A Literature Study to Explore Empirically: What is the Scientific Discipline of Human Factors and What Makes It Distinct from Other Related Fields

Karin Laumann [1], Martin Rasmussen [1], Ronald L. Boring [2]

[1]Norwegian University of Science and Technology (NTNU), Department for Psychology, Dragvoll, 7491 Trondheim, Norway
[2] Human Factors, Controls, and Statistics, Idaho National Laboratory, PO box 1625, Idaho Falls, Idaho 83415, USA

Abstract. The aim of this paper is to investigate which topics are studied within human factors, what are the "levels" studied (individuals, work group, organizations, societies), and which methods are used. The questions were answered by investigating 183 papers published in the *Human Factors* journal for 2015 and 2016. The results showed that more than five papers included the topics; car driving, physical workload, human-automation interaction, design and usability, human machine interface (displays, controls and alarms), mental workload, cognition, team work, training/simulations, and anthropometry. The topics that seem to be unique for human factors are all the topics that are about human-computer/technology interactions and the topic of design and usability. Experiments are the main method used in human factors and almost all of the studies are at the individual level.

Keywords: human factors, literature study, human computer interaction, human-technology interaction, design and usability.

1 Introduction

The most often cited definition of human factors is The International Ergonomic Association's definition (IEA) [1]: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people."

From our experience, when this definition is presented to students, researchers from other fields and others they do not do seem to understand the definition. It seems especially difficult to understand what makes the scientific field of human factors different from the other fields.

There might be different reasons why this definition is difficult to understand. The word "system" is used twice in this definition. A system could be defined as something that consists of interacting or interdependent components [2,3]. With this defini-

tion, a system could thus be everything from a cell, to a telephone, to a society. In addition, when the use of the words "element of a system" are added to the definition, the definition says that human factors study the interaction among humans and everything else that might exist.

Also Hollnagel [3] describes the difficulties with using the word system in the definition of human factors. Hollnagel [3] describes that a system could also be defined from a system theoretic or cybernetic perspective as "a set of mutually dependent function, hence characterized by what it does rather than what it is." This definition does not increase the clarity of the word "system" since it is equally difficult to understand which functions we refer to within human factors.

In addition, the human factors definition says that the purpose of human factors is to optimize human well-being and overall system performance. It is difficult to find any study in the entire field of psychology that is not concerned with either "well-being" or "performance" or both. However, this seems to apply for all sciences where humans are the main object of study, which applies for most of the social sciences (anthropology, sociology, and pedagogics), medicine, physiotherapy, and business management science.

The Human Factors and Ergonomic Society have collected several definitions of human factors. What characterizes all of these definitions is that they are so broad that they include the entire social science field with words like "systems" and "performance."

There has been some concern that human factors is not used as much as it should when for example new products are being developed [for example 4]. Part of this problem could be that the field of human factors is not defined or described in a way that is easy to communicate and understand for people from other fields like engineering or psychology. The purpose of this paper is to: a) investigate the questions presented below and to propose a more understandable description of what human factors is based on human factors literature, and b) describe how human factors it is different from other fields.

The questions investigated in this paper are:

a. Which topics are studied within human factors?
b. Which methods are used in human factors research?
c. What are the "levels" studied (individuals, work. group, organizations societies)?

To answer these questions, a literature review was performed.

2 Method

In this study we chose to investigate all papers from 2015 and 2016 in the journal, '*Human Factors: The Journal of the Human Factors and Ergonomics Society*.' This journal was selected, because of its name and because it has a broad definition of human factors that resembles the definition presented in the introduction of this paper. In addition, this is a highly-ranked journal. We argue that the last two years of papers in this journal should give us an answer to which topics are included within contemporary human factors, which methods are used, and which levels (individuals, work group, organization, society) are investigated.

In all 183 papers were selected for this study. One of the papers from 2015/2016 was left out because it was a short introduction to a special issue

To investigate which topics where included in the papers, a thematic analysis inspired by Brown and Clark method [5] was performed. The paper titles and abstracts, which for almost all papers consist of; objective, background, method, results, applications and keywords were copied to a table in a word document. The papers' themes or main topics were coded/interpreted, based on this information, for each paper. For some papers, further information from the papers had to be read to define their topic. Thereafter, all the codes from all the papers were compared with each other and color coding (one color for each topic/theme) was used to group the papers in broader topics or themes.

The papers were first coded by the first author. Subsequently the second author looked at the information from the papers and the codes and made his own judgements about the codes. There was a general consensus between the authors. Some small differences in judgements of themes/topics were discussed and based on these discussions some minor changes in the topics were performed. Finally all the themes/topics and the papers sorted into them were described by the first author.

The first author coded the methods and levels used in the papers. This information needed less interpretation and was therefore analyzed by one author. Since this paper is a conference paper with a limited length, there is not enough space to refer to all the papers included into the analysis.

3 Results

As can be seen in Table 1, we found twenty main themes or topics within the papers in the journal *Human factors*. The themes were: car driving, physical workload, human-automation interaction, design and usability, human machine interface (displays, controls and alarms), mental workload, cognition, team work, training/simulations, anthropometry, safety, virtual reality, human reliability, procedure, human factor method, cyber security, physical environment, stress, dynamic systems modeling and psychomotor test. Totally 164 papers, or approximately 90 percent of the papers, were about the first ten themes. The remaining ten themes included less than five papers each. Below we provide a short description of each of the topics.

3.1 Car Driving

Car driving was the topic most found and a total of 38 papers were sorted under this topic. There was a special issue, (issue 8, in 2015) about assessing cognitive distraction in driving. However, without that particular issue, car driving would still be the topic with the most papers included. All the papers within the car driving topic were related to safety. Within the category car driving, the topic most studied is distractions, which was covered in seventeen papers. There were two papers on attention and driving, which are related to the topic distraction since this topic is concerned with distraction from internal sources. There are four papers in this topic, which are related to autonomous car driving. Four studies investigate the usability of different support systems within the car, and three study the field of view. There are two papers that

investigate range anxiety in electrical vehicles There is also one paper on crossing behavior and decision making , driving styles and road safety, and pedal application and safety. One study tested if drivers take into account the action boundaries of their car when overtaking. One paper on car speeding in simulated hazard scenes and differences between young and novice drivers. There were two papers included within this category that are in the boundary of the topic, since their main concern is pedestrians. However, these studies were included in this category, since this is clearly related to safety and car driving.

3.2 Physical Workload

All the papers sorted into this topic are related to how different forms of physical workload such as standing, prolonged sitting, lifting, and hand force have a negative effect on the human body (such as muscles and back pain).

Twenty-six papers were included in this topic. In Issue 5 for 2016 there was a special section on the impact of Thomas Water on the field of ergonomics. This issue included nine papers that were included in this topic. However, without taking into account the special issue, a high number of papers were also included into this category. Four of the papers in this topic have also investigated physical workload in different occupations.

Some of the studies are related to another topic that we found namely design and usability in that they investigate how different interventions reduce physical workload. If papers seemed to focus more on the physical workload than the design and usability they were included into this category.

3.3 Human-Automation Interaction

All the papers in this topic are related to how humans interact with automation. Most of these papers seem to focus on how humans perceive autonomous systems and how their perceptions affect performance. In these studies, trust in automation seems to be a rather large topic. Some studies look at individual differences in perceiving, experiencing and performing, with automation One study investigated how a specific system affected performance, workload, and situation awareness and one study investigated how different types of automation failure affect performance.

One study looked at human automation interaction used in different fields and one study looked at different human sub-systems that are affected by human-automation interaction. There is one study investigating tactile language for human computer interaction, and one study that investigate human aware motion in human-robot collaboration. There is also one study that investigates the cooperation behavior of an agent.

Table 1. Topic/themes into which the papers in the journal Human Factor for 2015 and 2016 are sorted, the numbers of papers that are included in each theme for 2015 and 2016, and the total of these two years.

Topics/themes	2015	2016	Total
Car driving	24	14	38
Physical workload	12	14	26
Human-automation interaction	12	8	20
Design and usability	7	9	16
HMI (Displays, controls and alarms)	9	5	14
Mental workload	6	7	13
Cognition	6	6	12
Team work	4	6	10
Training/simulations	2	5	7
Anthropometry	4	2	6
Virtual reality	4	0	4
Safety	1	3	4
Human reliability	2	0	2
Procedure	1	1	2
Human factor method	1	1	2
Cyber security	1	1	2
Physical work environment	1	1	2
Stress	0	1	1
Dynamic systems modeling	0	1	1
Psychomotor test	1	0	1
Total	98	85	183

3.4 Design and Usability

Sixteen papers were grouped into this topic. Most of the studies within this topic are related to usability tests (performance and/or preference) of the design of a product for a particular situation, purpose, a group of people, or a combination of these three, or the testing and development of guidelines that have an aim to increase usability. There was also one study that developed and tested a user experience satisfaction scale. One study is concerned with culture in design. In this topic, there were two studies that evaluated a design with physiological measurements. These two studies are in this topic and not in the physical workload topic, because the main purpose seems to be the test of a design rather than the physiological workload in itself.

3.5 Human Machine Interface (Display, Controls and Alarms)

Fourteen papers were included into this topic. This topic is very much related to the last topic of design and usability. However, the studies that are included in this category are usability studies of the human-machine interface or, more specifically of displays, controls and alarms. Eight of these studies are concerned with displays, three studies on alarms, and one study on control responses. There was also one paper that studied the overall HMI. The studies within this topic could have been included in design and usability, however, since all of these papers studied human machine interface, they were collected under one topic.

3.6 Mental Workload

Thirteen papers were included under this topic. The topics in the papers were related to different types of mental workload such as sustained attention, interruptions, sleep disruptions, watch schedule, transitions in task demand, night shifts, break length, boredom in the workplace, shift length, and trajectory uncertainty. There are some papers that are concerned with measurement of mental workload.

3.7 Cognition

Twelve papers were included under this topic. The main purpose of the papers that ware sorted into this topic is to study the different cognitive processes and their effects on task performance. The main topics in these papers were: multitask resource allocation, uncertain contact location in simulated submarine track management, factors that influence the predictions of uncertain spatial trajectories, task switching when concurrence is impossible, goals and strategic mental models, effects of standing or walking on mental functions, sustained attention and loss of inhibitory control, reducing disruptive effects of interruption, operational decision making, situation awareness in offshore drillers, individual differences in verbal-spatial conflicts, and situation awareness in submarine track management.

3.8 Team Work

Eleven papers were included in this topic. In three of the papers, the main topic was team training and measuring effects of team training. These papers could also be in the training/simulation topic. The other papers in this category studied the effect of coacting observers, coordination strategies, haptic communication, increase of task relevant information, strategies for pre-handover preparation, and the effectiveness of brainstorming.

3.9 Training/Simulations

Seven papers were included in this topic. In two of these papers simulator or simulation training were the main topic. Two of the papers evaluated the realism and transferability of training from the simulator. For two of the studies, the topics studied were related to training in general (and not in a simulator). All the studies that were included in this topic were related to the context of training and technology.

3.10 Anthropometry

Six papers were included in this topic. All the papers that were included in this topic studied the measurement of the size and proportions of the human body that is useful for design.

3.11 Virtual Reality

Four papers were included in this topic. Each paper studied one of these topics: hand gesture, exertion of force, haptic perception, and localization of spatial differentiated virtual audio signals in virtual reality.

3.12 Safety

Four papers were included within this topic. The papers sorted under this topic are very different; however, all of them investigate some form of safety as the main topic. One of the papers investigated intervention to reduce slips, trips and falls in hospitals. In one study a maintenance questionnaire is developed. One investigated a system to analyze trading incident. Finally, one study explored interdependencies of human and organizational subsystems of multiple complex, safety-sensitive technological systems.

3.13 Human Reliability

Two papers were included under this topic. One study investigated visual inspection reliability, and one study investigated a new human reliability analysis method.

3.14 Procedures

Two papers were included in this topic. In one study, the effects of hand-off protocols were investigated, and in another study, an intervention to study procedural errors was investigated.

3.15 Human Factor Method

Two papers were included in this topic. One of these papers studied if thinking aloud influenced perceived time, and the other studied the use of link analysis.

3.16 Cyber Security

Two papers were included under this topic. One of the papers studied vulnerability to phishing attacks and the other paper studied the role of human factors in security in cyberspace.

3.17 Physical Environment

Two paper where included in this topic. One of the papers investigated motion sickness and the second paper investigated perceived spaciousness.

3.18 Stress

One paper was included in this topic, which investigate multidimensional assessment of task stress.

3.19 Dynamic System Modeling

One paper was included in this topic, which describes the modeling of factors influencing long-term viability of a food supply network.

3.20 Psychomotor Test

One paper was included in this topic, which estimated finger-tapping rates and load capacities.

3.31 Method Used and Level Studied in the Papers

Table 2 shows in how many papers used the different methods. The experiment was the most used method. Literature review, questionnaire, other qualitative methods (than experiment and questionnaire) and discussion, were used in some studies. Both qualitative and quantitative, qualitative meta-analysis and qualitative method was used in a few studies.

The levels (individuals, workgroup, organization or society) that the papers describe are shown in Table 3. The table shows that an individual level was investigated in almost all (160) papers, a work group level was investigated together in fourteen papers and an organizational level in together five papers and a society level in two studies. In six papers, it was not possible to interpret a level.

Table 2. Methods used in the papers in Human Factors journal for 2015 and 2016

Methods	Number
Experiment	125
Literature review	16
Questionnaire	12
Other quantitative methods[1]	11
Discussion paper	9
Both qualitative and quantitative	5
Qualitative meta-analysis	3
Qualitative	2

[1] than experiment and questionnaire

Table 3. Levels investigated in the Human Factor journals paper for 2015 and 2016

Levels	Number
Individual	160
Work group	10
Organization	1
Society	2
Individual/team/organization	4
Not possible to interpret level	6

4 Discussion

The results show that the main topics that are included by more than five papers in the journal 'Human factors' are; car driving, physical workload, human-automation interaction, design and usability, human machine interface (displays, controls and alarms), mental workload, cognition, team work, training/simulations, anthropometry. Some smaller topics, where less than five papers were included are: virtual reality, safety, human reliability, procedure, human factor method, cyber security, physical work environment, stress, dynamic systems modeling and psychomotor test.

The topics that seem to be unique for human factors are all the topics that are about a) human-computer/technology interactions (human-automation interaction, human machine interface (displays, controls and alarms), virtual reality, cyber security), and

b) the topic design and usability. Both anthropometry and physical and mental workload are related to and important for design and usability. Safety or human reliability could also be important for human computer/technology interactions, HMI, and design and usability

However, from the list and the description of the papers within the topics human factors seems to consist of topics that are unrelated and which are connected to different academic fields. For example, physical workload and anthropometry seems to be connected to physiology while topics like mental workload, team work, cognition and training/simulations are connected to psychology. Car driving or traffic, at least in Norway is an academic field in itself.

Even if human errors are often used as a dependent variable in the human factors experiments, safety and human reliability are small topics within the Human Factors journal, with altogether six papers that are sorted into these topics.

In the definition of human factors and in the general literature one might get the impression that human factors is a field that tries to include very much from other fields. It is a question if that is the best way for the academic field of human factors to proceed. If human factors overlap with several academic fields (e.g. cognitive psychology, work and organizational psychology, organizational science, safety science, traffic, physiology, anthropometry, and occupational therapy), it might be difficult to describe what a human factors expert is. One person would usually not have training in more than a few of these academic fields, and if he/she does have training in one or two of the fields, is that then sufficient to be a human factors expert? It is also difficult to know when you look for a human factors expert, what types of knowledge the person possesses.

We here argue that human factors should limit itself and not include several large scientific fields. The papers in the Human Factors journal do not reflect that human factors is covering the entire human field. Additionally, it is a bit ironic that in a field, where one of the main topics is usability, has been so vague on what human factors include or excludes.

The method used in most of the studies in the journal is experiments. Few paper used other methods.

Almost all of the papers described an individual level. Hence human factors is studying individuals, some studies on the work group level, and studies at the organizational and society level do almost not exist. From this, it could be argued, that human factors are more related to work psychology than to organizational psychology or to organizational science.

This paper has investigated the topics, methods and levels studied in the papers in the Human Factors journal. The papers that are included into a journal might again depend on several factors. The first one is the journal selection process by the authors. Usually authors would look at the former papers in the journal to see if their papers fit there. Furthermore, choosing a journal might depend on other journal options where the paper might fit better as well as the ranking of the journals. Thereafter, the editor(s) and the reviewers also make a decision whether a paper fit within the journal or not. It might be that not all research that is contemporary representing human factors research would be included in this journal. However, we think that the collective process between authors, reviewers and editors should give a broad representation of the research within human factors.

5 Conclusion

Our conclusion from investigating the papers in the Human Factor journal is that human factors should be limited to the study of humans interaction with computers/technology and usability of different types of design. It could be a good idea to split human factors and ergonomics where the ergonomic deals with topics like physical workload and anthropometry. The study of cognitions in itself, should continue to be included in cognitive psychology. However, cognition is also relevant for human interaction with computers/technology and for the usability of different types of design and in this context, it is relevant for human factors.

Teams, mental workload and stress have been studied in work and organizational psychology and can continue to belong there. It seems like organizational safety is included within safety science and organizational science, which is very different from human factors. The main method used in human factors is the experiment, and the data are analyzed at an individual level, which shows that human factors is not an organizational science. Reliability and human reliability also seem to be an academicals field in itself, however human reliability, which is often analyzed at an individual or work group level, seems closer to human factors than to organizational safety.

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