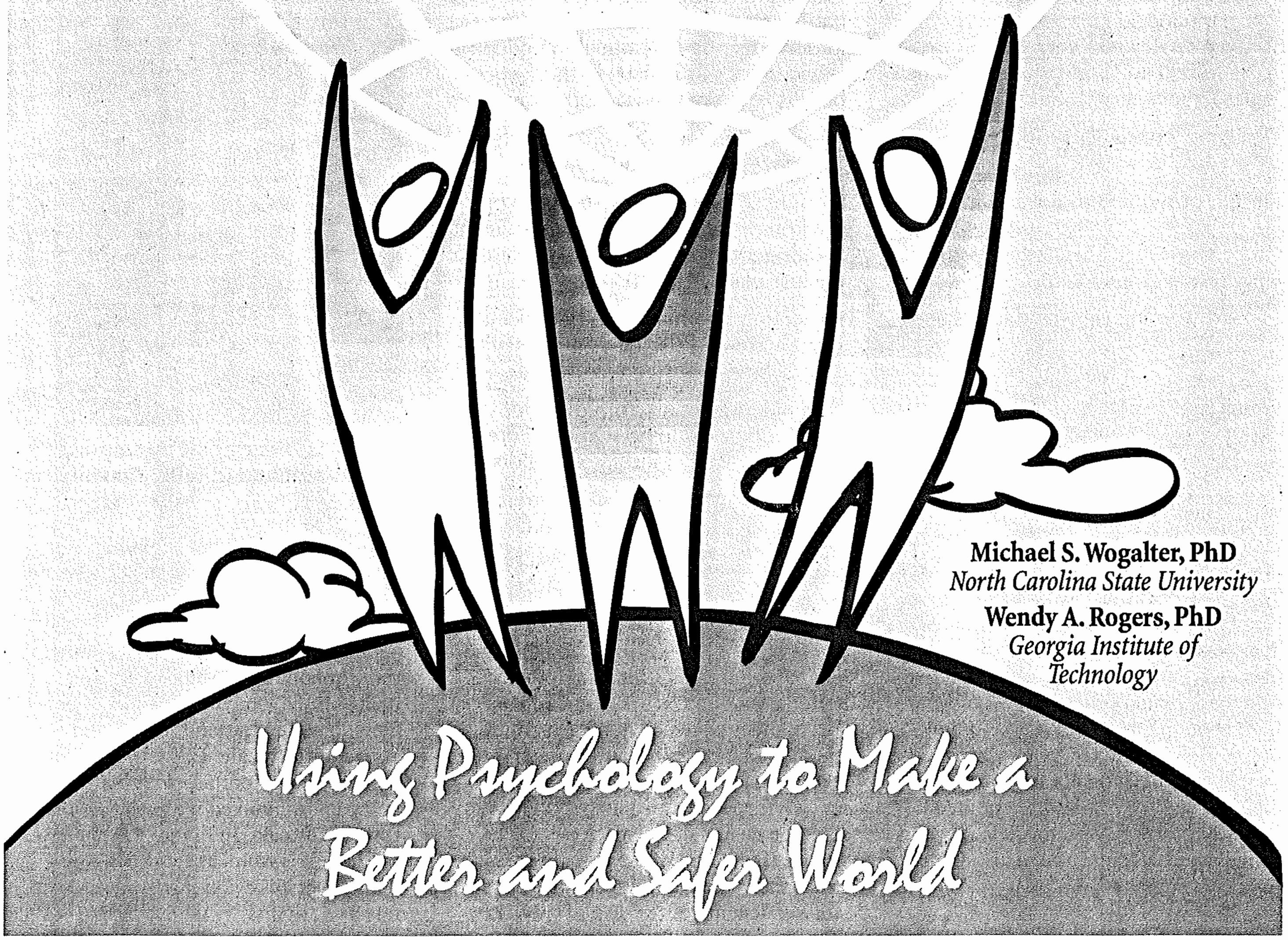
# Human Factors/Ergonomics



## Using Psychology to Make a Better and Safer World

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What is Human Factors/Ergonomics (HF/E), and why does the field have two names? The field of HF/E is the scientific discipline that attempts to find the best ways to design products, equipment, and systems so that people are maximally productive, satisfied, and safe. Historically, the term *human factors* has been used in the United States, and the term *ergonomics* has been used in Europe. Other terms used to describe the field are *engineering psychology* and *applied experimental psychology*. Whatever the name, HF/E is the science that brings together psychology and engineering design.

The field of HF/E is multidisciplinary and benefits from the input of experts from domains such as psychology, engineering, computer science, biomechanics, medicine, and others. Frequently, the HF/E professional plays the role of mediator between divergent interests advocating for the human point of view in the design of products, equipment, and systems by championing designs that make maximal use of the magnificent abilities that people possess and limiting the use of tasks where people could make errors.

Early contributions to the establishment of HF/E included the analysis of time and motion of people doing work, and determining human capabilities and limitations in relation to job demands. Most people credit the beginning of the field with the military during World War II. Pilots were flying their airplanes into the ground, and eventually psychologists were called in to find out why. We'd call it "human error" today, and part of the reason for the aircraft crashes was the lack of standardization between different aircraft models. The growing complexity of military hardware during this time period was revealing for the first time in history that even highly selected individuals who were given extensive training could not do the tasks that they needed to do. Pilots were not able to control their aircraft under stressful emergencies. The machines outstripped people's capabilities to use them. Investigations revealed that pilots had certain expectations of how things should work

This article is part of a continuing series on the various fields of psychology and the careers available within those fields.

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## TABLE 1

### Issues Addressed by Human Factors/Ergonomics

| Category | Examples |
|---|---|
| Human-computer interaction | Increasing ease-of-use of software and hardware; making the interface as intuitive as possible; developing input devices such as making better keyboards or voice recognition |
| Design of consumer products | Audio and video electronics; kitchen appliances; manual and power tools |
| Design of work systems and jobs | Designing the job tasks and workplace environments ranging from an efficient hot dog stand to the control room of a nuclear plant |
| Hazard warning signs and labels | Presenting information to help people make informed risk decisions, facilitate safe behavior, and reduce injury |
| Training | Training individuals from diverse populations including schoolchildren using computers, and fighter pilots |
| Transportation | Automotive displays and controls; intelligent transportation systems; mass transit operations |

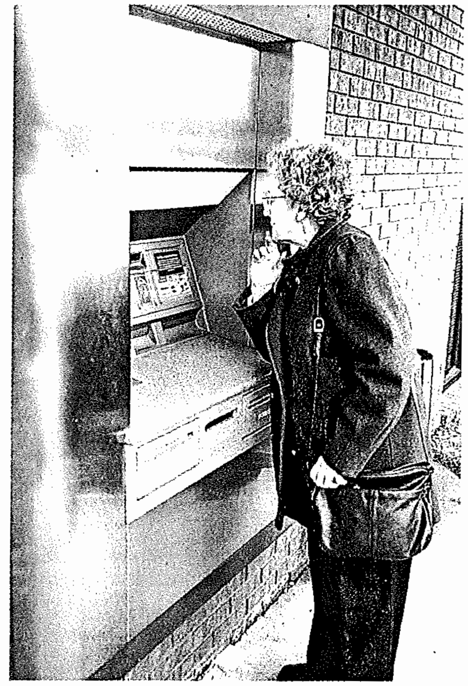

**Figure 1. Older adult attempting to use an automated teller machine (ATM).**

(for example, the location of the landing gear control and how to activate it), and these were frequently violated by aircraft designers (who frequently knew very little about people's abilities and limitations). Before WWII, it was assumed that people could eventually learn whatever they were given if they were trained properly. Since WWII, the field has blossomed as is evident from the examples provided in the next section.

## Examples of Human Factors/Ergonomics Applications

Most people, if they even know the term *ergonomics,* might recognize it as dealing with chairs or possibly automotive displays. While the design of chairs and automobiles is within the purview of HF/E, the field is much broader than that. In fact, many HF/E professionals believe that nearly all aspects of daily activities are within the domain of HF/E. The field deals with the interface between people and things, whether it be a dial on a car dashboard or a control on a stove top. The fundamental philosophy of HF/E is that all products, equipment, and systems are ultimately made for people and should reflect the goals of user satisfaction, safety, and usability. Table 1 lists some examples of the type of issues on which HF/E specialists focus.

Two specific examples might serve to illustrate HF/E considerations. The first is that as commonplace as automated teller machines (ATM) have become, many older adults do not use them even though they could benefit from their convenience (see Figure 1). The goal of an HF/E specialist would be to ensure that the design of the machine was easy to use (including the design of the buttons, the wording, the spatial layout and the sequencing of the displays, etc.). Moreover, an HF/E person might suggest employing an outreach training program to assist first-time users. The ultimate HF/E solution would be, however, to make the technology so obvious that training is not necessary. Many people can't program a VCR. You might know a statistics program that could be made easier to use and understand. These are the sort of systems that could benefit from HF/E considerations.

The second example concerns pictorial symbols. Increasingly, symbols are being used to convey concepts to people who do not understand the primary language of the locale, and this is becoming increasingly important with people and companies involved with international travel and trade. In Figure 2, the pictorial on the left is from an actual sign on automatic doors like you might see at hospitals and airports. What does it mean? The slash obscures a critical feature of the underlying symbol. The pictorial could be interpreted as "Do not stand" or the opposite, "Do not walk." The interpretation the door manufacturer wanted to convey is the first one, because the doors sometimes close unexpectedly. Can you

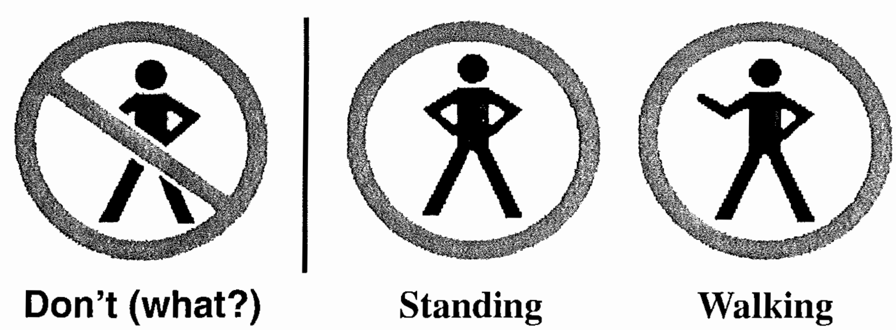


**Figure 2. The pictorial on the left has a slash that obscures a critical component needed for its interpretation.**

see that the pictorial symbol could be interpreted as the opposite of its intended meaning? The alternative interpretation was apparently missed by the designer. This is called a *critical confusion* because the meaning can create a hazard. Fortunately, most people probably do not have the chance to misinterpret this symbol. This is because whenever a person walks up to the door, the doors slide to the side, out of the way. The problem is (a) that the sensors sometimes do not pick up people standing at the threshold, and (b) that these people haven't seen the sign. People have been knocked to the ground by automatic doors that have closed unexpectedly, and for some fragile individuals that event has produced injury. An HF/E analyst would first want to "design out" the hazard (i.e., so it can't close on anyone) using, for example, better sensors and more reliable and better designed components and systems. If you can't design out the hazard, then at least you ought to guard against the hazard contacting and injuring people. When warnings are used, they ought to be designed so target audiences grasp the intended message quickly and readily with little time and effort.

## Careers in HF/E

There are a wide range of opportunities in the field of HF/E:

- aerospace systems
- accident analysis
- computer software and hardware design
- communications technology
- educational technology
- forensic psychology
- government research laboratories (Air Force, Army, Navy, NASA)
- graphics and information design
- health and medical technology design
- systems management
- training development
- university faculty
- usability analysis
- virtual reality
- workplace design

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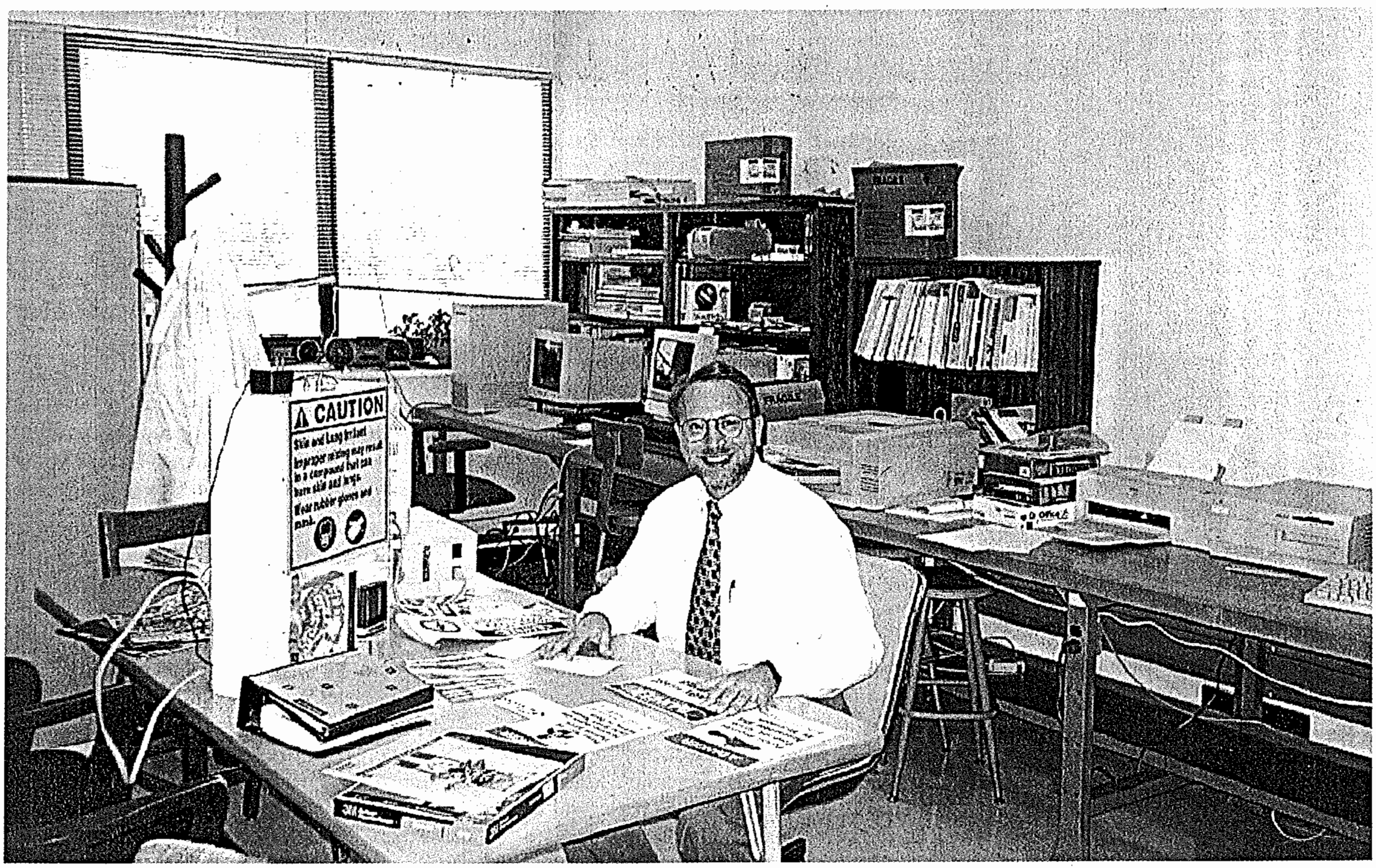


*Dr. Michael Wogalter in his lab.*

**Michael S. Wogalter, PhD,** is an associate professor of psychology at North Carolina State University, Raleigh, NC. Before coming to NCSU, he held faculty appointments at Rensselaer Polytechnic Institute and the University of Richmond. He received his PhD in human factors psychology from Rice University, an MA in human experimental psychology from the University of South Florida, and a BA in psychology from the University of Virginia.

He teaches graduate-level courses in human-computer interaction and risk communication, and undergraduate courses in ergonomics. Most of his research focuses on hazard perception, warnings, complex visual and auditory displays, and human information processing. An active member of the Human Factors and Ergonomics Society, he is currently secretary-treasurer and is a member of the Executive Council. He holds membership in several other professional organizations including APA, APS, the Ergonomics Society, and Sigma Xi. He is also on the editorial boards of the journals *Human Factors, Ergonomics, Psychology & Marketing,* and *Occupational Ergonomics.*

**Wendy Rogers, PhD,** is currently an associate professor in the School of Psychology at the Georgia Institute of Technology, where she is a member of the engineering psychology program. She received her BA from Southeastern Massachusetts University and her MS (1989) and PhD (1991) from Georgia Institute of Technology.

Her research interests include skill acquisition, human factors, training, attention, automaticity, individual differences, and cognitive aging. Her research is currently funded by the National Institutes of Health (National Institute on Aging) as part of the Center for Applied Cognitive Research on Aging. She serves on the editorial boards of *Psychology and Aging, Experimental Aging Research, Ergonomics in Design,* and *Human Factors.* She is immediate past president of the Division of Applied Experimental and Engineering Psychology (APA's Division 21). She is also the chair of Student Affairs and member of the Executive Council of the Human Factors and Ergonomics Society.

HF/E is an area in which one does not necessarily need a PhD or even a master's degree to work in the field (although most human factors psychologists with bachelor's degrees have had some relevant graduate school experience). A recent salary survey of HFES members (Lovvoll, 1997)—using data from only those people reporting that their last degree was from a psychology department—shows that a decent living may be earned at all education levels, although it must be noted that the totals cut across all years of experience (see Table 2).

Another method of assessing salaries in the field is to group the job categories as shown in Table 3.

**TABLE 2**

**Salary Levels of HF/E Professionals**

| Highest Degree | *N* | Median | Mean | *SD* |
|---|---|---|---|---|
| Bachelor's | 21 | $60,000 | $68,009 | $36,917 |
| Master's | 75 | $67,000 | $67,560 | $18,034 |
| Doctorate | 257 | $78,400 | $82,109 | $32,707 |

**TABLE 3**

**Mean Salary by Highest Degree and Job Sector**

| Type of Organization | Master's | Doctorate |
|---|---|---|
| Education/nonprofit | $30,375 (*n* = 4) | $79,568 (*n* = 77) |
| Federal government | $65,645 (*n* = 24) | $72,083 (*n* = 52) |
| Nonprofit | $38,500 (*n* = 2) | $86,455 (*n* = 9) |
| Industry | $64,572 (*n* = 65) | $87,290 (*n* = 91) |
| Service business | $61,563 (*n* = 36) | $85,710 (*n* = 71) |

*Dr. Wendy Rogers assisting Ralph Motsinger with a computer task.*

## Learning More About Human Factors/Ergonomics

Many students have not heard of the field of HF/E, in part because there is often not a course in the curriculum, it is usually not covered in other courses, and many psychology professors do not know enough about it to inform their students (Martin & Wogalter, 1997). However, there are several organizations that encourage student participation and membership.

**American Psychological Association (APA).** Division 21 of APA is the Division of Applied Experimental and Engineering Psychology. For more information about becoming a student member of the division, contact Cathy Gaddy at cgaddy@aaas.org. You may also access information about APA's Division 21 (Applied Experimental and Engineering Psychology) on the Internet: http://www.apa.org/about/division.html#d21.

**Human Factors and Ergonomics Society (HFES).** HFES is the largest U.S. organization in the field with approximately 5,000 members. Nearly half of the members are psychologists, with the other members coming from fields such as engineering, computer science, system design, and others. For more information about becoming a student member of HFES, contact Diane de Mailly at hfesdm@aol.com or call (301) 394-1811. The HFES home page may be found at http://hfes.org. From this site you can download the complete listing of HF/E graduate programs in the U.S. and Canada. They also have a year-round job placement service.

Another way to learn more about the field of HF/E is to head for the library and browse through a textbook on the topic. You will surely be amazed by the range of topics covered. Some of the standard textbooks in the field are:

Proctor, R. W., & Van Zandt, T. (1994). *Human factors in simple and complex systems.* Boston: Allyn and Bacon.

Salvendy, G. (1997). *Handbook of human factors and ergonomics.* New York: Wiley and Sons.

Sanders, M. S., & McCormick, E. J. (1993). *Human factors in engineering and design* (7th ed.). New York: McGraw-Hill.

Wickens, C. D. (1992). *Engineering psychology and human performance.* New York: HarperCollins.

The field of HF/E is exciting, challenging, and important. Specializing in this field will enable you to get involved in the development of the future as well as to help individuals interact safely and effectively with today's technology. Although things will, undoubtedly, get more complex, potentially they can be made easier to use, helping to benefit our lives.

## References


Lovvoll, D. (1997). Salary survey. *HFES Bulletin, 40*(5), 1–3.

Martin, D. W., & Wogalter, M. S. (1997). The exposure of undergraduate students to human factors/ergonomics instruction. *Proceedings of the 41st Annual Meeting of the Human Factors and Ergonomics Society* (pp. 470–473). Santa Monica, CA: HFES.