more training to learn to use them, these myths about older adults and new technologies are overstated. Rogers *et al.*'s (1998) focus group study illustrated a variety of new technologies that older adults reported encountering. Some technologies they had little choice about using, such as telephone menus, new gas pumps, or medical devices. However, some participants had voluntarily learned to use new devices, and most were eager to learn. These individuals did not wish to insulate themselves from changing technology. However, because of inadequate design and lack of accessible training, many had not been able to use a host of new technologies. An encouraging finding was the older adults' willingness to learn. Although they often acknowledged that they might have difficulty learning and require more time to learn, older individuals were eager to learn how to use various technologies.

Systems must be well designed and proper training must be provided. Does that guarantee that older adults will adopt new technologies to perform daily tasks? Not necessarily – adoption of new technologies is influenced by a variety of factors such as the relative advantage of the technology (in comparison to the previous method of accomplishing the activity) and the degree to which the innovation is compatible with one's values, experiences, and needs (Rogers 2003).

The factors that influenced adoption of new communication technologies were investigated by Melenhorst *et al.* (2006). In a focus group study, older adults were asked about how they would decide what communication method would be best suited for a particular communication goal such as sharing good news or making an appointment. The goal was to investigate perceived context-related benefits of communication technologies by older adults. Internet users and non-users were questioned about their preferences to use the telephone, a face-to-face visit, a letter, or the Internet. Of particular interest was the reasoning the participants used – why they selected a particular method of communication. The results revealed that older adults made their decisions primarily on the basis of the perceived benefits (or lack thereof) of the particular communication method afforded by the technology. These data are important as they indicate that the decision process seemed to rely mostly on whether the method suited their needs (i.e., was fast enough or personal enough or easy enough). Contrary to myths about older adults' use of technology, their decisions were not primarily based on negatives such as whether the method was too difficult or too costly or too time-intensive. These data support the notion that technology will be adopted by older individuals when the benefits of the technology are clear to them and meet their needs. Older adults seem willing to invest the time, resources, and money necessary to learn new technologies, if such benefits are clear. An implication of these results may be that introduction of new technology should involve making conscious the specific benefits, from the user's perspective.

We specifically assessed older adults' attitudes to advanced home technologies in a structured interview study to assess utility, privacy concerns, and the social acceptability of these systems (Melenhorst *et al.* 2004, in press; Mynatt *et al.* 2004). Issues of technology acceptance were examined in detail. The questions addressed both the participants' opinions about specific technological devices and the general concept of a technology-rich environment. The analyses of the qualitative data indicated a conditional acceptance of technology in the home by older adults. The perception of technology benefit or technology need seems to be an important incentive for older adults to overcome barriers such as expenses, lack of skills, and unfamiliarity. This study provides insight into preconditions of acceptance related to features of the technology. Insight into context- and person-related preconditions regarding technology use is necessary for a successful implementation of technology in the home, and for the development of supportive living environments.

Summary

There is no such thing as "the older adult." Older adults are a heterogeneous group with diverse needs, capabilities, and experiences (Lawton 1990). Cognitive aging theories (see Craik & Salthouse 2000 for a review) provide a general overview of typical, age-related changes in sensation, perception, and cognitive functioning. However, it is applied cognitive psychology that will lead to the scientific developments to provide support for older adults. But the problem domain is complex – there are many factors that must be considered when designing studies to test various hypotheses. It is critical that applied cognitive psychologists be prepared to employ numerous qualitative research approaches as well as the experimental and quasi-experimental approaches that are so well taught in the typical cognitive psychology graduate program of study.

When older people are asked about their hopes and aspirations, they often mention remaining independent and being able to take care of themselves. A serious fear among older adults is becoming dependent on others and losing their dignity (Lawton 1990). Current technology has the power to aid in the reduction of such fears by facilitating activities required for successful aging. Such technology can aid performance and leave intact, and indeed even enhance, a person's dignity. Unfortunately, investigation of the science and engineering of such advanced technology has been lacking from the perspective of the *human* in the human–machine system. The development of such technology is currently under-informed by the needs, capabilities, concerns, desires, and goals of older adults. Moreover, the factors that affect acceptance of such technologies are only beginning to be understood.

CONCLUSIONS

Applied cognitive psychology has a great deal of potential to enhance understanding of human behavior and improve lives. In fact, such efforts have already improved system design, education, job training, and health care – examples abound throughout this book (see also Durso *et al.* 1999; Vicente 2004).

Naturally, however, there is more to be learned. The fruits of applied psychological science may only provide a solution space, rather than the specific solution for a given problem. Such research is grounded in a problem space, but it is by no means atheoretical. Applied researchers must understand the relevance of theory and the importance of testing theory. It is important to emphasize that applied cognitive psychology is *not* simply applying the findings of so-called basic research.

Why haven't we solved all the problems yet? Because the problems are difficult! In addition, we probably have not even yet identified all of the problems that need to be solved. We have tried to illustrate the complexity of research problems in the domain of aging-in-place. Even though there have been decades of research on cognitive aging and many books have been written on the topic, it is not clear how to support the cognitive needs of older adults to enable them to maintain their functional independence.

There is nothing as practical as a good theory – this phrase was attributed to Lewin (Marrow 1969) and the concept is frequently debated (e.g., Eysenck 1987; Sandelands 1990). In our view, a theory may be practically relevant, but the theory had better be developed to accommodate the scale of complexity that surrounds many everyday activities. The success of applied cognitive psychology will be in the development of theories and principles that describe behavior, wherever that behavior occurs, be it in the workplace, the cockpit, the driver's seat, or the home.

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REFERENCES

Anderson, N. D. & Craik, F. I. M. (2000). Memory in the aging brain. In E. Tulving & F. I. M. Craik (eds.), *The Oxford Handbook of Memory* (pp. 411–425). Oxford: Oxford University Press.

Babbie, E. (1990). *Survey Research Methods* (2nd edn). Belmont, CA: Wadsworth.

Baddeley, A. (1998). *Human Memory: Theory and Practice* (2nd edn). Boston: Allyn and Bacon.

Balota, D. A., Dolan, P. O. & Duchek, J. M. (2000). Memory changes in healthy older adults. In E. Tulving & F. I. M. Craik (eds.), *The Oxford Handbook of Memory* (pp. 395–409). Oxford: Oxford University Press.

Baltes, M. M., Maas, I., Wilms, H.-U. *et al.* (1999). Everyday competence in old and very old age: theoretical considerations and empirical findings. In P. B. Baltes & K. U. Mayer (eds.), *The Berlin Aging Study: Aging from 70 to 100* (pp. 384–402). Cambridge: Cambridge University Press.

Battig, W. F. & Montague, W. E. (1969). Category norms for verbal items in 56 categories: a replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monograph*, *80*, 1–46.

Beith, B. H. (2001). Needs and requirements in health care for the older adult: Challenges and opportunities for the new millennium. In W. A. Rogers & A. D. Fisk (eds.), *Human Factors Interventions for the Health Care of Older Adults* (pp. 13–30). Mahwah, NJ: Lawrence Erlbaum Associates.

Broadbent, D. E. (1973). *In Defence of Empirical Psychology*. London: Methuen.

Brunswik, E. (1952). *The Conceptual Framework of Psychology*. Chicago: University of Chicago Press.

Brunswik, E. (1956). *Perception and the Representative Design of Psychological Experiments* (2nd edn). Chicago: University of Chicago Press.

Charness, N., Holley, P., Feddon, J. & Jastrzembski, T. (2004). Light pen use and practice minimize age and hand performance differences in pointing tasks. *Human Factors*, *46*, 373–384.

Cook, T. D. & Campbell, D. T. (1979). Quasi-experimentation: Design and Analysis for Field Settings. Chicago: Rand-McNally College Publishing.

Cooke, N. J. (1999). Knowledge elicitation. In F. T. Durso, R. S. Nickerson, R. W. Schvaneveldt, S. T. Dumais, D. S. Lindsay & M. T. H. Chi (eds.), *Handbook of Applied Cognition* (pp. 479–509). Chichester: John Wiley & Sons.

Craik, F. I. M. & Salthouse, T. A. (2000). *The Handbook of Aging and Cognition* (2nd edn). Mahwah, NJ: Lawrence Erlbaum Associates.

CTIA (2004). *Semi-annual Wireless Industry Survey* [electronic version]. Retrieved February 24, 2005, Available at: http://www.ctia.org/research_statistics/index.cfm/AID/10030.

Denzin, N. K. & Lincoln, Y. S. (1998). *Strategies of Qualitative Inquiry*. Thousand Oaks, CA: Sage.

Durso, F. T. & Manning, C. A. (2002). Spinning paper into glass: transforming flight progress strips. *Human Factors and Aerospace Safety*, *2*, 1–31.

Durso, F. T., Nickerson, R. S., Schvaneveldt, R. W. *et al.* (1999). *Handbook of Applied Cognition*. Chichester: John Wiley & Sons.

Eysenck, H. J. (1987). There is nothing more practical than a good theory. In W. J. Baker & M. E. Hyland (eds.), *Current Issues in Theoretical Psychology* (pp. 49–64). Oxford: North-Holland.

Fisher, D. L., Laurie, N. E., Glaser, R. *et al.* (2002). Use of a fixed-base driving simulator to evaluate the effects of experience and PC-based risk awareness training on drivers' decisions. *Human Factors*, *44*, 287–302.

Fisk, A. D. & Eggemeier, F. T. (1988). Application of automatic/controlled processing theory to training tactical and command control skills: 1. Background and task analytic methodology. *Proceedings of the Human Factors Society 32nd Annual Meeting*. Santa Monica, CA: Human Factors Society.

Fisk, A. D. & Kirlik, A. (1996). Practical relevance and age-related research: can theory advance without practice? In W. A. Rogers, A. D. Fisk & N. Walker (eds.) *Aging and Skilled Performance: Advances in Theory and Application* (pp. 1–15). Mahwah, NJ: Lawrence Erlbaum Associates.

Fisk, A. D., Rogers, W. A., Czaja, S. J. *et al.* (2004). *Designing for Older Users: Principles and Creative Human Factors Approaches*. Boca Raton, FL: CRC Press.

Fisk, A. D. & Schneider, W. (1983). Category and word search: generalizing search principles to complex processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *9*, 177–195.

Gillan, D. J. & Schvaneveldt, R. W. (1999). Applying cognitive psychology: bridging the gulf between basic research and cognitive artifacts. In F. T. Durso, R. S. Nickerson, R. W. Schvaneveldt, S. T. Dumais, D. S. Lindsay & M. T. H. Chi (eds.), *Handbook of Applied Cognition* (pp. 3–31). Chichester: John Wiley & Sons.

Halpern, D. F. (1984). Age differences in response time to verbal and symbolic traffic signs. *Experimental Aging Research*, *10*, 201–204.

Hammond, K. R. (1998). Representative design [electronic version]. Retrieved February 27, 2005, Available at: http://www.albany.edu/cpr/brunswik/notes/essay3.html.

Hammond, K. R. & Stewart, T. R. (2001). *The Essential Brunswik: Beginnings, Explications, Applications*. New York: Oxford University Press.

Hancock, H. E., Rogers, W. A. & Fisk, A. D. (2001). An evaluation of warning habits and beliefs across the adult lifespan. *Human Factors*, *43*, 343–354.

Hancock, H. E., Rogers, W. A., Schroeder, D. & Fisk, A. D. (2004). Safety symbol comprehension: Effects of symbol type, familiarity, and age. *Human Factors*, *46*, 183–195.

Hoffman, R. R. & Deffenbacher, K. A. (1992). A brief history of applied cognitive psychology. *Applied Cognitive Psychology, 6*, 1–48.

Hoffman, R. R. & Deffenbacher, K. A. (1993). An analysis of the relations between basic and applied psychology. *Ecological Psychology*, *5*, 315–352.

Hoffman, R. R. & Deffenbacher, K. A. (1994). Alternate schemes for the analysis of basic versus applied science: beauty is still in the eye of the beholder. *Ecological Psychology*, *6*, 125–130.

Hoffman, R. R., Shadbolt, N. R., Burton, A. M. & Klein, G. (1995). Eliciting knowledge from experts: a methodological analysis. *Organizational Behavior and Human Decision Processes*, *62*, 129–158.

Insurance Institute for Highway Safety (1988). Sixteen-year-old drivers' death rates rising at alarming rate. *Status Report*, *33*, 1–2.

Katz, S. (1983). Assessing self-maintenance: activities of daily living, mobility, and instrumental activities of daily living. *Journal of the American Geriatric Society*, *31*, 721–727.

Ketcham, C. J. & Stelmach, G. E. (2004). Movement control in the older adult. In R. W. Pew & S. B. Van Hemel (eds.), *Technology for Adaptive Aging* (pp. 64–92). Washington, DC: The National Academies Press.

Kirlik, A. (1995). Requirements for psychological models to support design: Toward ecological task analysis. In J. M. Flach & P. A. Hancock (eds.), *Global Perspectives on the Ecology of Human–Machine Systems* (pp. 68–120). Hillsdale, NJ: Lawrence Erlbaum Associates.

Kirlik, A., Fisk, A. D., Walker, N. & Rothrock, L. (1998). Feedback augmentation and part-task practice in training dynamic decision making skills. In J. A. Cannon-Bowers & E. Salas (eds.), *Making Decisions under Stress: Implications for Individual and Team Training* (pp. 91–113). Washington, DC: American Psychological Association.

Kirlik, A., Walker, N., Fisk, A.D. & Nagel, K. (1996). Supporting perception in the service of dynamic decision making. *Human Factors*, *38*, 288–299.

Klein, G. A. (1998). *Sources of Power: How People Make Decisions*. Cambridge, MA: MIT Press.

Kline, D. & Scialfa, C. T. (1997). Sensory and perceptual functioning: basic research and human factors implications. In A. D. Fisk & W. A. Rogers (eds.), *Handbook of Human Factors and the Older Adult* (pp. 27–54). San Diego, CA: Academic Press.

Kroemer, K. H. E. (2006) *"Extra-ordinary" Ergonomics: How to Accommodate Small and Big Persons, the Disabled, and Elderly, Expectant Mothers, and Children*. Boca Raton, FL: CRC Press and HFES.

Kroemer, K. H. E., Kroemer, H. B. & Kroemer-Elbert, K. E. (2001). *Ergonomics: How to Design for Ease and Efficiency*. Upper Saddle River, NJ: Prentice-Hall.

Landauer, T. K. (1989). Some bad and some good reasons for studying memory and cognition in the wild. In L. W. Poon, D. C. Rubin & B. A. Wilson (eds.), *Everyday Cognition in Adulthood and Late Life* (pp. 116–125). Cambridge: Cambridge University Press.

Lawton, M. P. (1990). Aging and performance on home tasks. *Human Factors*, *32*, 527–536.

Luczak, H. (1997). Task analysis. In G. Salvendy (ed.), *Handbook of Human Factors and Ergonomics* (2nd edn, pp. 340–416). New York: John Wiley & Sons.

McCarley, J. S., Kramer, A. F., Wickens, C. D. *et al*. (2004). Visual skills in airport-security screening. *Psychological Science*, *15*, 302–306.

McLaughlin, A. C., Rogers, W. A. & Fisk, A. D. (2003). Effects of attentional demand on input device use in younger and older adults. In *Proceedings of the Human Factors and Ergonomics Society 47th Annual Meeting* (pp. 247–251). Santa Monica, CA: Human Factors and Ergonomics Society.

Marrow, A. J. (1977). *The Practical Theorist: The Life and Work of Kurt Lewin*. New York: Teachers College Press.

Maylor, E. A. (1996). Does prospective memory decline with age? In M. Brandimonte, G. O. Einstein & M. A. McDaniel (eds.), *Prospective Memory: Theory and Applications* (pp. 173–197). Mahwah, NJ: Lawrence Erlbaum Associates.

Melenhorst, A. S., Fisk, A. D., Mynatt, E. D. & Rogers, W. A. (2004). Potential intrusiveness of aware home technology: perceptions of older adults. In *Proceedings of the Human Factors and Ergonomics Society 48th Annual Meeting* (pp. 266–270). Santa Monica, CA: Human Factors and Ergonomics Society.

Melenhorst, A. S., Rogers, W. A. & Bouwhuis, D. G. (2006). Older adults' motivated choice for technological innovation: evidence for benefit-driven selectivity. *Psychology and Aging*, *21*, 190–195.

Melenhorst, A. S., Rogers, W. A. & Fisk, A. D. (in press). When will technology in the home improve older adults' quality of life? In H. W. Wahl, C. Tesch-Römer & A. Hoff (eds.), *New Dynamics in Old Age: Individual, Environmental, and Societal Perspectives*. Amityville, NY: Baywood Publishing.

Moroney, W. F. & Cameron, J. A. (2004). The Design of Questionnaires and Surveys. Unpublished manuscript, University of Dayton.

Moss, M. S. & Lawton, M. P. (1982). Time budgets of older people: a window on four lifestyles. *Journal of Gerontology*, *37*(1), 115–123.

Mynatt, E. D., Igarashi, T., Edward, W. K. & LaMarca, A. (1999). Flatland: new dimensions in office whiteboards. In *Proceedings of the 1999 ACM Conference on Human Factors in Computing Systems* (pp. 346–353). Pittsburgh, PA: CHI 99.

Mynatt, E. D., Melenhorst, A. S., Fisk, A. D. & Rogers, W. A. (2004). Aware technologies for aging in place: Understanding user needs and attitudes. *IEEE Pervasive Computing*, *3*, 36–41.

National Electrical Manufacturers Association (1998). *American National Standard for Criteria for Safety Symbols* (ANSI Z535.5). Washington, DC: National Electrical Manufacturers Association.

Nichols, T. A., Stronge, A. J., Fisk, A. D. *et al*. (2004). Human factors and ergonomics: bridging psychology and technology in telemedicine applications. *International Journal of Healthcare Technology and Management*, *6*, 3–19.

Parasuraman, R. (1998). The attentive brain: issues and prospects. In R. Parasuraman (ed.), *The Attentive Brain* (pp. 3–15). Cambridge, MA: MIT Press.

Parasuraman, R. & Davies, D. R. (1984). *Varieties of Attention*. San Diego, CA: Academic Press.

Parasuraman, R., Mouloua, M. & Malloy, R. (1996). Effects of adaptive task allocation on monitoring of automated systems. *Human Factors*, *38*, 665–679.

Park, D. C. & Schwarz, N. (2000). *Cognitive Aging: A Primer*. New York: Psychology Press.

Parsons, H. M. (1999). A history of division 21 (applied experimental and engineering psychology). In D. A. Dewsbury (ed.), *Unification through Division: Histories of the Divisions of the American Psychological Association* (Vol. 3, pp. 43–72). Washington, DC: American Psychological Association.

Petrinovich, L. (1989). Representative design and the quality of generalization. In L. W. Poon, D. C. Rubin & B. A. Wilson (eds.), *Everyday Cognition in Adulthood and Late Life* (pp. 11–24). Cambridge: Cambridge University Press.

Posner, M. I. & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*, 25–42.

Rasmussen, J. (1986). *Information Processing and Human–Machine Interaction: An Approach to Cognitive Engineering*. New York: North-Holland.

Rogers, E. M. (2003). *Diffusion of Innovations* (5th edn). New York: Free Press.

Rogers, W. A. (2000). Attention and aging. In D. C. Park & N. Schwarz (eds.), *Cognitive Aging: A Primer*. Philadelphia, PA: Psychology Press.

Rogers, W. A., Campbell, R. H. & Pak, R. (2001). A systems approach for training older adults to use technology. In N. Charness, D. C. Park & B. A. Sabel (eds.), *Communication, Technology, and Aging: Opportunities and Challenges for the Future* (pp. 187–208). New York: Springer.

Rogers, W. A. & Fisk, A. D. (2001). Understanding the role of attention in cognitive aging research. In J. E. Birren & K. W. Schaie (eds.), *Handbook of the Psychology of Aging* (5th edn, pp. 267–287). San Diego, CA: Academic Press.

Rogers, W. A., Fisk, A. D., McLaughlin, A.C. & Pak, R. (2005). Touch a screen or turn a knob: choosing the best device for the job. *Human Factors*, *47,* 271–288.

Rogers, W. A., Meyer, B., Walker, N. & Fisk, A. D. (1998). Functional limitations to daily living tasks in the aged: a focus group analysis. *Human Factors*, *40*, 111–125.

Rogers, W. A., Mykityshyn, A. L., Campbell, R. H. & Fisk, A. D. (2001). Analysis of a "simple" medical device. *Ergonomics in Design*, *9*, 6–14.

Sanchez, J., Bowles, C. T., Rogers, W. A. & Fisk, A. D. (in press). Human factors goes to the golf course: knowledge engineering of a "simple" mowing task. *Ergonomics in Design*.

Sandelands, L. E. (1990). What is so practical about theory? Lewin revisited. *Journal for the Theory of Social Behavior*, *20*, 235–262.

Schieber, F. (2003). Human factors and aging: identifying and compensating for age-related deficits in sensory and cognitive function. In N. Charness & K. W. Schaie (eds.), *Impact of Technology on Successful Aging* (pp. 42–84). New York: Springer Publishing Company.

Schneider, W. & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search and attention. *Psychological Review*, *84*, 1–66.

Schvaneveldt, R. W. (2005). Finding meaning in psychology. In A. F. Healy (ed.), *Experimental Cognitive Psychology and Its Application* (pp. 211–224). Washington, DC: American Psychological Association.

Sixsmith, A. & Sixsmith, J. (2000). Smart care technologies: meeting whose needs? *Journal of Telemedicine and Telecare*, *6*, 190–192.

Stokes, D. E. (1997). *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington, DC: Brookings Institute Press.

Strayer, D. L. & Drews, F. A. (2004). Profiles in driver distraction: effects of cell phone conversations on younger and older drivers. *Human Factors*, *46*, 640–649.

Strayer, D. L. & Johnston, W. A. (2001). Driven to distraction: dual-task studies of simulated driving and conversing on a cellular telephone. *Psychological Science*, *12*, 462–466.

Taylor, H. L. (1994). *Who Made Distinguished Contributions to Engineering Psychology*? Washington, DC: American Psychological Association.

Thorndike, E. L. (1919). Scientific personnel work in the army. *Science*, *49*, 53–61.

US Census Bureau (2000). Retrieved October 30, 2004, Available at: www.census.gov/population/www/projections/natproj.html.

Vercruyssen, M. (1996). Movement control and the speed of behavior. In A. D. Fisk & W. A. Rogers (eds.), *Handbook of Human Factors and the Older Adult* (pp. 55–86). San Diego, CA: Academic Press.

Verhaeghen, P., Geraerts, N. & Marcoen, A. (2000). Memory complaints, coping, and well-being in old age: a systemic approach. *The Gerontologist, 40*, 540–548.

Vicente, K. (1994). A pragmatic conception of basic and applied research: commentary on Hoffman and Deffenbacher (1993). *Ecological Psychology*, *6*, 65–81.

Vicente, K. (2004). *The Human Factor: Revolutionizing the Way People Live with Technology*. New York: Routledge.

Walker, N., Fain, W. B., Fisk, A. D. & McGuire, C. L. (1997). Aging and decision making: driving related problem solving. *Human Factors*, *39*, 438–444.
Walker, N. & Fisk, A. D. (1995). Human factors goes to the gridiron: developing a quarterback training system. *Ergonomics in Design*, *3*, 8–13.
Willis, S. L. (1996). Everyday cognitive competence in elderly persons: conceptual issues and empirical findings. *The Gerontologist*, *36*, 595–601.
Willis, S. L., Allen-Burge, R., Dolan, M. M. *et al*. (1998). Everyday problem solving among individuals with Alzheimer's disease. *The Gerontologist*, *38*, 569–577.
Willis, S. L., Dolan, M. M. & Bertrand, R. M. (1999). Problem solving on health-related tasks of daily living. In D. C. Park, R. W. Morrell & K. Shifren (eds.), *Processing of Medical Information in Aging Patients: Cognitive and Human Factors Perspectives* (pp. 199–219). Mahwah, NJ: Lawrence Erlbaum Associates.
Zacks, R. T., Hasher, L. & Li, K. Z. H. (2000). Human memory. In F. I. M. Craik & T. A. Salthouse (eds.), *The Handbook of Aging and Cognition* (2nd edn, pp. 293–357). Mahwah, NJ: Lawrence Erlbaum Associates.