A History of Human Factors Psychology

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Abstract

This paper focuses on the history of human factors psychology. It starts off defining human factors before going on to its origin. The main influences of human factors before World War II were Fredrick Taylor and Frank and Lillian Gilbreth. These people put their energies into time and motion studies. World War II was the time of aviation psychology, which applied experimental psychology and the pervading problem of the airplanes being too advanced for pilots to keep up with psychological and physiologically. After the war was when human factors began to permeate throughout the military, universities, and industries (Lane, 2006). Human factors is a heavily applied science and there are those that think that it should contribute to psychology theoretically (Hancock & Drury, 2011) and provide societal change (Vicente, 2008).

 *Keywords*: history of human factors, ergonomics, engineering psychology

**A History of Human Factors Psychology**

 Human factors can be defined as the concern with people in relationship to machines and equipment in their environment (Hawkins, 1987; Wiener & Nagel, 1988). The term human factors is also interchangeably used with the term ergonomics, which is also defined as the field that studies a person's behavior in regards to their work environment (Brewer & Hsiang, 2002). At the same time, both terms are different in that human factors is more concerned with human performance as well as system interfaces while ergonomics does not focus on those aspects (Hawkins, 1987). Nevertheless, the terms are still used in reference to the same concept of helping human lives in regards to technology and living more efficiently.

**The Beginnings of Human Factors**

Human factors is a multidisciplinary branch of psychology that at first stemmed from industrial and organizational psychology (Lane, 2007; Brewer & Hsiang, 2002). There are sources that credit the start of I/O psychology to Hugo Munsterberg (Koppes, 2007; Lane, 2007; Wren & Greenwood, 1998), a German man who came to America, who also pioneered many branches of psychology such as forensic psychology. Munsterberg was also said to be inspired by a man named Frederick Taylor (Wren & Greenwood, 1998).

Frederick Taylor had the idea of scientific management and that people should be working smarter, not harder. The reason for adding the word scientific to the term scientific management is because Taylor emphasized the use of the scientific method when it came to studying the effect of change as well as using empirical measurements (Koppes, 2007). While he did not invent the concept of time studies, Taylor was the first to apply it to a worker’s motions (Wren & Greenwood, 1998; Chapanis, Garner, & Morgan, 1949). Instead of focusing on the total time a job took, Taylor focused on how a job should be done and how it could be more efficient with less fatigue on the worker. Not only was Taylor the brilliant originator of scientific management, he was also the one that paved the way for human resource management because of the need for an employment specialist (Wren & Greenwood, 1998).

**The Gilbreths**

While Taylor worked on time study, Frank Gilbreth was working on motion studies. Motion study mainly deals with the manipulations or movements humans use to perform any job and to find the best way to do any job by studying various ways that is can be done (Gilbreth & Gilbreth, 1917). He began his work with brick laying because he noticed that there were three distinct ways new workers were taught how to law bricks (Wren & Greenwood, 1998; Gilbreth & Carey, 1949). This was what sparked Gilbreth’s interest in motion study and he began to research it. Gilbreth came to the same conclusion as Taylor did, that wasted motion equated to more worker fatigue (Wren & Greenwood, 1998). To measure motion, Gilbreth used a method called micro-motion, where he used a motion picture camera, a cross-sectioned camera, and a clock (Wren & Greenwood, 1998; Gilbreth & Gilbreth, 1917). Gilbreth liked the idea of a camera better because it allowed for multiple views, since the human eye cannot follow all of human’s motions. He called each fundamental movement a therblig, which is Gilbreth backwards (Wren & Greenwood, 1998).

 Another piece of technology that Gilbreth uses for motion studies is the chronocyclegraph. The chronocyclegraph works by attaching small, electric-light bulbs to the fingers of the operator. To study the motion, a photograph is taken of the moving part of where the lights are attached and to study direction, the lights are made to show dot or dashes which will help track the direction the operator is going with their motions (Gilbreth & Gilbreth, 1917).

 Frank Gilbreth did not work alone though. He had a wife, Lillian Gilbreth, who worked with him on his management consulting firm. Lillian, originally Lillian Moller, received her bachelor’s and master’s degrees in English from the University of California in Berkley. She later went on to obtain her doctorate degree in psychology, under E. L. Thorndike, because the field best complimented Frank’s work (Wren & Greenwood, 1998). Together, they conducted motion studies and ran their own consulting business. Lillian herself wrote many books and articles regarding psychology, scientific management, and efficiency overall (Wren & Greenwood, 1998).

Over the years, the Gilbreths continued to work and at one point, Frank was called to duty in World War I (Wren & Greenwood, 1998). Their interest then transferred to design jobs, using motion studies for war veterans, especially those that had limbs amputated, so that they can go back to civilian life after the war. Out of this came technology that would assist the disabled and Lillian worked with the General Electric Company to design home appliances for disabled humans that stayed at home (Wren & Greenwood, 1998).

After the war, Frank and Lillian continued to work and in 1924, Frank was scheduled to speak in London and Prague along with Lillian. A few days before they were set to leave, Frank died of a heart condition that had followed him from World War I (Wren & Greenwood, 1998). His death struck Lillian hard but she continued to London and Prague to speak on his behalf. After this, Lillian continued the Gilbreth business and held motion study seminars throughout the United States. Since not many women were in management and engineering, she was the talk of the town and there were many people that took an interest in her. She became the first woman to receive a master’s degree in engineering and went on to be the first woman professor of management at the University of Michigan, Purdue University, and Newark College of Engineering (Wren & Greenwood, 1998). Lillian was an impressive woman and continued her work without her husband and partner and became the first lady of management. Her contributions along with her husband in motion studies pervaded the fields of engineering and psychology.

**The War Years**

 Human factors came about in World War I to optimize factory production (Hawkins, 1987), but World War II was where it began to truly break away from I/O psychology. World War II was when many psychologists had to do applied research, instead of theoretical research that was done in labs (Chapanis et al., 1949). Before, the psychologists that were brought in to work on military technology focused on the heavy experimental side that contributed to theory (Chapanis, 1999). After a few trials using the typical experimental method that they were taught in school, the psychologists decided that it was time to apply concepts to what was happening, not on how it would work out in the lab (Lane, 2007). This was the time that time and motion studies merged with experimental psychology which in turn made engineering psychology (Chapanis et al., 1949; Chapanis, 1999). This was because during the war, there were a number of problems that had to do with the aircrafts.

Alphonse Chapanis, a pioneer to aviation psychology (Lane, 2007), dealt with a problem where pilots were retracting landing gear instead of landing flaps when they landed which in turn caused many accidents (Chapanis, 1999). Many people attributed this to pilot error (Chapanis, 1999; Hawkins, 1987) because it was the pilots that were operating the machinery. Instead, Chapanis (1999) inspected the cockpits and saw that there were two identical switches that were side by side, one for landing gear and the other for the landing flaps. Instead of faulting the pilot, Chapanis called this designer error, instead of pilot error. Hawkings (1987) also points out that the concept of pilot error focuses on what happened rather than why it happened, which is not the true focus of improving technology.

The problem with technology at the time was that there was pressure for machines to be improved which in turn called for the abilities of man to be tested (Chapanis et al., 1949). There were people that said that man had to be improved and made more efficient and this could be done through practice (Chapanis, 1999). The real solution though was to make machines more efficient (Chapanis et al., 1949). Humans have limits to their capabilities of operating while machines do not. Unlike machines, pilots become fatigued while they fly (Wiener & Nagel, 1988). Because of their fatigue, pilots were overlooking certain things such as fuel checking because this was located in their peripheral vision. Looking at the fuel meant neglecting other instruments in the plane and that was not an option to a fatigued pilot. Not only was their fatigue involved, but there was also stress which would then in turn affect a pilot’s performance (Weiner & Nagel, 1988).

 Machines that demand too much of a person will fail as well as jobs that push a person beyond their physical limit (Chapanis et al., 1949; Brewer & Hsiang, 2002). What has to be taken into account is the physiological and psychological capabilities of a human. While a machine can go up to tremendous speeds and heights, a normal human’s physical, processing, and other cognitive limits are being tested with these improvements (Brewer & Hsiang, 2002). Just because the equipment is better, does not necessarily mean that the performance of humans will be up to par (Chapanis et al., 1949). With all of this in mind, designers and engineers now have to keep in mind how a person sees and hears so that the technology can be designed to be better for the person (Chapanis et al., 1949).

**Post War Years**

Human factors psychology is an active discipline that aims for change (Vicente, 2008). The change focuses on improving the quality of human life by making technology more usable and safer to use during the war. After the war, the United States began to apply human factors engineering to military technology (Brewer & Hsiang, 2002). Not only that but engineering psychology, what it was referred to at the time, was being applied to other places as well. Alphonse Chapanis and other people that worked during the war went to different universities to continue research in engineering psychology (Lane, 2007). Soon, students were beginning to get graduate degrees in human factors in the late 1940s (Chapanis, 1999). As students began graduating from these programs, they were getting jobs from the military, universities, and industries (Lane, 2007). Examples of these industries include are Bell Telephone Laboratories and IBM’s Product Development Laboratory.

The post war years also brought on the creation of professional societies with the main focus being on human factors psychology. At first, engineering psychologists were members of Division 14, Division 19, or both of the American Psychological Association (Lane, 2007). Division 14 is the Society for Industrial and Organizational Psychology while Division 19 is the Society for Military Psychology. In 1957, Division 21 was formed which was then the Society of Engineering Psychologists, which is now called the Division of Applied Experimental and Engineering Psychologists (Chapanis, 1999).

While there is human factors psychology, there are many professionals work in human factors such as biomechanics, engineers, and work physiologists (Lane, 2007). Since there was a need for another society for all of those involved with human factors, the Human Factors of Society of America was created in 1956. The name would later change to the Human Factors Society (HFS) and then finally the Human Factors and Ergonomics Society (HFES). In 1958, the HFS published the journal *Human Factors*, a journal that Division 21 could not compete with when they wanted to when it was evident that many more people were going to HFS meetings and not Division 21 (Lane, 2007).

While human factors psychology has developed well over the years since its birth from industrial psychology, there are many painful lessons with in the discipline (Lane, 2007). Professionals must take into account the whole population of humans and not just a specific group of the population. Lane (2007) uses the example of air bags. The data used to design airbags were based on anthropometrics of the average male adult but were not designed for children or those of smaller stature. While the airbag did save many lives, there were deaths that would not have happened if the airbags were not deployed.

**Human Factors in Use**

 As mentioned before, human factors purpose is to change and improve the quality of human life (Vicente, 2008). Change is a good thing, especially when it comes to the safety of people in regards to technology. Sometimes the call for change may be tragic but tragedy allows others to make mistakes with the same technology with less tragic results (Casey, 2006).

 An example of a tragic accident that called for change is written by Casey (2006) in his book, *The Atomic Chef*. One of chapters is about a two-year child that had died from a window crushing her neck. The child was sitting in a car with the windows open and the key turned to the accessory position in the ignition. A puppy had then come up to the car and the child was curious and wanted to see it. To get a better look, the child got onto the armrest and looked out the window. The problem with his is that the armrest had a rocker switch to retract or put up the glass window. Tragically, the child hit the switch that put the glass window up and died from the crushing of her esophagus.

 There were other accidents similar to this that Casey (2006) reported and all of them were similar situations. Cars that had the technology to prevent such things from happening were considered luxury cars. Nowadays, cars have child safety switches that prevent such things from happening and the rocker switch is no longer a technology that is used by car manufacturers. While this is a tragic case, this is one of the ways that technology can be fixed. Though in some cases, there is a lag between cause and effect, as brought up by Vicente (2008).

Vicente (2008) brings up that it took a while for asbestos to be found harmful because the onset of cancer symptoms ranged from 10 to 40 years. As Vicente (2008) points out, this is a problem because the lag can sometimes not incite a large scale change. With the child in car incident, it was a relatively fast change because the tragic results were instant and the instances happened in a relatively large number.

 Another incident with technology is highlighted again by Casey (1998). This incident also has to with design. The machine in question is the Therac-25 cancer radiation machine. At the time, this was the state of the art technology when it came to cancer treatment. This machine functioned as an x-ray with high power, with a metal plate in place to lower intensity and an electron beam that was low power. To enter the most respectively, one just presses the x or e key on a keyboard to switch modes before proceeding.

 What had happened one day was that the technician had accidentally pressed the x key instead of the e key (Casey, 1998). It was an easy fix and the editing was done under eight seconds. The problem with this is that manufacturers had not considered this sort of commands and the string of commands was not tested when the machine was in development. While seemingly small, the problem was that the mirror from x-ray mode was retracted but the machine was still left on full power. The technician had no clue this had happened and when administering the treatment the first time, a malfunction message appeared. This particular message meant that the treatment was not given and so the technician gave it again. The patient was hit with three high bursts of radiation before he confronted the problem. Because the machine had malfunctioned, it did not seem to be a problem because the machine said that only a small treatment dose was given. The same incident had happened again in the same office and it also happened in different areas of the United States and Canada.

While no one was truly at fault, there were still tragic consequences to the malfunctioning machine. It is hard to think of all the possible scenarios that could possibly happen with technology, especially when it is supposed to be state of the art technology. This is the heart of Steven Casey’s books. Many of the chapters include tragic endings to the faults of technology because people generalize or do not think of all the issues that happen.

**The Future of Human Factors**

 While a beneficial field, there are those that are not satisfied with the current state of affairs in regards to the overall human factors field. Hancock and Drury (2011) suggest that empirical research done in human factors and ergonomics should also contribute to theory. In their article, they introduce a concept of the Quality of Life (QoL) and to whom this concept really applies to. There are studies on the QoL along with happiness that Hancock and Drury (2011) mention in their article. The point of mentioning QoL is that it should not be taken lightly and that there should be more about it. With the world becoming more and more interconnected, there is a call for more collective organization that includes all of the people in the world, not just a certain interest group that some may consider a sample of all people in the world.

 Vicente (2008) also brings out the idea that human factors is not really contributing to societal change. While technology is being improved, there are other problems that cannot be solved just by improving the technology. Vicente (2008) focuses his attention on things that prevent change such as ignorance in information or a lag between cause and effect of problems, such as asbestos as a carcinogen. Another problem is cost. To fix a huge problem that spreads throughout a country costs a lot of money and even if it is short term. A main point from the article though is that people are afraid of change and that those that advocate change are threatening the current state of affairs (Vicente, 2008). To incite change and be able to change society effectively, there has to be an understanding of political and social forces at work within society.

 With that being said, it can be argued though that human factors is already heavily tied in with application, research, and professional development (Lane, 2007). Human factors stemmed from I/O psychology which had stemmed from experimental psychology. While Lane (2007) points at the there was a split between application and experiments in engineering after separate texts were being written for I/O and human factors. While there is this split, the two still interact and that is a beneficial attribute to human factors. The fact that it can interact with I/O psychology and that it encompasses so many other fields to make things happen such as technology becoming safer and more usable makes it a very good science. While theory is not really emphasized in human factors, it is emphasized in I/O and other fields such as engineering and physiology. The theories are then combined and before it is applied to the technology. It is only speculation and opinion but human factors does not actually need to be applied because of the other subfields that make it up. As technology evolves, so do all of the fields in human factors and human factors itself. Human factors builds upon all of the theories at present time.

 In contrary to Hancock and Drury’s article, the opinion is that since human factors builds on theory, then it does not need to contribute to theory itself. It is enough for a field to take theories and apply them. To make work efficient, the Gilbreths applied motion and time studies to their work and built upon Taylor’s scientific management theory (Wren & Greenwood, 1998).

 Overall, there is still a future for human factors. As technology improves by the day, there are still likely to be accidents caused by technology and design error. For a field to move forward, it has to contribute somehow and human factors does just that. It is a needed discipline and it is not exclusive to just psychology, it includes other fields and that is what helps it grow more and more.

**Conclusion**

 Human factors encompasses many ideas from many different disciplines. It started out as Frederick Taylor’s idea of scientific management and Frank and Lillian Gilbreth’s motion studies, which then led to aviation and engineering psychology springing from industrial and organizational psychology during World War II. After the war, engineering psychology began to take hold in universities as human factors and ergonomics with students obtaining graduate degrees in the field. This was then applied to the military, government, and industry practices. With the field of human factors growing, specialized societies were formed such as Division 21 in the American Psychological Association and the Human Factors and Ergonomics Society.

 The use of human factors pervades today into making technology usuable for the average human and to improve the quality of human life (Vicente, 2008). While a decent discipline, there are those that want it to change or at least contribute a little more to the world when it comes to theory and society in general. Human factors is not without its flaws but without it, then the world be a different place than it is today. The work of the precursors and founders of human factors is not lost in today’s world. Technology is heavily integrated into society that without Alphonse Chapanis and other aviation psychologists, flight would not be as safe it is today. Without the Gilbreths and Taylor, there would be a lot of wasted energy and efficiency when it came to work. Frank Gilbreth was the one that suggested that the nurse give the doctor surgical instruments when it came to operations (Gilbreth & Carey, 1949).

 There is a future for human factors psychology and it is being written day by day. As technology improves, so does the field and the professionals in it. While humans cannot adapt to extreme physical conditions, they can make technology more usable for them to survive in this world. It is an amazing feat for people to have come this far and with technology, the human race is only growing and prospering.

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