Cognitive Psychology:
Applications and Careers

Kathy Pezdek
Claremont Graduate University

Kenneth A. Deffenbacher
University of Nebraska at Omaha

Shirley Lam
Claremont Graduate University

Robert R. Hoffman
Institute for Human and Machine Cognition

Psychological research is often conceptualized as being either basic research or applied research. Basic psychological research, usually laboratory based, is conducted to gain a scientific understanding of human behavior, often primarily for the purpose of advancing relevant theories. Applied psychological research is conducted for some additional reasons: to gain a scientific understanding of human behaviors that occur in work and everyday life, or to solve practical problems encountered in daily pursuits. In this chapter, historical and current trends in cognitive psychology research are presented to demonstrate the rich tradition of applied research in this specific field of psychological research.

Cognitive psychology is the study of human intelligence and how it works. This includes the study of thinking, reasoning, problem solving, decision making, memory, language, perception, and attention. Cognitive psychology research is well known for its strong theoretical base. Whether inductively (theory is derived from data) or deductively (the theory comes first and the empirical test follows), cognitive psychology research is strongly linked to theory. However, it is an oversimplification to categorize cognitive psychology as basic research, from which few applications have
been derived. Furthermore, it is a fact that many cognitive psychologists work in industry, educational settings, and the private sector (e.g., human factors consulting firms). From psychology’s early days to the present, there has been an interest in applications. The first President of the American Psychological Association (APA), G. Stanley Hall, conducted applied research, especially on topics in human development. Few realize that he was also the founder of the APA journal, *Journal of Applied Psychology* in 1917. The rich history of research in applied cognitive psychology is reviewed in more detail by Hoffman and Deffenbacher (1992).

The primary purpose of this chapter is to dispel the myth that cognitive psychology research is primarily basic research that has little applicability to real-world problems. This chapter briefly focuses on five domains of applied cognitive psychology. Each of these is a domain in which there is a rich history of research and in which a significant number of cognitive psychologists are currently employed outside of academia. The domains to be discussed are forensic psychology, marketing and advertising, education, the military, and human factors. Within each domain, a brief history of cognitive psychology research on this topic is discussed, some of the current work on this topic is presented, and examples of careers in this field are provided.

**FORENSIC APPLICATIONS OF COGNITIVE PSYCHOLOGY**

There are numerous forensic applications of cognitive psychology. In this chapter we focus on two of these, eyewitness identification and deception detection.

**Eyewitness Identification**

One of the most prominent psychologists prior to World War I was Hugo Munsterberg. Munsterberg received a PhD in physiology under Wilhelm Wundt, the founder of psychology as a science, and then obtained an M.D. degree. William James recruited Munsterberg to Harvard where in 1908, they established the Division of Applied Psychology. There he was engaged in research in many areas of applied psychology including advertising, film criticism, and legal psychology. Today, Munsterberg is especially well remembered for his work on psychology and law. In his book, *On the Witness Stand* (Munsterberg, 1908), he presented research demonstrating the unreliability of eyewitness perception and memory and argued that scientific psychology had much to offer the legal community.

Attorneys and legal scholars were outraged with Munsterberg’s suggestion that legal decisions should in any way be influenced by psychological research. Moore (1907), for example wrote, “Among the legal profession it is familiar learning that experiments are valuable only when the conditions are fairly identical with those attending the occurrence under investigation…. Imagine him (Munsterberg) butting in with his so-called scientific experiments to appraise the testimony of a witness” (p. 127). There was a deep-rooted tension between legal procedures and scientific methods, and attorneys and judges were not keen on changing their procedures. In fact, the records of American courts indicate that psychological research was not cited, nor did psychologists provide expert witness testimony, until the 1950s (Loh, 1981), and even then it was on topics of mental disorders, pretrial publicity, and civil rights, not on the veracity of eyewitness memory.

Today, the legal community has a somewhat more favorable view of psychological research in general, and specifically, of research on eyewitness memory. There are several reasons for this change. First, it is now clear that the information on eyewitness memory provided in expert testimony has “general acceptance” among psychologists (Kassin, Tubb, Hoach, & Memon, 2001). The consensus within the field of psychology regarding the standards of scientific proof has aided in the acceptance of this research in legal contexts. Second, it is now well established that errors in eyewitness identification are responsible for more cases of wrongful conviction than all other causes combined (Wells et al., 2000). Third, although police and the judicial system have no control over the personal and situation-specific factors connected to a crime, they can control the manner in which eyewitness memory is tested, whether by interview or lineup. Researchers have determined that some methods of assessing witness memory are likely to promote incomplete or inaccurate recall or false identifications of innocent suspects (Wells et al., 2000). The quality and quantity of their research has been such that the U.S. Department of Justice has issued a set of national guidelines for the collection of eyewitness evidence in criminal cases (Technical Working Group for Eyewitness Evidence, 1999). Applied cognitive psychology research provided the scientific basis for the content of these guidelines, and some of the researchers actually participated in writing them.

Finally, sufficient reliable evidence has accumulated in the past 30 years that we now have a much clearer understanding of how the personal and situation-specific variables operate on memory with respect to crime (Cutler & Penrod, 1995). These variables include the duration of time the witness had

\[1\] According to the Frye test, scientific evidence can be presented in court by an expert witness only if it is "sufficiently established to have gained general acceptance in the particular field in which it belongs" (*Frye v. United States*, 1923, p. 1014).
to view the perpetrator, the amount of time between the occurrence of the crime and the testing of the witnesses' memory, the level of stress experienced by the witness during the encoding of his or her memories of the crime, and whether the witness and perpetrator were of different races.

As a consequence of the explosion of eyewitness memory research, it has become common for eyewitness memory researchers to testify as expert witnesses. In fact, in the frequently cited decision of People v. McDonald, 1984, the Court wrote,

> When an eyewitness identification of the defendant is a key element of the prosecution's case but is not substantially corroborated by evidence giving it independent reliability, and the defendant offers qualified expert testimony on specific psychological factors shown by the record that could have affected the accuracy of the identification but are not likely to be fully known to or understood by the jury, it will ordinarily be error to exclude that testimony. (p. 254)

An expert witness is an individual with special knowledge or expertise who can assist jurors in evaluating the facts of a case. Expert witnesses are usually retained by one side—either the defense or the prosecution. Most cognitive psychologists who testify as eyewitness expert witnesses do so as consultants, as have the first two authors of this chapter; they have an academic position and qualify as expert witnesses based on their publication record. Eyewitness experts are permitted to testify about general factors that are known to affect the accuracy of eyewitness evidence; they are not ordinarily permitted to testify about the facts in the specific case in which they are testifying, or the memory ability of specific eyewitnesses. This is to prevent the expert witness from "invading the province of the jury," a legal cliché that refers to taking over the role of the jury in determining the outcome of any trial.

**Detecting Deception**

Throughout history people have sought effective ways to detect deception. During the Middle Ages, Germans used excruciating torture techniques to elicit confessions from the accused, but then, ironically, had priests and clerics witness the confessions to determine if they were true confessions or not. False confessions were punishable by death; true confessions were not. The success of these early deception detection techniques will never be known. The scientific quest for behavioral indicators of deceit has become more rigorous in the past few decades (see DePaulo et al., 2003, for a review of this work). This may be due in part to an upsurge of highly publicized cases involving inaccurate assessment of truth and deception. For example, in the Central Park jogger case, five young men (aged 14–16) confessed to assaulting and raping a jogger. According to Kassin (2002), who reviewed videotaped confessions, the young men appeared truthful and their narratives were particularly compelling because they were detailed and seemingly the product of personal experience. The young men were convicted and sent to prison based on this confession evidence alone. Thirteen years later, someone else confessed to the crime. DNA evidence subsequently proved the young men innocent; they had been coerced into falsely confessing by police investigators' leading techniques. (See Kassin, 1997, for a discussion of the psychology research on false confessions.) Are there cues that effectively differentiate between descriptions of true and false events—even self-incriminating confessions?

Deception detection is a “hot topic” in applied cognitive psychology now because although there exist three classes of forensic techniques for detecting deception, the empirical support for each of these is mixed. There is clearly room here for additional research and the development of more valid forensic techniques for detecting deception.

The first forensic tool for detecting deception is the polygraph. The assumption underlying the use of the polygraph is that compared to truth-tellers, liars will show differential patterns of specific physiological reactions. However, a number of researchers have questioned the scientific support for the correlation between deception and physiological reactions (Iacono, 2001; Lykken, 1998). According to these critics, physiological reactions shown in a polygraph test can also be the result of an innocent person's anxiety about being the subject of an investigation. A blue ribbon panel appointed by the National Research Council recently reviewed the scientific evidence on the polygraph and concluded that the polygraph is not a valid technique for detecting deception (CRSEP, 2002).

The second forensic tool for detecting deception involves observing people's nonverbal behaviors—gestures, eye contact, smiling, facial musculature movement, and blinking—while they describe events. It has been proposed that whereas verbal behavior is not automatically processed, nonverbal behavior is automatically processed. As such, nonverbal behaviors associated with lying should be more difficult to mediate cognitively, and thus should be more revealing of deception. In two recent reviews of the psychological research on detecting deception, DePaulo et al. (2003) and Vrij (2000) reported that a number of nonverbal behaviors can be effective in detecting deception. However, there is a great deal of inconsistency in findings among these studies, and it appears, for example, that many nonverbal behaviors may be effective in identifying lies only when the lies are more difficult to tell.

In the 1990s the Supreme Court of Germany ruled that credibility assessment must be conducted in all contested cases of child sexual abuse and expert testimony on the findings must be provided to the court (Undeutsch,
1989). This served as a serious call to action for forensic psychologists. The third deception detection approach, the Criterion-Based Content Analysis (CBCA), followed from this call. The CBCA, was developed in Germany in the 1950s by Udo Undeutsch (see Undeutsch, 1989). It is an important deception detection technique because it is reported to be the most widely used veracity assessment technique worldwide (Vrij, Akersheurt, Soukara, & Bull, 2002). The main assumption of this approach is that narratives of deceptive accounts differ qualitatively from those of truth-tellers; they will include, for example, more details, more superficial details, and more contextual embedding. Although empirical tests of the validity of this content analysis technique have not been impressive (Lamb et al., 1997; Pezdek et al., 2004; Vrij, 2005), some of the features in this technique have proven to be effective discriminating between true and deliberately fabricated accounts. Of interest for cognitive psychologists is that fact that the most discriminating features are those that tap memory processes and cognitive characteristics that have also been effective in discriminating between real versus imagined event memories (Johnson, Foley, Suengas, & Raye, 1988).

Detecting deception is a practical real-world problem. Clearly there is a need to develop tools to detect deception more effectively, and cognitive psychologists are ideally suited for this task. Whether those who work on deception detection are employed by police departments, government agencies such as the FBI, or universities, cognitive psychology research will eventually make a significant contribution to solving this practical problem.

COGNITIVE PSYCHOLOGY APPLIED TO MARKETING AND ADVERTISING

Since the early 1900s, psychologists have successfully promoted the applicability of their research to business consumers. The psychology of advertising can be traced to the turn of the century, when H. S. Gale lectured at the University of Minnesota and demonstrated principles of perception and attention using advertisements (Gale, 1900). Around that same time, Walter Dill Scott took up the psychology of advertising while at Northwestern University. The field of advertising was experiencing a period of rapid growth and an increasing number of advertisers came to believe that psychology could help them influence people's thoughts and behaviors. In 1901, Scott was asked by an advertising executive to present some lectures to business groups on advertising and public speaking. These talks were published in advertising magazines as well as in a series of six articles in Psychological Bulletin published between 1911 and 1916, and in his two early books (Scott, 1903, 1907). Later, Scott (1910) broadened his area of study and published a more general book on the psychology of business.

Munsterberg's applied interests also included the psychology of advertising. In his book Business Psychology, Munsterberg bridged a gap between psychological science and the business world, explaining that "really to understand mental conditions in business means to understand the structure and function of the mind" (Munsterberg, 1917, p. 25). He addressed topics such as the "prevailing prejudice against applied psychology," and also discussed theories of perception, memory and attention and their application to business.7

Since the early 20th century, many market researchers and advertisers have embraced the methods, concepts, and theories from cognitive psychology. The fields of marketing and advertising—really interdisciplinary fields—have benefited a great deal from the inclusion of cognitive psychology research. The application of cognitive psychology to survey methodology is just one area that has strongly influenced market research. A prime example is Sudman, Bradburn, and Schwarz's book, Thinking About Answers: The Application of Cognitive Process to Survey Methodology (1996), which provides guidelines for producing better survey instruments by understanding the factors that influence respondents' answers.

Through the application of cognitive research, market researchers have developed procedures for how to conceptualize, design, and implement surveys that increase the ease with which respondents answer questions. Survey designers need to take into account such factors as the order of questions, context effects, and the specificity of a question. For example, instead of asking demographic information (e.g., age, ethnicity, and income) at the beginning of a survey, it may serve well to ask these personal questions later on, after the respondent feels invested and is more likely to complete the survey and less likely to leave questions blank. The field of marketing has adapted tools and techniques from cognitive psychology in other areas as well, such as in the development of interviewing methods (Bradburn & Sudman, 1979), questionnaire design (Schuman & Presser, 1981), and protocol analysis (Ericsson & Simon, 1993).

The study of consumers' unconscious processes has been a hot topic in marketing and advertising research. Although consumers engage in decisive, conscious processing of information in advertisements, unconscious information processing occurs as well. The research on unconscious processing is grounded in the empirical literature on implicit learning and memory (Krishnan & Trappey, 1999). Researchers in this area assess how consumer behavior is affected by the information that is processed without awareness (Bargh, 2002).

With the publication of Vance Packard's (1957) best selling book, The Hidden Persuaders, Americans became intrigued with the notion that they were

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7For a complete review of psychology of marketing and advertising leading up to the 1940s, see Pollenberger (1942).
pervasively being influenced by subliminal stimuli. A conspiracy theory even emerged that movie theaters were using subliminal messages presented on the screen as an advertising ploy to drive up profits at concession stands. Later, self-help tapes were sold with the promise that you could stop a bad habit just by listening to a tape while you slept. However, cognitive researchers have debunked this urban legend of subliminal brainwashing. Studies experimenting with display times, auditory messages, and nonsense versus "real" subliminal messages revealed that subliminal perceptual effects were minimal, if present at all (Moore, 1982).

There are many examples of cognitive psychologists who have conducted basic research and are now turning their attention to applied problems in marketing and advertising. For example, Richard Harris, a leader in the area of basic psycholinguistic research on memory and comprehension of metaphor, has also conducted research on people's memory for advertising (Harris, Dubitsky, Perch, Ellerman, & Larson, 1980; Harris, Trusty, Bechtold, & Wasinger, 1989). This research assessed people's ability to remember whether statements from advertisements were merely implied or explicitly asserted. Results suggest that people generally do not remember whether an advertisement asserted a statement concerning a product's performance (e.g., Tylenol stops headaches) or merely implied this claim (e.g., Tylenol helps reduce headaches). Also, memory for advertisements may change over time, generally from remembering a weak implied claim to believing that the product will perform much better than was actually stated.

It has also been useful for cognitive psychologists to take an information-processing approach to considering how viewers process marketing and advertising information. For example, it is important to know how to attract and maintain viewers' attention, how much information viewers are able to process in a specific period of time, and how to communicate information so that it is likely to be remembered over time. According to James Bettman's information-processing model of consumer choice (Bettman, 1979), consumer choice results directly from a consumer's motivations, information acquisition, and processing capacity.

One application of the information-processing approach is found in research concerning consumers' processing of brand information. Richardson, Dick, and Jain (1994) examined consumer loyalty to national brands over store brands despite product similarity and higher prices for national brands. To evaluate brand loyalty, the researchers compared participants' responses to national brand and store brand products in terms of their extrinsic characteristics (e.g., price, packaging, brand name—attributes that are not physically a part of the product) and intrinsic characteristics (e.g., ingredients—attributes that are physically a part of the product). They reported that consumers chiefly processed extrinsic rather than intrinsic product information.

11. COGNITIVE PSYCHOLOGY

In addition to market and advertising research concentrating on increasing consumption, the principles of marketing and advertising have also been applied to promoting prosocial causes and marketing health and social programs. For example, researchers have examined how media can be used to favorably change society's attitudes toward gays and lesbians (Riggle, Ellis, & Crawford, 1996). It was reported that viewing videos depicting events surrounding a gay protagonist can have positive impact on participants' attitudes toward homosexuals in general. Similarly, Crano and his colleagues (cf. Dawson, Burgoon, & Crano, 2003) have implemented an effective media program to inform school-age children about AIDS prevention. Crano has also evaluated the effectiveness of the television advertisements used in the National Youth Anti-Drug Campaign launched by the 1998 White House Office of National Drug Control Policy. Many federal agencies, such as the National Institute on Drug Abuse (NIDA), the Food and Drug Administration (FDA) and the Centers for Disease Control and Prevention (CDC) employ cognitive psychologists as part of market research and advertising teams to promote a variety of programs. The media interventions described by Albert Bandura in chapter 3 in this volume are also relevant examples of how marketing and advertising research can be productively applied to improve the condition of people.

EDUCATIONAL APPLICATIONS OF COGNITIVE PSYCHOLOGY

Some of the earliest research in applied psychology involved educational applications. Ebbinghaus (1885), well known for his seminal memory experiments, was also interested in the development of intelligence and school psychology. Along these lines he conducted experiments on the memorization of poetry, then a common classroom task (Hoffman, Bringmann, Bamberger, & Klein, 1987).

It is interesting to note that the APA journal, Journal of Educational Psychology, was founded in 1916, one year prior to the founding of the Journal of Applied Psychology. In its first year, the Journal of Educational Psychology published a lively symposium on "Mentality Tests" (1916). The contrasting views of Alfred Binet and Robert M. Yerkes were published as part of this symposium. Alfred Binet and Theophile Simon (1905a, 1905b) worked for the French Ministry of Public Instruction and developed mental tests for school children. They introduced the concept of "mental age," the precursor of the construct, intelligence. C. Stanley Hall is well known as a founding figure in developmental psychology in North America. His book, Educational Problems (1911), provides a two-volume discussion of a wide range of educational topics to which he felt psychology could contribute.
Cognitive psychology naturally lends itself to numerous applications in education. Today, research on teaching mathematics and reading stand out as domains where cognitive psychology research has advanced educational practice. Many cognitive psychologists are working on these domains in both academic and applied settings.

Mathematics Instruction

Two facts have become clear to researchers and educators who study mathematics instruction in the United States. First, the basic level of mathematics achievement in this country has declined over recent decades. And second, mathematics achievement of Japanese and Chinese students far exceeds that of U.S. students. Harold Stevenson and James Stigler with their colleagues (Stevenson et al., 1985) administered mathematics tests to first and fifth graders in 120 classrooms in Taipei (Taiwan), Sendai (Japan), and the Minneapolis (U.S.) metropolitan areas. The tests required computation and problem-solving skill. They found that the highest-scoring classrooms in the United States obtained an average score lower that of the lowest-scoring Japanese classroom and all but one of the 20 classrooms in Taipei. These findings compelled Stevenson and Stigler (1982) to investigate the cultural differences and features of classroom instruction that might account for these trends. Their research teams systematically observed classrooms in each of these three countries. They identified classroom differences associated with cognitive processing advantages for the Asian students. These include, for example, the finding that Asian lessons are more coherent, they are more likely to be motivated by a practical problem, and lessons are oriented toward problem solving rather than rote learning.

Looking at mathematical achievement at the level of the individual, educators have increasingly realized that mathematics achievement can be remedied by understanding the cognitive processes underlying mathematical thinking. For example, Resnick (1984) demonstrated that novices who make mistakes do not do so at random. Every mathematical problem solver has a mental model for how to solve a specific type of problem, and they use this mental model in deriving a solution. A novice problem solver is likely to have an incorrect or imperfect mental model that they apply to solve a problem (Chi, Feltovich, & Glaser, 1981). By analyzing the types of mathematical errors made by students, one can understand the nature of the mental model they are utilizing, diagnose their cognitive processing errors, and then remediate their procedural solutions. Much of the cognitive research on mathematics is of this type. John Seely Brown and Richard Burton, working in the 1970s at Bolt Beranek and Newman, developed the earliest diagnostic models for debugging students' procedural errors in basic mathematics (Brown & Burton, 1978). In terms of considering sources of funding available for applied cognitive research, it is interesting to note that their research was funded both by the Army Research Institute and the Navy Personnel Research and Development Center.

Reading

Teaching and learning reading is another educational domain in which there has been a substantial contribution by cognitive psychologists. Reading is a paradox. For adults who read well, reading is an apparently effortless activity. However, for many children, learning to read is a difficult and very effortful process. Reading with an alphabetic writing system such as ours involves learning letter-to-sound and letter-to-meaning correspondences. And although an alphabetic writing system is economical, learning to read English is difficult because the phonemes in English can be represented in multiple ways; each vowel sound is not coded with a unique symbol. For example, the vowel sound in bat is about the same as that in laugh. In American English, there are more than a dozen vowel sounds but only five vowel letters (a, e, i, o, and u). Thus, each vowel letter can be pronounced multiple ways.

Learning to read involves cognitive, linguistic, and social skills that develop from early childhood. The most important of these is a child's language competence. Most of the language skills prerequisite to reading develop prior to preschool. For example, knowledge of grammar develops rapidly and the basic syntactic structures of language are learned by age 2 (Bloom, Barss, Nicol, & Conway, 1994).

Two approaches have been taken by cognitive psychologists researching the process of learning to read—stage theories and nonstage incremental theories. There are a number of stage theories of reading, each specifying sequential steps involved in learning to read (e.g., see Gough & Juel, 1991). Each stage theory of reading begins with a visual association stage, in which a child learns the association between the visual features of letter sequences and sounds. The last stage of reading involves associating strings of words to their sounds and meanings. Alternatively, recent incremental theories propose that reading involves many types of knowledge that are gradually acquired (see Perfetti, 1992). According to incremental reading theories, what appear to be stages or qualitative shifts in reading strategies result not from progressive stages, but from changes in the complexity and quantity of the information acquired.

There are important implications for teaching reading from the cognitive research on this topic. The major instructional methods that have traditionally been used to teach reading have been whole-word and phonics instruction. The cognitive research clearly suggests a disadvantage for the whole-word approach, and this has been confirmed by assessments of
reading instruction programs (Foorman, Francis, Fletcher, Schatschneider,
& Mehta, 1998). A more recent approach to teaching reading is called whole-
language instruction. The whole-language approach involves teaching lan-
guage meanings that focus on language experiences of the child. For exam-
ple, the child dictates short stories that are transcribed and is then taught
to read the stories. This approach has been adopted in numerous school
districts throughout the United States. Although whole-language instruction
helps to make reading fun and meaningful for children, the research clearly
suggests that children become more skilled independent readers if they are
also taught alphabetic and phonemic principles (Rayner, Foorman, Perfetti,
Pesetsky, & Seidenberg (2001).

Many cognitive psychologists work in educational settings. The most
common opportunity for such applied work is doing program evaluation re-
search for school districts. Most large school districts and all State Depart-
ments of Education employ researchers to do program and outcome evalua-
tions, for example, as educational research analysts for district initiatives
and to evaluate school reform programs for underperforming schools. Cog-
nitive psychologists are especially well trained for such positions. Cognitive
psychologists also work for companies such as Educational Testing Service
and other companies that produce educational materials. Finally, many
cognitive psychologists conduct research on educational issues in aca-
demic and applied research settings. This research is often funded by the
traditional funding sources such as the U.S. Department of Education, as
well as by the research divisions of the branches of the armed services.

APPLICATIONS OF COGNITIVE PSYCHOLOGY
TO THE MILITARY

The entry of the United States into World War I in 1917 prompted major un-
takeings on the part of psychologists. Psychologists helped solve some of
the practical problems created by a sudden and massive mobilization of
the armed forces and their adoption of new technology such as airplanes
and submarine hydrophones (sonar). One of the most notable successes in
applying psychology to the needs of the military was the development of a
means for testing the mental abilities (intelligence) of approximately
1,700,000 recruits by war’s end.

The U.S. Army needed a means to select and evaluate recruits in the
armed forces. In particular they wanted to be able to identify individuals
with mental deficiencies, to classify them by their intelligence level, and to
select those for special training (officers, for instance). In the interests of ef-
ciciency, they wanted a group test, one that was easy to administer and
score. Given that 40% of recruits at the time were illiterate and many were
not fluent in English, an intelligence test that could be administered to them
was needed, as well. A committee headed by noted comparative psycholo-
gist Robert M. Yerkes, with the help of Lewis Terman, the developer of the
Stanford–Binet intelligence test, Edward Thorndike, the well-known learn-
ing theorist, and others, quickly developed the Army Alpha group intelli-
gence test for literate persons and the Army Beta test for illiterates and
those who spoke another language (Yoakum & Yerkes, 1920).

Psychologists applied their human research and evaluation skills to a
number of other military applications during World War I. Many of these ap-
lications related to developing means of proper selection and training peo-
ple for specific military jobs, particularly flight training. Other applications
had to do with assessing the performance of military personnel under ad-
verse environmental conditions, for instance, the effects of fatigue and oxy-
gen deprivation on aviators. The success of wartime research and develop-
ment by psychologists not only gave birth to military psychology as a
discipline in American psychology but also helped to spur an increased postwar interest in applying psychological knowledge and techniques more
generally (Hoffman & Deffenbacher, 1992).

The entry of the United States into World War II in 1941 produced yet an-
other burst of application of psychological science to military needs. More
than 2,000 psychologists contributed to the war effort. Applications of cog-
nitive psychology included continuation of the work begun in World War I
concerning the effects of environmental factors on human performance and
the selection and training of persons for special duties such as aviator or
radar operator. However, the research on selection and training soon re-
valed many cases of soldiers’ misuse of or improper training to use equip-
ment. These results were a contributing factor to psychologists becoming
involved in the analysis of human errors, the preparation of training and
operating manuals, and the design of radar and sonar consoles, gun sights,
aircraft instrument panels, communication systems, and much more.

Born in World War I, military psychology certainly matured in World
War II. For present purposes, the principal new development was the emer-
gence of an understanding of the importance of the fit of human and ma-
chine: "Probably the most important contribution of the psychologists of
World War II was to demonstrate that the man-machine, rather than the ma-
           machine alone, is the fundamental fighting unit" (Bra, 1948, p. 224). Indeed,
           this demonstration helped set the research agenda for much postwar in-
dustrial as well as military research involving the application of cognitive
psychology. The method for much research of this sort became one of ana-
yzing training procedures and errors produced in human-machine interac-
tion. The goal was to develop training guidelines and machine design stan-
dards that would enable humans to optimize their performance in terms of
efficiency and safety, by having the workplace environment fit well with hu-
human needs and capabilities. As we see in the next section of this chapter, this goal became the definition of a new field of psychology that emerged in the years following World War II, a field referred to in North America as "engineering psychology," "human factors engineering," and "ergonomics."

The major areas of application of psychology to the military include personnel selection and classification, training, human factors, leadership and team effectiveness, clinical diagnosis and treatment, survey research, and the study of environmental stressors (Gal & Mangelsdorff, 1991). Hence, these areas involve all the major disciplines in psychology, including industrial/organizational, clinical, cognitive, and social psychology. Our focus is on the areas of application to which cognitive psychology has made and will continue to make the greatest contributions—training, human factors, and environmental stressors.

Applications to Military Training

Today, as since World War I, an obvious emphasis for the military has been to develop more effective means to train personnel, particularly to ensure the maximum level of operational readiness. Among the principal applications for research by cognitive psychologists are training for basic skills (reading and mathematics, for example), military skills such as infantry and seamanship, technical skills (electronics, foreign languages, for instance), and special skills such as flight training. Most recently, research on team training and training for situational awareness is receiving special emphasis. In the process of conducting research to solve the practical problems related to training, cognitive psychologists borrow as needed from the established base of research and theory in cognitive psychology but likewise contribute to this base. They do so by refining existing models and developing new models of cognitive and information processing as a result of cognitive task analysis and research they conduct in task ecologies in which military personnel must operate. For instance, efforts to test and refine existing knowledge and to develop new knowledge are occurring for applied cognitive psychologists who seek to understand the nature of training task requirements and the design of instructional systems, how to assess training performance through criterion-referenced procedures, and how to enhance training through the use of technology such as simulators and computer-based training (e.g., Cuevas, Fiore, Bowers, & Salas, in press).

Human Factors Research in the Military

From the time of World War II, there has been considerable research emphasis on changing equipment design to enhance human performance (Hoffman & Defenbacher, 1992). More recently, researchers have also sought to im-

prove human performance by seeking ways to reduce operator workload (through the use of job aids, for instance) as well as ways to reduce the potentially negative impact of acute stress such as that elicited in combat. Use of artificial intelligence to enhance human decision making has also been receiving increased attention by researchers (Gal & Mangelsdorff, 1991).

Though the military views the study of environmental stressors as a distinct area of research emphasis, we view application of cognitive psychology to such study as simply another use of human factors psychology. Research is conducted to improve the mutual fit of personnel and equipment under adverse operational conditions (Gal & Mangelsdorff, 1991). These conditions include sustained operations without sleep, operating under environmental extremes such as noise, heat, cold, or high altitude, operating with vehicles that produce high acceleration, vibration, motion sickness, or stress, and operating under hazardous atmospheric conditions (toxic fumes, radiological, chemical, or biological warfare).

Employment Opportunities

Work settings for cognitive psychologists researching military applications are quite diverse. Many researchers in this area are university faculty with research grants or contracts from a branch of the Department of Defense or they are employed either as uniformed or civilian psychologists by a military research laboratory. There are many such laboratories, each employing from several persons to hundreds. Alternatively, some cognitive psychologists working on military applications are employed by private sector contractors, working either in the contractor's laboratory or onsite at a military laboratory. Applied cognitive psychologists also work at military bases and schools performing research related to the training function. Regardless of employer, applied cognitive psychologists who can help in the creation of decision-making architectures for cognitively complex tasks and who know how to do cognitive task analysis are much in demand; this sort of applied research is often referred to as cognitive engineering.

COGNITIVE PSYCHOLOGY AND HUMAN FACTORS ENGINEERING

Though we earlier indicated that the birth of human factors psychology as an identifiable field occurred in the years after World War II, human factors research by other names was being conducted a century ago. Hoffman and Defenbacher (1992) have reviewed a number of these studies. Consider just some of the research sponsored by the railroad industry, for instance. Perhaps the most famous of these studies was that conducted by Bryan and
Harter (1987), a study concerning the learning of Morse code. Morse code is a system for communicating on radio waves using patterns of dashes and dots as alphabetic signals. Hugo Munsterberg (1913) developed a number of laboratory “tasks in miniature,” based on analyses of the tasks performed by railroad motormen under emergency conditions, particularly analyses of decisions made. Finally, George Stratton (1909), an early cognitive psychologist who founded the psychology department at the University of California, studied the rapid perceptual judgments made by locomotive engineers. His research not only included laboratory studies with special apparatus but also nocturnal field studies and observations made from trains.

A much more recent example of research related to the issue of safety in the transportation industry is a fascinating analysis of how the application of cognitive psychology can help reduce the problem of collisions between trains and vehicles at railroad grade crossings (Leibowitz, 1985). The problem is a serious one, for there are approximately 650 fatalities per year from 7,000 railroad collisions occurring annually, a relatively large number, considering there are about 27,000 locomotives in operation.

Certainly motorists have considerable advance warning, either by an active warning system or a passive one involving a crossbuck sign and perhaps warning painted on the pavement. Trains are required to sound their horns on approach to a crossing and to activate their headlights even during daylight; they are also required to travel at slower speeds within more urban areas. Locomotives are large, roughly 3 m wide by 4.5 m high. Despite such warnings and adequate visibility, however, drivers often choose to cross the track in front of an approaching train, certainly a risky decision. On a flat grade, without attached rail cars, a locomotive traveling 48 km/hr (30 mph) requires about 185 m to come to a stop, after emergency brakes are applied. If its speed is greater or it is pulling a load, the stopping distance will be proportionately greater.

Why do motorists make such risky decisions? For one thing, we are often an impatient lot, a tendency that is exaggerated at railroad crossings, for we never know how long we might be delayed at an intersection if we decide to stop and wait for the train to pass. Second, most of the time we can safely ignore the official warnings. Whenever we make the decision to cross and do so safely, that behavior is reinforced, thereby increasing our self-confidence in our judgment and the probability that we shall make the same decision again. Further increasing the probability of taking the risky decision is that on a particular day the probability of injury or death for a given person is extremely low. Additionally, perceived risk of a collision with a train is likely reduced even further by our experience of the low frequency of encountering trains at certain crossings.

Inasmuch as nearly 80% of all grade crossings in the United States only have crossbuck signs as a warning, many drivers must make their crossing decision based on their estimate of the safe time interval (Leibowitz, 1985). Clearly, sensory and perceptual cues as to the distance and speed of an oncoming train are critical to these drivers’ safe time estimates. Two sorts of cues identified by cognitive psychologists interested in perception would appear to be most relevant here. The most important of these imparts a systematic bias in the direction of underestimating the speed of the approaching train and therefore overestimating the amount of time available for a safe crossing. This phenomenon is referred to as the illusion of velocity and size (Leibowitz, 1985). For actually equal velocities, the larger of two objects will be seen to be moving more slowly. The onrushing locomotive is actually traveling much faster than it appears.

The second perceptual cue pertains to the fact that if two objects are moving in straight lines at constant velocities and are on a collision course, their relative positions remain constant in the visual field. As a result, the most accurate cue to the velocity of the oncoming train, in this case, is the rate of increase in the size of the expansion pattern on the driver’s retina. This rate of growth in the size of the visual angle created by the image of the train is not linear. For a train at a distance at which a driver’s decision is usually made, the rate of growth of the expansion pattern is relatively low; as the distance decreases from there, the expansion pattern grows at a rapidly accelerating rate, ordinarily a signal of imminent collision (Leibowitz, 1985). Unfortunately, the automobile driver who has made the decision to go ahead and attempt a crossing is no longer observing this rapidly growing expansion pattern on his or her retina and misses information that might otherwise lead to a decision to stop and wait for the train to pass.

Clearly separating highways and railroads by means of overpasses or bridges is not economically feasible in most cases. Therefore driver education programs that make clear the nature of the various factors that bias railway crossing decisions would appear to be the best bet. It might also be possible, of course, to increase the perceived velocity of large objects such as locomotives by means of special markings or lights placed on them.

Of course, human factors psychologists are concerned with much more than safety issues involving transportation, the workplace, and home use of certain products. A number of them have published descriptions of the sorts of work they have been doing; these accounts have been published on a regular basis for the past several years in Psychological Science Agenda, the newsletter of the Science Directorate of the American Psychological Association. Some of these psychologists have been concerned with human-centered approaches to the design of instruments and controls for the aircraft cockpit, for space vehicles, for aircraft control centers, for ships, and for various land vehicles. Others have been concerned with development of both partial-task and full-scale simulations to improve communications, training, and team resource management. A substantial number of human
factors psychologists are involved with human–computer interaction (HCI) and information technology applications. Some of those working on HCI applications design graphic and multimedia human–computer interfaces and interactive voice response systems for telecommunications companies. Others working on HCI applications are employed by companies that produce computer hardware and/or software. Here, for example, a human factors psychologist might apply cognitive psychology research to explain flaws in the design of the software for a user interface she might be concerned with exploring attention and perception questions for users who need or desire to navigate 3-D virtual environments.

Regardless of the particular application of cognitive psychology, human factors psychologists find employment opportunities with all sorts of employers, including government (especially federal), not-for-profit institutions, consulting firms, private industry, and universities. For instance, federal government opportunities exist in the Department of Defense, Department of Transportation, Federal Aviation Administration, National Aviation and Space Administration, National Institute for Occupational Safety and Health, and the Nuclear Regulatory Commission, among others.

CONCLUSIONS

Cognitive psychologists have made substantial contributions to solving applied problems in a wide range of domains. As with most applied projects, cognitive psychologists working in industry, educational settings, and the private sector tend to work in interdisciplinary teams. For example, cognitive psychologists working in the field of human factors are likely to be working with engineers and industrial designers. Cognitive psychologists working in forensic settings are likely to be working with criminologists and sociologists. Those working in market research and advertising companies are likely to be working with social psychologists and individuals with business training. In addition to mastering cognitive psychology, individuals seeking careers in applied settings would do well to study related fields to familiarize themselves with the content and methods that their future colleagues are likely to be employing.

It is also advisable for those seeking applied careers to seek internship opportunities as part of their training. Internship experience will not only help make a more competitive resume, it will also help individuals decide what types of work settings they are more likely to enjoy and be productive in. It is encouraging to know, however, that cognitive psychologists have a toe-hold in many applied domains, and given the short history of the field of cognitive psychology, this trend is only likely to increase into the future.

REFERENCES


Stratton, G. M. (1909). Some experiments on the perception of the movement, color, and direction of lights, with special reference to railway signaling. Psychological Review: Monograph Supplements, 10(40), 85-104.


