What is Human Factors and Ergonomics?

Eric F. Shaver, Ph.D. & Curt C. Braun, Ph.D.
www.benchmarkrs.com

Human factors and ergonomics focuses on designing the world to better accommodate people.

As a unique scientific discipline, human factors and ergonomics systematically applies the knowledge of human abilities and limitations to the design of systems with the goal of optimizing the interaction between people and other system elements to enhance safety, performance, and satisfaction.

Human factors are relevant anywhere people work with systems, whether they are social or technical in nature. The breadth of these sociotechnical systems include situations and circumstances where people interact with other system elements including:

- Artifacts (e.g., tools, machines, products, software, etc.)
- Tasks
- Environments
- Teams
- Organizations
- Legal (e.g., regulations, enforcement, etc.) and political

To learn more about each of these elements, the interested reader should consult the writings of Carayon (2006), Carayon and Smith (2000), Karwowski (2000), Moray (2000), and Wilson (2000).

Within the last 100 years, a broad spectrum of industries have benefitted by deliberately focusing on how people interact with systems. These industries include:

- Aerospace
- Automotive
- Chemical
- Computer
- Consumer products
- Construction
- Defense
- Forestry
- Healthcare
- Manufacturing
- Mining
- Nuclear
- Petroleum
- Telecommunications
- Textile

The gamut of work human factors and ergonomics practitioners perform is great and has been discussed in greater detail by Karwowski (2005; 2006) and Salvendy (2006).

A Brief History of HF and E

Born of necessity and collaboration

In the United States, the discipline of human factors and ergonomics, is generally considered to have originated during World War II (Wickens & Hollands, 2000), although advances that contributed to its formation can be traced to the turn of the 20th century. Prior to World War II, the focus was "designing the human to fit the machine" (i.e., trial and error), instead of designing machines to fit the human (p. 3). This can be found in Frederick Taylor's work studying selection, training, work-rest schedules, and time & motion studies of industrial workers (Taylor, 1911), and through the extension of his time & motions studies, by Frank and Lillian Gilbreth (Gilbreth, 1914; Gilbreth & Gilbreth, 1917).

Many of the human factors and ergonomic advances originated out of military necessity. With the start of World War I, the first conflict to employ the newly invented airplane in combat, the need arose for methods to rapidly select and train qualified pilots. This prompted the development of aviation psychology and the beginning of aeromedical research. Although advances were made in this time period, according to Meister (1999), the impetus for developing the discipline wasn't met due to a lack of "critical mass of technology and personnel as there was in World War II" (p. 149).

The time between World War I and World War II saw a reduction in research, although some achievements were made. Aeromedical research continued to see advances in laboratories built at Brooks Air Force Base in Texas and Wright Field in Ohio. These laboratories performed studies that focused on further identifying the characteristics of successful pilots, and determining what effects environmental stressors had on flight performance. Also, the basics of anthropometry (the study of human body measurements) were applied to the design of airplanes in this time period. In the private sector, automobile driving behavioral research was also conducted (Forbes, 1939).

The outbreak of World War II, and the two inherent needs it generated, formed the catalyst for developing the human factors and ergonomics discipline. First, the need to mobilize and employ vast numbers of men and women made it impractical to select individuals for specific jobs. Thus, the focus shifted to designing for people's capabilities, while minimizing the negative consequences of their limitations. Second, World War II witnessed the tipping point where the technological advances had finally outpaced the ability of people to adapt and compensate to poor designs. This was most evident in airplane crashes by highly-trained pilots due to problems with control configurations (Fitts & Jones, 1947a) and instrument displays (Fitts & Jones, 1947b). Also, enemy contacts were missed by motivated radar operators (Wickens & Hollands, 2000). Experimental psychologists were retained to study these issues by adapting laboratory techniques to solve applied problems. Consequently, the discipline of human factors and ergonomics was born, even if the people (e.g., Paul Fitts, Alphonse Chapanis, Arnold Small, etc.) involved didn't realize it at the time (Meister, 1999).

The two decades following the end of World War II saw the continuation of military-sponsored research, driven in large part, by the Cold War. Military research laboratories established during the war were expanded and additional ones were developed by the Army (Human Engineering

Laboratory), the Air Force (Air Force Personnel and Training Research Center), and the Navy (Naval Electronics Laboratory). Universities also established laboratories, with the assistance of government funding, including ones at the University of Illinois (Aviation Psychology Laboratory) in 1946, and Ohio State University (Laboratory of Aviation Psychology) in 1949. The private sector saw the establishment of human factors and ergonomics groups in aviation companies (e.g., Boeing, McDonnell Douglass, and Grumman Corporation, etc.) and electronics and communication (e.g., Bell Laboratories, etc.).

The Human Factors Society, the main professional organization for human factors and ergonomics practitioners in the US, was formed in 1957 with approximately 90 people attending the first annual meeting. The name was changed to the Human Factors and Ergonomics Society in 1992. Today the society has more than 4500 members, many of whom participate in one or more of the 23 technical groups, local and student chapters, and attend the annual meeting.

Starting in the mid-1960s, the discipline continued to grow and develop in previously established areas. Moreover, it expanded into other areas including computer hardware (1960s); computer software (1970s); nuclear power plants & weapon systems (1980s); the Internet & automation (1990s), and adaptive technology (2000s), just to name a few. Most recently, new areas of interest have emerged including affect, neuroergonomics, and nanoergonomics.

A consistent theme that has emerged over the years is the ever expanding sphere of influence human factors and ergonomics has sought to encompass, as technology advances and grows. What started out as a narrowly defined break off of experimental psychology that focused on the interaction of people with machine controls has grown to encompass almost any interaction of people with their surroundings. With the rapid advances in science and technology, in such areas as bio- and nanotechnology, it's interesting to speculate on what newly discovered problems human factors and ergonomics will be called on to solve. Several authors have theorized about the future directions for the discipline, including Brewer and Hsiang (2002), Cacciabue (2008), Hancock and Diaz (2002), Rasmussen (2000), and Vicente (2008).

Today, as it was at its inception, HFE remains a multi-disciplinary profession. In the United States, the profession grew from the behavioral sciences, like experimental psychology, and certain engineering disciplines. Among European nations, the profession finds its roots in the physical sciences, like human physiology. Today, individuals from a number of disciplines ranging from psychology, engineering and physiology, focus their unique skills and abilities to the study of how people interact with systems.

Readers interested in learning more about the formal history of the human factors and ergonomics discipline are encouraged to read the very informative text authored by Meister (1999). The authors of this abbreviated history are very much indebted to this work. Also, the reader may want to consult O'Brien and Meister (2002).

Further Reading

Besides the many references listed in this writing, there are a few other general texts on the topic of human factors & ergonomics the interested reader might consider acquiring. They can be purchased in most bookstores, and include Casey (1998), Norman (1988; 2007), and Vicente (2003).

References

Brewer, J.D., & Hsiang, S.M. (2002). The 'ergonomics paradigm': Foundations, challenges and future directions. *Theoretical Issues in Ergonomics Science, 3,* 285-305.

Cacciabue, P.C. (2008). Role and challenges of ergonomics in modern societal contexts. *Ergonomics, 51,* 42-48.

Carayon, P. (2006). Human factors of complex sociotechnical systems. *Applied Ergonomics, 37,* 525-535.

Carayon, P., & Smith, M.J. (2000). Work organization and ergonomics. *Applied Ergonomics, 31,* 649-662.

Casey, S. (1998). *Set phasers on stun: And other true tales of design, technology, and human error* (2nd ed). Santa Barbara, CA: Aegean Publishing Company.

Fitts, P.M., & Jones, R.E. (1947a). *Analysis of factors contributing to 460 "pilot error" experiences in operating aircraft controls* (Report No. TSEAA-694-12). Dayton, OH: Aero Medical Laboratory, Air Materiel Command, U.S. Air Force.

Fitts, P.M., & Jones, R.E. (1947b). *Psychological aspects of instrument display. Analysis of 270 "pilot-error" experiences in reading and interpreting aircraft instruments* (Report No. TSEAA-694-12A). Dayton, OH: Aero Medical Laboratory, Air Materiel Command, U.S. Air Force.

Forbes, T.W. (1939). The normal automobile driver as a traffic problem. *The Journal of General Psychology. 20,* 471-474.

Gilbreth, L.M. (1914). *The psychology of management: The function of the mind in determining, teaching and installing methods of least waste.* New York, NY: Sturgis & Walton Company.

Gilbreth, F.B., & Gilbreth, L.M. (1917). *Applied motion study: A collection of papers on the efficient method of industrial preparedness.* New York, NY: Sturgis & Walton Company.

Hancock, P.A., & Diaz, D.D. (2002). Ergonomics as a foundation for a science of purpose. *Theoretical Issues in Ergonomics Science, 3,* 115-123.

Karwowski, W. (2000). Symvatology: The science of an artifact-human compatibility. *Theoretical Issues in Ergonomics Science, 1,* 76-91.

Karwowski, W. (2005). Ergonomics and human factors: the paradigms for science, engineering, design, technology and management of human-compatibility systems. *Ergonomics, 48,* 436-463.

Karwowski, W. (2006). The discipline of ergonomics and human factors. In G. Salvendy (Ed.), *Handbook of Human Factors and Ergonomics, 3rd ed.* (pp. 3-31). Hoboken, NJ: John Wiley & Sons.

Meister, D. (1999). *The history of human factors and ergonomics.* Mahwah, NJ: Lawrence Erlbaum Associates.

Moray, N. (2000). Culture, politics and ergonomics. *Ergonomics, 43,* 858-868.

Norman, D. A. (1988). *The design of everyday things.* New York, NY: Doubleday.

Norman, D.A. (2007). *The design of future things.* New York, NY: Basic Books.

O'Brien, T.G., & Meister, D. (2001). Human factors testing and evaluation: An historical perspective. In S.G. Charlton & T.G. O'Brien (Eds.), *Handbook of Human Factors Testing and Evalution* (pp. 5-20). Mahwah, NJ: Lawrence Erlbaum Associates.

Rasmussen, J. (2000). Human factors in a dynamic information society: Where are we heading? *Ergonomics, 43,* 869-879.

Salvendy, G. (2006). *Handbook of Human Factors and Ergonomics* (3rd ed). Hoboken, NJ: John Wiley & Sons.

Taylor, F.W. (1911). *The principles of scientific management.* New York, NY: Harper & Brothers Publishers.

Vicente, K.J. (2003). *The human factor.* New York, NY: Routledge.

Vicente, K.J. (2008). Human factors engineering that makes a difference: Leveraging a science of societal change. *Theoretical Issues in Ergonomics Science, 9,* 1-24.

Wickens, C.D., & Hollands, J.G. (2000). *Engineering psychology and human performance (*3rd ed). Upper Saddle River, NJ: Prentice Hall.

Wilson, J.R. (2000). Fundamentals of ergonomics in theory and practice. *Applied Ergonomics, 31,* 557-567.

Eric F. Shaver, Ph.D. is a senior consultant with Benchmark Research & Safety, Inc. where he specializes in human factors and ergonomics, safety, and applied decision making. Dr. Shaver's work has emphasized achieving a good fit between people and technology to facilitate their safety, performance, and satisfaction.

Curt C. Braun, Ph.D. is the president, CEO, and founder of Benchmark Research & Safety, Inc. Dr. Braun has brought psychological and human factors principles to a variety of industries including aviation, software development, public administration and research, and wildland management. In each field, Dr. Braun has worked to identify and shape the psychological and system design factors that promote human performance

Benchmark Research & Safety, Inc. specializes in providing consulting and professional services for a variety of areas including human factors design and usability, product and occupational safety, and training. For more information about how human factors and ergonomics initiatives might benefit your organization, please contact Dr. Shaver at eshaver@benchmarkrs.com or 208-407-2908.